Appendix 4B-8: Investigation of Long-Term Stability and Phosphorus Accretion by an Aquatic System with a Long History of Submerged Aquatic Vegetation Dominance

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Investigation of long-term stability and phosphorus accretion by an aquatic system with a long history of submerged aquatic vegetation dominance

Final Report for:

South Florida Water Management District

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EXECUTIVE SUMMARY

Lake Panasoffkee, Sumter County, Florida, is a shallow, hard-water lake with extensive communities of emergent and submersed aquatic vegetation (SAV). It is, therefore, well suited to study the history of a SAV-dominated community and its potential role in phosphorus sequestration in sediments. The objectives of this study were to use paleolimnological techniques to reconstruct the history of SAV abundance in Lake Panasoffkee, to identify the dominant sources of organic matter to the sediment, and to evaluate how sediment phosphorus accumulation has changed historically relative to SAV abundance. These results are potentially relevant for evaluating the effectiveness of using a system of submersed aquatic vegetation and limerock (SAV/LR) to reduce concentrations of total phosphorous (TP) in runoff from the Everglades Agriculture Area (EAA).

Our findings indicate that Lake Panasoffkee has not always been dominated by SAV. Prior to the late 1800s, SAV abundance and primary productivity were relatively low in Lake Panasoffkee and sedimented organic carbon was derived mostly from emergent vegetation, probably from the extensive wetlands that still exist today along its eastern shore. Primary productivity and SAV abundance increased in the late 1800s in response to increased P loading from early settlement and forest clearance for logging and turpentine extraction activities.

Previous studies have shown that low nutrient loading in shallow-water Florida lakes favors a primary producer community dominated by SAV and associated microflora. We conclude that increased nutrient loading beginning in the late 1800s promoted SAV growth in Lake Panasoffkee. Under such conditions, increased SAV

production and associated microflora (i.e., periphytic algae) became a sink for soluble P, thereby helping to maintain clear water and low nutrient concentrations.

Living SAV biomass may only serve as a temporary sink for P if large amounts of nutrients are released to the water column upon death of macrophytes. In addition, the capacity of the macrophyte community to assimilate nutrients is limited, and will eventually reach saturation. It is therefore important to determine if P uptake by macrophyte communities increases P accumulation in sediments, which serves as a more permanent P sink. Sediment P concentrations in Lake Panasoffkee increase in conjunction with other proxies for increased productivity and SAV biomass, suggesting that increased productivity of macrophytes and/or their associated microflora increases P retention in sediments. Epiphytic algae may be important for P sequestration because of their high photosynthetic activity, which draws down CO_2 and promotes the precipitation of calcium carbonate. Calcite precipitation is an effective means for sedimenting periphyton and P through adsorption and incorporation into nucleating calcite crystals.

Increased productivity of macrophytes and/or their associated microflora in response to increased P loading beginning in the late 19th century appears to have led to increased accumulation of organic carbon and P in Lake Panasoffkee sediments. The long-term stability of P sequestration is difficult to assess, however, because SAV dominance was largely limited to the last century and most of the increase in P accumulation occurs in the upper 10 cm. These recently deposited sediments are still subject to biogeochemical diagenesis and P can be released back to the water column.

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PROJECT BACKGROUND

One of the more promising water treatment technologies to reduce P in runoff to the Florida Everglades is the use of submersed aquatic vegetation and limerock (SAV/LR) (Gu et al., 2001). Phosphorus concentrations are reduced by plant uptake and by adsorption/coprecipitation with calcium carbonate. Results with experimental mesocosms and constructed wetlands (ENR Cell 4) suggest that SAV wetlands reduce TP levels effectively (Gu et al., 2001; Nungesser and Chimney, 2001), but these short-duration experiments have not assessed long-term stability and P accumulation in SAV treatment systems. Preliminary results show that a large portion of the P removed from the inflow is stored within the SAV biomass. It is not known what portion of the SAV-bound P is permanently sequestered in sediment. One approach for collecting long-term data on stability and phosphorus sequestration is to study a natural, hard-water aquatic system with a long history of SAV dominance.

Lake Panasoffkee, Sumter County, Florida (Fig. 1), was selected for study because it has high alkalinity and was thought to have a long history of SAV dominance. A nutrient budget analysis of Lake Panasoffkee indicated that in-lake processes were responsible for retention of about 41% of the nitrogen and 72% of the phosphorus input loads to the lake (CH2MHill, 1995). Hence, it was chosen to study long-term phosphorus sequestration and retention in sediments and potentially evaluate SAV/LR system performance.

RESEARCH OBJECTIVES

The objective of this study was to collect data on the long-term history of SAV abundance, sources of sedimented organic matter, and P accumulation in sediment cores from Lake Panasoffkee. Primary questions that were addressed included: 1) How long has Lake Panasoffkee been dominated by SAV? 2) What are the sources of sedimented organic carbon and nitrogen? 3) What are the rates of P accumulation in this system and how do they relate to changing SAV abundance? Answers to these questions were sought using paleolimnological techniques, including ^{210}Pb dating, elemental and stable isotopic analysis, and macrofossil and pollen analysis.

SITE SELECTION AND DESCRIPTION

Lake Panasoffkee, Sumter County, Florida is a large (18.05 km^2), shallow (mean depth = 1.3 m) waterbody that lies at 28°48'22" N Lat x 82°07'26" W Long (Fig. 1). The lake can be characterized as meso-eutrophic based on the mean total P (27 $\mu g\ L^{-1}$) and total N (774 $\mu g\ L^{-1}$) values recorded for 66 sampling dates (Florida Lakewatch, 1996). Secchi disk depth averages ~1.25 m and mean chlorophyll *a* concentrations are generally low (mean = 11 $\mu g\ L^{-1}$). A large percentage (94%) of the lake bottom is covered by SAV, including *Ceratophyllum*, *Hydrilla*, *Chara*, *Vallisneria*, *Najas*, and other genera (Florida Lakewatch, 1996). Emergent vegetation is also abundant surrounding the lake, and the entire east shore consists of an extensive wetland (Fig. 2). In contrast, the west shore of the lake is characterized by residential and commercial development. The lake is fed by groundwater and surface water contributions from Shady Brook (also called Panasoffkee Creek), Little Jones Creek, and Big Jones Creek. The only surface outflow from the lake is Outlet River (Fig. 1), which connects Lake

Panasoffkee to the Withlacoochee River. The lake water has high alkalinity (94.8 mg L^{-1} as $CaCO_3$) and calcium carbonate precipitates from solution. Surface and subsurface sediments are dominated by marl that is rich in calcitic ostracod carapaces and aragonitic gastropod shells.

Sediment cores were collected from two sites in Lake Panasoffkee from the north (LP1) and south (LP2) parts of the lake (Fig. 1). The sites differed with respect to long-term average sedimentation rate. The rationale for coring two distinct sites with different sedimentation rates was that it allowed for intra-basin comparison of site-specific nutrient accumulation rates and comparison of trends over the past century. Station LP1 was located northeast of Outlet River. Station LP2 was located southeast of Tracy's Point Fish Camp (TPFC in Fig. 1). Cores were collected from places that were not completely colonized with macrophytes to prevent smearing of material along the core barrel during the coring process.

Sampling of emergent vegetation was limited to the area around Tracy's Point Fish Camp (TPFC; Fig. 1). Samples of aquatic macrophytes, plankton, and water were collected at multiple stations to assess spatial variability of primary productivity and macrophyte species abundances.

SAMPLING AND ANALYTICAL METHODS

Field Sampling

Lake Panasoffkee was sampled on 30 May and 21 December 2001, to obtain sediment cores, surface sediments, water samples, as well as live snails, ostracods, and plant (algal and macrophyte) samples. The University of Florida sampling team

consisted of Mark Brenner, Jason Curtis, David Hodell, and William Kenney. Binhe Gu accompanied the team on 30 May and represented the South Florida Water Management District.

Two sampling sites were chosen for sediment coring during the May visit (see Appendix I). The first site, designated LP-2 was located at 28°47'09.4" N, 82°06'50.2" W (Fig. 1). Locations were determined with a Garmin emap® GPS. Macrophytes that dominated at site LP-2 included *Najas* and *Vallisneria*. A 140-cm long sediment/water interface core was collected at the site using a piston corer with a clear polycarbonate core barrel (Fisher et al., 1992). The core was sectioned on the boat at 2-cm intervals to a depth of 40 cm, and at 4-cm intervals thereafter to a depth of 140 cm. A second coring site (LP-1; Fig. 1) was located at 28°48'46.9" N, 82°07'57.3" W, and the retrieved section was 136 cm long. *Potamogeton* was the dominant macrophyte at the site. The core was sampled at 4-cm intervals to a depth of 136 cm. Sampling intervals for the two cores were chosen based on previous experience dating cores from Florida lakes as well as our previous results from Lake Panasoffkee. Both cores were removed from the core barrel in a vertical position by upward extrusion into a PVC tray mounted on top of the polycarbonate coring tube. Each stratigraphic sample was transferred to a labelled plastic cup that was covered and placed on ice in a cooler for transport to the laboratory.

In May 2001, aquatic macrophytes were collected near the two coring sites (LP-2 and LP-1) as well as at a third site (LP-3: 28°47'35.6" N, 82°07'01.2" W). Additional macrophyte samples were collected near the shore. Some littoral and ditchbank species were collected at Tracy's Point Fish Camp. Samples were placed in Zip-lock® or Whirl-Pak® bags and labelled with a sampling locality and a tentative identification. Common

submersed taxa that were sampled included *Najas*, *Vallisneria*, *Potamogeton*, *Hydrilla*, *Nymphaea* and *Ceratophyllum*. Sampled nearshore and onshore taxa that may contribute organic matter to sediments included *Typha*, *Pontederia*, *Salix*, and *Scirpus*. We also collected filamentous algae as well as periphyton growing on *Vallisneria* leaves. Thirty plant samples were collected for stable isotope and elemental analysis (see Appendix I).

Water samples were also collected in May at sites LP-1, LP-2, and LP-3. Samples for $\delta^{18}O$ analysis were collected in Qorpak® bottles, while samples for $\delta^{13}C$-DIC were placed in dark (taped BOD) bottles to which mercuric chloride ($HgCl_2$) was added to stop biological activity. Collection times for the $\delta^{13}C$-DIC samples were noted: LP-2 (1100 hr), LP-1 (1317 hr), and LP-3 (1420 hr).

Plankton samples were collected by filtering surface water samples through precombusted quartz fiber filters. Four samples were collected from site LP-1 and LP-3, respectively. All water, plant, filter, and sediment samples were transported to the laboratory in an ice chest and were either refrigerated at 4°C or frozen on arrival.

On 21 December 2001, we collected samples from nine additional sites in the lake. A third core was collected from 28° 46.876' N, 82° 06.689' W, near the site where a long core was obtained in January 1998. We used this opportunity to collect numerous living snails and ostracods and to re-sample the common macrophytes in the system. We also took surface sediment samples to compare isotopic signatures of organic matter in near-surface muds with the plants growing above them. Water column samples were filtered for isotopic and total C and total N analysis.

Radionuclide Analysis

For ^{210}Pb dating, tared plastic Sarstedt™ tubes were filled with dry sediment to a height of ~30 mm. Sample mass was determined and tubes were sealed with epoxy glue and allowed to set for three weeks to allow ^{214}Bi and ^{214}Pb to equilibrate with *in situ* ^{226}Ra. Isotopic activities in samples were measured by direct gamma counting, using ORTEC™ Intrinsic Germanium Detectors connected to a 4096 channel, multichannel analyzer. Total ^{210}Pb activity was obtained from the photopeak at 46.5 kilo electron volts (keV). Supported ^{210}Pb activity, expressed as ^{226}Ra activity, was estimated by averaging the activity of ^{214}Pb (295.1 keV), ^{214}Pb (351.9 keV), and ^{214}Bi (609.3 keV). ^{137}Cs activity was determined from the 662 keV photopeak. All radioisotopic activities are expressed as decays per minute per gram dry sediment (dpm g^{-1}).

