6-1998

Analysis of Hydric Pine Flatwood Ephemeral Pool Macroinvertebrate and Crustacean Assemblages Along a Temporal and Spatial Gradient From a Hypothesized Colonial Source

Henry Leon Griffith
Columbus State University

Recommended Citation

Griffith, Henry Leon, "Analysis of Hydric Pine Flatwood Ephemeral Pool Macroinvertebrate and Crustacean Assemblages Along a Temporal and Spatial Gradient From a Hypothesized Colonial Source" (1998). *Theses and Dissertations*. 10.
https://csuepress.columbusstate.edu/theses_dissertations/10

ANALYSIS OF HYDRIC PINE FLATWOOD EPHEMERAL POOL MACROINVERTEBRATE AND CRUSTACEAN ASSEMBLAGES ALONG A TEMPORAL AND SPATIAL GRADIENT FROM A HYPOTHESIZED COLONIAL SOURCE

Henry Leon Griffith III

Columbus State University

The College of Science

The Graduate Program in Environmental Science

Analysis of Hydric Pine Flatwood Ephemeral Pool Macroinvertebrate and Crustacean Assemblages along a Temporal and Spatial Gradient from a Hypothesized Colonial Source.

A Thesis in

Environmental Science

by

Henry Leon Griffith III

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

June 1998

I have submitted this thesis in partial fulfillment of the requirements of the degree of Master of Science.

22 May 1998
Date

Henry L. Griffith III
Henry L. Griffith III

We approve the thesis of Henry Leon Griffith III as presented here.

22 MAY 1998
Date

James A. Gore
James A. Gore, Professor of
Environmental Science, Thesis Advisor

22 May 1998
Date

George E. Stanton, Professor of Biology

24 May 1998
Date

William J. Frazier
William J. Frazier, Professor of Geology

22 May '98
Date

William S. Birkhead, Professor of Biology

Abstract

A survey of the macroinvertebrate and crustacean assemblages in hydric pine flatwood wetlands during fill and drawdown periods was conducted from September to November 1998, in Lee County, Florida. Physical and chemical information, relationships between community composition and physical and chemical conditions were analyzed and a monitoring plan for detecting impacts of declining water supply in hydric pine flatwood communities was proposed. In addition, possible sources of colonists and patterns of community assemblage were investigated. Twelve ephemeral pools and three associated intermittently exposed cypress heads were sampled monthly, over three months, using 1 D-ring benthic sweep, 2 Hester-Dendy multiple plate artificial substrates, 2 bottle brush artificial substrates, and 1 funnel trap per site. Bray-Curtis based ordinations and cluster analysis revealed significant dissimilarity between and among macroinvertebrate, chironomid, and crustacean assemblages in ephemeral pool and intermittently exposed cypress head habitats at distances within 200 meters. A Principle Components Analysis (PCA) of non-chironomid macroinvertebrate assemblages and the physical and chemical parameters measured revealed that the distribution of the taxa collected could not be significantly correlated with any of the physical or chemical criteria. The pattern of colonization of the temporary wetlands within the Flint Pen Strand hydric pine flatwoods mimics those for invasion of isolated islands in the world's oceans. Species invasion is rapid by active dispersers and slightly slower by passive dispersers. Colonization is dependent upon distance to the recipient islands, both spatially and temporally, and the number of intervening "stepping-stone islands" acting as temporary refugia. The isolated

Abstract (Continued)

island effect is not constant in the hydric pine flatwood sites. During the initial rainy season, there is probably a surface water connection from the more persistent water bodies to the hydric pine wetland. However, as the dry season proceeds, the more distant sites become hydrologically isolated. The macroinvertebrate fauna of the temporary wetlands associated with the hydric pine flatwoods represent unique associations different from those of semi-permanently flooded or intermittently exposed bodies of water. Cluster analysis of non-chironomid macroinvertebrate, chironomid, and crustacean assemblages support this conclusion. From the cluster analysis, a species list of abundant and common species expected in the represented zones was created. Although a number of different types of artificial substrates were put to use, the standard D-ring dip net is the suggested methodology to provide a composite sample necessary to determine the health of these ecosystems. Since chironomids have been shown to be indicators of changes in water quality and this study indicates that they are representative of the various changes in distance from source, area, and volume effects, concentration on this taxon is suggested for future monitoring. Taxa such as dragonflies, damselflies, *Caenis* sp., *Ablabesmyia rhamphe* grp., and *Zavreliella marmorata* could be expected to be indicators of adequate wetland conditions. In the larger wetland areas, the loss of longer-lived species, like the dragonflies and mayflies, indicate drydown effects, as does an increase in semi-aquatic forms, like the Collembola and Ceratopogonidae.

Table of Contents

Table of Contents

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES

Acknowledgements

I would like to thank Dr. Jim Gore, Columbus State University, for his field assistance and advice during the course of this study and Mr. David Addison, The Conservancy of Southwest Florida, for his assistance in the field and knowledge of Florida's natural environments. I am especially thankful to Mr. Steve Mortellaro, South Florida Water Management District, who provided logistical support, field assistance and valuable insights into the ecology of hydric pine flatwood wetlands in South Florida. In addition, I would like to thank Dr. George Stanton, Columbus State University, Dr. William Frazier, Columbus State University, and Dr. William Birkhead, Columbus State University for their comments and suggestions in the preparation of this thesis. This research was supported through a contract with the South Florida Water Management District.

Dedication

This work is dedicated to: George C. Peeples, who instilled in me an appreciation and curiosity for nature and its inhabitants; Nicole L. Griffith, my loving wife, who graciously tolerated the late hours in the lab and behind the computer and provided much needed support; and to my soon to be born son, Cameron L. Griffith, whom I hope will someday enjoy and appreciate the little spineless wonders of this world.

INTRODUCTION

Various isolated and ephemeral bodies of water can be found throughout the world. In south Florida, hydric pine flatwoods provide a unique example of this type of ecosystem. For most of the year, hydric pine flatwoods function as uplands. However, during the wet season, they are flooded and apparently function as wetlands. As they dry down in the fall and winter months, their characteristics shift towards upland pine communities. Although there is considerable information concerning the change in flatwood vegetation with changes in hydroperiod (Abrahamson and Hartnett 1990), there has been little attention paid to the changes in the aquatic communities during the wet/dry cycle. How this duality of function is reflected in the aquatic life forms that may seasonally occupy these hydric pine flatwoods is unknown.

ISLAND BIOGEOGRAPHIC PRINCIPLES

According to the equilibrium theory of island biogeography (MacArthur and Wilson 1967), the dynamic equilibrium of immigration and extinction, influenced by distance from a source of colonist and size of the island, contributes extensively to the number of inhabiting species (Fig. 1). This model predicts that an interaction between decreasing island size and increasing distance from a source of colonist, negatively influences the rate of immigration and positively influences the rate of extinction. Points of equilibrium in the model reflect the approximate number of species that could inhabit an island. As source distance increases and the size of the recipient island decreases, the model predicts that fewer species will inhabit the island due to decreased immigration and increased

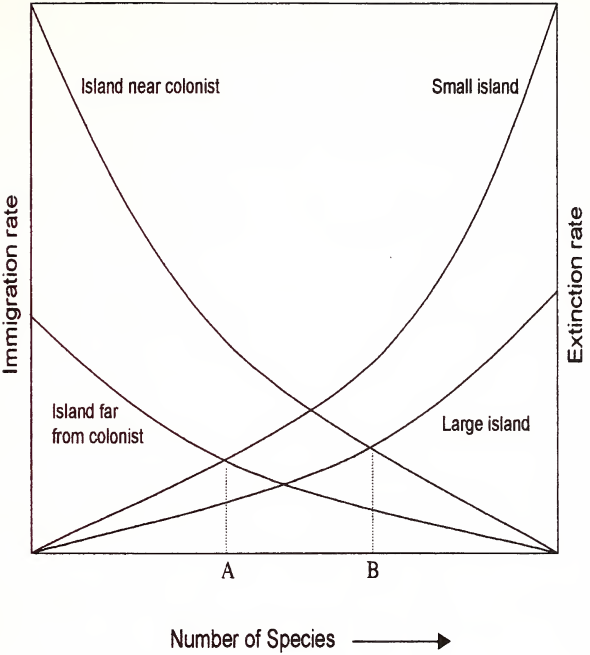


Figure 1: Spatial equilibrium theory of island biogeography (redrawn from MacArthur and Wilson 1967). A and B are points of equilibrium in the model, reflecting the approximate number of species that could inhabit a small, far away, recipient island and a large, near, recipient island respectively.

extinctions. This theory, developed for oceanic islands, has also been applied to isolated patches of habitat with unique spatial characteristics and appears to be applicable to temporally isolated habitats (Williams 1987). March and Bass (1995) confirmed that macroinvertebrate density and number of taxa in six temporary pools were positively correlated with increase in pool size (measured as volume of water). Investigating the crustaceans of 149 lowland waters, Fryer (1985) reported that large bodies of water produced the most diverse fauna with 13 of the 125 species being only found in ponds, and thus presumed to be small. This indicates that smaller bodies of water contain unique taxa not found in larger ones. Chironomid diversity (Driver 1977) also appears to be positively related to surface area.

When Ebert and Balko (1987) applied MacArthur and Wilson's equilibrium model to their data from temporary pools in southern California, species-area curves for crustaceans and higher plant species were only roughly correlated (r = 0.54 and 0.52 respectively). This variability inspired an analogous model applicable to temporary aquatic habitats. Their model (Fig. 2) incorporated the influence of frequency and duration of inundation. According to Ebert and Balko (1987), frequency of habitat occurrence in time is analogous with spatial distance from a source, and habitat duration is analogous to the physical size of an island in space. It seems reasonable that infrequently inundated ephemeral pools be considered temporally distant from a colonial source when their primary source of colonists (diapause eggs or instars) must survive through long dry periods (distant time) for favorable emergent conditions. Similarly, ephemeral pools of short duration in comparison to a pool of longer duration are

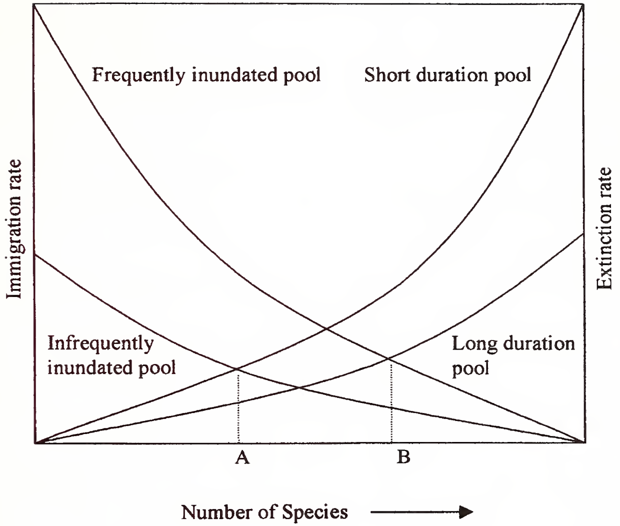


Figure 2: Temporal equilibrium theory of island biogeography (redrawn from Ebert and Balko 1987). A and B are points of equilibrium in the model, reflecting the approximate number of species that could inhabit a short duration, infrequently inundated, pool and a long duration, frequently inundated, pool respectively.

considered temporally smaller. Accordingly, when pool size is constant, those pools that are infrequently inundated for short periods will maintain fewer species than a pool frequently inundated for short or long periods.

COLONIZATION

The source of invertebrate colonists and community composition in seasonal hydric pine flatwood wetlands is unknown. It would seem that adjacent, more permanent bodies of water (either ponds or cypress-head wetlands) should serve as the source of colonists that annually repopulate these areas. Dispersal from these sources could occur through aerial dispersal by adults, or larval and nymphal movement in ground and surface water flow. Under certain circumstances, groundwater may flow from cypress swamp areas into surrounding pine flatwoods (Crownover *et al.* 1995). This might allow some colonization to occur through this connection. However, since flow rates have been reported to be less than 60 cm/d, this is probably a small contribution to temporary wetlands farther than 30 or 40 m from the cypress head (Crownover *et al.* 1995). Furthermore, in the case of the Flint Pen Strand in Lee County, Florida, ground water flow is directed towards the cypress head and away from upland habitats (Doug Shaw, hydrologist, SFWMD, personal communication). This would appear to limit colonization to either overland flow or aerial dispersing mechanisms.

In addition to the influence of the physical and temporal attributes of ephemeral pools, interspecific competition for resources also influences community structure (Williams 1987). Typically, the first to appear in newly created habitats are non-predatory species.

The delayed arrival of predatory species is dependent upon adequate prey numbers. As predators increase in number, prey numbers may decrease significantly, even to the point of extinction of some populations/species. In temporary pools, the assessment of an apparent decrease in prey populations is complicated by the passage of some species into diapause stages of their life cycle (Williams 1987). Fish, typically limited to pools that remain flooded, are not the top predators in temporarily inundated pools (Batzer and Wissinger 1996). Larger macroinvertebrates such as odonate nymphs, coleopteran larvae, and hemipterans serve as predators, especially in the absence of fish.

LIFE CYCLE ADAPTATIONS

Small temporary wetlands may contain a unique assemblage composed of species adapted to a variable temporal pattern. There is little research about the impacts of surface water drawdown on aquatic invertebrates found in these ecosystems. However, some research on ephemeral ponds in Africa suggests that macroinvertebrates, especially aquatic insects, can be adapted to this unique environment and will be found in distinctive communities, unlike those from adjacent permanent water bodies (Hinton 1960).

In hydric pine flatwoods the unique seasonal alternation from wetland to upland habitat imposes many formidable survival conditions on aquatic invertebrates, both physiologically as well as ecologically. Perhaps the most influential condition imposed is the loss of water during the dry season. Because of this, many organisms that live under these conditions are well adapted either to drying conditions or posses the ability to migrate effectively (Williams 1987). Ebert and Balko (1987) stated simply that organisms faced with imminent environmental deterioration could do one of at least three things: leave, become dormant, or die.

For invertebrates living in temporary pool conditions, there are two general life cycle strategies (Batzer and Wissinger 1996, Williams 1987). The first, exhibited by flightless organisms, is desiccation resistant eggs. Eggs, deposited in or on the substrate, survive dry periods in a state of diapause and hatch with filling of the pool. This allows these organisms to take advantage of the newly available nutrient resources and increase in number before predatory species arrive. Desiccation resistance is best documented for protists, rotifers, crustaceans, annelids, and mollusks (Batzer and Wissinger 1996, Alekseev and Starobogatov 1996, Fryer 1996, Williams 1987). The use of diapause, desiccation resistant, eggs has also been documented in insects taxa such as dragonflies, caddisflies, beetles, and some dipterans (Batzer and Wissinger 1996, Williams 1987). A second common life strategy for aquatic insects with the ability to fly, is to produce adults that emigrate to temporary pools and deposit eggs (Batzer and Wissinger 1996). Often the first to emigrate are dipterans, such as mosquitoes and midges (Batzer and Wissinger 1996). The most common strategy for aquatic insects living in temporary conditions is to produce alternating non-migratory and migratory generations. That is, dry-down initiates emergence or production of a generation capable of migrating to a permanent body of water adjacent to the temporary pools. Aerial adults return to the ephemeral water bodies during subsequent storm events (Wiggins *et al.* 1980). This phenomenon is widely known among the Hemiptera and Coleoptera, and it has been recorded for some Odonata (Batzer and Wissinger 1996, Williams 1987).

CHIRONOMID ADAPTATIONS

Hinton (1960) reported, among the chironomids, dominant macroinvertebrates in most isolated wetlands in south Florida (Gore *et al.* 1997), African species of *Polypedilum* survive increased water temperatures and desiccation in a cryptobiotic state. For purposes of this paper, diapause and cryptobiosis are considered synonymous and are defined as a dormant state, induced from dehydration, and followed by a growth phase upon re-hydration (Williams 1987). Desiccated larvae can be revived after several years and tolerate extremely high and low temperatures while in a cryptobiotic state. Adams (1984) has shown that a single generation of *Polypedilum* can be reactivated as water levels rise and fall during several seasons.

Those species unable to enter a cryptobiotic state adopt an alternative survival strategy, an extremely short life cycle. Cantrell and McLachlan (1982) found that many ephemeral pond chironomids completed their life cycle in two weeks or less during times of temporary inundation. Grodhaus (1980) reported that several species, including several genera in the Tanytarsinae, produced aestivating larval stages during the dry months in vernal pools in California. This cocoon stage is apparently obligatory and a specific adaptation to living in predictably ephemeral environments. Grodhaus reported that aestivating stages could remain alive for over 32 months.

Many macroinvertebrates require specific hydroperiods and/or water depths at particular times of the year to complete their life cycles (Mitsch and Gosselink 1993). In temporary ponds in Italy, duration of wet phase, dissolved oxygen content, and sediment organic matter influenced the composition of the chironomids, with Chironominae and Tanypodinae dominating long-duration, low-oxygen environments. On the other hand, Orthocladinae dominated short-duration, high-oxygen environments (Bazzanti *et al.* 1997). However, there are few data to suggest that similar relationships exist between hydrological conditions and the success of macroinvertebrates in hydric pine flatwoods.

CRUSTACEAN ADAPTATIONS

In addition to the chironomids, micro-crustaceans are prevalent in temporary habitats. Micro-crustaceans, primarily Cladocera, have been utilized in past studies for the analysis of factors associated with length of water duration (Ebert and Balko 1987, and Morton and Bayly 1977) and pond area (Fryer 1985). Ebert and Balko (1987) report a positive correlation between the number of crustacean species in temporary pools in San Diego, California and pool area ($r = 0.52$, slope $= 0.355 \pm 0.082$). Additionally, a significant negative correlation was found between the number of crustacean species and an increase in pool drying frequency ($r = 0.81$).

Because of their limited autogenic dispersal ability, crustaceans rely upon hydrological mechanisms (overland and groundwater flow), wind, or other animals for dispersal. In addition, they posses the ability to withstand desiccation (Alekseev and Starobogatov 1996, Brendonck 1996, Fryer 1996, Korovchinsky and Boikova 1996, Schwartz and

Hebert 1987, and Mellors 1975). The most common form of desiccation survival appears to be via diapausing instars (Alekseev and Starobogatov 1996). In some cases, desiccation and re-wetting is a prerequisite for the breaking of diapause (Brendonck 1996), leading to staggered hatching or emergence. *Streptocephalus seali* hatching appears to be maximal after four months of storage under wet conditions, whereas *S. dichotomus* hatching is greatest in ten to twenty days (Moore 1967). In Ctenopods, the ability of diapause eggs to survive desiccation has been reported to increase in the sequence: (*Holopedium*, *Limnosida*) – *Sida* – *Latona* – *Diaphanosoma* (Korovchinsky and Boikova 1996). In addition to desiccation, changes in osmotic pressure, oxygen pressure, pH, CO_2, temperature, and light have also been found to control hatching of diapause eggs (Brendonck 1996). Although these controls have not been investigated specifically within flatwood ephemeral pools, it seems reasonable that staggered emergence and differential ability to survive dry periods would affect assemblage composition under seasonal drying conditions.

It appears then, that several strategies may be available to some macroinvertebrate genera as a means to survive the seasonally dry periods or persist in unusually dry years. Thus, community richness and diversity in hydric pine flatwoods may not be dependent upon the existence of an adjacent source of colonists.

OBJECTIVES

The objectives of this study were to collect and identify macroinvertebrates and crustaceans from isolated temporary wetlands in the Flint Pen Strand, Lee County, Florida, to record physical and chemical information from each site, to analyze any relationships between community composition and these conditions, and to recommend a monitoring plan which might aid District staff in detecting impacts of declining water supply in hydric flatwood communities. With these data, I analyzed possible sources of colonists and patterns of community assemblage.

MATERIALS AND METHODS

To evaluate ephemeral pool macroinvertebrate and crustacean assemblages along a temporal and spatial gradient from a hypothesized colonial source, hydric pine flatwood areas located in Lee county Florida were selected for study. This locality was chosen because of its inclusion in the South Florida Water Management District (SFWMD) monitoring and evaluation program. The program was developed to evaluate present drawdown criteria and establish cause-and-effect relationships between District-permitted hydrologic activities and adverse ecological changes in isolated wetlands. The location, specified as the Flint Pen (FP) Strand by the (SFWMD) is located approximately 16 to 24 kilometers east of Fort Myers, Florida.

Within the Flint Pen strand two intermittently exposed cypress heads (FP6-5 and FP7-1), previously designated as FP6 and FP7 by the SFWMD, were chosen as hypothesized colonial sources due to their persistent water holding capacity. A shallower cypress head (FP9-1), not previously designated by the SFWMD, was utilized as a third colonial source (see map, Fig. 3). This site was shallower and broader than the other two and was thus classified for purposes of this study as a cypress prairie. The intermittently exposed classification conferred upon FP6-5 and FP7-1 is utilized because under extreme drought conditions they may become dry.

The adjoining pine flatwoods were typical of the pine flatwood communities found in southwest Florida. Although slash pines (*Pinus elliotti*) were clearly the dominant species, cypress (*Taxodium* sp.), wax myrtle (*Myrica cerifera*), and dahoon holly (*Ilex*

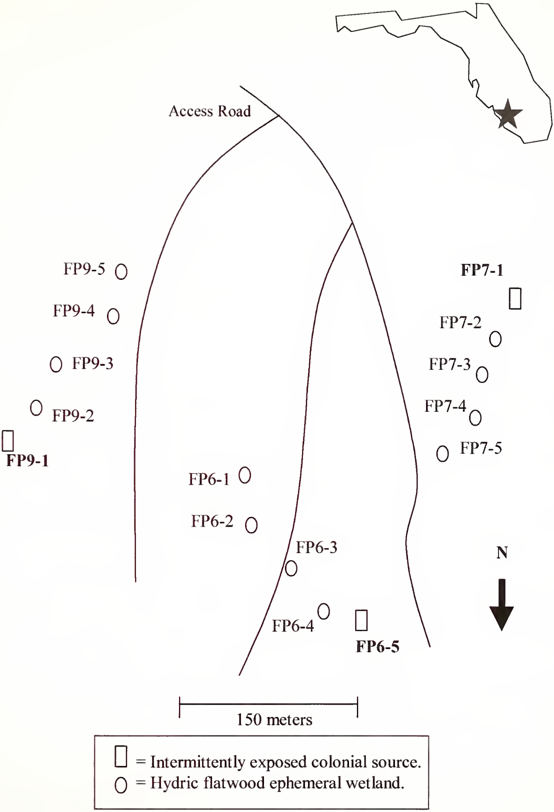


Figure 3: Flint Pen sampling sites – Lee County, FL.
(All distances are approximated)

cassine) were scattered throughout the pines. Occasional clumps of saw palmetto (*Serenoa repens*) were also present, especially at site FP6-3. FP6-2 was the most homogeneous in terms of vegetation, consisting primarily of *Hypericum* sp. and grasses. This mosaic of vegetation is indicative of the varying environmental conditions found throughout the hydric pine flatwoods in the study areas (Abrahamson and Hartnett 1990).

Within the pine flatwoods, sample sites were chosen which appeared to perform as discrete, intermittent, depression-storage, catchment basins for overland flow, and contained some amount of aquatic macrophytic growth (often, *Utricularia* spp.). In most cases, a visible macroinvertebrate component was observed. At two of these sites, FP7 and FP9, samples were taken at a series of isolated water bodies with increasing distance from the cypress head (see map, Fig. 3). Each site was given a hyphenated designation so that, for example, FP7-1 was a site within the cypress head while FP7-5 was the most distant from that semi-permanent body of water, approximately 150 m away. FP6's hyphenated designation is in reverse order from that stated above, so that FP6-5 is the permanent head. At site FP6, a smaller body of water (FP6-1, a small cypress swamp) was located approximately 150 m away from FP6-5. It was assumed that this site was intermittently exposed like the deeper cypress heads at FP7-1 and FP6-5, but later was classified as seasonally flooded. Thus, the intervening sampling sites were varying distances from two hypothesized sites of colonists with FP6-3 being approximately equidistant from each "permanent" site. Although FP6-3 is located within the flatwoods, it is a small depression (possibly man-made), with an area of approximately 6 m^2 and 15 cm deep. Descriptions of individual sites are listed in Table 1.

Table 1: Habitat descriptions of individual cypress heads and flatwood sampling locations within the Flint Pen Strand, Lee County, Florida.