Elemental Analysis

Dry sediment samples were analyzed for organic matter content, inorganic carbon content, total nitrogen (TN) content, and total phosphorus (TP) content. Organic matter content in the sediments was estimated by weight loss on ignition at 550 °C (Hakanson and Jansson, 1983). In addition, we measured organic carbon and nitrogen content by measuring total C and N on acid-treated sediment samples using an elemental analyzer. Samples were first treated with 1N HCl to remove carbonate and then filtered on 0.5-µm quartz-fiber filters using copious amounts of distilled water to remove chloride. Approximately 1 mg of carbonate-free bulk sediment was loaded into tin capsules and placed in a 50-position sample carousel connected to a Carlo-Erba NA1500 C/N/S elemental analyzer. After flash combustion in a quartz column at 1020 °C in an oxygen-

rich atmosphere, the sample gas was transported in a helium (He) carrier stream and passed through a hot reduction column (650 °C) consisting of elemental copper to remove oxygen and reduce NO_x to N_2. Water was removed by passing the gas through a chemical trap consisting of magnesium perchlorate. Molecular N and CO_2 were separated in time on a chromatographic column and peaks were detected using a thermal conductivity detector (TCD). Sample peak areas were converted to mass of C and N using a standard curve consisting of 4-5 analyses of a standard (atropine) of known elemental composition. Weight percent (Wt%) C and N were obtained by dividing the mass of C and N by the total carbonate-free sample weight. Analytical precision was estimated to be ±0.3% for C and ±0.03% for N on the basis of analyzing the standard atropine.

Inorganic C (i.e., carbonate) in the sediments was measured by coulometric titration (Engleman et al., 1985) with a UIC/Coulometrics Model 5011 coulometer. Analytical precision, estimated by repeated analysis of reagent-grade (100%) $CaCO_3$, was ±1%.

TP was measured using a Technicon Autoanalyzer II with a single-channel colorimeter, following digestion with H_2SO_4 and $K_2S_2O_8$ (Schelske et al., 1986). Total P concentrations in sediments are expressed as amount (mg or µg) per unit dry mass. Using these values and bulk sediment accumulation rates computed from ^{210}Pb models (g cm^{-2} yr^{-1}), P accumulation rates (mg cm^{-2} yr^{-1}) were calculated.

Stable Isotopic Analysis

Sediment and modern biota for organic C isotopic analysis were treated with 1N HCl to remove carbonate and then filtered on 0.5-μm quartz fiber filters using copious amounts of distilled water to remove chloride. Approximately 1 mg of carbonate-free bulk sediment was loaded into tin capsules and placed in a 50-position zero-blank sample carousel attached to a Costech ECS 4010 elemental analyzer. After flash combustion in a quartz column at 1020°C in an oxygen-rich atmosphere, the sample gas was transported in a He carrier stream and passed through a hot reduction column (650 °C) consisting of elemental copper to remove oxygen. Water was removed by passing the gas through a magnesium perchlorate trap. The effluent stream from the elemental analyzer was interfaced with the mass spectrometer via a ThermoFinnigan ConFlo III interface, consisting of an open-split to the mass spectrometer and capillaries to inject reference gas pulses into the He carrier stream. Isotopic ratios were measured using a ThermoFinnigan Delta-Plus XL mass spectrometer in continuous-flow mode. Carbon and N isotopic results were measured relative to an internal laboratory reference standard and calibrated to Pee Dee Belemnite (PDB) and air, respectively, using international standards. Isotopic ratios are expressed in standard delta notation relative to PDB for C and air for N:

$$\delta^{13}C = [(({}^{13}C/{}^{12}C)_{sample} / ({}^{13}C/{}^{12}C)_{PDB})-1] * 1000$$

$$\delta^{15}N = [(({}^{15}N/{}^{14}N)_{sample} / ({}^{15}N/{}^{14}N)_{air})-1] * 1000$$

Analytical precision was estimated by repeated analysis of international standards CH-6 (sucrose) and N-1 and expressed as 1 standard deviation about the mean. Precision was ± 0.2‰ for $\delta^{13}C$ and ± 0.2‰ for $\delta^{15}N$.

Carbon isotopic ratios were measured on sedimented shells of individual species of ostracods and gastropods. Bulk sediment samples were disaggregated in DI-H_2O and washed through a 150-μm sieve. Coarse material (>150 μm) was dried at 60°C. Adult gastropod shells were picked from the >850 μm portion of the dried samples, soaked in 15% H_2O_2, ultrasonically cleaned in deionized water, and rinsed with methanol before drying. Adult ostracods belonging to the species *Candona angulata* were picked from the 500-850 μm fraction and cleaned in a similar manner to the gastropods, but without sonication to avoid breakage of fragile ostracod carapaces. Shell carbonate samples for carbon isotope analysis were reacted in 100% orthophosphoric acid at 70°C using a ThermoFinnigan Kiel III automated preparation system. Isotopic ratios of purified CO_2 gas were measured on-line with a ThermoFinnigan 252 mass spectrometer and compared to an internal gas standard. All carbonate isotopic values are expressed in conventional delta (δ) notation relative to Vienna PeeDee Belemnite (VPDB). Analytical precision was estimated by measuring 8 standards (NBS-19) with each carousel containing 38 samples, and was ± 0.06‰ for $\delta^{18}O$ and ± 0.03‰ for $\delta^{13}C$.

Carbon isotopic ratios were measured on modern gastropods and ostracods. Modern (living) gastropods were selected based on organic rich coatings on shells while modern ostracods were selected by staining near-surface sediment with Rose Bengal, which colors living and recently-dead organic tissue. These modern samples were then soaked in 15% H_2O_2 to remove organic material, the gastropods sonicated, and gastropods and ostracods rinsed in methanol before drying. Carbon isotopes of modern carbonate were measured as described above.

Carbon isotopic ratios were measured on material in the water column that was collected by filtration onto pre-combusted, 0.5-µm quartz-fiber filters. Multiple filters were collected at each site and analyzed independently. Carbonate was removed from the filtered material by acidifying the filter with 1N HCl followed by rinsing with copious amounts of distilled water to remove chloride. Approximately 0.5 mg of filtered material was loaded into tin capsules and measured using a Costech ECS 4010 elemental analyzer coupled with a Finnigan-MAT Delta-Plus mass spectrometer with a ConFlo III interface as described above.

Samples for dissolved inorganic C (DIC) were collected in 250-ml BOD bottles and poisoned with $HgCl_2$ according to the procedure outlined in DOE (1994). Carbon isotopes of DIC were measured by liberating CO_2 by acidification followed by cryogenic distillation using the methods of Gremillion (1994). Carbon isotopes of CO_2 were measured using a VG (Micromass) PRISM stable isotope mass spectrometer.

Sediment Macrophyte Analysis

Twenty subsamples, ten from each of two cores (LP-1-01 and LP-2-01), were taken for macrophyte macrofossil remains. Samples were sieved through three mesh sizes (0.71 mm, 0.56 mm, 0.31 mm) using a gentle stream of water from a wash bottle. When most of the macrofossils consisted of fragile vegetative strands, samples were first placed in a beaker and dispersed in water. Samples were then poured onto the largest sized mesh and most of the stems were lifted off before further washing. Sieves were examined with a dissecting microscope and all macrofossils with recognizable structure were retained. Seeds and discrete structures were counted, while only the relative abundance of the different strand types was noted due to the wide variation in the size of fragments.

Identification of seeds was based on Martin and Barkley (1961) and Godfrey and Wooten (1979, 1981). Identification of vegetative structures was based on a comparison with plants collected from Lake Panasoffkee. The "type" designation is only meant to be descriptive.

Sediment Pollen Analysis

Twenty samples, 10 levels each from LP-1-01 and LP-2-01, were processed for pollen analysis, using measured amounts (1 to 2 cm^3) of sediment. One tablet containing a known quantity (12,542 ± 416 grains) of *Lycopodium* spores was added to each sample to estimate the concentration (grains cm^{-3}) of pollen per sample in addition to quantitative procedures for the estimation of concentration. Pollen was extracted by processing the samples through a series of strong acids and bases (KOH, HCL, HF, and an acetic anhydride/sulfuric acid mixture). The pollen residue was suspended in a measured volume of tertiary butyl alcohol, and measured aliquots of the suspension were mounted on a microscope slide. The entire slide was scanned at 400x magnification to obtain minimum pollen sums of 300 grains per level.

RESULTS

Modern Aquatic and Terrestrial Plants

A total of 84 plant samples were measured for $\delta^{13}C_{org}$ and included terrestrial vegetation surrounding the lake, emergent taxa, floating-leaved macrophytes, submersed non-rooted macrophytes, and submersed rooted macrophytes. The mean and standard deviation of $\delta^{13}C_{org}$ was calculated for each genus of aquatic macrophyte, and emergent

macrophytes and terrestrial species were treated as a single group (Table 1; Appendix II). Results are presented in order of increasing $\delta^{13}C$ values from the most negative (least ^{13}C-enriched) to least negative (most ^{13}C enriched) values.

The lowest $\delta^{13}C$ values, averaging -27‰, were measured for emergent near-shore and on-shore plants such as *Typha*, *Pontederia*, *Salix*, and *Scirpus* (Table 1). Floating-leaved macrophytes generally had higher (i.e., less negative) $\delta^{13}C$ values than terrestrial plants but lower values than submersed macrophytes: *Hydrocotyle* (-27‰), *Nymphaea* (-25‰), and *Pistia* (-25‰). *Ceratophyllum*, a submersed unrooted macrophyte, had a mean $\delta^{13}C$ of -20‰. Filamentous algae (*Cladophora*) had a mean $\delta^{13}C$ value of -19‰. The submersed rooted macrophytes, which dominate the bottom of Lake Panasoffkee, had the highest mean $\delta^{13}C$ values: *Najas* (-16‰), *Vallisneria* (-16‰), *Potamogeton* (-13‰), and *Hydrilla* (-13‰).

Plants with positive $\delta^{15}N$ values in decreasing order included *Pistia* (2.5‰), *Vallisneria* periphyton (1.8‰), shoreline emergents (1.6‰), *Hydrocotyle* (1.2‰), and filamentous algae (1.1‰). All rooted submersed and free-floating macrophytes had negative $\delta^{15}N$ values: *Najas* (-0.8‰), *Ceratophyllum* (-1.2‰) *Potamogeton* (-1.3‰), *Hydrilla* (-1.4‰), and *Najas* (-1.7‰). *Nymphaea mexicana*, a floating leaved, rooted macrophyte, had the lowest $\delta^{15}N$ value (-3.1‰) of all plants measured.

Weight percent (wt%) carbon and nitrogen were measured on dried plant samples and used to calculate C/N weight% ratios (Table 1; Appendix II). Emergent nearshore plants displayed the highest C/N ratios (~22) reflecting a high proportion of structural carbon (e.g., cellulose), and macrophytes had lower values ranging from 10 to 20. Phytoplankton had the lowest C/N ratios, averaging 6.5.

Modern Plankton and Periphyton

Plankton samples were collected on two days from 6 locations by filtering lakewater through precombusted quartz fiber filters. The mean $\delta^{13}C$ for all samples was -22.8‰, but values at individual sites ranged from -26.6‰ to -17.8‰ (Table 1; Appendix III). We measured an average $\delta^{13}C$ of -20.2‰ for periphyton attached to *Vallisneria* leaves.

Nitrogen isotopes of plankton collected on 30 May 2001 showed considerable variability, with one station averaging 0.9‰ and the other 3.1‰ (Appendix III). $\delta^{15}N$ of plankton samples collected on 21 December 2001 showed a narrower range, from 1.9 to 2.6‰. The overall, mean $\delta^{15}N$ value of plankton was 2.2‰, and the C/N ratio was 6.5.

Modern DIC of lake water

The $\delta^{13}C$ of DIC in the lake was spatially and temporally variable (Appendix IV). On 21 December 2001, $\delta^{13}C_{DIC}$ ranged from -3.5 to -1.6‰ with northern stations (LP 6, 7, and 8) near Outlet River averaging –1.8‰ and southern stations (LP 4 and 5) averaging -3.3‰. There were also differences in $\delta^{13}C_{DIC}$ near the same location on different dates. For example, stations 2 and 4 are very close to one another, yet $\delta^{13}C_{DIC}$ was -6.4‰ (station 2) on 5 May 2000 and -3.5‰ (station 4) on 21 December 2001.

Sediment Cores

Radionuclide Analysis

The ^{226}Ra activity was constant throughout core LP-1-01, and total ^{210}Pb decreased rapidly downcore, presumably reaching supported levels by 14cm (Fig. 3A; Appendix V). A broad peak in ^{137}Cs activity was centered at ~10 cm.

In Core LP-2-01, ^{226}Ra activity decreased irregularly from the surface to 26 cm depth, where it abruptly increased and then remained constant to a depth of 40 cm (Fig. 4A; Appendix VI). The total ^{210}Pb activity in core LP-2-01 was clearly non-linear and inflected. Values were low and fairly constant in the upper 8 cm, but then increased to a peak at ~14cm. With the exception of a very low value measured at 26 cm, ^{210}Pb activity decreased linearly between 14 cm and 40 cm. Supported ^{210}Pb values were reached at ~30 cm if the low value at 26 cm is excluded. A broad peak in ^{137}Cs activity occurred between 12 cm and 30 cm.

Sediment Geochemistry

Core LP-1-01 (Northern Basin)

Weight percent loss on ignition (%LOI) was low, averaging 8% from the base of the core to ~25 cm, where %LOI increased abruptly and values averaged ~20% to the top of the core (Fig. 5A; Appendix V). The records of wt% organic carbon and nitrogen were similar to one another with low values from the base of the core to ~24 cm (Fig. 5B & 5C; Appendix VII). Wt% C and N steadily increased between 24 cm and 12 cm reaching peak values between 12 cm and 8 cm, and then decreased slightly in the topmost

sample. The C/N ratio averaged 29.5 from the base of the core to ~24 cm (Fig. 5D). Values declined from 24 cm to 12 cm and averaged ~17 in the top 10 cm.

$\delta^{13}C_{org}$ values were -24.4‰ at the base of core LP-1-01 and slowly declined to -27.2‰ at 65 cm (Fig. 5E). Thereafter, $\delta^{13}C$ values increased to a peak of -24.3‰ between 44 cm and 36 cm and then declined again reaching values of -26.4‰ between 28 cm and 20 cm. $\delta^{13}C_{org}$ values steadily increased from 20 cm to the top of the core with a value of -22.9‰ in the topmost sample.

The pattern of $\delta^{15}N_{org}$ variation was nearly identical to that for carbon isotopes. Nitrogen isotopic values averaged -2‰ from the base of the core to ~60 cm (Fig. 5F). From 60 cm to 52 cm, $\delta^{15}N_{org}$ increased slightly, averaging -1.3‰ between 52 cm and 40 cm. Values decreased again from 40 cm to 28 cm and averaged -2.3‰ between 28 cm and 20 cm. The upper 20 cm of the core display a pronounced increase in $\delta^{15}N_{org}$ values, reaching a maximum of 0.5‰ in the topmost sample.

TP concentrations were variable and averaged ~0.35 mg/g from the base of the core to 70 cm (Fig. 3D; Appendix V). TP values decreased slightly between 70 cm and 40 cm and then increased in two steps at ~36 cm and 16 cm, reaching concentrations of ~0.5 mg/g at the top of the core.

Carbon and oxygen isotopes of shell carbonate were measured on the gastropod genus *Tryonia* and ostracod species *Candona angulata* in Core LP-1-01 (Fig. 6A-D). The highest $\delta^{13}C$ values in both records occurred near the base of the core, and decreased at ~125 cm. Carbon isotopic values were fairly constant thereafter averaging –4‰ for *Tryonia* and –2‰ for ostracods. Oxygen isotopes of both *Tryonia* and *Candona angulata*

showed a similar pattern with mean values relatively unchanged from the base of the core to 40 cm where $\delta^{18}O$ values increased by ~0.5‰.

Core LP-2-01 (Southern Basin)

The sediments in Core LP-2-01 were dominated by calcium carbonate (75-90 wt%) and organic C and N concentrations were determined on a carbonate-free basis by sample acidification (Appendix VIII). The profiles of wt%LOI, wt%C, and wt%N were virtually identical and will be described simultaneously (Fig. 7A-C). Organic C and N content were relatively low between 140 cm and 36 cm, and then increased abruptly between ~36 cm and 30 cm. At the same time, C/N ratios decreased from an average of ~25 below 35 cm to an average of ~17 in the top 30 cm (Fig. 7D).

Between 140 cm and 85 cm, $\delta^{13}C_{org}$ averaged -26.4‰, and then increased to a peak value of -23.2‰ at 68 cm (Fig. 7E). Values decreased again from 65 cm to 52 cm and averaged about –26‰ until 30 cm. From 30 cm to the top of the core, $\delta^{13}C$ values progressively decreased by ~3‰ and orgC in surface sediment had a $\delta^{13}C_{org}$ of -23‰.

Between 140 and 116 cm $\delta^{15}N_{org}$ averaged -2.3‰, and then increased slightly to a mean of -1.9‰ from 112 cm to 68 cm (Fig. 7F). Nitrogen isotopic values decreased steadily between 68 cm and 40 cm, reaching a minimum value of -3‰. From 40 cm to 20 cm, $\delta^{15}N_{org}$ increased steadily and averaged -0.4‰ in the upper 20 cm. The topmost sediment sample had a $\delta^{15}N_{org}$ of -0.84‰.

TP concentrations averaged ~0.45 mg/g from the base of the core to 98 cm followed by rapid drop in TP between 98 and 94 cm (Fig. 4D; Appendix VI). From 94 to 42 cm, TP averaged 0.35 mg/g. TP concentrations increased again at 40 cm to ~0.45

mg/g. An abrupt increase occurred at 22 cm and TP peaks at a value of 0.83 mg/g at 21 cm. TP concentrations declined again at 16 cm and averaged 0.51 mg/g between 16 and 4 cm, followed by an increase to 0.62 mg/g in the upper 2 cm.

Carbon isotopes of *Tryonia* in Core LP-2-01 averaged -4‰ from the base of the core to ~22 cm where values decreased to a mean value of -7‰ in the upper 20 cm (Fig. 8A-D). The $\delta^{13}C$ of ostracods averaged -2‰ from the base of the core to 25 cm and then exhibited high variability in the uppermost 25 cm. Oxygen isotopes of *Tryonia* averaged -1.5‰ from the base of the core to 75 cm and then increased to a mean of -2.2‰ in the top 75 cm. The ostracod $\delta^{18}O$ signal didn't show any clear trend except for occasionally lower values in the upper 25 cm of the core.

Plant Macrofossil

The plant macrofossil results are primarily qualitative because the sample sizes were relatively small, and the number of discrete macrofossils was also limited (Figs. 9 & 10; Appendix IX). The volume of macrofossil remains was greater in core LP-1-01 than in core LP-2-01. Fragments of *Ceratophyllum* were present in all samples except 40 cm in Core LP-2-01. Unmagnified, the various strands appeared thread-like. The majority of these strands are tubular with another strand within, and singularly or together were found in all samples. Flat and short black strands occurred in about half the samples. What appeared to be stem nodes were more abundant in the upper levels of core LP-1-01. Fragments of caddisfly cases and small cream-colored eggs were common in both cores. An unidentified minute pod-like macrofossil was common in the lower levels of core LP-1-01 either singly or as a chain of up to five sections.

Seeds were not abundant. *Najas guadalupensis* was present in most samples from core LP-2-01 and one level from LP-1-01. The total number of seeds and the variety of seeds were greater in LP-2-01. Other seeds that were identified include *Vallisneria*, *Eleocharis*, *Potamogeton,* and *Chenopodium*. Seeds that appeared similar to a small *Arabis*-type (spherical and encircled by a flange/wing) and an Asteraceae-type (cylindrical with a truncated end) were also present as well as three additional unidentified types (two with single occurrences).

The overall abundance of macrofossil remains was not constant. Macrofossils were less abundant in samples from 20-28 cm in LP-1-01 and samples from 28-40 cm in LP-2-01. This was primarily due to the diminished abundance of tubular strands.

Pollen

The pollen spectra, consisting of relative percentages, were similar in both cores (Figs. 11 & 12; Appendices X & XI). The dominant taxa were pine (*Pinus*), oak (*Quercus*), and cypress (*Taxodium*-type). The aquatic macrophytes were under-represented, and the remaining taxa primarily represented trees from floodplain and other mesic habitats together with widely distributed herbaceous taxa. The alga *Pediastrum subgranulatum* (following Komárek and Jankovská 2001, others have identified the form as *P. duplex* var. *subgranulatum*) was more prevalent in the upper levels. The two unidentified algal types were essentially absent from the upper portion of both cores. In addition, percentages for pine, *Taxodium*-type and Chenopodiaceae-Amaranthaceae exhibited declining trends toward the top of the cores, whereas percentages for oak increased. The change to an abundance of *Pediastrum* roughly coincided with the

initiation of the trends in the dominant taxa. This transition can be approximately placed at a depth of 32 cm in core LP-2-01 and 20 cm in core LP-1-01.

In both cores, pollen concentration increased with depth. The average concentration of pollen in core LP-1-01 was 2.12 times the average concentration in samples from LP-2-01. Estimations of pollen concentration using the proportional presence of *Lycopodium* spores added to the samples were consistently and significantly higher than estimates based on volumetric proportions of the subsample to the total suspension. The average of the *Lycopodium* estimates was 60% greater than the volumetric estimates in core LP-1-01 and 47% greater for LP-2-01. Maximum concentrations did not occur in the basal level, but rather in the level before the transition from the unidentified algal types to *Pediastrum*.

DISCUSSION

Sediment Dating and Accumulation Rates

Cesium-137 can sometimes be used to identify the period of maximum atmospheric bomb testing around 1960 (Krishniswami and Lal, 1978). Unfortunately, the ^{137}Cs peak is blurred in both cores LP-1-01 and LP-2-01, as is often the case in Florida lake sediment profiles. This has been attributed to the low clay content of the sediments and their consequent low binding capacity (Brenner et al., 2001).

Core LP-2-01 (sectioned in 2-cm intervals) was the only datable core of the two recovered (Fig. 15A; Appendix XII). The ^{210}Pb profile was modeled using the constant rate of supply model (c.r.s.) that assumes a constant net rate of supply of ^{210}Pb from the lake waters to the sediments, irrespective of varying sedimentation rate (Appleby and

Oldfield, 1978, 1983). The ^{210}Pb activity at 24-26 cm is unusually low (Fig. 4A) and thus yielded an unreasonably high sediment accumulation rate for a brief time. Hence we present accumulation rates of bulk sediment, organic matter, and total P only for the period since ~1917 (Fig. 15B-D; Appendix XII). Bulk sediment accumulation rates in LP-2-01 generally increased over the past ~80 years, with recent rates of accumulation about 30 times greater than values computed for the early part of the twentieth century. Concentrations of organic matter and total P in the ^{210}Pb-datable portion of the core (0-24 cm) display relatively small variations with depth (Fig. 4C & 4D). It is therefore the large shift in bulk sediment accumulation over time that is principally responsible for dramatic increases in calculated rates of organic matter and TP accumulation.

Pollen

The major change in the terrestrial environment is the decline of pine and cypress (Figs. 11 & 12), most likely attributable to logging and turpentine-extraction activities. The aquatic macrophytes do not present a clear trend. However, the change in algal communities implies a change in limnetic conditions. *Pediastrum subgranulatum* is generally associated with a significant presence of aquatic macrophytes (Komárek and Jankovská, 2001), and its low representation in the lower portion of the cores implies a limited presence of macrophytes. The timing of the change was probably concurrent in both cores, and is estimated to have occurred in the mid-to-late 1800s on the basis of the ^{210}Pb profile in Core LP-2-01. The difference in the depth between the two cores of the *Pediastrum* increase reflects different inter-site sedimentation rates, with sedimentation rates being slower in core LP-1-01. Grasses, watermilfoil (*Myriophyllum),* water lily (*Nymphaea*) and willow (*Salix*) tend to have increased concentrations after cypress

begins to decline. This may reflect a general expansion of macrophytes and shoreline marsh.

Downcore Macrophyte Remains

Najas and *Vallisneria* were noted as common plants at the coring site of LP-2-01 and they are more abundant in this core than LP-1-01 (Figs. 9 and 10). The paucity of seeds suggests that vegetative growth is the predominant method of reproduction for macrophytes in Lake Panasoffkee. The low numbers of macrofossils in the lower section of the cores corresponds with the change in algal representation noted in the pollen analyses, and reinforces the speculation that there was a change in limnetic conditions in the mid-to-late 1800s.