Location	Description of habitat at location
FP6-1	Shallow cypress swamp, moderately dense cypress canopy, moderately dense midstory and ground vegetation, moderate organic substrate.
FP6-2	Dominated by moderately dense *Hypericum* midstory, grass understory and open canopy, sparse organic substrate.
FP6-3	Small depression, possibly man made, bordered on three sides by saw palmetto and slash pines, moderately open canopy, moderate organic substrate.
FP6-4	Cypress head edge, moderately dense canopy and midstory dominated by cypress, aquatic macrophytes present, thick organic substrate.
FP6-5	Deep cypress head, surrounded on all sides by cypress, moderately dense canopy and midstory, *Salvinia* and *Lemna* present on water surface.
FP7-1	Deep cypress head, surrounded on all sides by cypress, moderately dense canopy and midstory, *Lemna* present on water surface.
FP7-2	Dominated by a moderately open cypress and slash pine open canopy and midstory, aquatic macrophytes present, moderate organic substrate.
FP7-3	Dominated by a moderately open cypress and slash pine canopy with scattered *Hypericum* midstory, moderate organic substrate.
FP7-4	Dominated by an open slash pine canopy with scattered saw palmetto and *Hypericum* midstory, sparse organic substrate.
FP7-5	Dominated by a moderately open slash pines canopy and midstory with a scattered saw palmetto understory, sparse organic substrate.
FP9-1	Cypress prairie swamp, dominated by a moderately open cypress canopy, thick organic substrate, aquatic macrophytes present.
FP9-2	Cypress prairie, dominated by a moderately open cypress and slash pine canopy, moderate organic substrate.
FP9-3	Dominated by a dense canopy of slash pine, sweet bay, and cypress with scattered saw palmetto, thick organic substrate.
FP9-4	Dominated by moderately open canopy of cypress and slash pine with an understory comprised of wiregrass (*Aristida*), sparse organic substrate.
FP9-5	Dominated by moderately open canopy of cypress and slash pine with an understory comprised of wiregrass (*Aristida*), sparse organic substrate.

Sampling was conducted at four-week intervals, from September 26, 1998 through November 21, 1998, for a total of three sampling visits. This time period corresponds to the late wet-early drawdown period in these pine flatwoods and was chosen in order to evaluate the effects of drawdown. Prior to and during the first sampling visit, sufficient rainfall occurred to saturate the soil and inundate the flatwood locations.

At each sampling location, one D-frame dip net (Merritt *et al.* 1995) sweep was utilized to sample aquatic vegetation, surficial substrate, and the water column. In addition, two types of artificial substrates were employed. Two bottlebrush substrates and two Hester-Dendy multiple plate samplers were employed at each location. Bottlebrush substrates (Gore *et al.* 1997) were used to emulate colonizable substrates with similar complexity to wetland macrophytes and other woody debris. They were set in place by pushing the handle, which was bent at a ninety-degree angle, into the substrate so that the side of the brush was in contact with the soil (Fig. 4). Hester-Dendy multiple plate samplers (Hester and Dendy 1962) were used to mimic interstices or hard substrates. The multiple plate samplers were placed on their sides in order to maximize surface area exposure (Fig. 5). Both types of artificial substrates were set out during the first sampling event and recovered during the subsequent October sampling event. The artificial substrates were recovered and placed into double strength zip-lock bags (Hester-Dendy) or whirl packs (Bottlebrush) and preserved in 70% ethanol. New substrates were placed in the same location to be recovered during the November sampling. Handling of substrates during the November sampling followed the same protocol of double bagging and preservation in 70% ethanol.

Figure 4: Bottlebrush substrate (Gore *et al.* 1997): used to emulate colonizable substrates with similar complexity to wetland macrophytes and other woody debris.

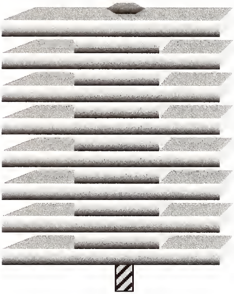


Figure 5: Hester-Dendy multiple plate artificial substrate (redrawn from Hester and Dendy 1962) used to emulate interstices or hard substrates.

Since the previously indicated methods were inadequate to capture ample numbers of micro-crustaceans, funnel-traps were also utilized. The funnel traps were constructed from a small polyethylene funnel with the stem inserted into a hole in a 50 ml polyethylene bottle (Fig. 6). The bottle was filled with water from the sampling site and placed funnel-side down, into the substrate at each sample site. At the time of the September sampling trip, funnel traps were placed at each site during sampling visits and retrieved later in the day. On subsequent trips, funnel traps were placed at each site on the evening before sampling and were retrieved at the time that other sampling and measurements occurred. Samples were bagged in whirl-packs and preserved with 70% ethanol.

In addition to the macroinvertebrate samples, water depth, water temperature, dissolved oxygen concentration, pH, conductivity, salinity, and total dissolved solids were measured for each sampling location. Temperature and pH were recorded using a portable Hach Company EC10, model 50050, pH/mV/temperature meter. Conductivity, total dissolved solids, and salinity were recorded using a Hach Company CO150, model 50150, conductivity meter. For dissolved oxygen, a Yellow Springs Instrument Company model 57 dissolved oxygen meter was utilized. Water depth was recorded in close proximity to the artificial substrates. Measurement of water quality and physical parameters was conducted prior to collection of macroinvertebrate samples. Hydroperiod data for sites FP6 and FP7 were provided by the South Florida Water Management District.

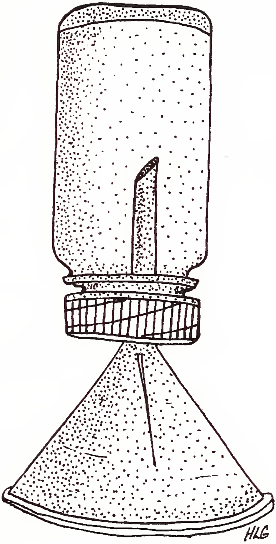


Figure 6: Funnel trap, used to collect ample numbers of micro-crustacean.

All samples were transported to the lab, sorted, counted and identified to the lowest possible taxon, usually specific or generic levels. Regional and specific taxonomic keys were utilized primarily. Because of the lack of undescribed or unassociated adult stages for many of the larval chironomids, the taxonomic list (Tables 2-4) includes genera with species identified by letter or number designations only (Epler 1992). This form of identification is common in the genus *Tanytarsus,* in Florida, and may, with future research, be re-described as alternative genera (Gore *et al.* 1997). Therefore, these identifications should be considered tentative. Chironomids were removed from samples utilizing flotation and hand sorting techniques. CMC-10 mounting medium was used for the clearing and mounting of specimens on microscope slides (Epler 1992).

Comparison of community composition for each site was accomplished using a combination of multivariate techniques including Bray-Curtis polar ordination (Bray and Curtis 1957, Gauch 1982), cluster analysis (Krebs 1989, Gauch 1982), and Principle Components Analysis (PCA) (Gauch, 1982). In a few cases, where catch effort or density was not comparable between sites, data were converted to abundance measurements. Abundance measurements were generated from raw individual data utilizing a tri-level classification (1 = rare, 2 = common, and 3 = abundant). The resulting ordinations were then compared to physical and chemical conditions to ascertain any influences on the temporal changes in community composition.

Bray-Curtis polar ordination emphasizes complex interactions of environmental factors including physical, chemical, and competition elements. The ordination is a map that indicates "by the relative proximity of different features and their varying spatial patterns, the degree to which the features may participate in a mutually determined complex of factors" (Bray and Curtis 1957:327). Linear alignment of sites along an axis is indicative of a trend in a dominating environmental or spatial factor affecting taxonomic composition. Movement of individual sites along an axis indicates a temporal shift in taxonomic composition. The ordinations do not indicate what environmental factors are affecting taxonomic composition, only relative dissimilarity to other sites. Ordination locations were calculated using ECOLOGICAL ANALYSIS (Eckblad 1989) with Bray-Curtis method endpoint selection.

Cluster analysis based on percent dissimilarity (Bray-Curtis) classifies a series of sample locations based on taxonomic dissimilarity. The most taxonomically similar sites cluster together. Cluster distance, a measure of dissimilarity between clusters is used to determine significance (Krebs 1989, Gauch 1982). For purposes of this paper, 85 percent dissimilarity was utilized as the significance value in grouping samples. Those sites below the 85 percent significance level were grouped together into functional monitoring units. Cluster distances were calculated utilizing the Bray-Curtis flexible strategy of ECOLOGICAL ANALYSIS (Eckblad 1989).

Principal components analysis (PCA) is an ordination method in which community or assemblage characteristics and environmental information is incorporated (Gauch 1982). The rotation around the centroid reflects the inclination of an environmental factors influence on a site location or species. The greater the rotation from the primary axis, the less significance (Gauch 1982). The PCA was calculated using the SPSS/PC+ (Norusis 1990) statistical package.

Table 2: Taxonomic list of non-chironomid macroinvertebrates collected in the Flint Pen Strand, Lee County, Florida.

Class	Order/Suborder	Family	Genus	Species
Acari	Hydracarina			sp.
Insecta	Collembola			sp.
	Ephemeroptera	Baetidae		sp. (nymph)
			Callibaetis	sp. (nymph)
			Baetis	sp. (nymph)
		Caenidae	*Caenis*	sp. (nymph)
	Odonata/Anisoptera	Aeshnidae	*Anax*	sp. (nymph)
		Corduliidae	*Epitheca*	*cynosura* (nymph)
				stella (nymph)
		Libellulidae		sp. (nymph)
			Celithemis	sp. (nymph)
				eponina (nymph)
			Erythemis	sp. (nymph)
			Erythrodiplax	sp. (nymph)
			Ladona	*deplanata* (nymph)
			Libellula	*incesta* (nymph)
			Miathyria	*marcella* (nymph)
			Nannothemis	*bella* (nymph)
			Pachydiplax	sp. (nymph)
				longipennis (nymph)
			Pantala	sp. (nymph)
	Odonata/Zygoptera	Coenagrionidae		sp. (nymph)
			Enallagma	sp. (nymph)
				dubium (nymph)
			Ischnura	sp. (nymph)
				hastata (nymph)
				posita (nymph)
			Nehalennia	sp. (nymph)
				integricollis (nymph)
	Hemiptera	Belostomatidae	*Lethocerus*	*americanus*
			Belostoma	sp.
		Corixidae	*Graptocorixa*	sp.
		Gerridae		sp.
			Trepobates	sp.
		Hydrometeridae	*Hydrometra*	sp.
		Macroveliidae	*Oravelia*	sp.
		Naucoridae	*Limnocoris*	sp.
		Saldidae		sp.
		Veliidae	*Microvelia*	sp.
	Trichoptera	Leptoceridae	*Oecetis*	sp. (larvae)
			Oecetis	*inconspicua* (larvae)
		Hydroptilidae	*Oxyethira*	sp. (larvae)
	Lepidoptera	Cosmopterigidae	*Pyroderces*	sp. (larvae)
		Noctuidae	*Simyra*	sp. (larvae)

Table 2 (continued): Taxonomic list of non-chironomid macroinvertebrates collected in the Flint Pen Strand, Lee County, Florida.

Class	Order/Suborder	Family	Genus	Species
	Lepidoptera	Pyralidae	*Petrophila*	sp. (larvae)
	Coleoptera			sp. (adult)
				sp. (pupae)
		Carabidae		sp. (adult)
		Chrysomelidae		sp. (larvae)
		Dryopidae		sp. (larvae)
			Dryops	sp. (larvae)
			Pelonomus	*obscurus* (adult)
		Dytiscidae		sp. (larvae)
			Agabetes	*acuductus* (larvae)
			Bidessonotus	*longovalis* (adult)
			Celina	sp. (larvae)
				contiger (adult)
				imitatrix (adult)
			Copelatus	sp. (larvae)
			Cybister	*fimbriolatus crotchi* (adult)
			Derovatellus	*lentus floridanus* (larvae)
			Desmopachria	sp. (larvae)
			Hydaticus	sp. (larvae)
			Hydrovatus	sp. (larvae)
				sp. (adult)
			Ilybius	sp. (larvae)
				oblitus (larvae)
			Laccophilus	*gentilis gentilis* (adult)
			Laccornis	sp. (larvae)
			Liodessus	sp. (larvae)
			Pachydrus	*princeps* (larvae)
			Uvarus	sp. (larvae)
		Elmidae		sp. (larvae)
			Promoresia	sp. (adult)
		Gyrinidae	*Dineutus*	*carolinus* (adult)
		Hydraenidae	*Hydraena*	*marginicollis* (adult)
		Hydrophilidae		sp.
			Anacaena	*suturalis* (larvae)
			Berosus	sp. (larvae)
			Derallus	*altus* (larvae)
			Enochrus	sp. (adult)
				sp. (larvae)
				blatchleyi (adult)
				interruptus (adult)
				ochraceus (adult)
			Helobata	sp. (larvae)
				larvalis (adult)

Table 2 (continued): Taxonomic list of non-chironomid macroinvertebrates collected in the Flint Pen Strand, Lee County, Florida.

Class	Order/Suborder	Family	Genus	Species
	Coleoptera (cont.)	Hydrophilidae	*Helocombus*	*bifidus* (larvae)
			Hydrobiomorpha	*casta* (larvae)
			Hydrochus	sp. (adult)
			Paracymus	sp. (adult)
				nanus (adult)
			Phaenonotum	sp. (adult)
			Tropisternus	sp. (larvae)
				lateralis nimbatus (adult)
		Noteridae	*Hydrocanthus*	sp. (larvae)
				sp. (adult)
				oblongus (adult)
		Salpingidae		sp. (larvae)
		Scirtidae		sp. (larvae)
		Staphylinidae	*Thinobius*	sp. (adult)
	Diptera			sp. (larvae)
				sp. (pupae)
		Ceratopogonidae		sp. (adult)
			Alluaudomyia	sp. (larvae)
			Atrichopogon	sp. (larvae)
			Bezzia	sp. (larvae)
			Culicoides	sp. (larvae)
			Dasyhelea	sp. (larvae)
			Forcipomyia	sp. (larvae)
		Chaoboridae		sp. (larvae)
			Chaoborus	*punctipennis* (Say) (larvae)
			Corethrella	sp. (larvae)
		Chironomidae		sp. (adult)
		Culicidae	*Uranotaenia*	sp. (larvae)
		Psychodidae	*Psychoda*	sp. (larvae)
			Telmatoscopus	sp. (larvae)
		Tabanidae		sp. (larvae)
			Chrysops	sp. (larvae)
		Tipulidae		sp. (larvae)
			Erioptera	sp. (larvae)
			Pseudolimnophila	sp. (larvae)
			Limonia	sp. (larvae)
			Limnophila	sp. (larvae)
			Megistocera	sp. (larvae)
			Molophilus	sp. (larvae)
			Ormosia	sp. (larvae)
			Pilaria	sp. (larvae)
		Stratiomyidae	*Odontomyia*	sp. (larvae)

Table 2 (continued): Taxonomic list of non-chironomid macroinvertebrates collected in the Flint Pen Strand, Lee County, Florida.

Class	Order/Suborder	Family	Genus	Species
Mollusca	Gastropoda	Ancilidae		sp.
		Physidae		sp.
		Planorbidae		sp.
	Bivalvia			sp.
Annelida	Hirudinea			sp.

Table 3: Taxonomic list of chironomids collected in the Flint Pen Strand, Lee County, Florida.

Family	Genus	Species
Tanypodinae	*Ablabesmyia*	*janta* (tent.)
		peleensis
		rhamphe grp.
		sp. B (Epler 1992)
	Clinotanypus	sp.
	Denopelopia	*atria*
	Krenopelopia	sp.
	Labrundinia	*becki*
		neopilosella
		sp. B (Epler 1992)
		sp. 4 (Epler 1992)
	Larsia	*berneri*
	Monopelopia	*boliekae*
		tillandsia
	Paramerina	sp.
	Procladius	*bellus* var. (Epler 1992)
	Tanypus	*carinatus*
Orthocladiinae	*Corynoneura*	sp.
	Pseudosmittia	sp.
Chironominae	*Asheum*	*beckae*
	Beardius	sp.
	Chironomus	(*Lobochironomus*) sp.
		ocreatus
	Cladopelma	sp.
	Cladotanytarsus	sp.
	Dicrotendipes	sp.
	Einfeldia	*austini*
	Glyptotendipes	sp. E (Epler 1992)
	Goeldichironomus	sp.
		amazonicus
		holoprasinus
		cf. *natans*
	Hudsonimyia	sp. (tent.)
	Kiefferulus	sp.
	Nimbrocera	sp.
		limnetica
	Parachironomus	sp. A (tent.) (Epler 1992)
		alatus
		frequens
		hirtalatus
	Paratanytarsus	sp. A (Epler 1992)
		sp. B (Epler 1992)

Table 3 (continued): Taxonomic list of chironomids collected in the Flint Pen Strand, Lee County, Florida.

Family	Genus	Species
Chironominae (cont.)	*Polypedilum*	sp.
		convictum grp.
		illinoense grp.
		trigonus
		tritum
	Pseudochironomus	sp.
	Tanytarsus	sp.
		sp. B (Epler 1992)
		sp. E (Epler 1992)
		sp. F (Epler 1992)
		sp. G (Epler 1992)
		sp. K (Epler 1992)
		sp. L (Epler 1992)
		sp. O (Epler 1992)
		sp. P (Epler 1992)
		sp. R (Epler 1992)
		sp. T (Epler 1992)
	Zavreliella	*marmorata*

Table 4: Taxonomic list of crustaceans collected in the Flint Pen Strand, Lee County, Florida.

Order/suborder	Family	Genus	Species
Decapoda	Cambaridae	*Procambarus*	sp.
			alleni
	Palaemonidae	*Palaemonetes*	*paludosus*
Amphipoda	Hyalellidae	*Hyalella*	*azteca*
Cladocera	Daphnidae	*Ceriodaphnia*	*laticaudata*
			quadrangula
			rigaudi
		Daphnia	*laevis*
		Simocephalus	*serrulatus*
			vetulus
	Chydoridae	*Acroperus*	*harpae*
		Alona	*setulosa*
		Alonella	*guttata*
			karua
		Alonopsis	*elongata*
		Camptocercus	*rectirostris*
		Leydigia	*quadrangularis*
		Oxyurella	*tenuicaudis*
	Macrothricidae	*Echinisca*	sp.
		Illyocryptus	*acutifrons*
			spinifer
		Macrothrix	*laticornis*
			rosea
	Sididae	*Diaphanosoma*	*leuchtenbergianum*
			branchyurum
		Latonopsis	*fasciculata*
			occidentalis
		Pseudosida	*bidentata*
Copepoda	Calanoida		sp.
	Cyclopoida		sp.
Ostracoda			sp.

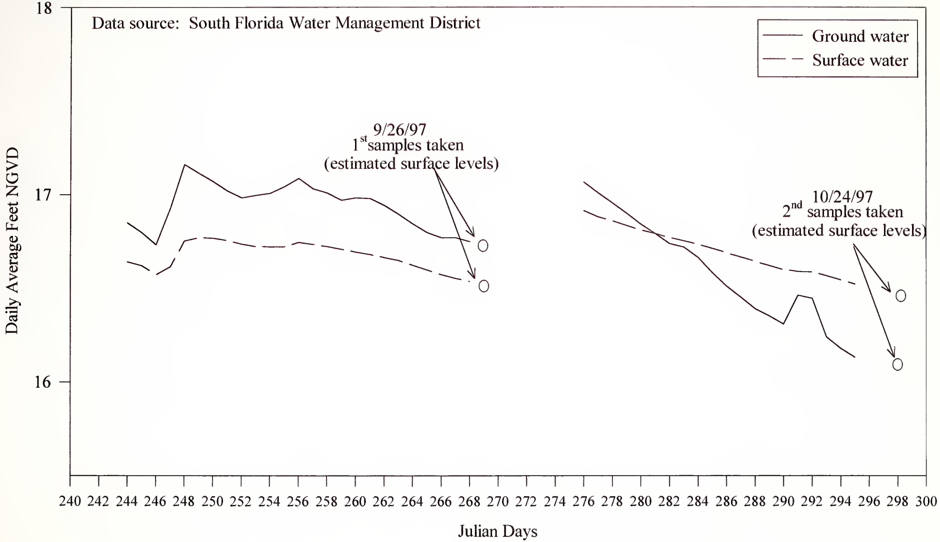
RESULTS

PHYSICAL AND CHEMICAL CONDITIONS

Physical and chemical conditions are reported for each sampling site and day in Tables 5-7. In general, chemical and physical conditions followed patterns that might be predicted for a desiccating environment. Conductivity and salinity increased over time, while temperature decreased. Dissolved oxygen concentrations did not follow a pattern of decline with increasing temperature and decreasing depth. It should be noted that site FP7-2 had a conductivity of 0µS during the November sampling. This unusual result was not due to equipment failure but the fact that this site was recently hydrated with rainwater.

Hydrological data for FP6 and FP7 intermittently exposed cypress heads, obtained from the South Florida Water Management District, demonstrated differences in the peak and low surface and groundwater levels for the two sites (Figures 7 and 8). Flint Pen 6 demonstrated a peak groundwater level of 17.4007 feet NGVD on September 27, 1997, just one day after the first sampling event occurred. The unit NGVD is defined as a fixed datum adopted as a standard geodetic reference for heights (Michaud 1995). Surface water did not peak until September 28, 1997, 17.4721 feet NGVD. Flint Pen 6 low groundwater and surface water levels were 16.0502 and 16.8199 feet NGVD, respectively. The low surface water level was observed on September 25 and October 22, 1997, one and two days respectively before sampling occurred. Flint Pen 7 demonstrated a peak ground water level of 17.1139 feet NGVD on September 6, 1997, 20

Figure 7: FP7 surface and ground water levels Sep. 1 - Oct. 22, 1997.

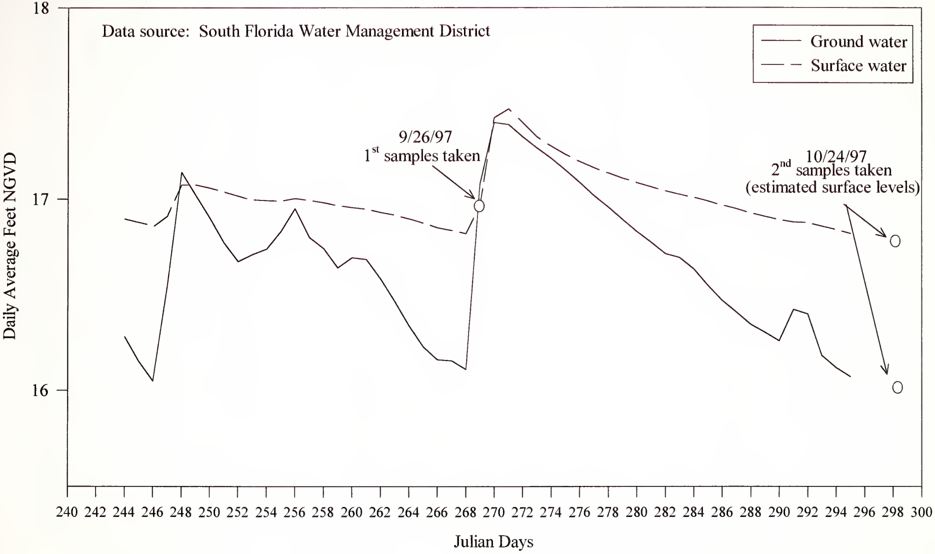


Data source: South Florida Water Management District

9/26/97
1st samples taken
(estimated surface levels)

10/24/97
2nd samples taken
(estimated surface levels)

Figure 8: FP6 surface and ground water levels   Sep. 1 - Oct. 22, 1997.



days before the first sampling event occurred. Surface water did not peak until October 3, 1997, 16.9134 feet NGVD, 7 days after the first sampling event. Flint Pen 7 low groundwater and surface water levels were 16.1313 and 16.5212 feet NGVD, respectively. The low surface water level occurred on October 22, 1997, two days before the second sampling event. Due to lack of ground and surface water levels from Julian dates 269-275, the above peaks and lows for FP7 are based on incomplete data. No further ground or surface water data were provided for dates beyond October 22, 1997.

MACROINVERTEBRATE COMMUNITIES

The general perception has been that, although little has been reported on the faunal composition of this wetland type, there would be a relatively impoverished fauna contained within these temporary wetlands. Although some of the wetlands sampled had a surface area of less than 20 m^2 and an average depth of less than 15 cm, a total of 4226 macroinvertebrates and 1106 crustaceans, for a total of 5332 individuals, were collected during the sampling period. This collection represented 227 recognizable taxa, of which 61 were various species of Chironomidae.