Sources of Sedimented Organic Matter

There are three potential sources of organic matter to Lake Panasoffkee sediments: 1.) allochthonous carbon derived from emergent vegetation along the shore including the extensive shoreline marshes along the eastern edge of the lake (Fig. 2); 2.) autochthonous carbon from floating-leaved and submersed macrophytes; and 3.) autochthonous carbon from phytoplankton and periphyton associated with macrophytes. If the isotopic compositions ($\delta^{13}C$ and $\delta^{15}N$) and/or C/N ratios of phytoplankton, aquatic macrophytes, and terrestrial plants are distinct from one another, then isotopic and elemental ratios of organic matter (OM) in sediment profiles can be potentially useful for tracing the relative importance of these carbon and nitrogen sources to bottom sediment (Boutton, 1991). To assess this, we compared the $\delta^{13}C$, $\delta^{15}N$, and C/N ratios measured

on potential modern organic carbon sources to sediments (SAV, emergent macrophytes, terrestrial vegetation, periphyton, plankton, etc.). Next, we compared the $\delta^{13}C$, $\delta^{15}N$, and C/N ratios measured in sediments with various types of modern vegetation and plankton to estimate the relative contribution of each to the sediment organic C and N pools.

Within each plant group, the variability of $\delta^{13}C$ was high, but significant differences in mean $\delta^{13}C$ values are nevertheless discernible among some groups. For $\delta^{13}C$, the rooted SAV (*Najas*, *Vallisneria*, *Potamogeton*, *Hydrilla*) clearly have higher $\delta^{13}C$ values (-12.8 to -15.9‰) than any other organic carbon sources (Fig. 13; Appendix II). The main control on the $\delta^{13}C$ in submersed aquatic macrophytes is the CO_2 in the water available for photosynthesis (Goericke, et al. 1994). Carbon assimilation is more difficult for submersed macrophytes than for emergent and floating-leaved plants, which have access to atmospheric CO_2. Submersed plants must obtain their CO_2 from the water column, where gas diffusion is several orders of magnitude slower than in air (Wetzel, 1983). When CO_2 is low and water is stagnant or sluggish, boundary layer diffusion and/or HCO_3^- uptake determine the $\delta^{13}C$ values of submersed plants, which typically fall between -10 and -15‰ (Osmond et al., 1981). This range is nearly identical to the $\delta^{13}C$ values (-12.8 to -15.9‰) measured for the dominant species of rooted SAV in Lake Panasoffkee (Fig. 13; Table 1). The relatively high $\delta^{13}C$ values of rooted SAV provide a useful indicator for estimating their contribution to sedimented organic matter.

The floating-leaved macrophytes have $\delta^{13}C$ values that range from -25 to -27‰, much lighter than the rooted submersed plants (Table 1). This difference can be attributed to the availability of atmospheric CO_2 to the floating leaved macrophytes. Emergent vegetation has the lowest $\delta^{13}C$ values (-27‰) and highest C/N ratio (22),

reflecting unlimited CO_2 availability and a greater quantity of lignified tissue. Compared to emergent vegetation, floating and submersed vegetation have lower C/N ratios (10-20) reflecting less lignified supportive and conductive tissue than emergent vegetation. Periphyton, filamentous algae, and phytoplankton have the lowest C/N ratios (7-10).

In Figure 13, we compare the $\delta^{13}C_{org}$ and C/N values in sediment core LP2-01 with those measured in modern terrestrial/emergent vegetation, SAV and plankton. Sediment $\delta^{13}C$ values ranged from -22.7 to -27.1 with a core-top value of -23.1, and C/N ranged from 15.5 to 28.6 with a core-top value of ~16. In $\delta^{13}C$-C/N space, the mean sediment values are closest to emergent vegetation and floating-leaved macrophytes. The entire east shore of Lake Panasoffkee is dominated by wetlands (Fig. 2), so emergent macrophytes (*Typha*, *Pontederia*) and terrestrial vegetation could contribute significantly to the sediment carbon pool. In addition, emergent vegetation has high C/N ratios relative to submersed macrophytes and algae, and the structural C (lignin, cellulose) of emergent vegetation is resistant to decomposition. The mean $\delta^{13}C$ for plankton samples (-22.8‰) is close to the core-top value (-23.1‰), but C/N ratios are significantly lower (averaging 6.5). It is possible that the higher C/N ratio of sediment relative to plankton is a reflection of organic matter diagenesis in the sediment. Sediment C/N ratios may increase as labile N-bearing compounds (proteins) are preferentially decomposed, leaving behind only high-C/N compounds such as cellulose and lignin.

The $\delta^{13}C_{org}$ of core-top and subsurface sediment is > 7‰ more negative than the ^{13}C-enriched rooted SAV. At face value, this suggests that SAV contribute very little C to the sediment organic pool (Fig. 13). This is surprising considering the high biomass of rooted SAV that covers the bottom of the lake today, although rates of SAV production

may be relatively low. Upon death of rooted SAV, decomposition may release most of the C back to the water column, leaving little to be sedimented. The low $\delta^{13}C_{org}$ of sediments relative to rooted SAV may also reflect selective microbial degradation of labile ^{13}C-enriched compounds such as proteins and carbohydrates that are found in high concentrations in SAV compared to emergent vegetation. The sedimented carbon would therefore reflect more refractory ^{13}C-depleted compounds such as cellulose, lipid, and lignin derived from emergent vegetation (Benner et al., 1987). However, even the topmost sediment, which serves as the substrate for rooted SAV, has significantly lower $\delta^{13}C$ values suggesting that little of the ^{13}C-enriched C from SAV is sedimented.

Nitrogen isotopes are less useful for distinguishing different organic matter sources to sediments because $\delta^{15}N$ values do not correspond well with distinct vegetation types (Fig. 14). The $\delta^{15}N$ of rooted submersed macrophytes is closer to core-top $\delta^{15}N$ values than rooted-submersed-macrophyte $\delta^{13}C$ were to core-top $\delta^{13}C$ values. This may indicate that rooted submersed macrophytes contribute proportionally a greater amount of N than C to the sediment carbon pool (Fig. 17).

Different sources of organic matter may vary with respect to their C and N contributions to sediments, depending upon both the C/N ratio of the sources and the susceptibility of different C- and N-containing compounds to decomposition. For example, emergent vegetation may be an important source of refractory sedimented C (e.g., lignin, cellulose), but emergent plants may contribute little to the sediment N pool because their structural tissues have high C/N ratios. In contrast, submersed macrophytes have a higher protein content, and thus more nitrogen, than do emergent macrophytes. Submersed plants may thus contribute a greater relative proportion (N per unit organic

matter) to sediments than do emergent plants. For this reason, the sediment C and N pools should be considered individually. The relative contribution from each source may be different with respect to C and N depending upon C/N ratios in source plants and the relative resistance of carbon- and nitrogen-bearing organic compounds to decomposition.

Historical Changes in SAV abundance

Several lines of evidence indicate an increase in SAV abundance beginning in the latter part of the 19th century. At a level of ~35 cm in core LP-2-01, organic C and N concentrations increase, C/N ratios decrease, and $\delta^{13}C_{orgC}$ values increase, and $\delta^{15}N$ values increase (Fig. 7). These changes are consistent with increased lake productivity and SAV abundance. Geochemical inferences are supported by sediment macrofossil evidence that shows a concurrent increase in aquatic macrofossil remains (Fig. 16), including stem nodes, strands, and seeds (especially *Najas*). In addition, the alga *Pediastrum*, which is generally associated with a significant presence of aquatic macrophytes, increased in abundance beginning at ~30 cm. The geochemical and floral changes occurred in the late 19th century, although the age uncertainty is large because it is close to the limit of ^{210}Pb dating.

Paleolimnological proxies suggest that prior to the late 1800s, SAV abundance and primary productivity were relatively low in Lake Panasoffkee and organic carbon in sediments was derived mostly from emergent vegetation. Primary productivity and SAV abundance increased in the late 1800s, probably in response to increased P loading from early settlement and forest clearance for logging and turpentine extraction activities (Homan, 1957). This interpretation is supported by pollen profiles that show a decrease

in the relative abundance of pine and cypress (Fig. 12) occurring at the same time as changes in trophic state indicators. It is also consistent with the history of the region as described in Florida Outdoors Magazine by Homan (1957):

> "In the earlier 1880's, when the Florida Central Railroad extended south from Wildwood, the first new station stop was at Panasoffkee. This meant fast, cheap transportation. Bachelor's Lumber Mill hired hundreds of hands and a steamship dragged millions of feet of cypress across the lake to the new railroad yards."

About 1884, a rock spillway was constructed on Outlet River to maintain a permanent channel between the Withlacoochee River and Lake Panasoffkee (Wharton, 1982). This construction may have also aided macrophyte colonization of the bottom by maintaining lower water levels, thereby increasing bottom irradiance, and expanding the lake bottom area available for optimal macrophyte growth.

Previous studies have shown that low nutrient concentrations in shallow-water Florida lakes favor a primary producer community dominated by submersed macrophytes and associated microflora (Scheffer et al., 1993; Kenney et al., 2002; Schelske et al., in prep.). We conclude that increased nutrient loading beginning in the late 1800s promoted SAV growth in Lake Panasoffkee. Under such conditions, increased macrophyte production and associated microflora (e.g., periphytic algae) became a sink for soluble P, thereby helping to maintain clear water and low nutrient levels. In addition, the extensive wetlands surrounding Lake Panasoffkee increase the lake's resistance to nutrient loading through their filtering and assimilatory capacity.

An interesting event in 1974 illustrates the sensitivity of the macrophyte community in Lake Panasoffkee. Water levels were very low in early 1974 following a protracted drought (McKinney et al., 1975). Heavy rains in July 1974 raised the lake

level by 2 feet in 14 days. Tannin-stained water flowed from adjacent swamps and decreased water clarity. Significant amounts of submersed vegetation were lost, and the lake became phytoplankton dominated for a few years. Macrophytes re-colonized the bottom by 1978. It is possible that extensive logging (especially cypress) in the late 19th century may have decreased tannin input to Lake Panasoffkee, thereby increasing water clarity and macrophyte colonization.

P Accumulation

Today, in-lake processes remove 72% of the phosphorus input loads to Panasoffkee (CH2MHill, 1995), suggesting that the lake is very effective at sequestering P. Living SAV biomass is only a temporary P sink because large amounts of nutrients are released to the water column upon death of macrophytes (Wetzel, 1983, p. 556). In addition, the capacity of the submersed macrophyte community to assimilate nutrients is limited, and will eventually reach saturation (steady state). It is therefore important to determine if P uptake by submersed macrophyte communities leads to increased accumulation of P in sediments, which act as a more permanent nutrient sink. Sediment P concentrations in Core LP-2-01 increase in conjunction with other proxies for increased productivity and SAV biomass (Fig. 17), suggesting that increased macrophyte productivity and/or their associated microflora may increase P sequestration in sediments.

Although sediment P concentrations increased when the lake switched from an oligotrophic system dominated by emergent vegetation to a submersed-macrophyte-dominated system, the macrophytes themselves may not be responsible for increased sediment P concentrations. In 12 cores from Florida lakes, Kenney et al. (2002) found

that TP was 2.6-fold greater in phytoplankton sediments than macrophyte sediments. They suggested that macrophyte-dominated systems have lower P accumulation rates compared to phytoplankton-dominated systems. However, the epiphytic community associated with macrophytes in Lake Panasoffkee may play an important role in P sequestration. Photosynthetic activity of associated epiphytic algae can be very high, often exceeding that of the submersed macrophytes (Wetzel, 1983). High photosynthetic rates of SAV and periphyton draw down CO_2 (Eqn. 1), and promote the precipitation of calcium carbonate (Eqn. 2). Calcite precipitation can be an effective means for sedimenting periphyton and P through adsorption and incorporation into nucleating calcite crystals (Mickle and Wetzel, 1978; Koschel et al., 1983; Kufel and Kufel, 2002). It can also serve as a nucleus for the formation of Ca-P compounds (Brown, 1980).

The long-term stability of P sequestration in Lake Panasoffkee sediments is difficult to assess because SAV dominance has been largely limited to the last century, and most of the increase in P accumulation occurs in the upper 10 cm (Fig. 15D). These recently deposited sediments are still subject to biogeochemical diagenesis and P can be readily released back to the water column. Studies in shallow Florida lakes have shown, however, that changes in redox potential that occur with postburial diagenesis have little effect on P solubility in calcareous sediments containing low concentrations of Fe (Olila and Reddy, 1997).

CONCLUSIONS

1. Lake Panasoffkee has been dominated by SAV for the past 100 to 150 years. Prior to the late 1800s, the predominant source of sedimented organic matter was probably emergent macrophytes from the extensive marshes along the east shore of the lake.
2. Beginning in the late 1800s, primary productivity and SAV abundance increased in response to increased P loading from early settlement and forest clearance for logging and turpentine extraction activities.
3. Increased macrophyte production and associated microflora (i.e., periphytic algae) became a sink for soluble P, thereby helping to maintain clear water and low nutrient levels.
4. Despite the high density of submersed vegetation in the lake today, rooted SAV contribute little carbon to the sediment organic matter pool or the high $\delta^{13}C$ signature of the rooted SAV is not reflected in the sediment because of microbial diagenesis (Cloern et al., 2002).
5. Increased productivity of macrophytes and/or their associated microflora appears to result in increased accumulation of organic carbon and P in sediments. Nonetheless, the long-term stability of P sequestration in Lake Panasoffkee sediments is difficult to assess because of the relatively recent increase in P accumulation. Additionally, the macrophytes themselves may not be responsible for increasing sediment P retention, but rather the increase in productivity of the periphyton community coupled with calcite precipitation may be highly effective means for sedimenting P. The importance of macrophytes relative to the periphyton and phytoplankton community in increasing accumulation of organic carbon and P in sediments merits further study.

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		n	mean $\delta^{13}C$	stdev	mean $\delta^{15}N$	stdev	mean%C	stdev	mean%N	stdev	%C/%N
Emergent/terrestrial	emergent shoreline	9	-27.00	0.8	1.62	2.31	48.20	2.55	2.16	0.64	22.3
Hydrocotyle	floating leaved	2	-27.06	0.3	1.20	1.53	47.62	0.11	2.39	0.24	19.9
Nymphaea mexicana	floating leaved	6	-25.06	0.8	-3.07	2.94	46.31	1.65	3.29	0.95	14.1
Pistia	floating leaved	1	-25.03		2.47		44.91		3.06		14.7
Phytoplankton (filtered)		6	-22.81	3.3	2.18	0.76					6.5
Ceratophyllum	submersed free-floating	7	-20.26	1.9	-1.18	1.57	44.82	2.41	3.02	0.39	14.8
Vallisneria Periphyton		6	-20.24	1.2	1.84	1.18	37.76	2.77	3.70	0.49	10.2
Filamentous Algae	macroalga	7	-18.49	3.3	1.11	1.30	43.50	2.69	4.33	1.58	10.0
Najas	submersed attached	12	-15.90	2.9	-1.67	2.58	43.23	1.46	2.70	0.51	16.0
Vallisneria	submersed attached	20	-15.47	3.0	-0.78	2.72	43.26	6.05	3.25	1.07	13.3
Potamogeton	submersed attached	9	-13.20	2.6	-1.25	2.86	44.94	1.53	2.23	0.66	20.2
Hydrilla	submersed attached	3	-12.80	2.7	-1.35	0.74	43.81	0.84	3.23	0.37	13.6

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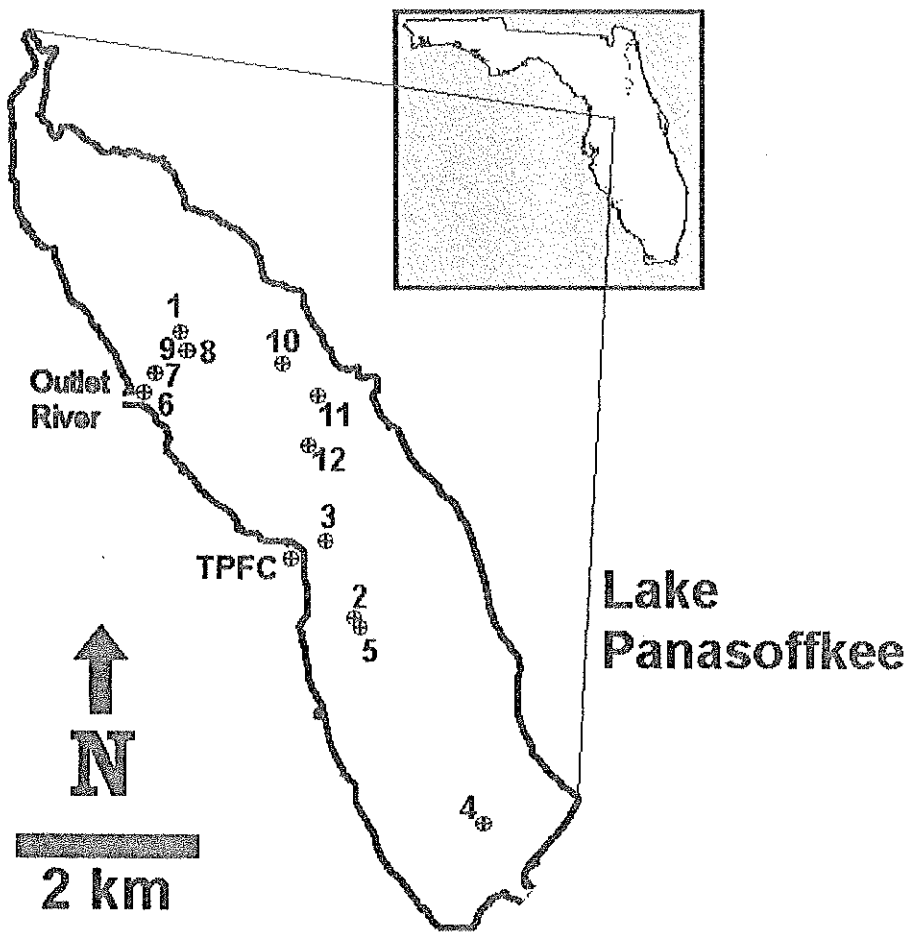

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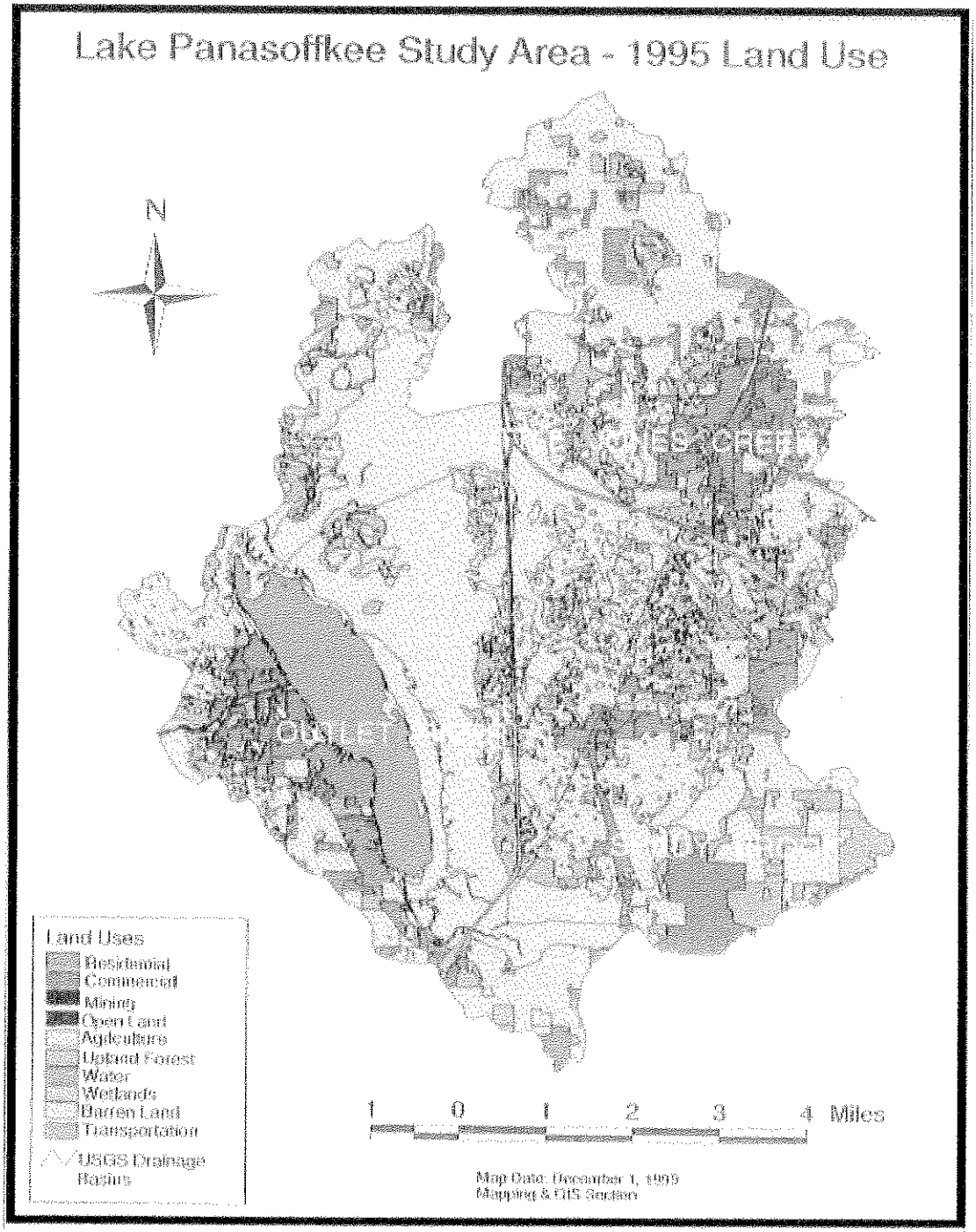

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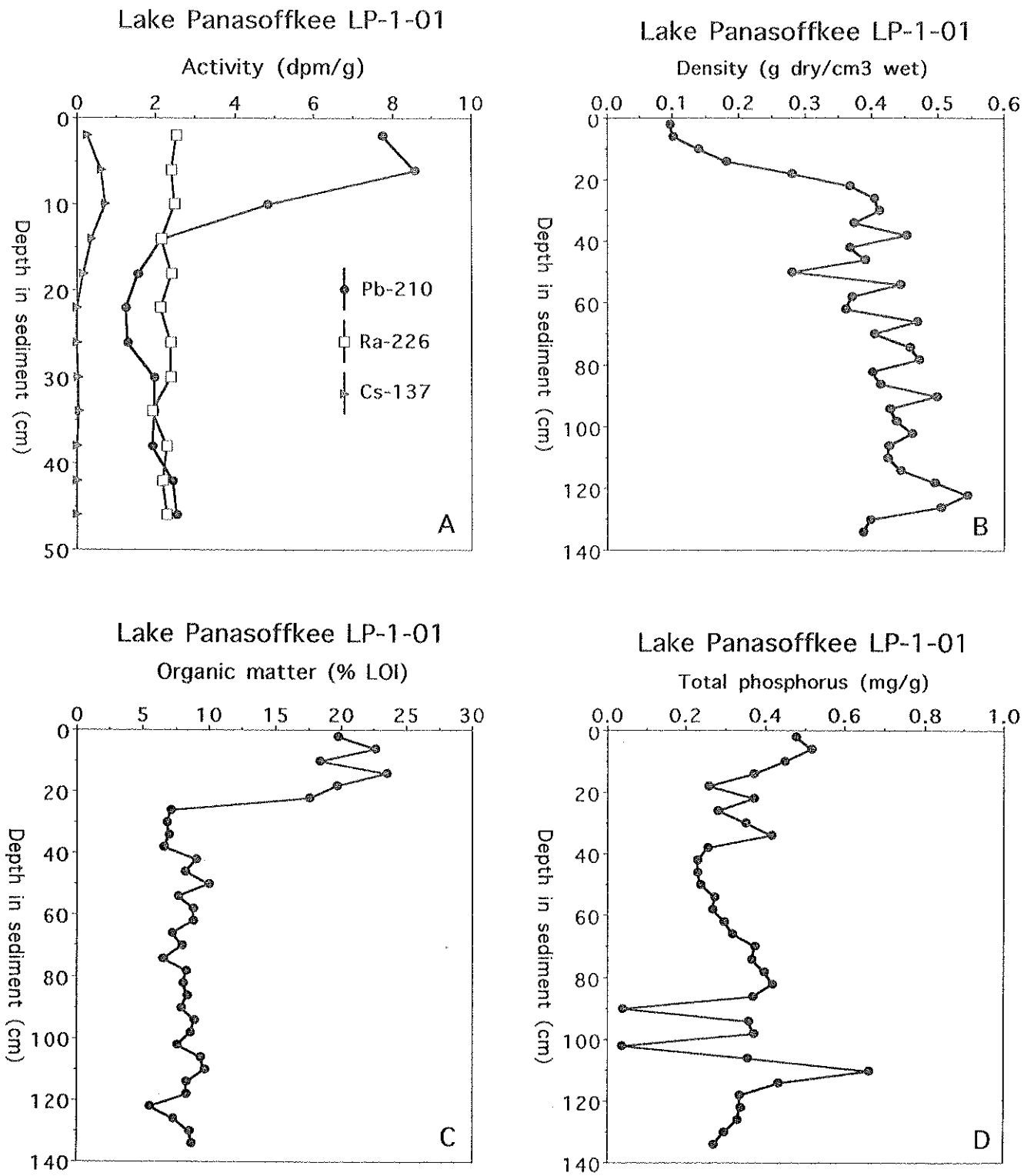