NON-CHIRONOMID MACROINVERTEBRATE ASSEMBLAGE

Composite non-chironomid macroinvertebrate community data are presented in Tables 8 through 10. Among the non-chironomids, the sites contained macroinvertebrate faunas dominated by coleoptera and non-chironomid dipterans. In general, the number of individuals, taxa, and diversity in each isolated wetland community declined with distance from the intermittently exposed cypress swamps (Figures 9-14). Some of this

Table 5: Physical and chemical conditions of the isolated wetlands at site FP7.

		9/26/97	10/24/97	11/21/97
FP7-1	Temperature (C°)	26.7	21.1	20.2
	Conductivity (µS)	83.6	84.6	110.6
	Salinity	0	0	0.1
	TDS (mg/L)	40	40	53
	pH	6.48	6.02	6.20
	DO (mg/L)	3.65	2.15	2.60
	Depth (feet)	0.93	0.70	0.37
FP7-2	Temperature (C°)	28.5	19.7	22.3
	Conductivity (µS)	73.2	88.2	0
	Salinity	0	0	0
	TDS (mg/L)	35	42	0
	pH	6.7	6.3	6.41
	DO (mg/L)	5.6	3.3	5.5
	Depth (feet)	0.47	0.23	0.08
FP7-3	Temperature (C°)	29.6	21.0	ndt
	Conductivity (µS)	31.2	130.5	ndt
	Salinity	0	0.1	ndt
	TDS (mg/L)	14	61	ndt
	pH	6.96	7.08	ndt
	DO (mg/L)	5.4	3.4	ndt
	Depth (feet)	0.29	0.08	saturated
FP7-4	Temperature (C°)	28.6	ndt	ndt
	Conductivity (µS)	132.3	ndt	ndt
	Salinity	0.1	ndt	ndt
	TDS (mg/L)	63	ndt	ndt
	pH	7.48	ndt	ndt
	DO (mg/L)	5.3	ndt	ndt
	Depth (feet)	0.30	saturated	moist
FP7-5	Temperature (C°)	27.0	ndt	ndt
	Conductivity (µS)	159.9	ndt	ndt
	Salinity	0.1	ndt	ndt
	TDS (mg/L)	78	ndt	ndt
	pH	7.07	ndt	ndt
	DO (mg/L)	4.35	ndt	ndt
	Depth (feet)	0.24	moist	moist

Table 6: Physical and chemical conditions of the isolated wetlands at site FP6.

		9/26/97	10/24/97	11/21/97
FP6-1	Temperature (C°)	27.7	ndt	ndt
	Conductivity (µS)	39.8	ndt	ndt
	Salinity	0	ndt	ndt
	TDS (mg/L)	19	ndt	ndt
	pH	6.45	ndt	ndt
	DO (mg/L)	5.70	ndt	ndt
	Depth (feet)	0.46	moist	moist
FP6-2	Temperature (C°)	28.7	ndt	ndt
	Conductivity (µS)	26.4	ndt	ndt
	Salinity	0	ndt	ndt
	TDS (mg/L)	12	ndt	ndt
	pH	6.51	ndt	ndt
	DO (mg/L)	5.90	ndt	ndt
	Depth (feet)	0.23	dry	saturated
FP6-3	Temperature (C°)	28.6	ndt	ndt
	Conductivity (µS)	52.3	ndt	ndt
	Salinity	0	ndt	ndt
	TDS (mg/L)	25	ndt	ndt
	pH	5.75	ndt	ndt
	DO (mg/L)	5.10	ndt	ndt
	Depth (feet)	0.59	dry	moist
FP6-4	Temperature (C°)	28.4	22.1	ndt
	Conductivity (µS)	74.3	96.0	ndt
	Salinity	0	0	ndt
	TDS (mg/L)	35	45	ndt
	pH	6.26	6.39	ndt
	DO (mg/L)	5.60	5.80	ndt
	Depth (feet)	0.24	0.70	saturated
FP6-5	Temperature (C°)	27.9	22.4	21.4
	Conductivity (µS)	66.3	84.1	91.3
	Salinity	0	0	0
	TDS (mg/L)	40	31	39
	pH	6.13	5.95	5.9
	DO (mg/L)	3.55	2.3	1.3
	Depth (feet)	0.51	0.23	0.74

Table 7: Physical and chemical conditions of the isolated wetlands at site FP9.

		9/26/97	10/24/97	11/21/97
FP9-1	Temperature (C°)	27.4	25.9	27.0
	Conductivity (µS)	220.0	221.0	263.0
	Salinity	0.1	0.1	0.1
	TDS (mg/L)	99	105	125
	pH	7.41	7.18	7.19
	DO (mg/L)	5.10	6.10	6.70
	Depth (feet)	0.47	0.50	0.60
FP9-2	Temperature (C°)	26.8	27.9	ndt
	Conductivity (µS)	161.6	114.8	ndt
	Salinity	0.1	0.1	ndt
	TDS (mg/L)	76	70	ndt
	pH	7.48	6.84	ndt
	DO (mg/L)	5.80	6.30	ndt
	Depth (feet)	0.24	0.24	saturated
FP9-3	Temperature (C°)	27.0	26.7	ndt
	Conductivity (µS)	133.4	206.0	ndt
	Salinity	0.1	0.1	ndt
	TDS (mg/L)	63	98	ndt
	pH	7.13	7.10	ndt
	DO (mg/L)	3.95	1.20	ndt
	Depth (feet)	0.22	0.10	saturated
FP9-4	Temperature (C°)	27.7	ndt	ndt
	Conductivity (µS)	88.1	ndt	ndt
	Salinity	0	ndt	ndt
	TDS (mg/L)	41	ndt	ndt
	pH	6.83	ndt	ndt
	DO (mg/L)	4.65	ndt	ndt
	Depth (feet)	0.12	moist	moist
FP9-5	Temperature (C°)	27.6	ndt	ndt
	Conductivity (µS)	132.3	ndt	ndt
	Salinity	0.1	ndt	ndt
	TDS (mg/L)	62	ndt	ndt
	pH	7.14	ndt	ndt
	DO (mg/L)	3.60	ndt	ndt
	Depth (feet)	0.18	saturated	moist

Table 8: Flint Pen 7 composite non-chironomid macroinvertebrate community data.

					Flint Pen 7 Sep. 26					Flint Pen 7 Oct. 24				
Class	Order/suborder	Family	Genus	Species	7-1	7-2	7-3	7-4	7-5	7-1	7-2	7-3	7-4	7-5
Acari	Hydracarina			sp.		1				1				
Insecta	Collembola			sp.										1
	Ephemeroptera	Baetidae		sp. (nymph)							4	1		
			Callibaetis	sp. (nymph)		5						2		
			Baetis	sp. (nymph)			17							
		Caenidae	*Caenis*	sp. (nymph)		11	41	1		2	4	41		
	Odonata/ Anisoptera	Libellulidae		sp. (nymph)				1						
			Pachydiplax	sp. (nymph)	2	2	3							
			Nannothemis	*bella* (nymph)								2		
			Erythrodiplax	sp. (nymph)										
	Odonata/ Zygoptera	Coenagrionidae		sp. (nymph)										
			Enallagma	sp. (nymph)		3								
	Hemiptera	Corixidae	*Graptocorixa*	sp.		1								
		Macroveliidae	*Oravelia*	sp.								1		
		Naucoridae	*Limnocoris*	sp.		1								
		Saldidae		sp.										
	Trichoptera	Leptoceridae	*Oecetis*	sp. (larvae)		4	1				3			
	Coleoptera			sp. (pupae)										
		Dytiscidae		sp. (larvae)										
			Celina	sp. (larvae)										
			Celina	*contiger* (adult)						1				
			Cybister	*fimbriolatus crotchi* (adult)										
			Desmopachria	sp. (larvae)										
			Hydaticus	sp. (larvae)		2								
			Hydrovatus	sp. (larvae)			1							
			Ilybius	sp. (larvae)							1			
			Ilybius	*oblitus* (larvae)			1							
			Laccornis	sp. (larvae)										
			Liodessus	sp. (larvae)				1						
			Uvarus	sp. (larvae)										
		Gyrinidae	*Dineutus*	*carolinus* (adult)	1									

Table 8 (continued): Flint Pen 7 composite non-chironomid macroinvertebrate community data.

Class	Order/suborder	Family	Genus	Species	Flint Pen 7 Sep. 26					Flint Pen 7 Oct. 24				
					7-1	7-2	7-3	7-4	7-5	7-1	7-2	7-3	7-4	7-5
Insecta	Coleoptera	Hydraenidae	*Hydraena*	*marginicollis* (adult)										
		Hydrophilidae		sp.										
			Anacaena	*suturalis* (larvae)				3						
			Berosus	sp. (larvae)		1	1	2				1		
			Derallus	*altus* (larvae)		2								
			Enochrus	sp. (larvae)				3						
			Enochrus	sp. (adult)				1						
			Enochrus	*ochraceus* (adult)										
			Hydrobiomorpha	*casta* (larvae)										
			Paracymus	*nanus* (adult)			1							
			Tropisternus	sp. (larvae)										
			Tropisternus	*lateralis nimbatus* (adult)			1							
		Noteridae	*Hydrocanthus*	*oblongus* (adult)				3						
	Diptera			sp. (pupae)										
		Ceratopogonidae		sp. (adult)										
			Bezzia	sp. (larvae)		1	2	29			2	3		
			Alluaudomyia	sp. (larvae)			1	1				1		
			Dasyhelea	sp. (larvae)			16	103				19		
			Forcipomyia	sp. (larvae)										
		Chaoboridae	*Chaoborus*	*punctipennis* (Say) (larvae)	1									
		Psychodidae	*Telmatoscopus*	sp. (larvae)										
			Psychoda	sp. (larvae)										
		Tabanidae	*Chrysops*	sp. (larvae)			1							
		Tipulidae	*Pseudolimnophila*	sp. (larvae)			1	1						
			Limnophila	sp. (larvae)				12						
			Megistocera	sp. (larvae)										
		Stratiomyidae	*Odontomyia*	sp. (larvae)				1						
Mollusca	Gastropoda	Physidae		sp.			4							
		Planorbidae		sp.		1	5	2		10		1		
		Ancilidae		sp.		3		7		2	1			
Annelida	Hirudinea										1	1		
Total					4	38	97	171	0	16	16	73	0	1

Table 8 (continued): Flint Pen 7 composite non-chironomid macroinvertebrate community data.

					Flint Pen 7 Nov. 21					
Class	Order/suborder	Family	Genus	Species	7-1	7-2	7-3	7-4	7-5	total
Acari	Hydracarina			sp.	5					7
Insecta	Collembola			sp.	7	41	43	11		103
	Ephemeroptera	Baetidae		sp. (nymph)	1					6
			Callibaetis	sp. (nymph)	12					19
			Baetis	sp. (nymph)						17
		Caenidae	*Caenis*	sp. (nymph)	9	1	2			112
	Odonata/ Anisoptera	Libellulidae		sp. (nymph)						1
			Pachydiplax	sp. (nymph)						7
			Nannothemis	*bella* (nymph)						2
			Erythrodiplax	sp. (nymph)	1					1
	Odonata/ Zygoptera	Coenagrionidae		sp. (nymph)	1					1
			Enallagma	sp. (nymph)						3
	Hemiptera	Corixidae	*Graptocorixa*	sp.						1
		Macroveliidae	*Oravelia*	sp.						1
		Naucoridae	*Limnocoris*	sp.						1
		Saldidae		sp.			1			1
	Trichoptera	Leptoceridae	*Oecetis*	sp. (larvae)	1					9
	Coleoptera			sp. (pupae)		1		1		2
		Dytiscidae		sp. (larvae)				1		1
			Celina	sp. (larvae)		2				2
			Celina	*contiger* (adult)		1				2
			Cybister	*fimbriolatus crotchi* (adult)	1					1
			Desmopachria	sp. (larvae)		1				1
			Hydaticus	sp. (larvae)			1			3
			Hydrovatus	sp. (larvae)						1
			Ilybius	sp. (larvae)						1
			Ilybius	*oblitus* (larvae)						1
			Laccornis	sp. (larvae)		1				1
			Liodessus	sp. (larvae)		1				2
			Uvarus	sp. (larvae)	2	1	1			4
		Gyrinidae	*Dineutus*	*carolinus* (adult)						1

Table 8 (continued): Flint Pen 7 composite non-chironomid macroinvertebrate community data.

Class	Order/suborder	Family	Genus	Species	Flint Pen 7 Nov. 21					
					7-1	7-2	7-3	7-4	7-5	total
Insecta	Coleoptera	Hydraenidae	*Hydraena*	*marginicollis* (adult)		1				1
		Hydrophilidae		sp.			2			2
			Anacaena	*suturalis* (larvae)			9	2		14
			Berosus	sp. (larvae)						5
			Derallus	*altus* (larvae)		3	1			6
			Enochrus	sp. (larvae)						3
			Enochrus	sp. (adult)		2				3
			Enochrus	*ochraceus* (adult)		1				1
			Hydrobiomorpha	*casta* (larvae)			5			5
			Paracymus	*nanus* (adult)		2	1			4
			Tropisternus	sp. (larvae)			1			1
			Tropisternus	*lateralis nimbatus* (adult)	1					2
		Noteridae	*Hydrocanthus*	*oblongus* (adult)						3
	Diptera			sp. (pupae)	1		8			9
		Ceratopogonidae		sp. (adult)			2			2
			Bezzia	sp. (larvae)	1	2	13	1		54
			Alluaudomyia	sp. (larvae)						3
			Dasyhelea	sp. (larvae)			426			564
			Forcipomyia	sp. (larvae)		2				2
		Chaoboridae	*Chaoborus*	*punctipennis* (Say) (larvae)						1
		Psychodidae	*Telmatoscopus*	sp. (larvae)		2				2
			Psychoda	sp. (larvae)				1		1
		Tabanidae	*Chrysops*	sp. (larvae)						1
		Tipulidae	*Pseudolimnophila*	sp. (larvae)						2
			Limnophila	sp. (larvae)			7			19
			Megistocera	sp. (larvae)	1					1
		Stratiomyidae	*Odontomyia*	sp. (larvae)						1
Mollusca	Gastropoda	Physidae		sp.				2		6
		Planorbidae		sp.	26		7			52
		Ancilidae		sp.	3	1	2			19
Annelida	Hirudinea									2
Total					73	66	532	19	0	1106

Table 9: Flint Pen 6 composite non-chironomid macroinvertebrate community data.

Class	Order/suborder	Family	Genus	Species	Flint Pen 6 Sep. 26					Flint Pen 6 Oct. 24				
					6-1	6-2	6-3	6-4	6-5	6-1	6-2	6-3	6-4	6-5
Acari	Hydracarina			sp.									2	
Insecta	Collembola			sp.	2	2				2	3		36	
	Ephemeroptera	Baetidae		sp. (nymph)	4									
			Callibaetis	sp. (nymph)	19			17						
			Baetis	sp. (nymph)									1	
		Caenidae	*Caenis*	sp. (nymph)	1			10		1			6	
	Odonata/ Anisoptera	Aeshnidae	*Anax*	sp. (nymph)	1									
		Corduliidae	*Epitheca*	*stella* (nymph)						1				
		Libellulidae	*Pachydiplax*	sp. (nymph)	2				3					
			Pachydiplax	*longipennis* (nymph)										
			Celithemis	sp. (nymph)		1								
			Erythemis	sp. (nymph)					1					
			Libellula	*incesta* (nymph)										
	Odonata/ Zygoptera	Coenagrionidae		sp. (nymph)	2	1								
			Enallagma	sp. (nymph)										
			Enallagma	*dubium* (nymph)	2									
			Ischnura	sp. (nymph)									1	
	Hemiptera			sp. (early instar)										
		Gerridae		sp.										
		Gerridae	*Trepobates*	sp.										
		Hydrometeridae	*Hydrometra*	sp.									1	2
		Macroveliidae	*Oravelia*	sp.							1			
	Trichoptera	Leptoceridae	*Oecetis*	*inconspicua* (larvae)		1								
		Hydroptilidae	*Oxyethira*	sp. (larvae)		1								
	Lepidoptera	Noctuidae	*Simyra*	sp. (larvae)					9					1
		Cosmopterigidae	*Pyroderces*	sp. (larvae)					1					
		Pyralidae	*Petrophila*	sp. (larvae)										
	Coleoptera			sp. (pupae)										1
				sp. (adult)										1
		Chrysomelidae		sp. (larvae)									1	
		Dryopidae		sp. (larvae)										
			Dryops	sp. (larvae)										
			Pelonomus	*obscurus* (adult)									1	

Table 9 (continued): Flint Pen 6 composite non-chironomid macroinvertebrate community data.

Class	Order/suborder	Family	Genus	Species	Flint Pen 6 Sep. 26					Flint Pen 6 Oct. 24				
					6-1	6-2	6-3	6-4	6-5	6-1	6-2	6-3	6-4	6-5
Insecta	Coleoptera	Dytiscidae	*Agabetes*	*acuductus* (larvae)										1
			Celina	sp. (larvae)				5	1				1	1
			Celina	*contiger* (adult)				1						
			Celina	*imitatrix* (adult)									1	1
			Copelatus	sp. (larvae)										
			Desmopachria	sp. (larvae)										
			Hydaticus	sp. (larvae)										1
			Hydrovatus	sp. (adult)										
			Ilybius	*oblitus* (larvae)	2			6						
			Liodessus	sp. (larvae)		2								
			Uvarus	sp. (larvae)										1
		Elmidae		sp. (larvae)			1							
			Promoresia	sp. (adult)		1								
		Hydraenidae	*Hydraena*	*marginicollis* (adult)									5	1
		Hydrophilidae	*Anacaena*	*suturalis* (larvae)										
			Berosus	sp. (larvae)				1						
			Derallus	*altus* (larvae)	2									
			Enochrus	sp. (larvae)						3				
			Enochrus	*blatchleyi* (adult)										2
			Enochrus	*interruptus* (adult)										
			Helocombus	*bifidus* (larvae)										
			Hydrochus	sp. (adult)	1									
			Paracymus	sp. (adult)		1								
			Phaenonotum	sp. (adult)									1	
		Noteridae	*Hydrocanthus*	sp. (larvae)	1				1					
	Diptera			sp. (pupae)		7								
		Ceratopogonidae	*Bezzia*	sp. (larvae)	2	2	5	4					10	
			Culicoides	sp. (larvae)			21							
			Alluaudomyia	sp. (larvae)		5								
			Dasyhelea	sp. (larvae)		2								
			Forcipomyia	sp. (larvae)										
			Atrichopogon	sp. (larvae)		2								
		Chaoboridae	*Corethrella*	sp. (larvae)										
		Chironomidae		sp. (adult)										1

Table 9 (continued): Flint Pen 6 composite non-chironomid macroinvertebrate community data.

					Flint Pen 6	Sep. 26				Flint Pen 6	Oct. 24			
Class	Order/suborder	Family	Genus	Species	6-1	6-2	6-3	6-4	6-5	6-1	6-2	6-3	6-4	6-5
Insecta	Diptera	Psychodidae	*Telmatoscopus*	sp. (larvae)										
		Tipulidae		sp. (larvae)										
			Limonia	sp. (larvae)										
			Limnophila	sp. (larvae)		4	10			2				
			Pilaria	sp. (larvae)									1	
			Molophilus	sp. (larvae)										
Mollusca	Gastropoda	Physidae		sp.		3	4		1		8			
		Planorbidae		sp.	2	4		1					4	2
		Ancilidae		sp.		1								1
					43	40	41	45	17	9	12	0	70	17

Table 9 (continued): Flint Pen 6 composite non-chironomid macroinvertebrate community data.

					Flint Pen 6	Nov. 21				
Class	Order/suborder	Family	Genus	Species	6-1	6-2	6-3	6-4	6-5	total
Acari	Hydracarina			sp.			1			3
Insecta	Collembola			sp.	30	3	15	111	82	286
	Ephemeroptera	Baetidae		sp. (nymph)						4
			Callibaetis	sp. (nymph)						36
			Baetis	sp. (nymph)						1
		Caenidae	*Caenis*	sp. (nymph)					5	23
	Odonata/ Anisoptera	Aeshnidae	*Anax*	sp. (nymph)						1
		Corduliidae	*Epitheca*	*stella* (nymph)						1
		Libellulidae	*Pachydiplax*	sp. (nymph)						5
			Pachydiplax	*longipennis* (nymph)					3	3
			Celithemis	sp. (nymph)						1
			Erythemis	sp. (nymph)						1
			Libellula	*incesta* (nymph)					1	1
	Odonata/ Zygoptera	Coenagrionidae		sp. (nymph)						3
			Enallagma	sp. (nymph)					1	1
			Enallagma	*dubium* (nymph)						2
			Ischnura	sp. (nymph)						1
	Hemiptera			sp. (early instar)					1	1
		Gerridae		sp.				1		1
		Gerridae	*Trepobates*	sp.					1	1
		Hydrometeridae	*Hydrometra*	sp.						3
		Macroveliidae	*Oravelia*	sp.						1
	Trichoptera	Leptoceridae	*Oecetis*	*inconspicua* (larvae)						1
		Hydroptilidae	*Oxyethira*	sp. (larvae)						1
	Lepidoptera	Noctuidae	*Simyra*	sp. (larvae)						10
		Cosmopterigidae	*Pyroderces*	sp. (larvae)						1
		Pyralidae	*Petrophila*	sp. (larvae)				1		1
	Coleoptera			sp. (pupae)				2	5	8
				sp. (adult)						1
		Chrysomelidae		sp. (larvae)						1
		Dryopidae		sp. (larvae)			1			1
			Dryops	sp. (larvae)				5		5
			Pelonomus	*obscurus* (adult)						1

Table 9 (continued): Flint Pen 6 composite non-chironomid macroinvertebrate community data.

Class	Order/suborder	Family	Genus	Species	Flint Pen 6 Nov. 21					
					6-1	6-2	6-3	6-4	6-5	total
Insecta	Coleoptera	Dytiscidae	*Agabetes*	*acuductus* (larvae)				1		2
			Celina	sp. (larvae)						8
			Celina	*contiger* (adult)					6	7
			Celina	*imitatrix* (adult)						2
			Copelatus	sp. (larvae)				2		2
			Desmopachria	sp. (larvae)				1		1
			Hydaticus	sp. (larvae)						1
			Hydrovatus	sp. (adult)					3	3
			Ilybius	*oblitus* (larvae)						8
			Liodessus	sp. (larvae)				1		3
			Uvarus	sp. (larvae)						1
		Elmidae		sp. (larvae)						1
			Promoresia	sp. (adult)						1
		Hydraenidae	*Hydraena*	*marginicollis* (adult)				1		7
		Hydrophilidae	*Anacaena*	*suturalis* (larvae)			3	34	4	41
			Berosus	sp. (larvae)						1
			Derallus	*altus* (larvae)				5		7
			Enochrus	sp. (larvae)						3
			Enochrus	*blatchleyi* (adult)						2
			Enochrus	*interruptus* (adult)				1		1
			Helocombus	*bifidus* (larvae)				2		2
			Hydrochus	sp. (adult)						1
			Paracymus	sp. (adult)						1
			Phaenonotum	sp. (adult)						1
		Noteridae	*Hydrocanthus*	sp. (larvae)						2
	Diptera			sp. (pupae)				1		8
		Ceratopogonidae	*Bezzia*	sp. (larvae)				12	4	39
			Culicoides	sp. (larvae)						21
			Alluaudomyia	sp. (larvae)					1	6
			Dasyhelea	sp. (larvae)			2	14		18
			Forcipomyia	sp. (larvae)				23	3	26
			Atrichopogon	sp. (larvae)						2
		Chaoboridae	*Corethrella*	sp. (larvae)					1	1
		Chironomidae		sp. (adult)					1	2

Table 9 (continued): Flint Pen 6 composite non-chironomid macroinvertebrate community data.

					Flint Pen 6 Nov. 21					
Class	Order/suborder	Family	Genus	Species	6-1	6-2	6-3	6-4	6-5	total
Insecta	Diptera	Psychodidae	*Telmatoscopus*	sp. (larvae)				15	3	18
		Tipulidae		sp. (larvae)				3		3
			Limonia	sp. (larvae)				2		2
			Limnophila	sp. (larvae)			1		1	18
			Pilaria	sp. (larvae)						1
			Molophilus	sp. (larvae)			1	17		18
Mollusca	Gastropoda	Physidae		sp.			1			17
		Planorbidae		sp.	3			5	1	22
		Ancilidae		sp.					1	3
					33	3	24	260	128	742

Table 10: Flint Pen 9 composite non-chironomid macroinvertebrate community data.

					Flint Pen 9	Sep. 26				Flint Pen 9	Oct. 24			
Class	Order/suborder	Family	Genus	Species	9-1	9-2	9-3	9-4	9-5	9-1	9-2	9-3	9-4	9-5
Acari	Hydracarina			sp.						1				
Insecta	Collembola			sp.					2			6	3	1
	Ephemeroptera	Baetidae		sp. (nymph)		2					1			
			Callibaetis	sp. (nymph)	3									
			Baetis	sp. (nymph)							1	1		
		Caenidae	*Caenis*	sp. (nymph)	13	5	1			13	6	1		
	Odonata/ Anisoptera	Corduliidae	*Epitheca*	*coynosura* (nymph)										
		Libellulidae	*Pachydiplax*	sp. (nymph)	1		1							
			Pachydiplax	*longipennis* (nymph)					4			1		1
			Celithemis	*eponina* (nymph)		1								
			Ladona	*deplanata* (nymph)										
			Miathyria	*marcella* (nymph)								1		
			Pantala	sp. (nymph)	1									
	Odonata/ Zygoptera	Coenagrionidae		sp. (nymph)										
			Enallagma	sp. (nymph)					1			2		
			Ischnura	sp. (nymph)	1		3		1			1		
			Ischnura	*hastata* (nymph)		1								
			Ischnura	*posita* (nymph)										
			Nehalennia	sp. (nymph)						2				
			Nehalennia	*intergricollis* (nymph)						1				
	Hemiptera	Belostomatidae	*Lethocerus*	*americanus*		1								
			Belostoma	sp.										1
		Veliidae	*Microvelia*	sp.			1							
	Trichoptera	Leptoceridae	*Oecetis*	sp. (larvae)	2	3								
	Coleoptera			sp. (pupae)								6		
		Carabidae		sp. (adult)		1								
		Dryopidae		sp. (larvae)										
			Dryops	sp. (larvae)										

Table 10 (continued): Flint Pen 9 composite non-chironomid macroinvertebrate community data.

Class	Order/suborder	Family	Genus	Species	Flint Pen 9 Sep. 26					Flint Pen 9 Oct. 24				
					9-1	9-2	9-3	9-4	9-5	9-1	9-2	9-3	9-4	9-5
Insecta	Coleoptera	Dytiscidae		sp. (larvae)					1					
			Bidessonotus	*longovalis* (adult)								1		
			Celina	sp. (larvae)					1	1		1		
			Celina	*contiger* (adult)							1			
			Dervovatellus	*lentus floridanus* (larvae)								2		
			Desmopachria	sp. (larvae)								1		
			Hydaticus	sp. (larvae)		1								
			Hydrovatus	sp. (larvae)		1								
			Hydrovatus	sp. (adult)		1								
			Ilybius	sp. (larvae)		1								
			Ilybius	*oblitus* (larvae)		1						1		1
			Laccophilus	*gentilis gentilis* (adult)		1			1					
			Liodessus	sp. (larvae)		1								3
			Pachydrus	*princeps* (larvae)		1			1					
			Uvarus	sp. (larvae)					1					1
		Hydraenidae	*Hydraena*	*marginicollis* (adult)								5		
		Hydrophilidae	*Anacaena*	*suturalis* (larvae)		1								1
			Berosus	sp. (larvae)	1	1			3		1			
			Derallus	*altus* (larvae)					1					
			Enochrus	sp. (larvae)		4			8			4		2
			Helobata	sp. (larvae)					2					
			Helobata	*larvalis* (adult)										
			Paracymus	*nanus* (adult)										1
			Tropisternus	sp. (larvae)	1									
			Tropisternus	*lateralis nimbatus* (adult)		4								
		Noteridae	*Hydrocanthus*	sp. (adult)										
			Hydrocanthus	*oblongus* (adult)					6					
		Salpingidae		sp.		1								
		Scirtidae		sp. (larvae)								1		1
		Staphylinidae	*Thinobius*	sp. (adult)										

Table 10 (continued): Flint Pen 9 composite non-chironomid macroinvertebrate community data.

Class	Order/suborder	Family	Genus	Species	Flint Pen 9 Sep. 26					Flint Pen 9 Oct. 24				
					9-1	9-2	9-3	9-4	9-5	9-1	9-2	9-3	9-4	9-5
Insecta	Diptera			sp. (pupae)		1				1	2			1
				sp. (larvae)										
		Ceratopogonidae	*Bezzia*	sp. (larvae)	10	2			3			1		6
			Alluaudomyia	sp. (larvae)	12									
			Forcipomyia	sp. (larvae)										
			Dasyhelea	sp. (larvae)					9	1	1			5
			Corethrella	sp. (larvae)										
		Culicidae	*Uranotaenia*	sp. (larvae)								10		
		Psychodidae	*Telmatoscopus*	sp. (larvae)										3
			Psychoda	sp. (larvae)										
		Tabanidae		sp. (larvae)					1					
		Tipulidae	*Erioptera*	sp. (larvae)										
			Limnophila	sp. (larvae)		1			5					5
			Limonia	sp. (larvae)										
			Molophilus	sp. (larvae)										
			Ormosia	sp. (larvae)										
Mollusca	Gastropoda	Physidae		sp.	1	1			6	2				2
		Planorbidae		sp.					1	1	2			1
		Ancilidae		sp.		2			2		1			1
	Bivalvia													
Annelida	Hirudinea					1								1
					46	41	6	0	60	22	16	46	3	38

Table 10 (continued): Flint Pen 9 composite non-chironomid macroinvertebrate community data.

Class	Order/suborder	Family	Genus	Species	Flint Pen 9	Nov. 21				
					9-1	9-2	9-3	9-4	9-5	total
Acari	Hydracarina			sp.		1			5	7
Insecta	Collembola			sp.	1	22	41	8	31	115
	Ephemeroptera	Baetidae		sp. (nymph)	2					5
			Callibaetis	sp. (nymph)						3
			Baetis	sp. (nymph)	7					9
		Caenidae	*Caenis*	sp. (nymph)	40					79
	Odonata/ Anisoptera	Corduliidae	*Epitheca*	*coynosura* (nymph)		1				1
		Libellulidae	*Pachydiplax*	sp. (nymph)						2
			Pachydiplax	*longipennis* (nymph)	1		2			9
			Celithemis	*eponina* (nymph)						1
			Ladona	*deplanata* (nymph)	1					1
			Miathyria	*marcella* (nymph)						1
			Pantala	sp. (nymph)						1
	Odonata/ Zygoptera	Coenagrionidae		sp. (nymph)		1				1
			Enallagma	sp. (nymph)						3
			Ischnura	sp. (nymph)						6
			Ischnura	*hastata* (nymph)	1					2
			Ischnura	*posita* (nymph)	1					1
			Nehalennia	sp. (nymph)	1					3
			Nehalennia	*intergricollis* (nymph)	1					2
	Hemiptera	Belostomatidae	*Lethocerus*	*americanus*						1
			Belostoma	sp.					2	3
		Veliidae	*Microvelia*	sp.						1
	Trichoptera	Leptoceridae	*Oecetis*	sp. (larvae)	1					6
	Coleoptera			sp. (pupae)			3		1	10
		Carabidae		sp. (adult)						1
		Dryopidae		sp. (larvae)				1		1
			Dryops	sp. (larvae)			9			9

Table 10 (continued): Flint Pen 9 composite non-chironomid macroinvertebrate community data.

Class	Order/suborder	Family	Genus	Species	Flint Pen 9 Nov. 21 9-1	9-2	9-3	9-4	9-5	total
Insecta	Coleoptera	Dytiscidae		sp. (larvae)					1	2
			Bidessonotus	*longovalis* (adult)						1
			Celina	sp. (larvae)	1					4
			Celina	*contiger* (adult)						1
			Dervovatellus	*lentus floridanus* (larvae)						2
			Desmopachria	sp. (larvae)						1
			Hydaticus	sp. (larvae)						1
			Hydrovatus	sp. (larvae)						1
			Hydrovatus	sp. (adult)						1
			Ilybius	sp. (larvae)						1
			Ilybius	*oblitus* (larvae)						3
			Laccophilus	*gentilis gentilis* (adult)						2
			Liodessus	sp. (larvae)		2				6
			Pachydrus	*princeps* (larvae)						2
			Uvarus	sp. (larvae)		1			3	6
		Hydraenidae	*Hydraena*	*marginicollis* (adult)					1	6
		Hydrophilidae	*Anacaena*	*suturalis* (larvae)		3	9	13	1	28
			Berosus	sp. (larvae)	1					7
			Derallus	*altus* (larvae)		4				5
			Enochrus	sp. (larvae)		3				21
			Helobata	sp. (larvae)						2
			Helobata	*larvalis* (adult)			1			1
			Paracymus	*nanus* (adult)		1				2
			Tropisternus	sp. (larvae)						1
			Tropisternus	*lateralis nimbatus* (adult)						4
		Noteridae	*Hydrocanthus*	sp. (adult)	2					2
			Hydrocanthus	*oblongus* (adult)						6
		Salpingidae		sp.						1
		Scirtidae		sp. (larvae)						2
		Staphylinidae	*Thinobius*	sp. (adult)					1	1

Table 10 (continued): Flint Pen 9 composite non-chironomid macroinvertebrate community data.

Class	Order/suborder	Family	Genus	Species	Flint Pen 9		Nov. 21			
					9-1	9-2	9-3	9-4	9-5	total
Insecta	Diptera			sp. (pupae)				1		6
				sp. (larvae)					1	1
		Ceratopogonidae	*Bezzia*	sp. (larvae)	6	32	21	5	14	100
			Alluaudomyia	sp. (larvae)	1					13
			Forcipomyia	sp. (larvae)		35	10		43	88
			Dasyhelea	sp. (larvae)	11	3	3	11	12	56
			Corethrella	sp. (larvae)		2				2
		Culicidae	*Uranotaenia*	sp. (larvae)						10
		Psychodidae	*Telmatoscopus*	sp. (larvae)		8	2		2	15
			Psychoda	sp. (larvae)		8	6		7	21
		Tabanidae		sp. (larvae)						1
		Tipulidae	*Erioptera*	sp. (larvae)			1			1
			Limnophila	sp. (larvae)				4	6	21
			Limonia	sp. (larvae)					4	4
			Molophilus	sp. (larvae)			1	1		2
			Ormosia	sp. (larvae)				1		1
Mollusca	Gastropoda	Physidae		sp.	10	3			1	26
		Planorbidae		sp.	2	7	1			15
		Ancilidae		sp.	2	1			1	10
	Bivalvia								2	2
Annelida	Hirudinea									2
					93	137	110	45	134	797

Figure 9: Flint Pen 7 non-chironomid macroinvertebrate species richness and second order regression of all three sampling periods.

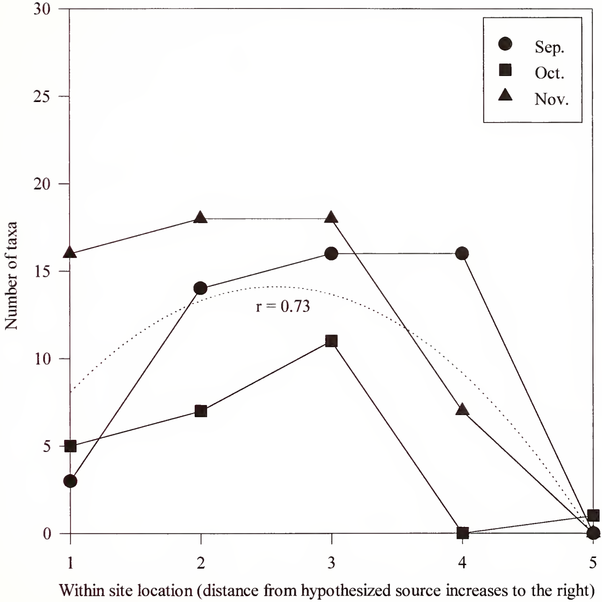


Figure 10: Flint Pen 6 non-chironomid macroinvertebrate species richness and third order regression of all three sampling periods.

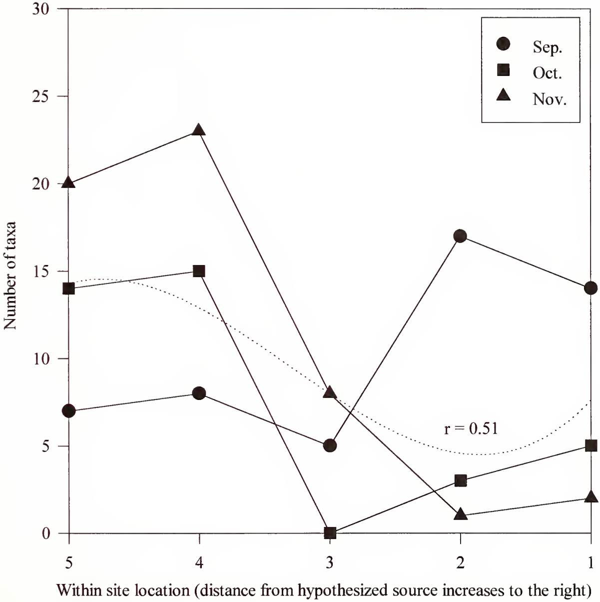


Figure 11: Flint Pen 9 non-chironomid macroinvertebrate species richness and third order regression of all three sampling periods.

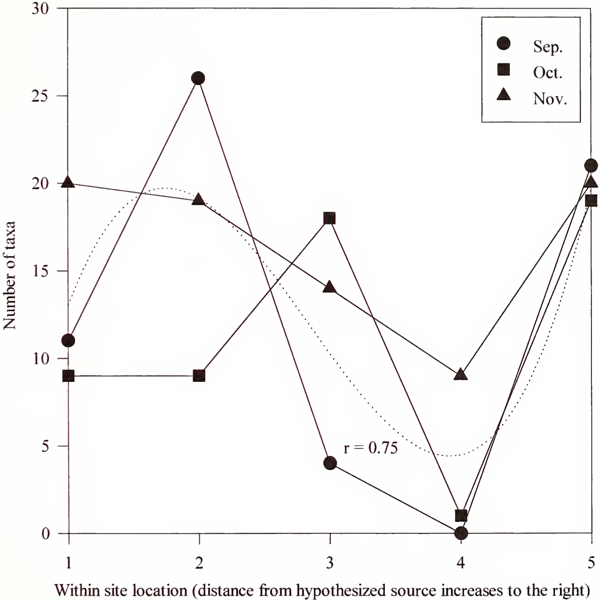


Figure 12: Flint Pen 7 non-chironomid macroinvertebrate Shannon (H') diversity and second order regression of all three sampling periods.

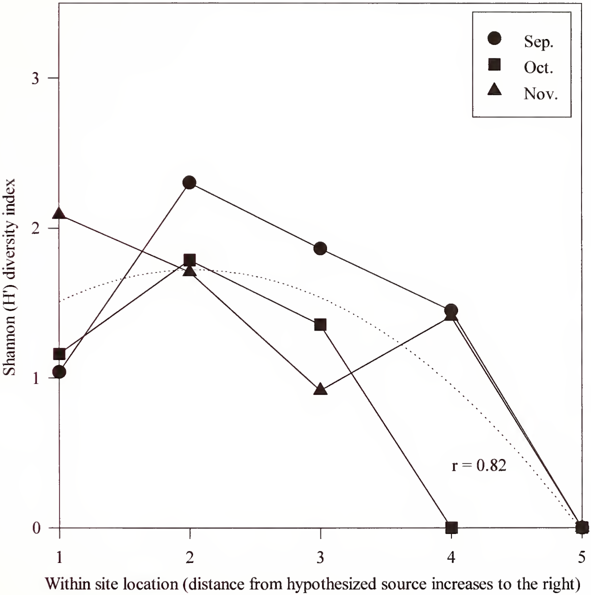


Figure 13: Flint Pen 6 non-chironomid macroinvertebrate Shannon (H') diversity and third order regression of all three sampling periods.

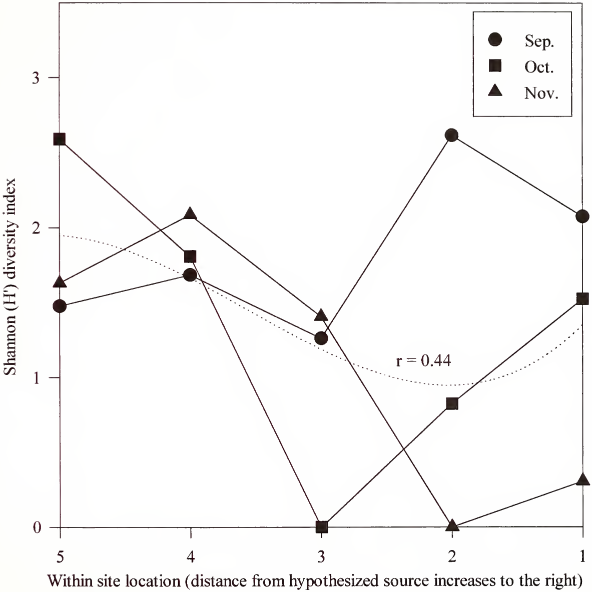
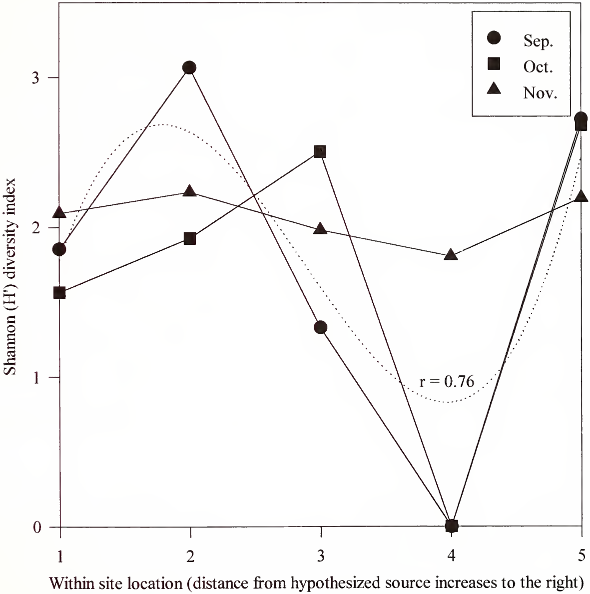


Figure 14: Flint Pen 9 non-chironomid macroinvertebrate Shannon (H') diversity and third order regression of all three sampling periods.



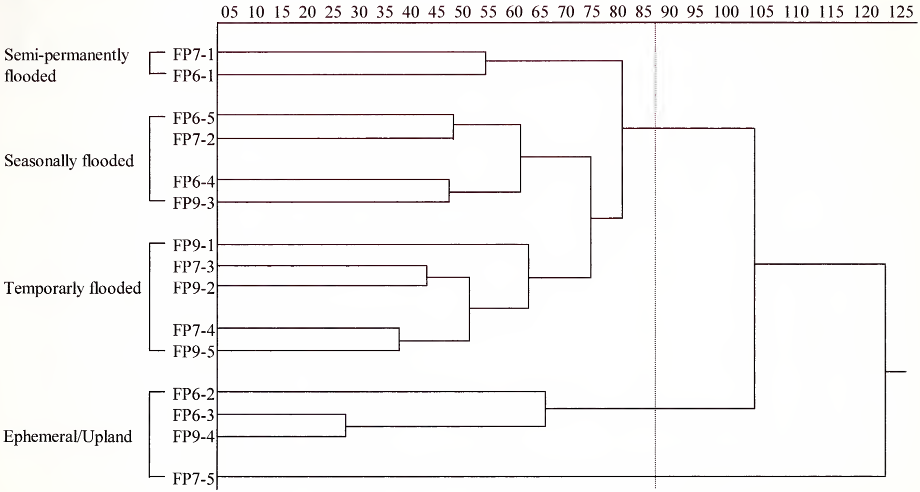
taxonomic loss was from species known to be representative of persistent bodies of water, such as the mayfly, *Caenis*, and many of the longer-lived odonates, such as *Anax*, *Libellula*, and *Pantala*. However, the most distant communities also contained taxa (especially among the Coleoptera and Diptera) unlike any of those in the persistent or intermittently exposed water bodies. There was a slight increase in the number of individuals, taxa, and diversity at most sites nearest to intermittently exposed cypress heads. Flint Pen 6 and 9 (Figures 10,11,13,14) exhibited composite bimodal distributions of taxa and diversity. This was expected at Flint Pen 6, with two hypothesized colonial sources, but unexpected at Flint Pen 9.

A Bray-Curtis based cluster analysis of non-chironomid macroinvertebrate assemblages revealed that locations most distant from an intermittently exposed head, in each isolated wetland community, clustered out separately (significantly different at 102.558 cluster units) from the closer locations (Fig. 15). Additionally, three distinct clusters were found demonstrating progressively less significant clusters.

A principal components analysis (PCA) of non-chironomid macroinvertebrate assemblages and the physical and chemical parameters measured revealed that the distribution of the taxa collected could not be significantly correlated with any of the physical or chemical criteria measured. Only 30% to 50% of the variability of taxonomic composition was described by changes in the physical and chemical conditions of the wetlands.

Figure 15: Bray-Curtis based cluster analysis of combined non-chironomid macroinvertebrate abundance data.

Based on percent dissimilarity



CHIRONOMIDAE ASSEMBLAGE

The midges (Diptera: Chironomidae) represented almost one-third of the total number of invertebrates collected (1544 individuals, 29%). Since the chironomids were a dominant component of each community and have been shown to be potential indicators of ecosystem condition (Gore *et al.* 1997, Wiederholm 1976, and Saether 1979), chironomid assemblages were analyzed separately (Tables 11-13). Like the other macroinvertebrate taxa, the number of individual chironomids, taxa, and diversity decreased with distance from the cypress-head wetlands (Figures 16-21). Some of this taxonomic loss was from species apparently restricted to more persistent bodies of water, exemplified by several species of the genus *Chironomus*, some species of the genus *Tanytarsus*, and *Zavreliella marmorata.* However, sites that were more distant also contained taxa not represented in the cypress-head sites. This suggests that sources other than the intermittently exposed water bodies contributed to the assembly of the isolated small hydric pine wetland communities. Several species (*Monopelopia tillandsia*, *Krenopelopia* sp., among the predatory chironomids, and *Tanytarsus sp. B*) dominated the isolated wetland sites but were rare or not found in the intermittently exposed sites. Finally, four species, *Ablabesmyia rhamphe* grp., *Polypedilum trigonus*, *Chironomus ocreatus*, and *Tanytarsus sp. G* were relatively common in the intermittently exposed as well as the ephemeral wetland types. This suggests that these species are able to withstand changes in chemical and physical conditions and/or could complete their life cycles in a short period. Flint Pen 6 demonstrated a slight composite bimodal distribution for taxonomic richness and diversity (Figures 17 and 20), with the secondary increase resulting from a second hypothesized colonial source.

Table 11: Flint Pen 7 composite chironomid community data.

			Flint Pen 7 Sep. 26					Flint Pen 7 Oct. 24					Flint Pen 7 Nov. 21					
Tanypodinae	**Trophic Relationship**	**Habit**	7-1	7-2	7-3	7-4	7-5	7-1	7-2	7-3	7-4	7-5	7-1	7-2	7-3	7-4	7-5	total
Ablabesmyia (*Karelia*) sp.	predator / collector	Sprawler			1													1
Ablabesmyia rhamphe grp.	predator / collector	Sprawler		32	24			2	5	25			23	27				138
Clinotanypus sp.	predator / engulfers	Burrower							1									1
Krenopelopia sp.	predator / engulfers	Sprawler						1		3				1	1			6
Labrundinia becki	predator / engulfers / piercers	Sprawler											8					8
Labrundinia neopilosella	predator / engulfers / piercers	Sprawler											1					1
Labrundinia sp. B (Epler 1992)	predator / engulfers / piercers	Sprawler						1		1			12					14
Labrundinia sp. 4 (Epler 1992)	predator / engulfers / piercers	Sprawler	1															1
Larsia berneri	predator / engulfers / piercers	Sprawler							1									1
Monopelopia boliekae	predator / engulfers	Sprawler							1				2					3
Monopelopia tillandsia	predator / engulfers	Sprawler												1	1			2
Procladius bellus var. (Epler 1992)													1					1
Tanypus carinatus	predator / collector	Sprawler	3					2					2					7
Orthocladiinae																		
Corynoneura sp.	collector-gatherer	Sprawler						1					1					2
Chironominae																		
Asheum beckae													1					1
Beardius sp.				4	4	9			2	1								20
Chironomus (Lobochironomus) sp.	collector-gatherer	Burrower		1														1
Chironomus ocreatus	collector-shredder	Burrower		6				5	1	1			11	2				26
Cladopelma sp.	collector-gatherer	Burrower		2				2	2				3					9
Cladotanytarsus sp.	collector-gatherer				1													1
Dicrotendipes sp.	collector-gatherer	Burrower	1															1
Einfeldia austini	collector-gatherer	Burrower	1															1
Goeldichironomus natans?	collector-gatherer	Burrower											1					1
Hudsonimyia sp. (tent.)									1									1
Kiefferulus sp.	collector-gatherer	Burrower	2															2
Nimbrocera limnetica									1									1
Parachironomus sp. A (tent.) (Epler 1992	predator / collector	Sprawler	1															1
Parachironomus frequens	predator / collector	Sprawler	1															1
Parachironomus hirtalatus	predator / collector	Sprawler		1						2								3
Polypedilum convictum grp.	shredder / collector	Climber / Clinger		1	16					1								18
Polypedilum trigonus	shredder / collector	Climber / Clinger		4	27	25		1	5	6			1	7	1			77

Table 11 (continued): Flint Pen 7 composite chironomid community data.