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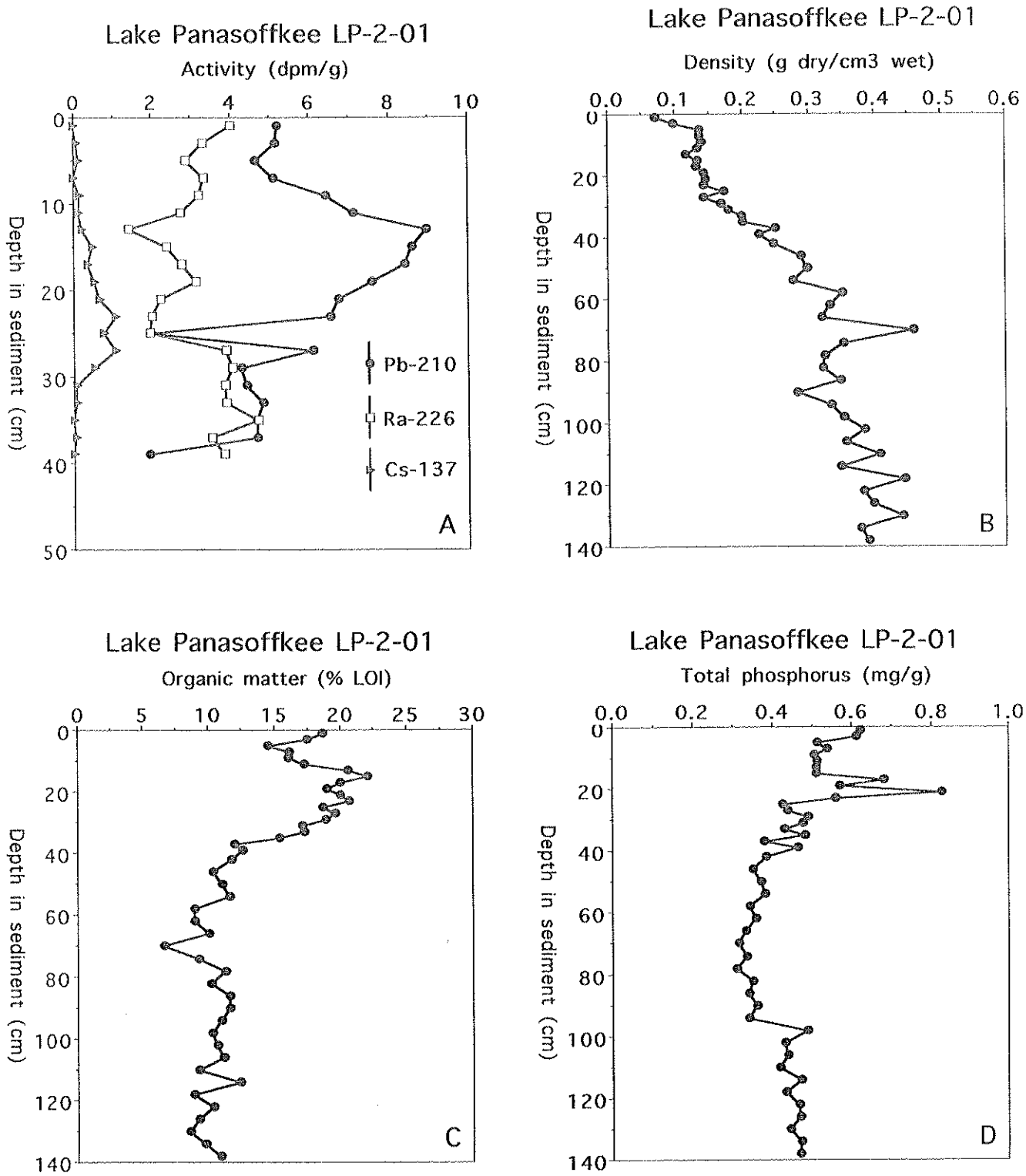

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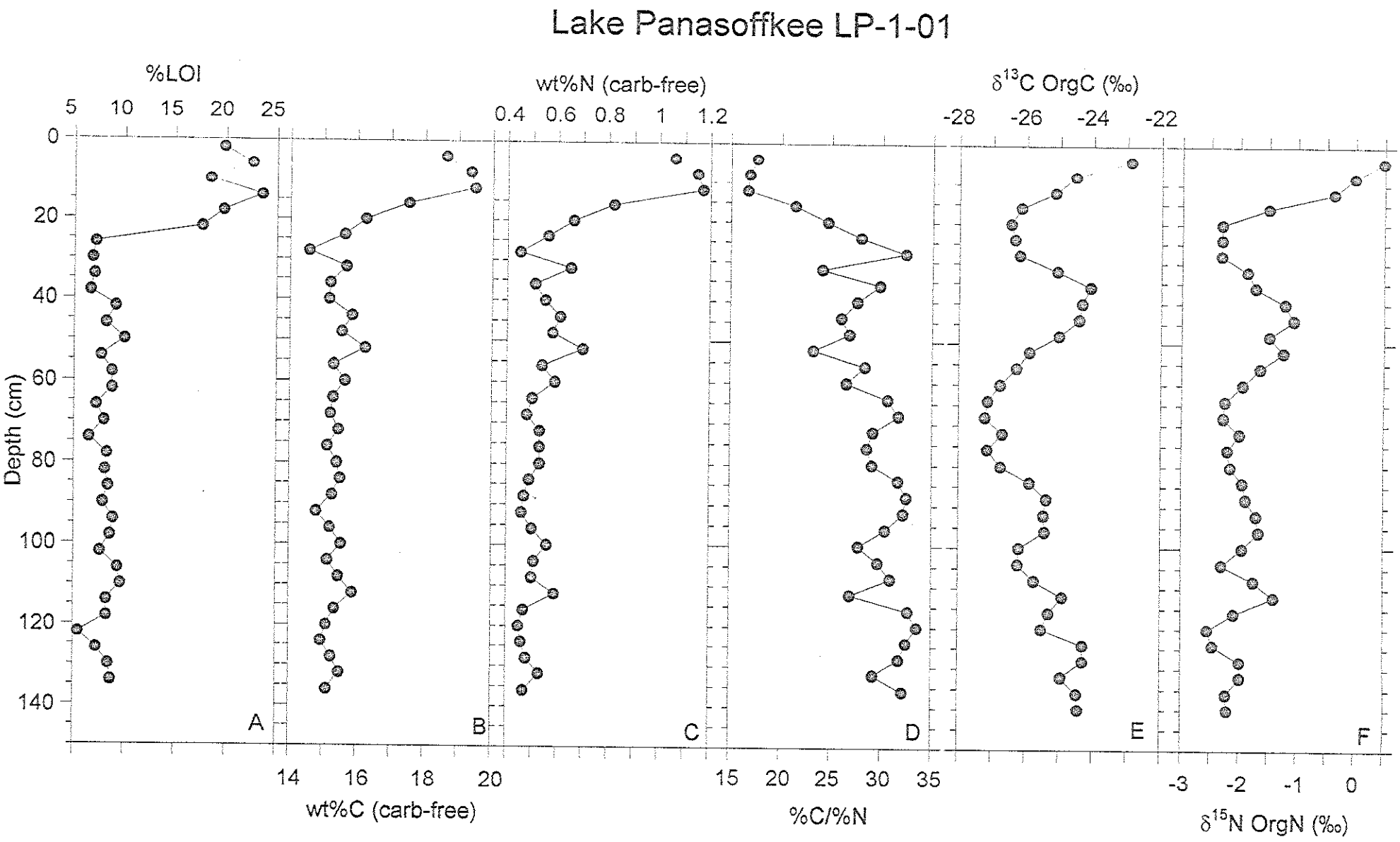

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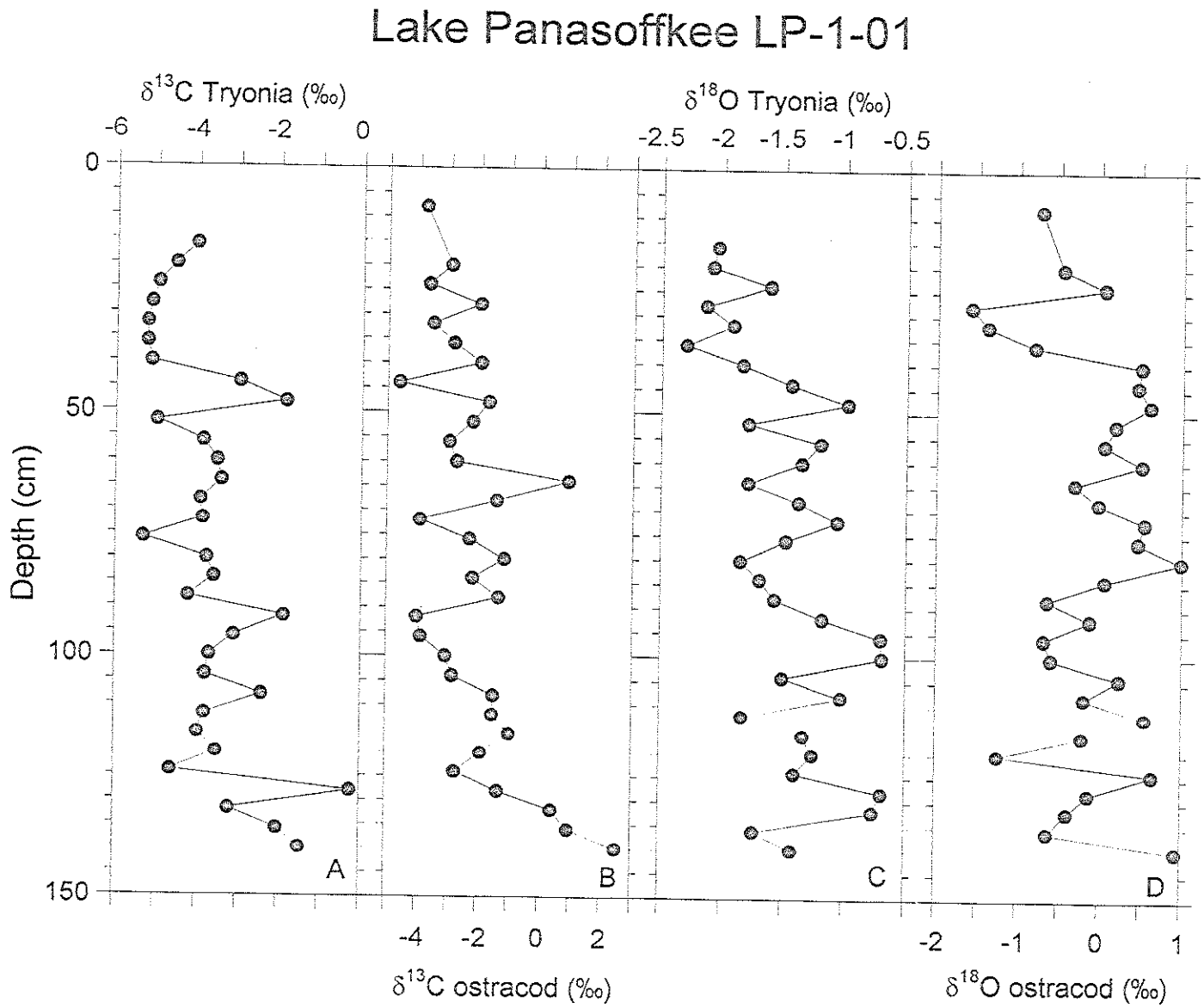