			Flint Pen 7 Sep. 26					Flint Pen 7 Oct. 24					Flint Pen 7 Nov. 21					
Chironominae (continued)	**Trophic Relationship**	**Habit**	7-1	7-2	7-3	7-4	7-5	7-1	7-2	7-3	7-4	7-5	7-1	7-2	7-3	7-4	7-5	total
Polypedilum tritium	shredder / collector	Climber / Clinger				1				1			2					4
Pseudochironomus sp.	collector-gatherer	Burrower				1									2			3
Tanytarsus sp. E (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger		2	1								1					4
Tanytarsus sp. G (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger		3	4	3			4	5			131	4	1			155
Tanytarsus sp. K (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger		2	3	5				1				1				12
Tanytarsus sp. L (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger											1					1
Tanytarsus sp. O (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger		33	1													34
Tanytarsus sp. P (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger				1								1				2
Tanytarsus sp. R (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger			2					1								3
Tanytarsus sp. T (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger		1														1
Zavreliella marmorata	collector-gatherer	Climber / Sprawler	2	7	2			6					39					56
TOTAL			12	99	86	45	0	21	24	48	0	0	241	44	6	0	0	626

Table 12: Flint Pen 6 composite chironomid community data.

			Flint Pen 6 Sep. 26					Flint Pen 6 Oct. 24					Flint Pen 6 Nov. 21					
Tanypodinae	**Trophic Relationship**	**Habit**	6-5	6-4	6-3	6-2	6-1	6-5	6-4	6-3	6-2	6-1	6-5	6-4	6-3	6-2	6-1	total
Ablabesmyia peleensis								1										1
Ablabesmyia rhamphe grp.	predator / collector	Sprawler	35			2	2		2			2		3				46
Ablabesmyia sp. B (Epler 1992)	predator / collector	Sprawler											46					46
Clinotanypus sp.	predator / engulfers	Burrower				1												1
Krenopelopia sp.	predator / engulfers	Sprawler		2		1			1					1				5
Labrundinia becki	predator / engulfers / piercers	Sprawler						1										1
Labrundinia sp. B (Epler 1992)	predator / engulfers / piercers	Sprawler		3			1		5									9
Monopelopia boliekae	predator / engulfers	Sprawler		2			2	1	1			2						8
Monopelopia tillandsia	predator / engulfers	Sprawler												2				2
Paramerina sp.		Sprawler							1									1
Tanypus carinatus	predator / collector	Sprawler						1										1
Orthocladiinae																		
Corynoneura sp.	collector-gatherer	Sprawler	18					2					3					23
Pseudosmittia sp.																1		1
Chironominae																		
Beardius sp.				3	7		1		1									12
Chironomus (Lobochironomus) sp.	collector-gatherer	Burrower		5			47		1									53
Chironomus ocreatus	collector-shredder	Burrower		7			13	5	15				7	2				49
Cladopelma sp.	collector-gatherer	Burrower				4	2					1						7
Dicrotendipes sp.	collector-gatherer	Burrower		1			1					1						3
Glyptotendipes sp. E (Epler 1992)	shredder / collector	Burrower					1											1
Goeldichironomus sp.	collector-gatherer	Burrower											1					1
Goeldichironomus holoprasinus	collector-gatherer	Burrower		2			3	1										6
Goeldichironomus natans?	collector-gatherer	Burrower					33											33
Kiefferulus sp.	collector-gatherer	Burrower					4											4
Polypedilum sp.	shredder / collector	Climber / Clinger											1					1
Polypedilum convictum grp.	shredder / collector	Climber / Clinger			1													1
Polypedilum illinoense grp.	shredder / collector	Climber / Clinger	1					1										2
Polypedilum trigonus	shredder / collector	Climber / Clinger		5	1	1	24		1									32
Polypedilum tritium	shredder / collector	Climber / Clinger	1	3				2					1					7

Table 12 (continued): Flint Pen 6 composite chironomid community data.

Chironominae (continued)	Trophic Relationship	Habit	Flint Pen 6 Sep. 26					Flint Pen 6 Oct. 24					Flint Pen 6 Nov. 21					
			6-5	6-4	6-3	6-2	6-1	6-5	6-4	6-3	6-2	6-1	6-5	6-4	6-3	6-2	6-1	total
Tanytarsus sp.	collector-gatherer-filterers-scraper	Climber / Clinger		1														1
Tanytarsus sp. B (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger												4				4
Tanytarsus sp. E (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger		1		5												6
Tanytarsus sp. F (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger	9					2					32					43
Tanytarsus sp. G (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger				2			4									6
Tanytarsus sp. K (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger		1		3												4
Tanytarsus sp. L (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger		1										5				6
Tanytarsus sp. O (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger				1												1
Zavreliella marmorata	collector-gatherer	Climber / Sprawler		1			15		2									18
TOTAL			64	38	9	20	149	16	34	0	0	6	91	17	0	1	0	445

Table 13: Flint Pen 9 composite chironomid community data.

			Flint Pen 9	Sep. 26				Flint Pen 9	Oct. 24				Flint Pen 9	Nov. 21				
Tanypodinae	**Trophic Relationship**	**Habit**	9-1	9-2	9-3	9-4	9-5	9-1	9-2	9-3	9-4	9-5	9-1	9-2	9-3	9-4	9-5	total
Ablabesmyia janta (tent.)	predator / collector	Sprawler															1	1
Ablabesmyia peleensis	predator / collector	Sprawler							1									1
Ablabesmyia rhamphe grp.	predator / collector	Sprawler	44	6				4	3	1			47	1		1		107
Clinotanypus sp.	predator / engulfers	Burrower						1										1
Denopelopia atria										2								2
Krenopelopia sp.	predator / engulfers	Sprawler		1	2		1	2				2	2	3	3			16
Labrundinia neopilosella	predator / engulfers / piercers	Sprawler								1			3					4
Labrundinia sp. B (Epler 1992)	predator / engulfers / piercers	Sprawler						1		1								2
Larsia berneri	predator / engulfers / piercers	Sprawler		1														1
Monopelopia boliekae	predator / engulfers	Sprawler							1						1			2
Monopelopia tillandsia	predator / engulfers	Sprawler			4		2			38		2		2	5			53
Paramerina sp.		Sprawler			2													2
Orthocladiinae																		
Corynoneura sp.	collector-gatherer	Sprawler											3		1			4
Chironominae																		
Beardius sp.			21	2				2	16			1	6	1				49
Chironomus (Lobochironomus) sp.	collector-gatherer	Burrower	1															1
Chironomus ocreatus	collector-shredder	Burrower						1	18	2			4	1				26
Cladopelma sp.	collector-gatherer	Burrower						3					2					5
Goeldichironomus amazonicus	collector-gatherer	Burrower					1											1
Goeldichironomus holoprasinus	collector-gatherer	Burrower		4														4
Goeldichironomus natans?	collector-gatherer	Burrower						1							1			2
Kiefferulus sp.	collector-gatherer	Burrower			1													1
Nimbrocera sp.							1											1
Parachironomus alatus	predator / collector	Sprawler		1														1
Parachironomus hirtalatus	predator / collector	Sprawler											1					1
Paratanytarsus sp. A (Epler 1992)		Sprawler	1															1
Paratanytarsus sp. B (Epler 1992)		Sprawler	1					1										2
Polypedilum sp.	shredder / collector	Climber / Clinger	1						1			1	1					4
Polypedilum convictum grp.	shredder / collector	Climber / Clinger		2			1	1	1			1						6
Polypedilum trigonus	shredder / collector	Climber / Clinger		4	2		3	2	4				5	7	2		3	32
Polypedilum tritium	shredder / collector	Climber / Clinger	14				1			2				1	6		3	27
Pseudochironomus sp.	collector-gatherer	Burrower		2	4			4	3	1			9					23

Table 13 (continued): Flint Pen 9 composite chironomid community data.

Chironominae (continued)	Trophic Relationship	Habit	Flint Pen 9 Sep. 26					Flint Pen 9 Oct. 24					Flint Pen 9 Nov. 21					
			9-1	9-2	9-3	9-4	9-5	9-1	9-2	9-3	9-4	9-5	9-1	9-2	9-3	9-4	9-5	total
Tanytarsus sp. B (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger													50			50
Tanytarsus sp. E (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger	4					1					1					6
Tanytarsus sp. G (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger		3	1			1	3	3			2	1			2	16
Tanytarsus sp. K (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger						1					1					2
Tanytarsus sp. L (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger							1								3	4
Tanytarsus sp. O (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger							3						1			4
Tanytarsus sp. P (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger					1										1	2
Tanytarsus sp. T (Epler 1992)	collector-gatherer-filterers-scraper	Climber / Clinger	2	2				2										6
Zavreliella marmorata	collector-gatherer	Climber / Sprawler							1				1					2
TOTAL			89	28	16	0	11	28	56	51	0	7	88	17	70	1	12	474

Figure 16: Flint Pen 7 chironomid species richness and second order regression of all three sampling periods.

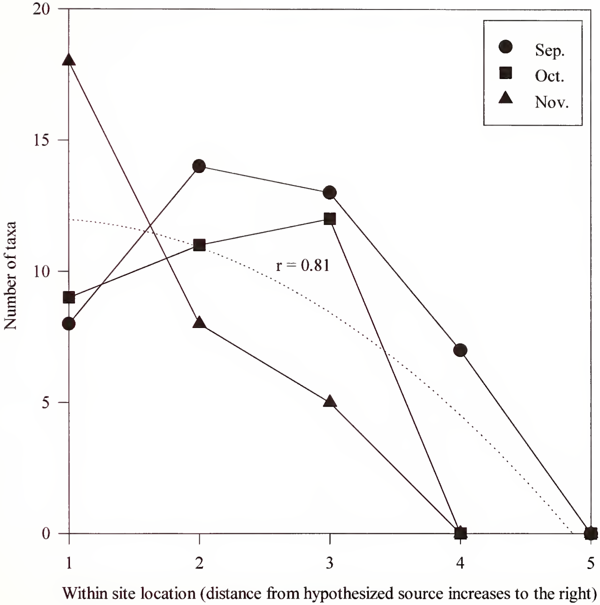


Figure 17: Flint Pen 6 chironomid species richness and second order regression of all three sampling periods.

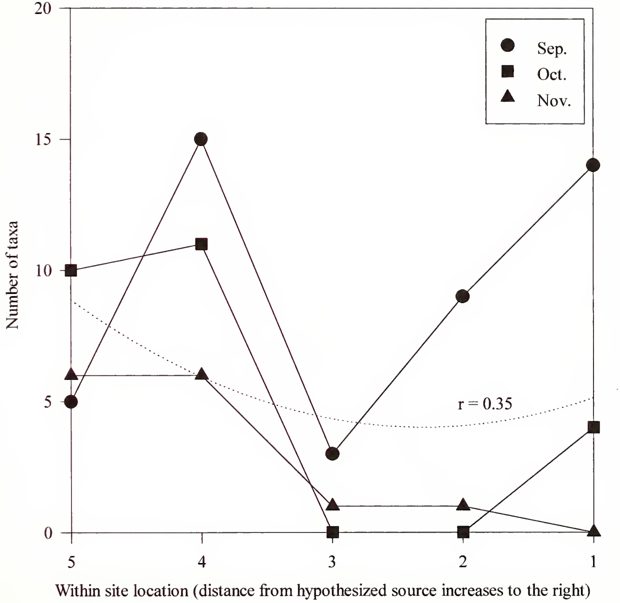


Figure 18: Flint Pen 9 chironomid species richness and second order regression of all three sampling periods.

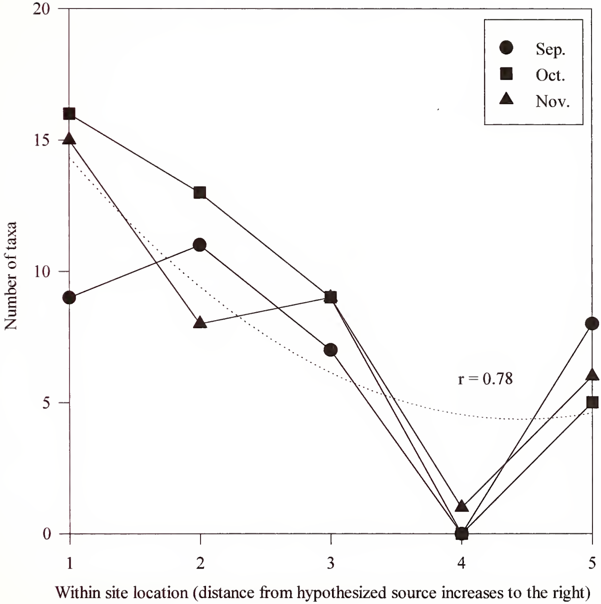


Figure 19: Flint Pen 7 chironomid Shannon (H') diversity and second order regression of all three sampling periods.

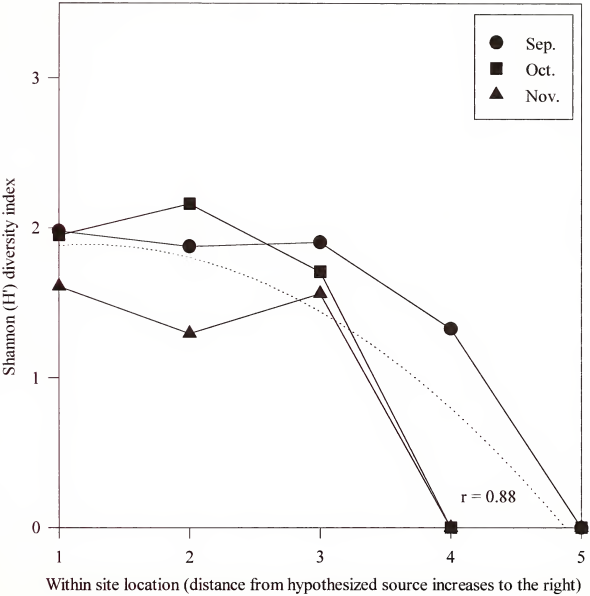


Figure 20: Flint Pen 6 chironomid Shannon (H') diversity and third order regression of all three sampling periods.

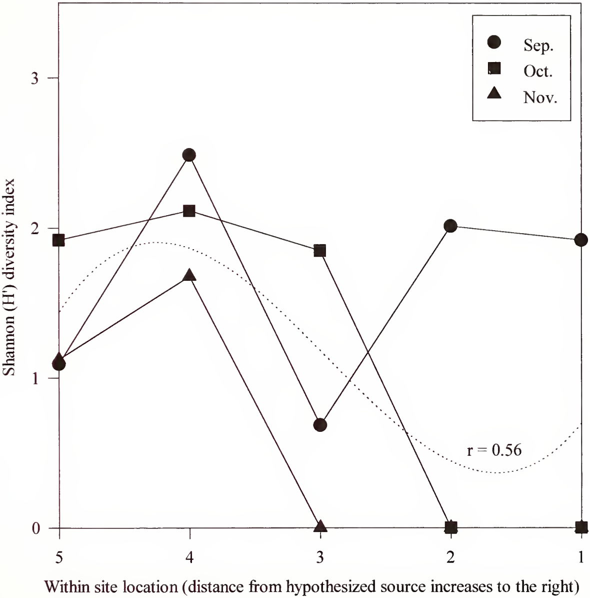
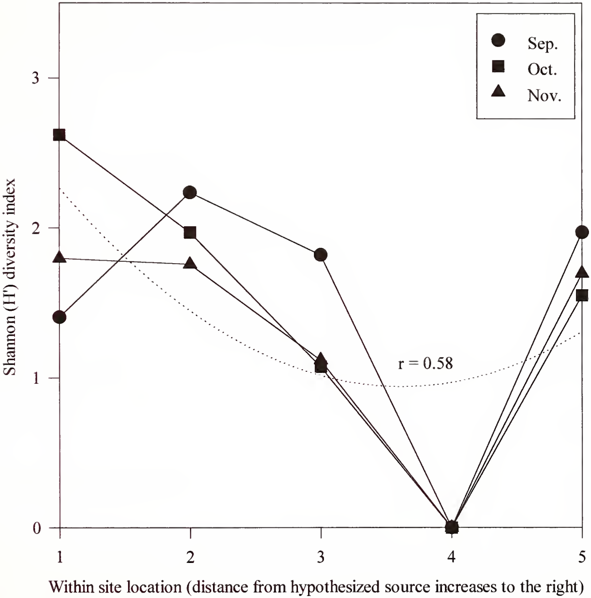


Figure 21: Flint Pen 9 chironomid Shannon (H') diversity and second order regression of all three sampling periods.



A Bray-Curtis based cluster analysis of chironomid assemblages revealed that locations distant from an intermittently exposed head, in each isolated wetland community, clustered out separately (significantly different at 108.367 cluster units) from the closer locations (Fig. 22). In addition, the intermittently exposed heads FP6-5 and FP7-1 along with FP6-1 clustered out separately (significantly different at 89.083 cluster units) from other closer location. Within the remaining cluster, two non-significant clusters could be distinguished.

CRUSTACEAN ASSEMBLAGE

Composite crustacean community data are presented in Tables 14 through 16. Sites containing crustacean fauna were dominated by cladocera and ostracoda. In general, the number of individuals, taxa, and diversity in each isolated wetland community declined with distance from the intermittently exposed cypress swamps (Figures 23-28). Some of this taxonomic loss was from species known to be representative of persistent bodies of water or known burrowers, such as *Procambarus alleni* and *Hyalella azteca*.

SAMPLING EFFICIENCY

Summarized assemblage data by sampling method are presented in Tables 17-19. In general, more non-chironomid macroinvertebrate and chironomid taxa were collected by sweep samples. The greatest numbers of crustacean taxa were collected utilizing funnel traps. Of the two artificial substrates, the Hester-Dendy multiple plate samplers collected the most taxa of non-chironomid macroinvertebrates and chironomids, while the bottlebrush's collected the most crustacean taxa of the two. A fixed factor three-way analysis of variance of taxa data, revealed significant differences at the .001 level among assemblage densities and methods and between assemblage densities and dates. In addition, a significant difference was found between methods and dates at the .01 level utilizing assemblage density data.

Figure 22: Bray-Curtis based cluster analysis of combined chironomid abundance data.

Based on percent dissimilarity

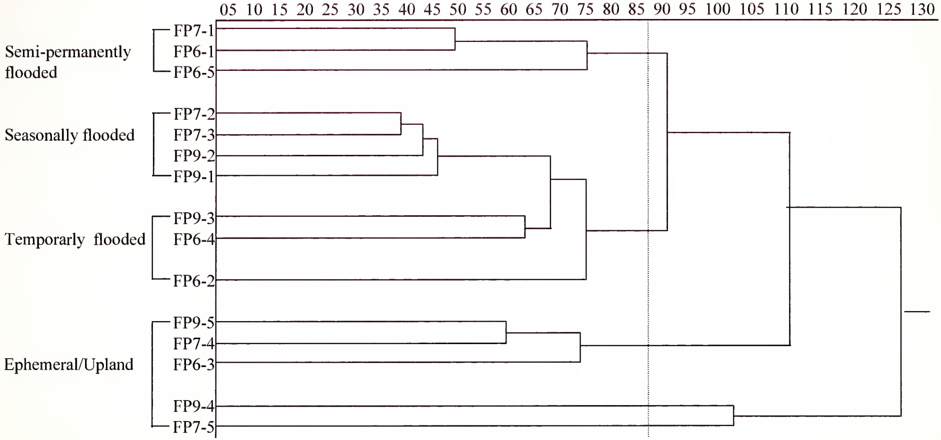


Table 14: Flint Pen 7 composite crustacean community data.

					Flint Pen 7 Sep. 26					Flint Pen 7 Oct. 24					Flint Pen 7 Nov. 21					
Class	**Order/suborder**	**Family**	**Genus**	**Species**	7-1	7-2	7-3	7-4	7-5	7-1	7-2	7-3	7-4	7-5	7-1	7-2	7-3	7-4	7-5	total
Crustacea	Decapoda	Cambaridae	*Procambarus*	sp.					14						2					16
			Procambarus	*alleni*					4											4
		Palaemonidae	*Palaemonetes*	*paludosus*	1	7			8						6					22
	Amphipoda	Hyalellidae	*Hyalella*	*azteca*						2	3	16			19	1				41
	Cladocera	Daphnidae	*Ceriodaphnia*	*laticaudata*											1					1
			Ceriodaphnia	*quadrangula*								1			6					7
			Ceriodaphnia	*rigaudi*					1						2					3
			Daphnia	*laevis*							1									1
			Simocephalus	*serrulatus*					2						1					3
			Simocephalus	*vetulus*							1	1			2					4
		Chydoridae	*Acroperus*	*harpae*							2				2					4
			Alonella	*guttata*							1									1
			Alonopsis	*elongata*							4				1					5
			Camptocercus	*rectirostris*	3															3
			Oxyurella	*tenuicaudis*							10				6					16
		Macrothricidae	*Echinisca*	sp.		1			1											2
		Sididae	*Diaphanosoma*	*brachyurum*	3	3														6
			Diaphanosoma	*leuchtenbergianum*					1											1
	Copepoda	Cyclopoida		sp.	1		1		7	3	4	81			66					163
		Calanoida		sp.								3			22					25
	Ostracoda			sp.			1		8	16	15	6	2		29	6	23			106
TOTAL					8	11	2	0	46	21	41	108	2	0	165	7	23	0	0	434

Table 15: Flint Pen 6 composite crustacean community data.

					Flint Pen 6 Sep. 26					Flint Pen 6 Oct. 24					Flint Pen 6 Nov. 21					
Class	**Order/suborder**	**Family**	**Genus**	**Species**	6-1	6-2	6-3	6-4	6-5	6-1	6-2	6-3	6-4	6-5	6-1	6-2	6-3	6-4	6-5	total
Crustacea	Decapoda	Cambaridae	*Procambarus*	sp.	11	1		2												14
			Procambarus	*alleni*	2		1	1												4
		Palaemonidae	*Palaemonetes*	*paludosus*															2	2
	Amphipoda	Hyalellidae	*Hyalella*	*azteca*															1	1
	Cladocera	Daphnidae	*Ceriodaphnia*	*quadrangula*															6	6
			Ceriodaphnia	*rigaudi*	1								1						1	3
			Simocephalus	*serrulatus*	2														3	5
			Simocephalus	*vetulus*															2	2
		Chydoridae	*Acroperus*	*harpae*										1						1
			Alonella	*karua*									2							2
			Alonopsis	*elongata*										2						2
		Macrothricidae	*Echinisca*	sp.									1							1
			Ilyocryptus	*spinifer*										1					1	2
			Macrothrix	*laticornis*										8						8
		Sididae	*Diaphanosoma*	*leuchtenbergianum*	1															1
			Diaphanosoma	*brachyurum*					1					2					2	5
			Latonopsis	*fasciculata*										1						1
			Latonopsis	*occidentalis*										1						1
	Copepoda	Cyclopoida		sp.					1	3	3		5	9					35	56
		Calanoida		sp.								1	2	11					2	16
	Ostracoda			sp.						4			12		1			4	1	22
TOTAL					17	1	1	3	2	7	3	1	23	36	1	0	0	4	56	155

Table 16: Flint Pen 9 composite crustacean community data.

					Flint Pen 9 Sep. 26					Flint Pen 9 Oct. 24					Flint Pen 9 Nov. 21					
Class	**Order/suborder**	**Family**	**Genus**	**Species**	9-1	9-2	9-3	9-4	9-5	9-1	9-2	9-3	9-4	9-5	9-1	9-2	9-3	9-4	9-5	total
Crustacea	Amphipoda	Hyalellidae	*Hyalella*	*azteca*						2	2				34					38
	Cladocera	Daphnidae	*Ceriodaphnia*	*quadrangula*						1					3					4
			Simocephalus	*vetulus*											3					3
		Chydoridae	*Alona*	*setulosa*											1					1
			Leydigia	*quadrangularis*											1					1
			Oxyurella	*tenuicaudis*											1					1
		Macrothricidae	*Echinisca*	sp.													1			1
			Ilyocryptus	*acutifrons*			1													1
			Ilyocryptus	*spinifer*								1			1					2
			Macrothrix	*laticornis*			2					2								4
			Macrothrix	*rosea*	1															1
		Sididae	*Diaphanosoma*	*brachyurum*											1					1
			Latonopsis	*fasciculata*								60			1					61
			Pseudosida	*bidentata*											1					1
	Copepoda	Cyclopoida		sp.			1					17			12					30
		Calanoida		sp.											4					4
	Ostracoda			sp.					8	13	4	53		5	70	9	37		9	208
TOTAL					1	0	4	0	8	16	6	133	0	5	133	9	38	0	9	362

Figure 23: Flint Pen 7 crustacean species richness and second order regression of all three sampling periods.

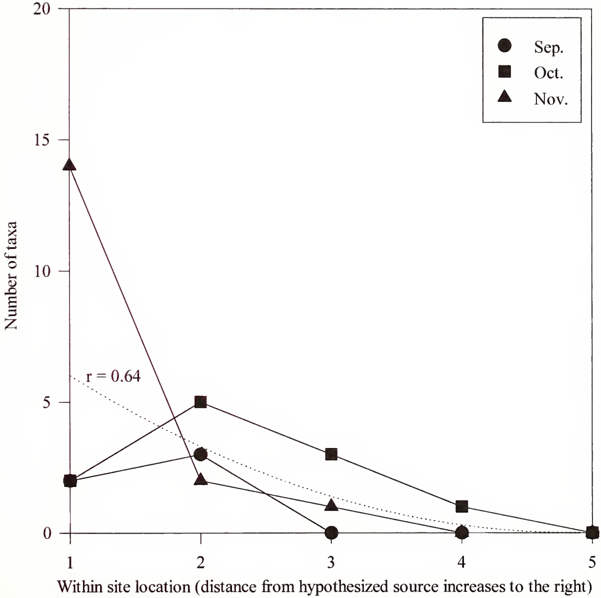


Figure 24: Flint Pen 6 crustacean species richness and third order regression of all three sampling periods.

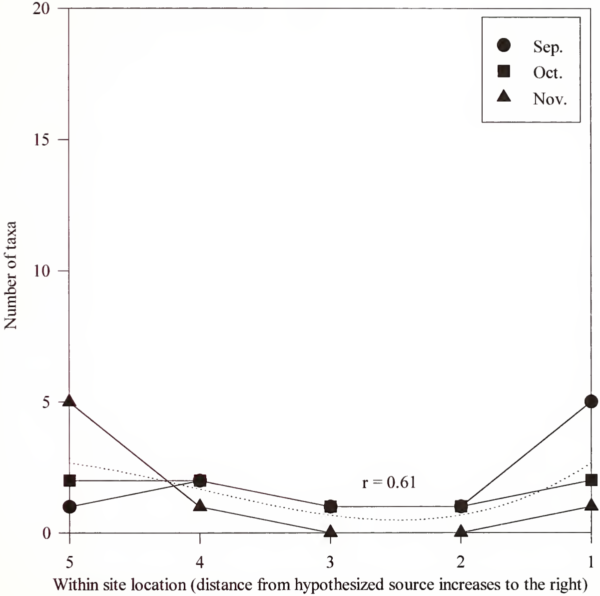


Figure 25: Flint Pen 9 crustacean species richness and second order regression of all three sampling periods.

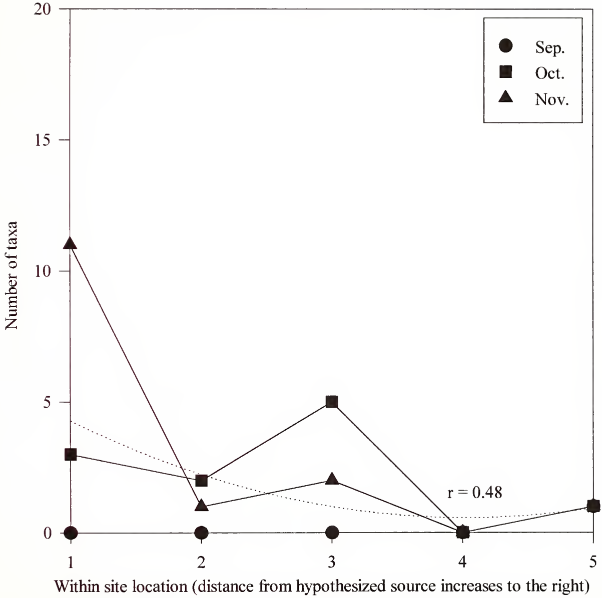


Figure 26: Flint Pen 7 crustacean Shannon (H') diversity and second order regression of all three sampling periods.

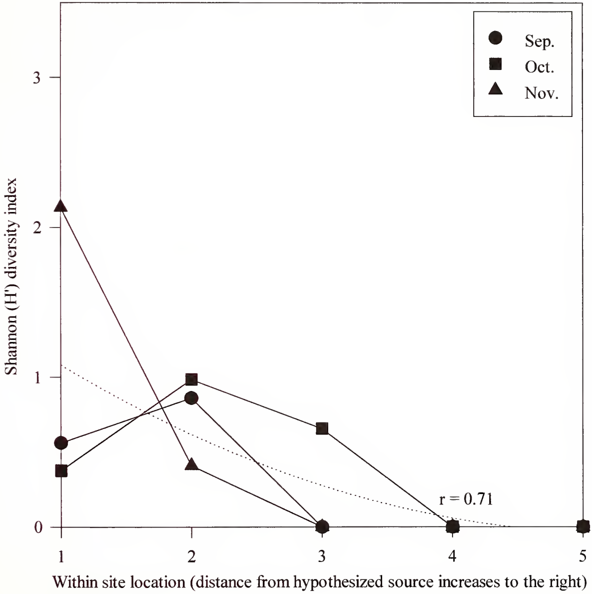


Figure 27: Flint Pen 6 crustacean Shannon (H') diversity and second order regression of three sampling periods.

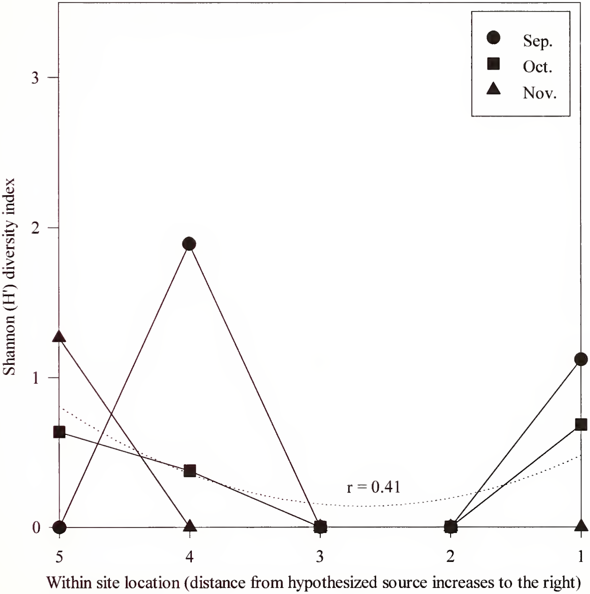


Figure 28: Flint Pen 9 crustacean Shannon (H') diversity and second order regression of all three sampling periods.

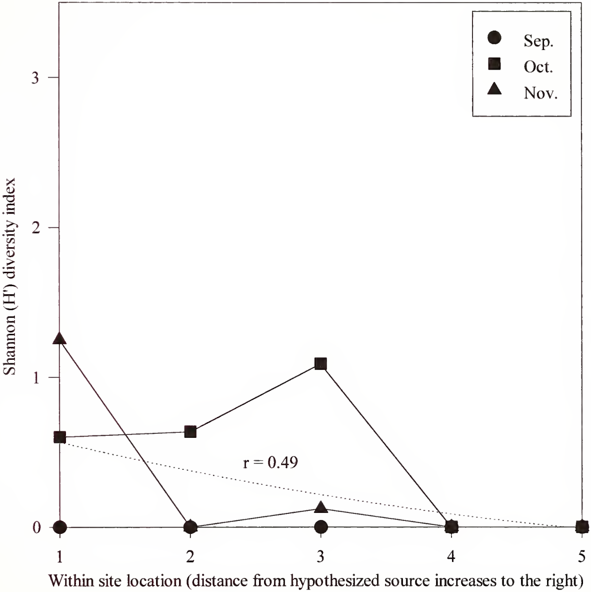


Table 17: Comparison of non-chironomid macroinvertebrate number of individuals and number of taxa collected for all four sampling methods.

Number of Individuals

		FP9-1	FP9-2	FP9-3	FP9-4	FP9-5	FP6-1	FP6-2	FP6-3	FP6-4	FP6-5	FP7-1	FP7-2	FP7-3	FP7-4	FP7-5	Total
Sweep samples	9/26/97	46	41	6	0	60	43	40	41	45	17	4	38	97	171	0	649
	10/24/97	8	13	2	0	28	6	0	0	17	5	5	8	66	0	0	158
	11/21/97	56	56	47	32	52	0	0	0	109	27	29	14	450	0	0	872
Bottle Brush substrates	10/24/97	12	3	11	3	1	3	12	0	37	7	11	8	7	0	1	116
	11/21/97	26	32	35	0	41	18	0	13	70	77	33	26	50	0	0	421
Hester-Dendy multiple plate substrates	10/24/97	3	0	33	0	8	0	0	0	18	5	0	0	0	0	0	67
	11/21/97	11	50	28	13	46	15	3	12	81	24	11	26	32	19	0	371
Funnel traps	9/26/97	0	1	0	0	7	0	0	1	0	0	0	0	0	0	0	9
	10/24/97	0	0	0	0	0	0	0	0	4	0	0	1	5	0	0	10
	11/21/97	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	7

Number of Taxa

		FP9-1	FP9-2	FP9-3	FP9-4	FP9-5	FP6-1	FP6-2	FP6-3	FP6-4	FP6-5	FP7-1	FP7-2	FP7-3	FP7-4	FP7-5	Total
Sweep samples	9/26/97	11	26	4	0	21	14	17	5	8	7	3	14	16	16	0	73
	10/24/97	4	6	2	0	12	3	0	0	7	4	4	5	7	0	0	27
	11/21/97	14	13	11	7	12	0	0	0	15	11	10	10	10	0	0	52
Bottle Brush substrates	10/24/97	4	3	5	1	1	2	3	0	7	6	3	4	5	0	1	24
	11/21/97	6	8	1	0	5	2	0	2	5	5	6	4	7	0	0	26
Hester-Dendy multiple plate substrates	10/24/97	2	0	14	0	5	0	0	0	8	5	0	0	0	0	0	26
	11/21/97	6	8	7	5	7	2	1	8	10	7	5	6	11	7	0	36
Funnel traps	9/26/97	0	1	0	0	6	0	0	1	0	0	0	0	0	0	0	6
	10/24/97	0	0	0	0	0	0	0	0	2	0	0	1	3	0	0	5
	11/21/97	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1

Table 18: Comparison of chironomid number of individuals and number of taxa collected for all four sampling methods.

Number of Individuals

		FP9-1	FP9-2	FP9-3	FP9-4	FP9-5	FP6-5	FP6-4	FP6-3	FP6-2	FP6-1	FP7-1	FP7-2	FP7-3	FP7-4	FP7-5	Total
Sweep samples	9/26/97	89	28	16	0	11	64	38	9	20	149	12	99	86	45	0	666
	10/24/97	19	50	12	0	7	8	25	0	0	6	18	15	39	0	0	199
	11/21/97	70	17	67	1	11	89	17	0	0	0	208	42	6	0	0	528
Bottle Brush substrates	10/24/97	2	3	3	0	0	5	1	0	0	0	1	1	4	0	0	20
	11/21/97	8	0	0	0	1	1	0	0	0	0	26	1	0	0	0	37
Hester-Dendy multiple plate substrates	10/24/97	7	3	36	0	0	4	8	0	0	0	2	8	5	0	0	73
	11/21/97	10	0	3	0	0	1	0	0	1	0	7	1	0	0	0	23
Funnel traps	9/26/97	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
	10/24/97	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
	11/21/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Number of Taxa

		FP9-1	FP9-2	FP9-3	FP9-4	FP9-5	FP6-5	FP6-4	FP6-3	FP6-2	FP6-1	FP7-1	FP7-2	FP7-3	FP7-4	FP7-5	Total
Sweep samples	9/26/97	9	11	7	0	8	5	15	3	9	14	8	14	12	7	0	48
	10/24/97	12	10	8	0	5	4	8	0	0	4	8	8	11	0	0	34
	11/21/97	9	8	7	1	6	6	6	0	0	0	10	7	5	0	0	24
Bottle Brush substrates	10/24/97	2	2	3	0	0	5	1	0	0	0	1	1	1	0	0	10
	11/21/97	3	0	0	0	1	1	0	0	0	0	6	1	0	0	0	11
Hester-Dendy multiple plate substrates	10/24/97	6	3	2	0	0	3	5	0	0	0	2	4	4	0	0	17
	11/21/97	8	0	3	0	0	1	0	0	1	0	7	1	0	0	0	15
Funnel traps	9/26/97	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
	10/24/97	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
	11/21/97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 19: Comparison of crustacean number of individuals and number of taxa collected for all four sampling methods.

Number of Individuals

		FP9-1	FP9-2	FP9-3	FP9-4	FP9-5	FP6-1	FP6-2	FP6-3	FP6-4	FP6-5	FP7-1	FP7-2	FP7-3	FP7-4	FP7-5	Total
Sweep samples	9/26/97	0	0	0	0	8	17	1	1	3	1	4	11	0	0	46	92
	10/24/97	1	1	0	0	5	0	0	0	0	0	3	4	14	0	0	28
	11/21/97	54	6	20	0	9	0	0	0	3	18	35	1	0	0	0	146
Bottle Brush substrates	10/24/97	15	5	15	0	0	7	3	1	5	3	8	15	3	2	0	82
	11/21/97	18	0	12	0	0	0	0	0	1	0	52	2	22	0	0	107
Hester-Dendy multiple plate substrates	10/24/97	0	0	118	0	0	0	0	0	3	0	5	1	1	0	0	128
	11/21/97	7	3	6	0	0	1	0	0	0	1	3	4	1	0	0	26
Funnel traps	9/26/97	1	0	4	0	0	0	0	0	0	1	4	0	2	0	0	12
	10/24/97	0	0	0	0	0	0	0	0	15	33	5	21	90	0	0	164
	11/21/97	14	0	0	0	0	0	0	0	0	37	75	0	0	0	0	126

Number of Taxa

		FP9-1	FP9-2	FP9-3	FP9-4	FP9-5	FP6-1	FP6-2	FP6-3	FP6-4	FP6-5	FP7-1	FP7-2	FP7-3	FP7-4	FP7-5	Total
Sweep samples	9/26/97	0	0	0	0	1	5	1	1	2	1	2	3	0	0	9	9
	10/24/97	1	1	0	0	1	0	0	0	0	0	1	3	2	0	0	4
	11/21/97	6	1	1	0	1	0	0	0	1	4	9	1	0	0	0	11
Bottle Brush substrates	10/24/97	3	2	2	0	0	2	1	1	2	2	2	3	2	1	0	10
	11/21/97	5	0	1	0	0	0	0	0	1	0	10	1	1	0	0	21
Hester-Dendy multiple plate substrates	10/24/97	0	0	5	0	0	0	0	0	1	0	1	1	1	0	0	6
	11/21/97	3	1	2	0	0	1	0	0	0	1	2	1	1	0	0	5
Funnel traps	9/26/97	1	0	3	0	0	0	0	0	0	1	2	0	2	0	0	6
	10/24/97	0	0	0	0	0	0	0	0	5	7	2	6	6	0	0	14
	11/21/97	5	0	0	0	0	0	0	0	0	7	6	0	0	0	0	12

DISCUSSION AND CONCLUSIONS

COLONIZATION

Macroinvertebrates:

Composite non-chironomid macroinvertebrate communities can be seen to ordinate along a single axis (Fig. 29). Flint Pen 7-5 and FP7-3 can be considered outliers to this relationship. Flint Pen 7-5 was nearly dry or completely dry during sampling. Flint Pen 7-3 was dominated by an extremely high number of individuals of the ceratopogonid, *Dasyhelea*. Indeed, if all sites were re-ordinated using abundance parameters ("abundant, common, and rare" instead of raw numbers) only FP7-5 remains unassociated with this axis (Fig. 30). Unfortunately, multivariate statistical analysis (Principal Components Analysis, PCA) did not reveal a source of the variation. However, it is apparent that with distance from the more persistent water bodies the temporary wetland communities are as much as 80% different in their taxonomic composition and abundance. At site FP9, the cypress-head site (denoted by broken line in Fig. 31) and associated flatwood wetlands generally become more taxonomically similar and change, through time, on a decreasing diagonal axis (denoted by arrow in Fig. 31) indicating a temporal shift in taxonomic composition. Flint Pen 9, containing the most diverse habitat, did not reveal any obvious patterns of colonization. The ordination does reveal a superficial alignment of the two most distant sites (FP9-4 and FP9-5) which remain distinctly dissimilar through October to the aligned near sites (FP9-1, FP9-2, and FP9-3). This may suggest surface area influences from the shallow cypress prairie not demonstrated in the isolated cypress heads. More precisely, a larger, less contained source, such as a cypress prairie, with greater habitat coverage, may have a greater effect on taxonomic

Figure 29: Ordination of combined non-chironomid macroinvertebrate raw data for all sample periods and methods except funnel traps. Ordination locations are based on (Bray-Curtis) percent dissimilarity. Large symbols represent intermittently exposed cypress heads/prairies. Small symbols represent ephemeral flatwood wetlands. Hyphenated numbers indicate individual wetlands within a Flint Pen location.

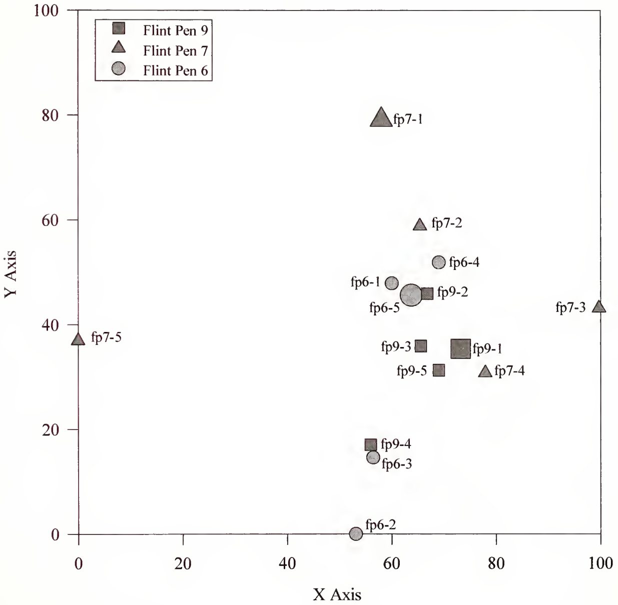


Figure 30: Ordination of combined non-chironomid macroinvertebrate abundance data for all sample periods and methods except funnel traps. Ordination locations are based on (Bray-Curtis) percent dissimilarity. Large symbols represent intermittently exposed cypress heads/prairies. Small symbols represent ephemeral flatwood wetlands. Hyphenated numbers indicate individual wetlands within a Flint Pen location.

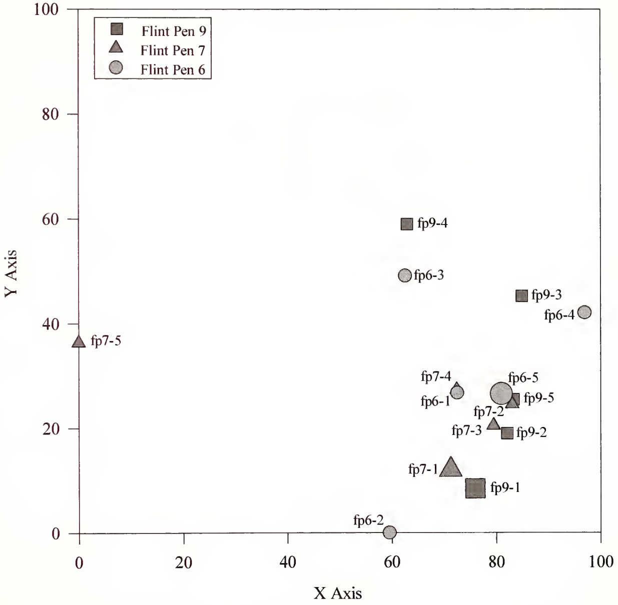
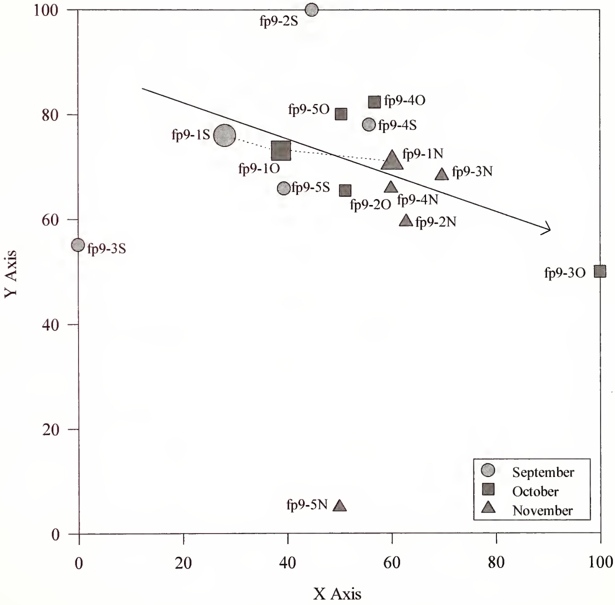


Figure 31: Ordination of FP9 non-chironomid macroinvertebrate raw data for all three sample periods and methods except funnel traps. Ordination locations based on percent dissimilarity (Bray-Curtis). Large symbols represent the intermittently exposed cypress prairie. Small symbols represent ephemeral flatwood wetlands. Hyphenated numbers indicate individual wetlands within the Flint Pen 9 location. The broken line represents temporal change in intermittently exposed cypress head FP9-1. The arrow indicates direction of increasing similarity indicating a temporal shift in taxonomic composition.



composition than a contained cypress head with limited habitat coverage. Ordination of early samples of FP7 indicates distance effects through time (Fig. 32) from a colonial source. Associated flatwood wetlands (broken line) remain distinctly different from the intermittently exposed head and lie on an almost linear axis. Yet, through time, the head and associated wetlands become more similar and lose their linear relationship. The early relationship suggests that the initial colonization of associated wetlands is influenced by the intermittently exposed head (FP7-1), but isolation and temporal influences, such as duration and frequency, have subsequent effects on taxonomic composition.

Sites FP6-2, FP6-3, and FP6-4, initially believed to represent intermediate areas between two intermittently exposed sources, demonstrated increasing non-linear similarity between sources and intermediate areas (Fig. 33). September samples produced similar ordinations to that of FP9, in that the intermittently exposed head is distinctly dissimilar from associated flatwood wetlands. As in FP9, the associated wetlands ordinate along a single axis, while FP6-3, the most isolated site, remains the most dissimilar. FP6-1, initially considered an intermittently exposed colonial source, became progressively drier in later sampling events and was reclassified as a seasonally flooded wetland. However, the ordination revealed that the other sites remained intermediate in similarity between sites FP6-1 and FP6-5 during dry down, indicating that FP6-1 was making some contribution to the organization of the fauna at the intermediate sites (Fig. 33). This relationship became more obvious in the ordination of November samples, where a nearly circular

Figure 32: Ordination of FP7 non-chironomid macroinvertebrate abundance data for all three sample periods and methods except funnel traps. Ordination locations based on percent dissimilarity (Bray-Curtis). Large symbols represent the intermittently exposed cypress head. Small symbols represent ephemeral flatwood wetlands. Hyphenated numbers indicate individual wetlands within the Flint Pen 7 location. The broken line indicates a nearly linear alignment of associated wetlands for September.