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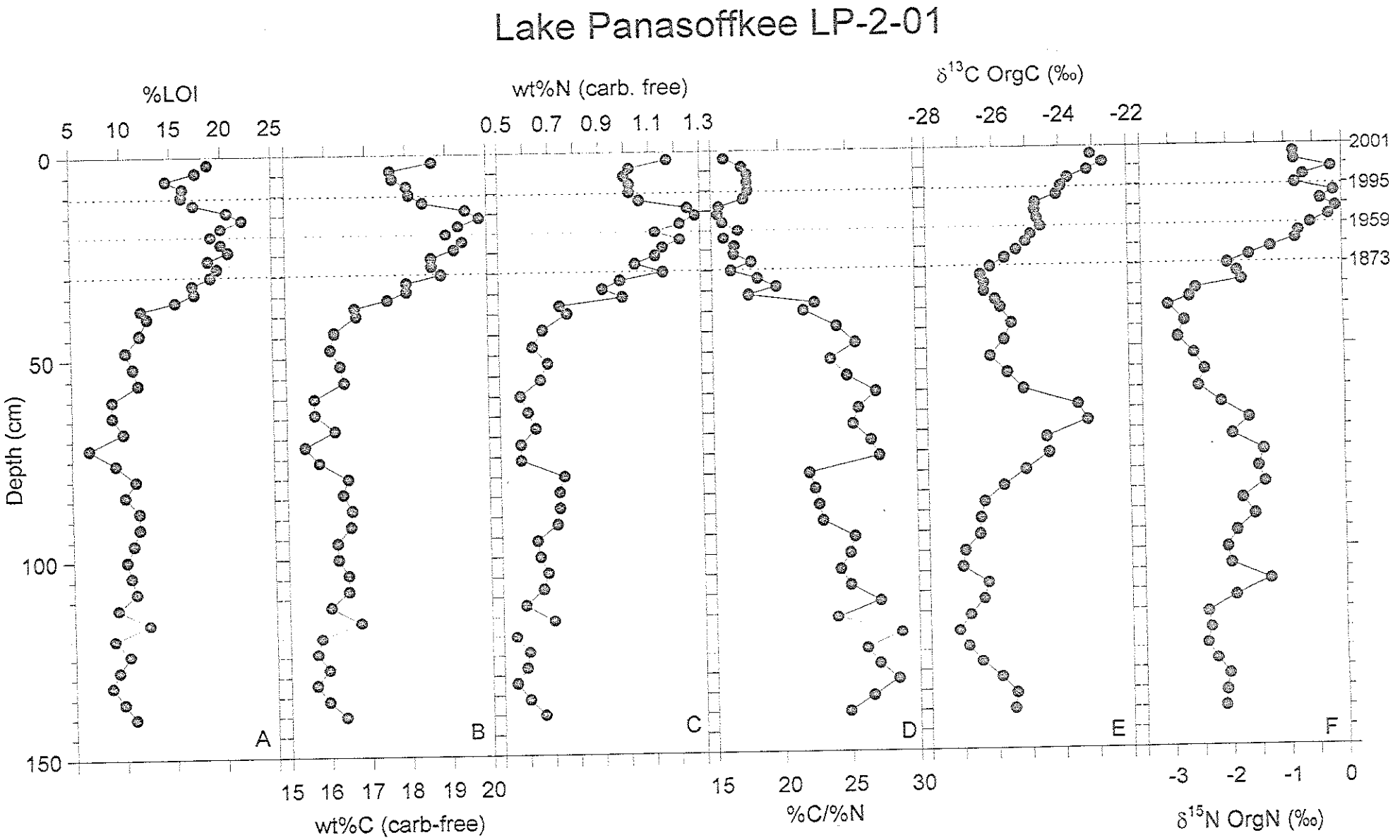

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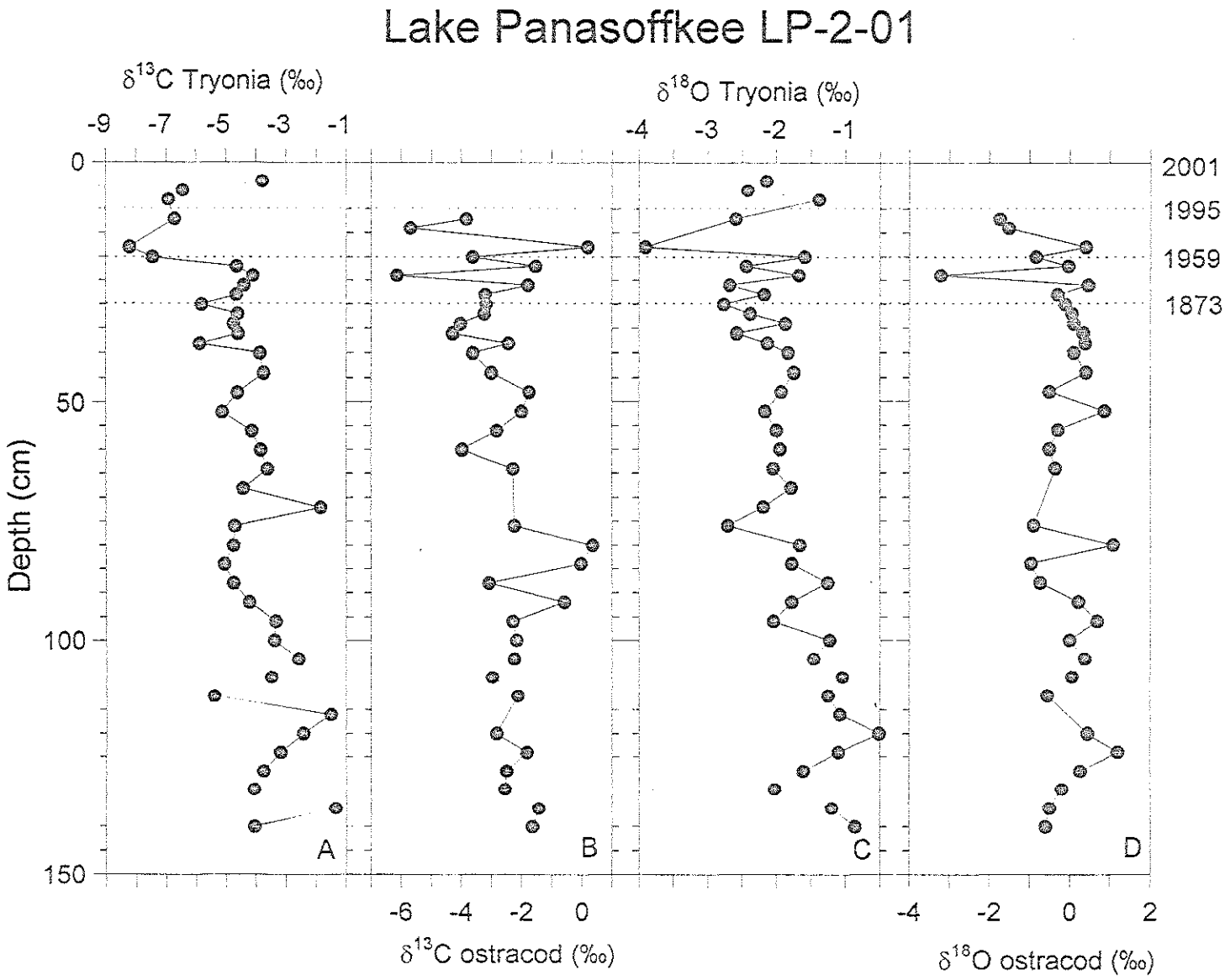

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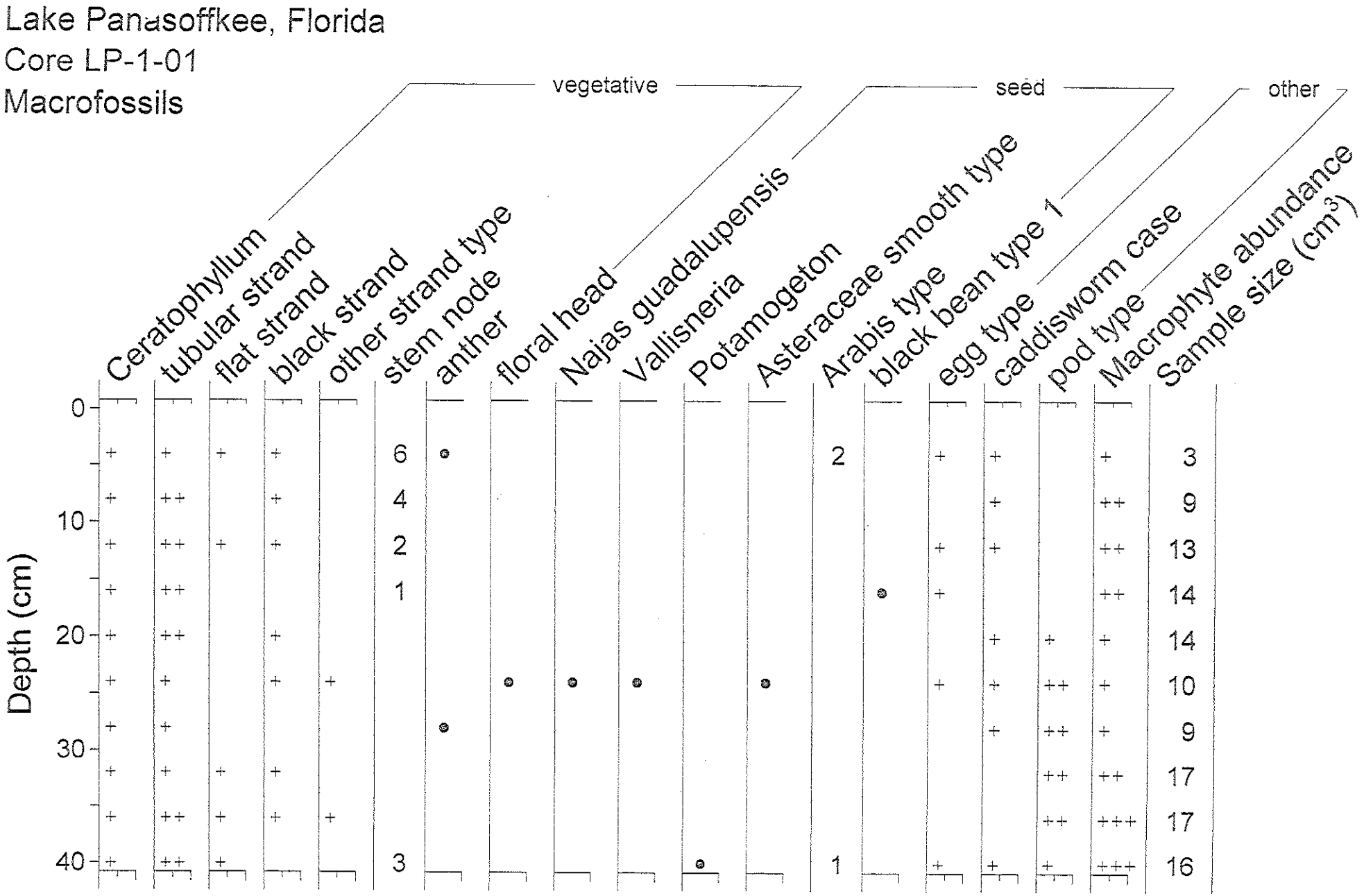