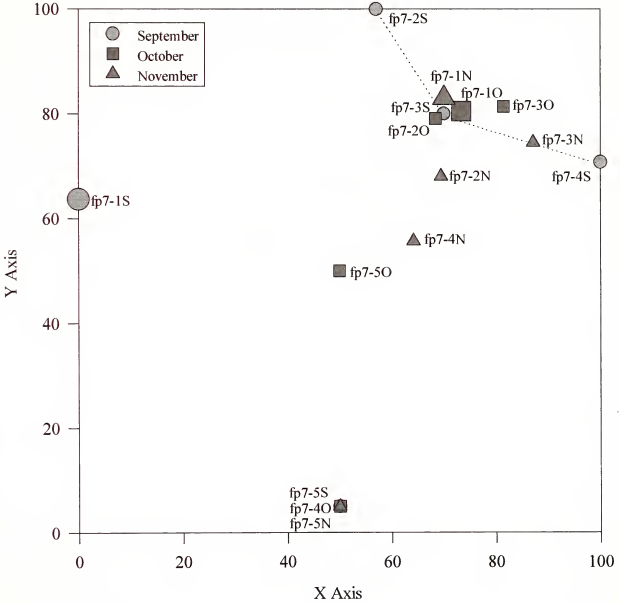
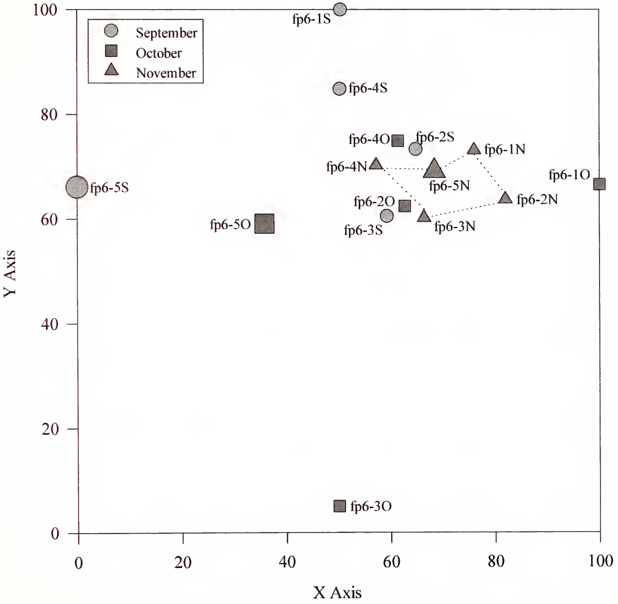


Figure 33: Ordination of FP6 non-chironomid macroinvertebrate abundance data for all three sample periods and methods except funnel traps. Ordination locations based on percent dissimilarity (Bray-Curtis). Large symbols represent the intermittently exposed cypress head. Small symbols represent ephemeral flatwood wetlands. Hyphenated numbers indicate individual wetlands within the Flint Pen 6 location. The broken line indicates a nearly circular pattern in the November samples, suggesting a spatial influence on taxonomic composition.



pattern of similarity between sites was observed (broken lines) with sites FP6-3 and FP6-2 being most dissimilar to the larger wet sites (FP6-5, FP6-4, and FP6-1).

Chironomids:

Ordinations of the chironomid assemblages alone do not produce any linear relationships (Figures 34-36). However, the ordinations do reveal that there is a distance effect in taxonomic composition. At site FP7, the cypress-head site (FP7-1) does change through time (denoted by the broken line in Fig. 34). Yet, through time, all of the pine flatwood wetlands remain distinctly different from the more persistent water body (FP7-1). Not surprisingly, FP7-2 is the most similar through time, but remains at least 30% dissimilar. At site FP9, the same trend was observed. The intermittently exposed site remains distinctly dissimilar from the pine flatwood sites through the drydown, although, in October some of the sites are more similar than in either September or November. The increased similarity in October may be due to sampling variability. Site FP9 (Fig. 36) displayed the greatest variability in ordination and site similarities. This is probably due to heterogeneity of the vegetation and organic input at each of the sites sampled. At the other sites, all of the pine flatwood wetlands were similar with regards to the amount of associated vegetation and exposure to sunlight. However, the pine flatwood sites at FP9 were variously shaded and had significant accumulations of organic material on the substrate. These variations in microhabitats could account for the greater variance seen at FP9.

As demonstrated by site FP6 (Figures 35 and 37), there is an observable size effect. Although it was smaller and shallower than FP6-5 and was only seasonally flooded, FP6-1 had an initial surface area and volume approaching conditions in the intermittently exposed cypress-head nearby (FP6-5). Thus, its community composition was also similar to FP6-5. With time, isolation, and desiccation, this site became increasingly dissimilar taxonomically. Although surface area and volume was not measured at each site, the ordinations suggest that there is an observable area effect. That is, large hydric pine flatwoods will have greater taxonomic diversity compared to smaller ones. The progressive desiccation during drydown also emphasizes the distance effect temporally. However, these two phenomena do not contribute entirely to the observed changes in the community composition of the pine flatwood wetlands.

When I began to sample site FP6, sites FP6-1 and FP6-5 were believed to be more persistent wetland sites; FP6-1 being a large, shallow cypress dominated, wetland, while FP6-5 was a deep cypress-head site. Thus, sites FP6-2, FP6-3, and FP6-4 were expected to represent intermediate areas, which would give an idea of colonization abilities or contributions of taxa from the cypress heads to these pine flatwood wetlands. It was later discovered that FP6-1 became entirely desiccated during and could be considered a large seasonally flooded wetland. However, the ordination revealed that the other sites remained intermediate in similarity between sites FP6-1 and FP6-5 during drydown and indicated that FP6-1 was contributing to the organization of the fauna at the intermediate sites. This relationship is most obvious in a composite ordination of all sites (Fig. 37) where a circular pattern of similarity between sites was

Figure 34: Ordination of FP7 chironomid raw data for all three sample periods and methods except funnel traps. Ordination locations based on percent dissimilarity (Bray-Curtis). Large symbols represent the intermittently exposed cypress head. Small symbols represent ephemeral flatwood wetlands. Hyphenated numbers indicate individual wetlands within the Flint Pen 7 location. The broken line indicates a nearly linear temporal shift in the taxonomic composition of FP7-1.

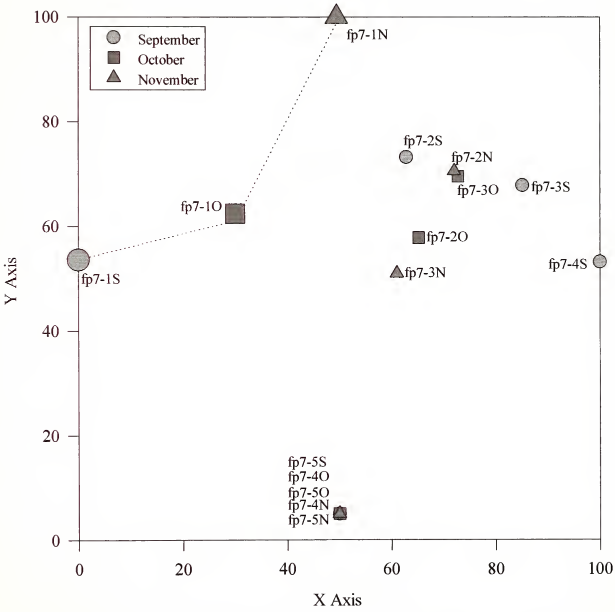


Figure 35: Ordination of FP6 chironomid raw data for all three sample periods and methods except funnel traps. Ordination locations based on percent dissimilarity (Bray-Curtis). Large symbols represent the intermittently exposed cypress head. Small symbols represent ephemeral flatwood wetlands. Hyphenated numbers indicate individual wetlands within the Flint Pen 6 location. The broken lines indicate drawdown and dessication of FP6-1.

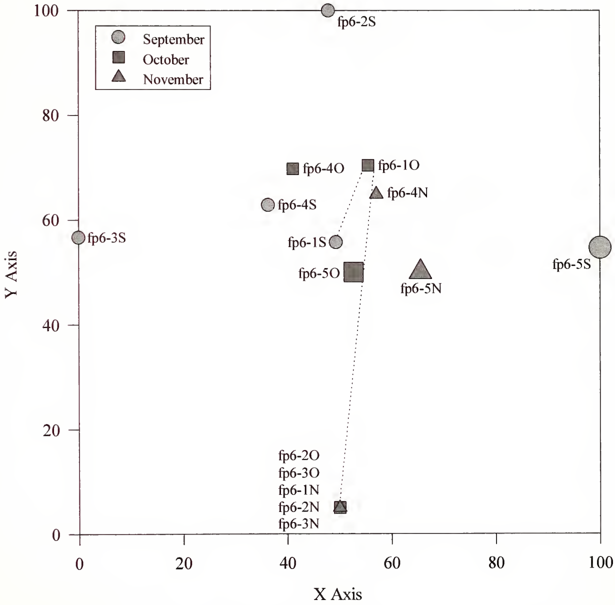


Figure 36: Ordination of FP9 chironomid raw data for all three sample periods and methods except funnel traps. Ordination locations based on percent dissimilarity (Bray-Curtis). Large symbols represent the intermittently exposed cypress prairie. Small symbols represent ephemeral flatwood wetlands. Hyphenated numbers indicate individual wetlands within the Flint Pen 9 location.

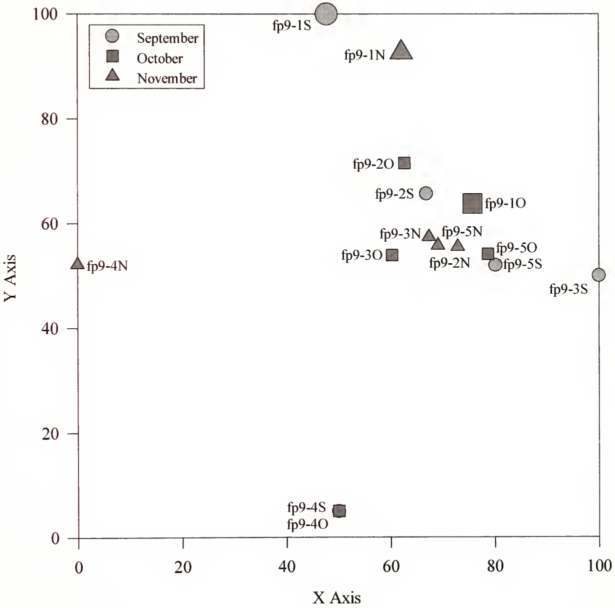
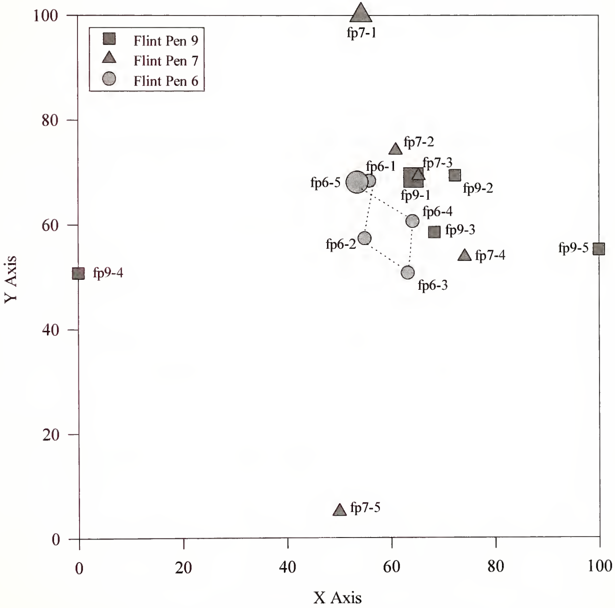


Figure 37: Ordination of combined chironomid raw data for all three sample periods and methods except funnel traps. Ordination locations based on percent dissimilarity (Bray-Curtis). Large symbols represent the intermittently exposed cypress heads/prairie. Small symbols represent ephemeral flatwood wetlands. Hyphenated numbers indicate individual wetlands within the Flint Pen Strand locations. The broken line indicates a nearly circular pattern in the FP6 sites, suggesting a spatial influence on taxonomic composition.



observed (broken lines) with site FP6-3 being most dissimilar to the larger wet sites. In addition, the composite ordination (Fig. 37) shows that site FP7 lies on a single axis and demonstrates a distinct distance effect. That is, taxonomic assemblage is a composite of the influence of distance from a source of colonists, the sizes of the recipient islands, and the source of colonists.

Crustaceans:

Composite crustacean communities can be seen to ordinate roughly along both the X and Y-axis (Fig. 38). If all sites were re-ordinated using abundance parameters (Fig. 39), FP9-4 remains completely unassociated with the rest of the ordinations. This site, FP9-4, became dry early in the sampling schedule and few crustaceans were collected at this site. Within the FP6 site, FP6-2 unexpectedly was found to be more similar to FP6-5 than to FP6-3. The connection appears to be through the abundance of cyclopoid copepods found in both sites. Otherwise, the FP6-2 site was relatively impoverished. This may be explained by cryptobiotic emergence from a past colonization event in which FP6-5 played a more prominent role through overland flow. The presence of cryptobiotic forms at these sites has not been investigated, but cryptobiotic eggs and diaupausing instars within micro-crustaceans are known to occur (Alekseev and Starobogatov 1996, Brendonck 1996, Fryer 1996, Korovchinsky and Boikova 1996, Schwartz and Hebert 1987, and Mellors 1975). Ordination of FP6 crustacean abundance data for all three sample periods (Fig. 40) produces discreet alignment of all sites along either the X or Y axis. Within each sampling date, with the exception of October, FP6-3 and FP6-2 are the most similar and remain intermediate between FP6-4, FP6-1 and FP6-5. Although not a circular pattern, this demonstrates the obvious distance and area effect previously observed with the chironomid data. Ordination of FP7 and FP9 crustacean data (Figures 41 and 42, respectively) revealed little about the colonization of these sites. This is due to inadequate numbers in sampling to produce comparisons between sites. The majority of sites within these two locations that did contain crustacean individuals were not taxonomically rich. Diversity and richness patterns of all the sites followed typical spatial and temporal island biogeographic patterns. That is, crustacean communities in all of the sites decreased in abundance and diversity with distance in space and time. All three sites (FP6, FP7, and FP9) were dominated by Decapoda, Amphipoda, Copepoda, and Ostracoda.

Invertebrate Assemblages:

The pattern of colonization of the temporary wetlands within the Flint Pen Strand hydric pine flatwoods generally mimics those for invasion of isolated islands in the world's oceans (MacArthur and Wilson 1967). Species invasion by active dispersers is rapid and slightly slower by passive dispersers. Species invasion achieves maximum density and diversity in a relatively short time. Colonization is dependent upon distance to the recipient islands, both spatially and temporally, and the number of intervening "stepping-stone islands" acting as temporary refugia (MacArthur and Wilson 1967 and Ebert and Balko 1987). In addition, the size of the source of colonists and the size of the recipient island, spatially and temporally, also influences the ultimate taxonomic composition (Simberloff and Wilson 1969, Simberloff 1976, Ebert and Balko 1987). This phenomenon has been frequently reported for temporary pools and ponds (Driver 1977,

Figure 38: Ordination of combined crustacean raw data for all three sample periods and methods except funnel traps. Ordination locations based on percent dissimilarity (Bray-Curtis). Large symbols represent the intermittently exposed cypress heads/prairie. Small symbols represent ephemeral flatwood wetlands. Hyphenated numbers indicate individual wetlands within the Flint Pen Strand locations.

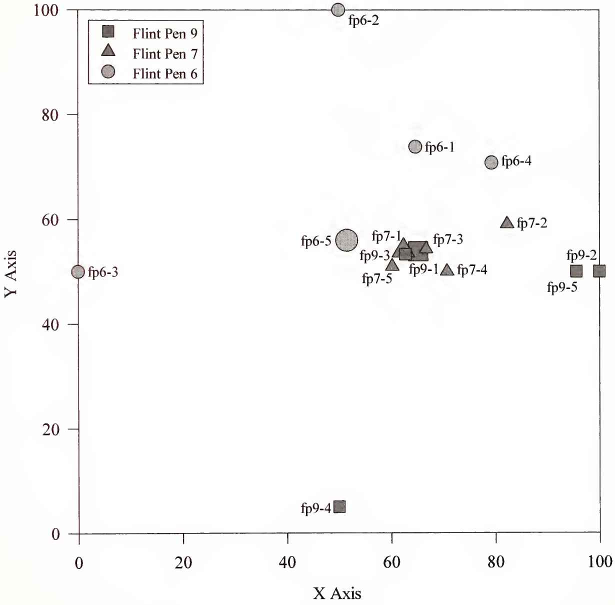


Figure 39: Ordination of combined crustacean abundance data for all three sample periods and methods except funnel traps. Ordination locations based on percent dissimilarity (Bray-Curtis). Large symbols represent the intermittently exposed cypress heads/prairie. Small symbols represent ephemeral flatwood wetlands. Hyphenated numbers indicate individual wetlands within the Flint Pen Strand locations.

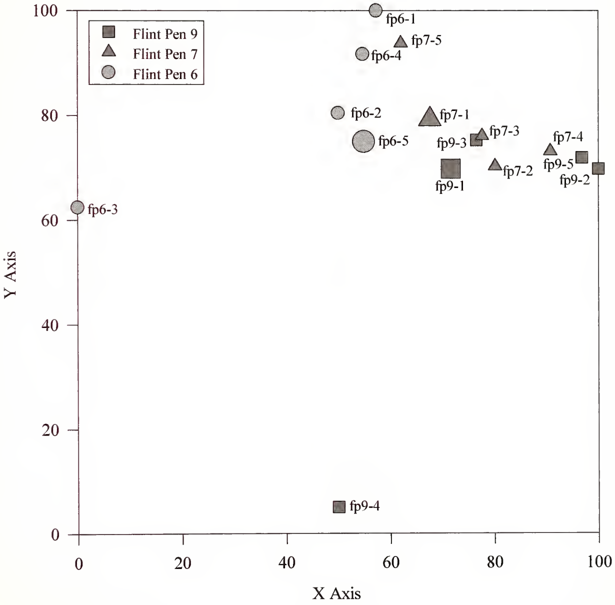


Figure 40: Ordination of FP6 crustacean abundance data for all three sample periods and methods except funnel traps. Ordination locations based on percent dissimilarity (Bray-Curtis). Large symbols represent the intermittently exposed cypress head. Small symbols represent ephemeral flatwood wetlands. Hyphenated numbers indicate individual wetlands within the Flint Pen 6 location.

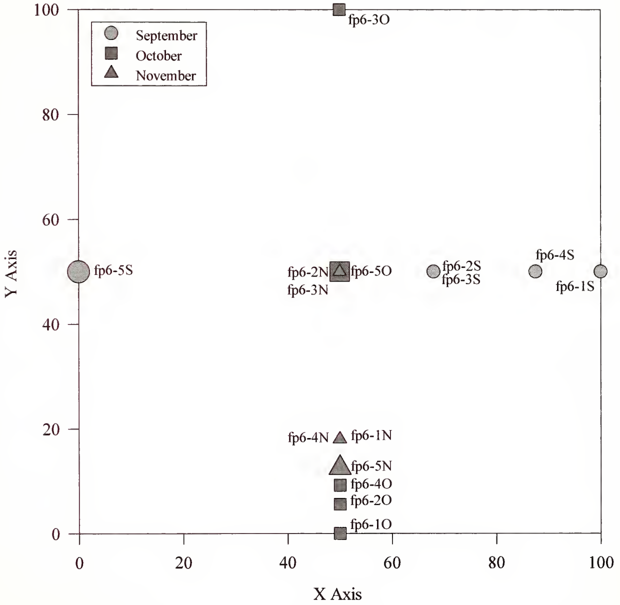


Figure 41: Ordination of FP7 crustacean abundance data for all three sample periods and methods except funnel traps. Ordination locations based on percent dissimilarity (Bray-Curtis). Large symbols represent the intermittently exposed cypress head. Small symbols represent ephemeral flatwood wetlands. Hyphenated numbers indicate individual wetlands within the Flint Pen 7 location.

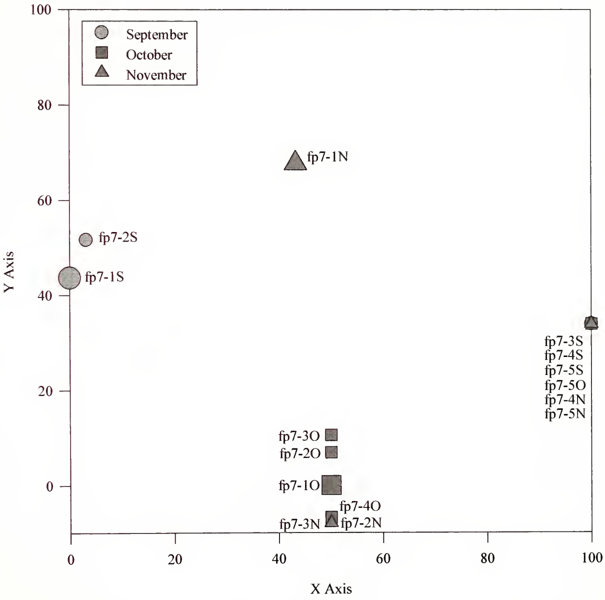
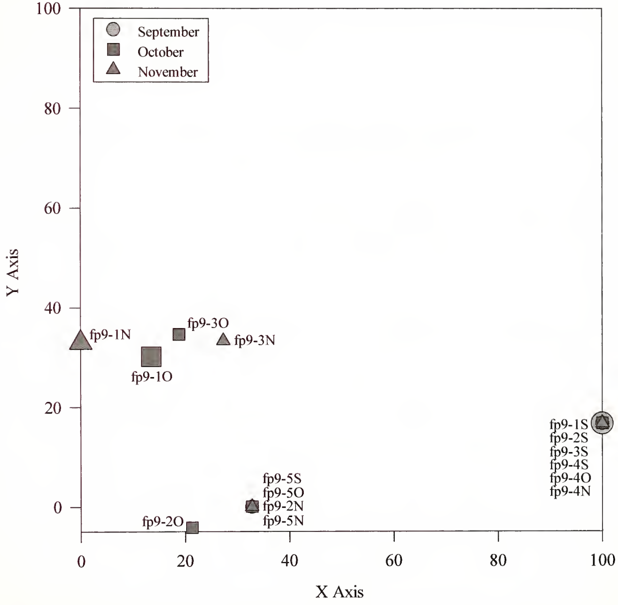


Figure 42: Ordination of FP9 crustacean abundance data for all three sample periods and methods except funnel traps. Ordination locations based on percent dissimilarity (Bray-Curtis). Large symbols represent the intermittently exposed cypress head. Small symbols represent ephemeral flatwood wetlands. Hyphenated numbers indicate individual wetlands within the Flint Pen 9 location.



March and Bass 1994 and Ebert and Balko 1987). Diamond (1975) suggested that communities are assembled through selection of colonists, adjustment of their abundance and compression of niches to match resources availability, and the carrying capacity of the island. This period of dynamic equilibrium (Simberloff 1978) during colonization results in a gradual decline in the abundance of some species and in overall richness to create a stabilized community.

The isolated island effect is not constant in the hydric pine flatwood sites. During the initial rainy season, there is probably a surface water connection from the more persistent water bodies to the hydric pine wetlands. However, as the dry season proceeds, the more distant sites become hydrologically isolated. Additionally, there may be a ground water connection which allows a certain amount of dispersal even when surface water connections are broken (Crownover *et al.* 1995). Yet, in the Flint Pen region, re-wetting occurs rather abruptly, following a topographic gradient from north to south, and is generally from flatwoods into the cypress swamps. The general direction of flow suggests that the intermittently exposed domes are not likely a significant source of groundwater-born dispersion into the flatwoods. This does not preclude dispersal from the more riverine cypress systems to the north (Doug Shaw, South Florida Water Management District, personal communication). However, few species in the cypress heads and hydric pine wetlands can be considered lotic forms. In addition, differences among taxonomic compositions of the pine flatwood wetlands suggest that there must be other sources of colonists in addition to or in place of the adjacent cypress heads. This may be due to aerial colonists from sources farther away or the emergence of cryptobiotic or aestival forms. These phenomena remain to be tested. Changes in the physical and chemical conditions (decreasing dissolved oxygen concentrations and depth along with concurrent increases in conductivity and salinity) must also contribute to the ability of some species to persist in these wetland areas.

CLASSIFICATION OF FLATWOOD WETLANDS

The non-chironomid macroinvertebrate, chironomid, and crustacean fauna of the temporary wetlands associated with hydric pine flatwoods in the Flint Pen Strand represent unique associations dissimilar to adjacent semi-permanently flooded or intermittently exposed bodies of water. Cluster analysis of non-chironomid macroinvertebrate, chironomid, and crustacean assemblages (Figures 15 and 22) supports this conclusion. Cluster analysis of crustacean assemblages did not provide any pattern of classification and established little guidance for monitoring and conservation efforts.

The macroinvertebrate and chironomid assemblages of the Flint Pen Strand hydric flatwood wetlands mirror the four zones of hydrological conditions in a natural cypress wetland utilized by Mortellaro *et al.* (1995). Four unique clusters can be observed for both the macroinvertebrates and chironomids (Figures 15 and 22). In both cases, the ephemeral/upland classified communities clearly clustered significantly different from increasingly permanent wetlands. The macroinvertebrates in wetland communities, which demonstrate a significant dissimilarity from ephemeral/upland communities, represent a more conservative classification for conservation purposes. The cluster analysis and subsequent classification of sites based upon chironomids suggests a working model for conservation and monitoring of these flatwood wetlands. In the case of the chironomids, three significantly different clusters are obvious: semi-permanently flooded; seasonally and temporarily flooded; and ephemeral/upland communities. The seasonally and temporarily flooded communities, although not significantly different from each other, do demonstrate a clustering pattern. Based on the chironomids alone, those wetland sites classified as semi-permanently flooded and seasonally flooded demonstrate taxonomic assemblages of more permanent wetland conditions. Wetlands classified as temporarily flooded and ephemeral/upland, increasingly exhibit taxa adapted to ephemeral and temporary conditions distinctly different from more permanent sites. An exception to this classification, based on observations in the field, may be FP6-4. FP6-4, which was located in close proximity to FP6-5, probably floods with only slight rises in surface water elevation at FP6-5. For this purpose, I suggest that FP6-4, regardless of clustering pattern, be monitored and considered as seasonally flooded.

From cluster analysis and hydrological zone classification, a species list of abundant and common species expected in the represented zones was created (Table 20). A typical macroinvertebrate and chironomid assemblage of semi-permanent and seasonally flooded habitats includes the larger predatory Odonata (dragonflies and damselflies) and the most frequently encountered *Ablabesmyia rhamphe* grp. of the chironomids. *Zavreliella marmorata* appears to be a good indicator species of wetland permanence in the Flint Pen Strand. It was found to be most abundant in sites classified as semi-permanent and

Table 20: Species list of abundant and common species expected in the representative hydrological zones.

	Semi Permanent	Seasonal	Temporarily Flooded	Ephemeral
Non-Chironomid Macroinvertebrates				
Abundant	Collembola sp. *Callibaetis* sp. *Caenis* sp. Planorbidae sp.	Collembola sp. *Caenis* sp. *Bezzia* sp. *Forcipomyia* sp.	Collembola sp. *Bezzia* sp. *Dasyhelea* sp.	
Common	*Baetidae* sp. *Pachydiplax* sp. *Coenagrionidae* sp. *Bezzia* sp.	Coleoptera sp. (pupae) *Celina* sp. (larvae) *Hydraena marginicollis* (adult) *Anacaena suturalis* (larvae) *Telmatoscopus* sp. (larvae) Planorbidae sp.	*Caenis* sp. *Anacaena suturalis* (larvae) *Berosus* sp. (larvae) *Limnophila* sp. (larvae) Physidae sp. Planorbidae sp. Ancilidae sp.	Collembola sp. *Bezzia* sp. *Dasyhelea* sp. *Limnophila* sp.
Chironomidae				
Abundant	*Ablabesmyia rhamphe* grp. *Chironomus ocreatus* *Zavreliella marmorata*	*Ablabesmyia rhamphe* grp. *Beardius* sp. *Polypedilum trigonus* *Tanytarsus sp. G*		
Common	*Monopelopia boliekae* *Corynoneura* sp. *Kiefferulus* sp. *Polypedilum trigonus*	*Krenopelopia* sp. *Chironomus ocreatus* *Polypedilum convictum grp.* *Pseudochironomus* sp. *Tanytarsus sp. K* *Zavreliella marmorata*	*Ablabesmyia rhamphe* grp. *Krenopelopia* sp. *Monopelopia tillandsia* *Chironomus ocreatus* *Polypedilum trigonus* *Tanytarsus sp. B* *Tanytarsus sp. G.*	*Beardius* sp. *Polypedilum trigonus*
Rare				*Tanytarsus sp. G.*

common in seasonally flooded sites. This species was found rarely or not at all in temporarily flooded and ephemeral/upland sites.

MONITORING RECOMMENDATIONS

Monitoring of hydric pine flatwood wetlands should be continued, especially during the initial wet phase and during the drydown period. Although a number of different types of artificial substrates were employed, changes in community composition and physical and chemical conditions of these ephemeral wetlands did not provide a sufficiently stable environment to allow adequate colonization of the artificial substrates. A fixed factor three-way analysis of variance of methods for chironomid samples revealed a significant difference ($p < 0.001$, $F = 11.8882$, 3 d.f.) among the number of individuals collected by the four methods utilized. Among the methods, D-ring dip net samples produced the greatest number of individuals and taxa of (Table 18). A fixed factor three-way analysis of variance of methods for non-chironomid macroinvertebrate samples revealed a significant difference ($p < 0.01$, $F = 4.29544$, 3 d.f.) among the four methods utilized. Again, D-ring dip net samples produced the greatest number of individuals and taxa (Table 17). For crustaceans, three-way analysis of variance produced no significant differences among densities due to the four methods. Despite this, the funnel traps proved effective in collecting a comparable number of individuals to the second most effective D-ring dip net samples (Table 19). Therefore, the use of a standard D-ring dip net, utilized over a variety of habitat types (exposed substrate, various types of macrophytes, leaf litter, etc.), is suggested to provide a composite sample necessary to determine the health of these ecosystems with minimal effort.

Traditionally, the diversity of the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), the “EPT fauna”, has been used to indicate the health of aquatic ecosystems, especially in running water (Plafkin *et al.* 1989). This is based on the assumption that the majority of these species are sensitive to pollution (Lenat 1988). Indeed, the ratio of EPT abundance to chironomid abundance has been viewed as an index of ecosystem stress (Resh and Jackson 1993). However, the use of EPT fauna in wetlands seems to be inappropriate since Plecoptera are rare in lentic ecosystems and Ephemeroptera and Trichoptera can be poorly represented when compared to streams. This seems to be the case for isolated wetlands in South Florida (Stansly *et al.* 1997). I suggest that the presence of long-generation species (i.e., larval or nymphal forms which take longer than six months to complete life cycles) and functional groups, such as predators which exist only in relatively predictable or stable environments, would be an observable indication of the absence of a seasonal or unexpected drawdown.

In the ephemeral/upland wetlands of the hydric pine flatwoods, short-lived species (those which can complete life cycles in less than three months) should be expected. Among the short-lived species, those most adapted to living under continual changes in physical and chemical conditions would be most likely to persist even when conditions of complete desiccation are imminent. The presence of those species at sites that are classified as semi-permanent or intermittently exposed wetlands should not be considered indicative of maintained ecosystem integrity. Indeed, as the density and diversity of those species increase, the more likely it is that some form of drawdown disturbance is occurring. A shift from long-generation species (EPT's) and predators (Odonates) to semi-aquatic forms (like Collembola) is probably the endpoint of a transition to a community impacted by drawdown. I suggest that a macroinvertebrate order (Odonata) which is known to have high diversity in wetland ecosystems, but which contains species with a wide variety of tolerances to likely physical and chemical changes such as those that occur during drawdown, can be used as a more effective indicator of sustained ecosystem integrity.

The greatest problem in any macroinvertebrate survey is the time spent in sorting and identifying the numerous individuals collected. Since chironomids have been shown to be indicators of change in water quality, and since this study indicates that they are representative of the various changes in distance from source, area, and volume effects, emphasis on the chironomid fauna may prove beneficial. Indeed, Nolte (1989) found that chironomid diversity and density increased with habitat complexity and water body longevity. Ebert and Balko (1987) suggested that increases in both macroinvertebrate and microcrustacean species is also highly correlated with the development of a more diverse macrophyte community.

Larvae of the family Chironomidae are an ecologically important component of the wetland macroinvertebrate community, often occurring in high densities and diversity. Chironomid larvae are known to exhibit a variety of feeding habits, ranging from predation to consumption of particulate organic matter to living algae and macrophytes to specializing on fungal and bacterial spores. It is not uncommon to collect between 50 and 100 species from most aquatic environments. Their short life cycles, variety of functional and trophic positions, and frequently, large total biomass give the chironomids an important energetic role in the proper functioning of aquatic ecosystems, both lotic and lentic (Coffman and Ferrington 1996). Most fish, waterfowl, and larger macroinvertebrate predators feed on chironomids at some point in their life cycle. Productivity in temperate aquatic ecosystems has been reported to range from as little as 50 kg ha^{-1} yr^{-1} (Titmus and Braddock 1980) to over 400 kg ha^{-1} yr^{-1} (Maitland and Hudspith 1974). The differences in production rates are apparently related to number of degree-days and the rate of accumulation of organic detritus (Simpson *et al*. 1983). Since chironomids occur in most types of aquatic habitats and exist over broad ranges of most chemical and physical conditions, they are frequently used to assess changes in the overall condition of aquatic ecosystems. Duration of the larval stage can vary from between two weeks to over two years, which makes chironomid larvae ideal monitors of change in chemical and physical condition of most aquatic environments. In lentic ecosystems, chironomids were among the first species used to assess the trophic status of lake ecosystems (Thienemann 1922, Wiederholm 1976, and Saether 1979). In general, those members of the subfamily Chironominae dominate the most eutrophic systems while Orthocladinae tend to be more typical of oligotrophic systems. The genera *Chironomus*, *Clinotanypus*, and *Procladius* are apparently good monitors of heavy metal contamination in lakes impacted by waste from mines and smelters (Summers and Gore 1982, Hare *et al*. 1991). Therefore, chironomid taxa could be used as indicators of ecosystem health and drawdown impact.

Despite traditional attitudes towards their taxonomy, chironomid larvae are relatively easy to identify and to separate from samples. A high diversity of chironomid species probably indicates adequate wetland conditions, but this judgement must also consider the dominant taxa in the assemblage. For example, the presence of species such as *Ablabesmyia rhamphe* grp., *Krenopelopia* sp., and *Tanytarsus sp. G* may not be an indication of adequate wetland conditions, since I found these species to inhabit the most desiccated wetland sites.

The results obtained in this study should provide guidance to wetlands managers as to what are appropriate indicators of sites not impacted by drawdown conditions. Those species that occurred commonly and only at sites FP6-5, FP6-4, FP7-1, FP7-2, FP9-1, and FP9-2 could be expected to be indicators of adequate wetland conditions. Conversely, those species that commonly occurred at the more distant sites could be considered "noise" in this analysis since these taxa were able to survive during the drydown period. In the larger wetland areas, the loss of longer-lived species, like the dragonflies and mayflies, will also indicate drydown effects. An increase in semi-aquatic forms, like the Collembola and Ceratopogonidae, will indicate a tendency to drier conditions.

REFERENCES

Abrahamson, W.G., and D.C. Hartnett. 1990. Pine flatwoods and dry prairies. pp. 103-149. *in*: R.L. Myers and J.J. Ewel (eds.) *Ecosystems of Florida*, University of Central Florida Press, Orlando.

Adams, A. 1984. Cryptobiosis in Chironomidae – two decades on. *Antenna* 8: 58-61.

Alekseev, V.R., and Y.I. Starobogatov. 1996. Types of diapause in Crustacea: definitions, distribution, evolution. *Hydrobiologia* 320: 15-26.

Batzer, D.P. and S.A. Wissinger. 1996. Ecology of insect communities in nontidal wetlands. *Annual Review of Entomology* 41: 75-100.

Bazzanti, M., M. Seminara, and S. Baldoni. 1997. Chironomids (Diptera: Chironomidae) from three temporary ponds of different wet phase duration in Central Italy. *Journal of Freshwater Ecology* 12: 89-99.

Bray, J.R. and J.T. Curtis. 1957. An ordination of the upland forest communities of southern Wisconsin. *Ecological Monographs* 27(4): 325-349.

Brendonck, L. 1996. Diapause, quiescence, hatching requirements: what we can learn from large freshwater branchiopods (Crustacea: Branchiopoda: Anastraca, Notostraca, Conchostraca). *in:* V.A. Alekseev and G. Fryer (eds.) *Diapause in the Crustacea*. Kluwer Academic Publishers, Belgium.

Cantrell, M.A., and A.J. McLachlan. 1982. Habitat duration and dipteran larve in tropical rain pools. *Oikos* 38: 343-348.

Coffman, W.P., and L.C. Ferrington, Jr. 1996. Chironomidae. pp. 551-652 *in*: R.W. Merritt and K.W. Cummins (eds.) *An Introduction to the Aquatic Insects of North America*. Third Edition. Kendal/Hunt Publishers, Dubuque, IA.

Crownover, S.H., N.B. Comerford, D.G. Neary, and J. Montgomery. 1995. Horizontal groundwater flow patterns through a cypress swamp-pine flatwoods landscape. *Soil Science Society of America Journal* 59: 1199-1206.

Diamond, J.M. 1975. Assembly of species communities. pp. 342-344 *in*: M.L. Cody and J.M. Diamond (eds.) *Ecology and Evolution of Communities*, Harvard Univ. Press, Boston.

Driver, E.A. 1977. Chironomid communities in small prairie ponds: some characteristics and controls. *Freshwater Biology* 7: 121-133.

REFERENCES (CONTINUED)

Ebert, T.A., and M.L. Balko. 1987. Temporary pools as islands in space and time: the biota of vernal pools in San Diego, Southern California, USA. *Arch. Hydrobiol.* 110: 101-123.

Eckblad, J. 1989. ECOLOGICAL ANALYSIS. Vol.3-PC.

Epler, J.H. 1992. Identification manual for the larval chironomidae (Diptera) of Florida. Florida Department of Environmental Regulation, Final Report, DER SP251.

Fryer, G. 1985. Crustacean diversity in relation to the size of water bodies: some facts and problems. *Freshwater Biology* 15: 347-361.

Fryer, G. 1996. Diapause, a potent force in the evolution of freshwater crustaceans. *Hydrobiologia* 320: 1-14.

Gauch, H.G., Jr. 1982. *Multivariate Analysis in Community Ecology. Cambridge Studies in Ecolgy*. Cambridge University Press, NY.

Gore, J.A., D.S. Addison, S.C. Nichols, D.W. Ceilley, and P.A. Stansly. 1997. The distribution of larval midge (Diptera: Chironomidae) assemblages in isolated wetlands of South Florida. Final Report/Technical Rpt. South Florida Water Management District, West Palm Beach, FL.

Grodhaus, G. 1980. Aestivating chironomid larvae associated with vernal pools. pp.315-322 *in*: D.A. Murray (ed.) *Chironomidae. Ecology, Systematics, Cytology and Physiology.* Pergamon Press, Oxford.

Hare, L., A. Tessier, and P.G.C. Cambell. 1991. Trace element distributions in aquatic insects: variations among genera, elements, and lakes. *Canadian Journal of Fisheries and Aquatic Sciences* 48: 1481-1491.

Hester, F.E., and J.S. Dendy. 1962. Multiple-plate sampler for aquatic macroinvertebrates. *Trans. Amer. Fish. Soc.* 91: 420-421.

Hinton, H.E. 1960. Cryptobiosis in the larva of *Polypedilum vanderplanki* Hint. (Chironomidae). *Journal of Insect Physiology* 5: 286-300.

Korovchinsky, N.M. and O.S. Boikova. 1996. The resting eggs of the Ctenopoda (Crustacea: Branchiopoda): a review. *Hydrobiologia* 320: 131-140.

REFERENCES (CONTINUED)

Krebs, C.J. 1989. *Ecological Methodology.* HarperCollins Publishers, NY.

Lenat, D.R. 1988. Water quality assessments of streams using a qualitative collection method for benthic macroinvertebrates. *Journal of the North American Benthological Society* 7: 222-233.

MacArthur, R.H. and E.O. Wilson. 1967. *The Theory of Island Biogeography.* Princeton University Press, NJ.

Maitland, P.S., and P.M.C. Hudspith. 1974. The zoobenthos of Loch Laven, Kinross, and estimates of its production in the sandy littoral area in 1970 and 1971. *Proceedings of the Royal Society of Edinburg* 74: 219-239.

March, F., and D. Bass. 1995. Application of island biogeography theory to temporary pools. *Journal of Freshwater Ecology* 10: 83-85.

Mellors, W.K. 1975. Selective predation of ephippial *Daphnia* and the resistance of ephippial eggs to digestion. *Ecology* 56: 974-980.

Merritt, R.W., K.W. Cummins, and V.H. Resh. 1995. Collecting, sampling, and rearing methods for aquatic insects. pp. 11-25 *in*: R.W. Merritt and K.W. Cummins (eds.) *An Introduction to the Aquatic Insects of North America.* Third Edition. Kendal/Hunt Publishers, Dubuque, IA.

Michaud, P.R. (1995). "*Statement of NGVD vs. MSL*". http://dco.cbi.tamucc.edu/guides/ngvd.html (16 Oct. 1997).

Mitsch, W.J., and J.G. Gosselink. 1993. *Wetlands.* Second Edition. Van Nostrand Reinhold Publishers, New York.

Moore, W.G. 1967. Factors affecting egg hatching in *Streptocephalus scali* (Branchiopoda: Anastraca). *in*: Proc. Symp. Crustacea, Part 2: 724-735.

Mortellaro, S., S. Krupa, L. Fink, and J. VanArman. 1995. Literature review on the effects of groundwater drawdowns on isolated wetlands. (WRE #330) Tech. Publ. 96-01. South Florida Water Management District, West Palm Beach, FL.

Morton, D.W. and I.A.E. Bayly. 1977. Studies on the ecology of some temporary freshwater pools in Victoria with special reference to microcrustaceans. *Australian Journal of Marine and Freshwater Resources* 28: 439-454.

REFERENCES (CONTINUED)

Nolte, U. 1989. Observations on neotropical rainpools (Bolivia) with emphasis on Chironomidae (Diptera). *Studies on Neotropical Fauna and Environment* 24: 105-120.

Norusis, M.J., and SPSS Inc. 1990. SPSS/PC+. Chicago: SPSS Inc.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. *Rapid Bioassessment Protocols for use in Streams and Rivers. Benthic Macroinvertebrates and Fish.* EPA/444/4-89/001. Office of Water Regulations and Standards, U.S. Environmental Protection Agency, Washington, D.C.

Resh, V.R., and J.K. Jackson. 1993. Rapid assessment approaches to biomonitoring using benthic macroinvertebrates. pp. 195-223 *in*: D.M. Rosenberg and V.H. Resh (eds.) *Freshwater Biomonitoring and Benthic Macroinvertebrates.* Chapman and Hall Publishers, NY.

Saether, O.A. 1979. Chironomid communities as water quality indicators. *Holarctic Ecology* 2: 65-74.

Schwartz, S.S. and P.D.N. Hebert. 1987. Methods for the activation of the resting eggs of *Daphnia*. *Freshwater Biology* 17: 373-379.

Simberloff, D.S. 1976. Experimental zoogeography of islands: effects of island size. *Ecology* 57: 629-648.

Simberloff, D.S. 1978. Using island biogeographic distributions to determine if colonization is stochastic. *American Naturalist* 112: 713-726.

Simberloff, D.S. and E.O. Wilson. 1969. Experimental zoogeography of islands: Colonization of empty islands. *Ecology* 50: 278-296.

Simpson, R.L., R.E. Good, M.A. Leck, and D.F. Whigham. 1983. The ecology of freshwater tidal wetlands. *BioScience* 33: 255-259.

Stansly, P.A., J.A. Gore, D.W. Ceilley, and M.B. Main. 1997. Inventory of freshwater macroinvertebrates for the South Florida Water Management District isolated wetland monitoring program. Tech. Rpt., South Florida Water Management District, Boca Raton, FL.

Summers, P.B., Jr. and J.A. Gore. 1982. Chironomid communities as indicators of water quality affected by acid mine drainage. *Proceedings of the Annual Conference of the South Eastern Association of fish and Wildlife Agencies* 35: 474-486.

REFERENCES (CONTINUED)

Thienemann, A. 1922. Die beiden Chironomusarten der tiefenfauna der nord-deutschen Seen. Ein hydrobiologishes Problem. *Archiv für Hydrobiologie* 13: 609-646.

Titmus, G., and R.M. Braddock. 1980. Production and emergence of chironomids in a wet gravel pit. pp. 299-305 *in*: D.A. Murray (ed.) *Chironomidae. Ecology, Systematics, Cytology, and Physiology.* Pergamon Press, Oxford.

Weiderholm, T. 1976. Chironomids as indicators of water quality in Swedish lakes. *Naturvårdsverkets Limnologiska Undersöknigar* 10: 1-17.

Wiggins, G.B., R.J. Mackay, and I.M. Smith. 1980. Evolutionary and ecological strategies of animals in annual temporary pools. *Archiv für Hydrobiologie Suppl.* 58: 97-206.

Williams, D.D. 1987. *The Ecology of Temporary Waters.* Timber Press, Portland, OR.

TAXONOMIC REFERENCES

Brigham, A.R., W.U. Brigham, and A. Gnilka. (Eds.) 1982. *Aquatic insects and oligocheates of North and South Carolina.* Midwest Aquatic Enterprises, Mahomet, Illinois.

Burch, J.B. 1982. Freshwater snails (Mollusca: Gastropoda) of North America. U.S. Environmental Protection Agency, EPA-600/3-82-026.

Daigle, J.J. 1991. Florida damselflies (Zygoptera): A species key to the aquatic larval stages. Florida Department of Environmental Regulation, Technical Series 11(1).

Daigle, J.J. 1992. Florida dragonflies (Anisoptera): A species key to the aquatic larval stages. Florida Department of Environmental Regulation, Technical Series 12(1).

DeLorme, L.D. 1991. Ostracods. pp. 691-722 *in*: J.H. Thorp and A.P. Covich (eds.) *Ecology and Classification of North American Freshwater Invertebrates.* Academic Press, NY.

Dodson, S.I., and D.G. Frey. 1991. Cladocera and other Branchiopoda. pp. 723-786 *in*: J.H. Thorp and A.P. Covich (eds.) *Ecology and Classification of North American Freshwater Invertebrates.* Academic Press, NY.

Edmunds, G.F., Jr., S.L. Jensen, and L. Berner. 1976. *The mayflies of North and Central America.* University of Minnesota Press, Minneapolis.

Epler, J.H. 1992. Identification manual for the larval chironomidae (Diptera) of Florida. Florida Department of Environmental Regulation, Final Report, DER SP251.

Epler, J.H. 1996. Identification manual for the water beetles of Florida. Florida Department of Environmental Protection, Final Report, DEP WM621.

Hobbs, H.H., Jr. 1942. The crayfishes of Florida. University of Florida Publication, Biological Science Series, Vol. 3(2).

Hobbs, H.H., Jr. 1976. Crayfishes (Asticidae) of North and Middle America. U.S. Environmental Protection Agency, Water Pollution Control Series 18050.

Hobbs, H.H., Jr. 1981. The crayfishes of Georgia. *Smithsonian Contributions to Zoology* No. 318.

Klemm, D.J. 1982. Leeches (Annelida: Hirudinea) of North America. U.S. Environmental Protection Agency, EPA-600/3-82-025.

TAXONOMIC REFERENCES (CONTINUED)

Merritt, R.W., and K.W. Cummins. 1984. *An Introduction to the Aquatic Insects of North America.* Second Edition. Kendall/Hunt Publishers, Dubaque, IA.

Merritt, R.W., and K.W. Cummins. 1996. *An Introduction to the Aquatic Insects of North America.* Third Edition. Kendall/Hunt Publishers, Dubaque, IA.

Pluchino, E.S. 1984. Guide to the common water mite genera of Florida. Florida Department of Environmental Regulation, Technical Series 7(1).

Pennak, R.W. 1978. *Fresh-water invertebrates of the United States*. John Wiley and Sons, Inc., NY.

Rosenzweig, M.L. 1995. *Species diversity in space and time.* Cambridge University Press, NY.

Wiggins, G.B. 1977. *Larvae of the North American caddisfly genera (Trichoptera)*. University of Toronto Press, Toronto.

Williamson, C.E. 1991. Copepoda. pp. 787-822. *in:* J.H. Thorp and A.P. Covich (eds.) *Ecology and Classification of North American Freshwater Invertebrates.* Academic Press, NY.