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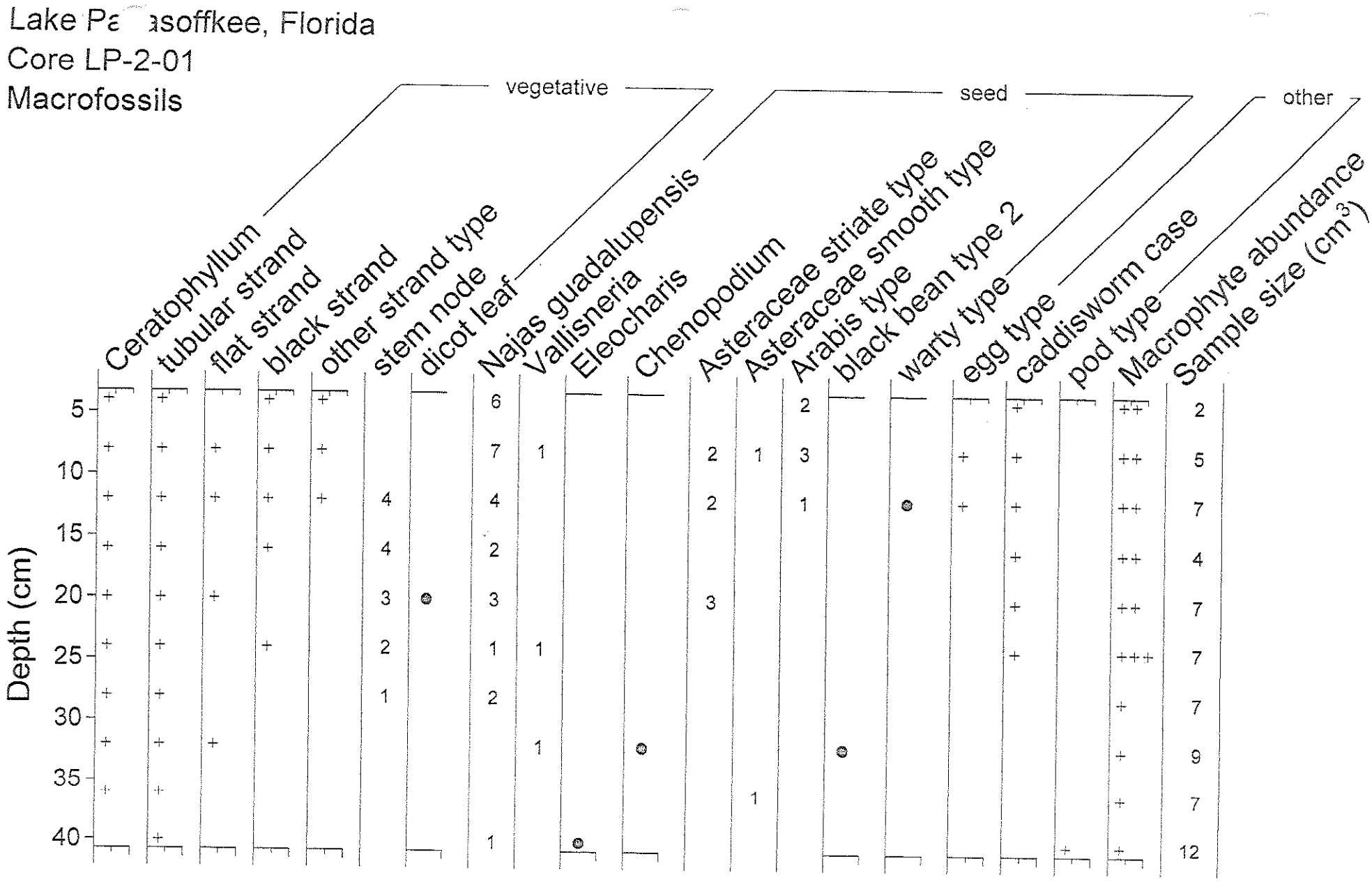

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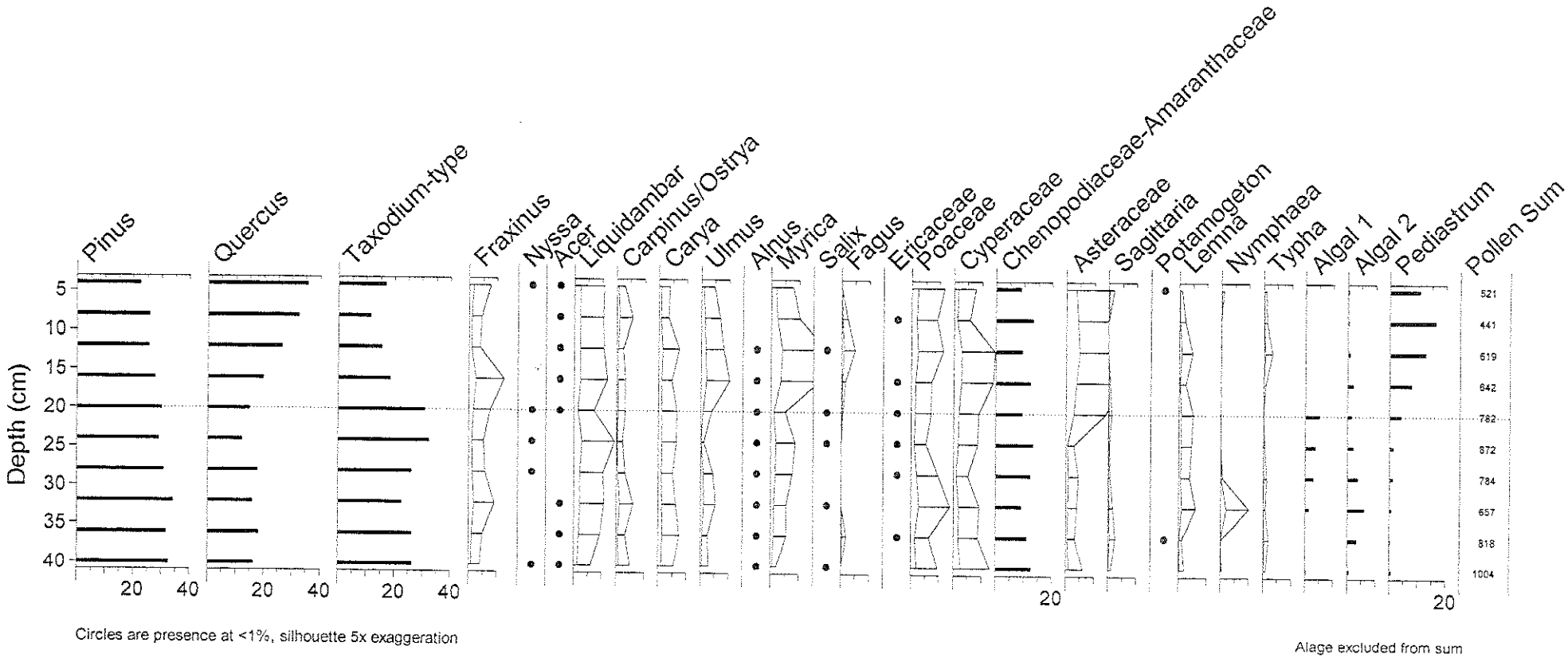
Lake Panasoffkee, Florida

Pollen Percentage Diagram

Core LP-1-01



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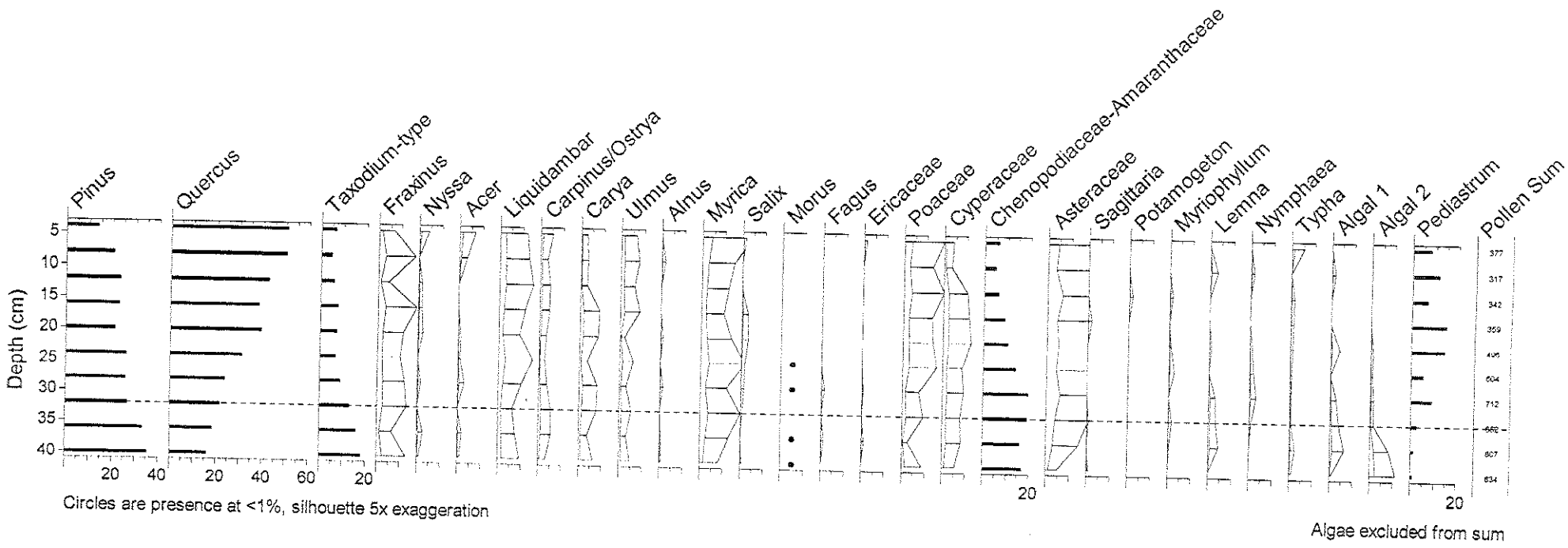
Lake Panasoffkee, Florida

Pollen Percentage Diagram

Core LP-2-01



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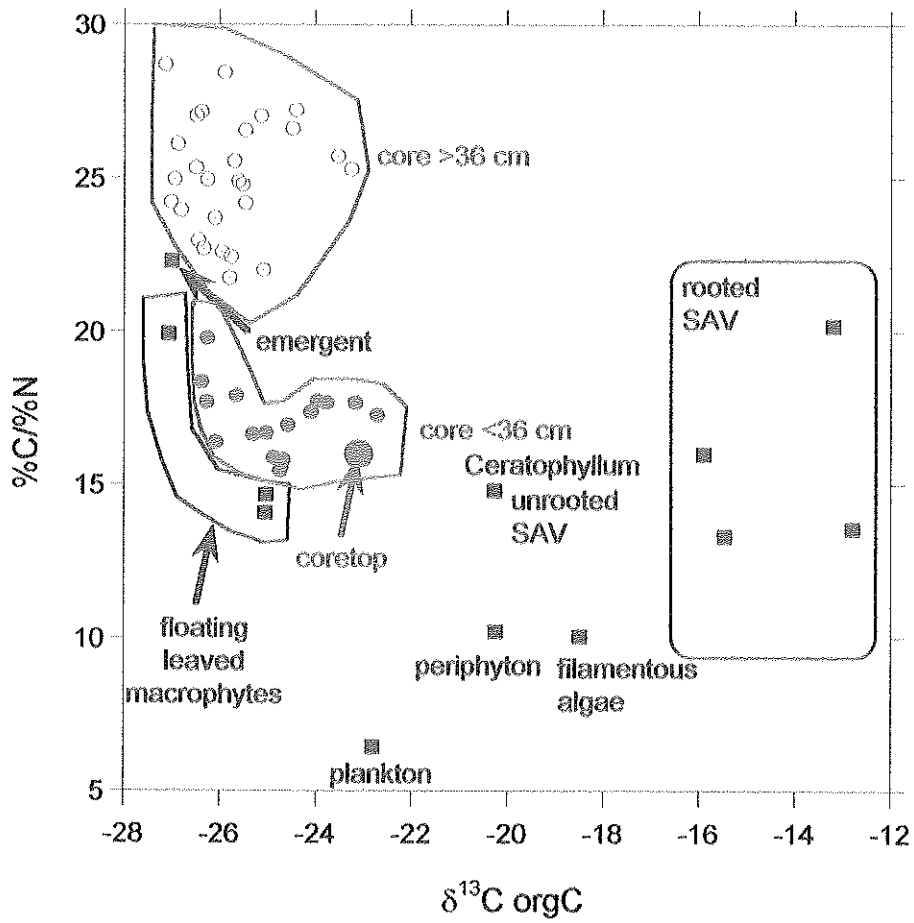

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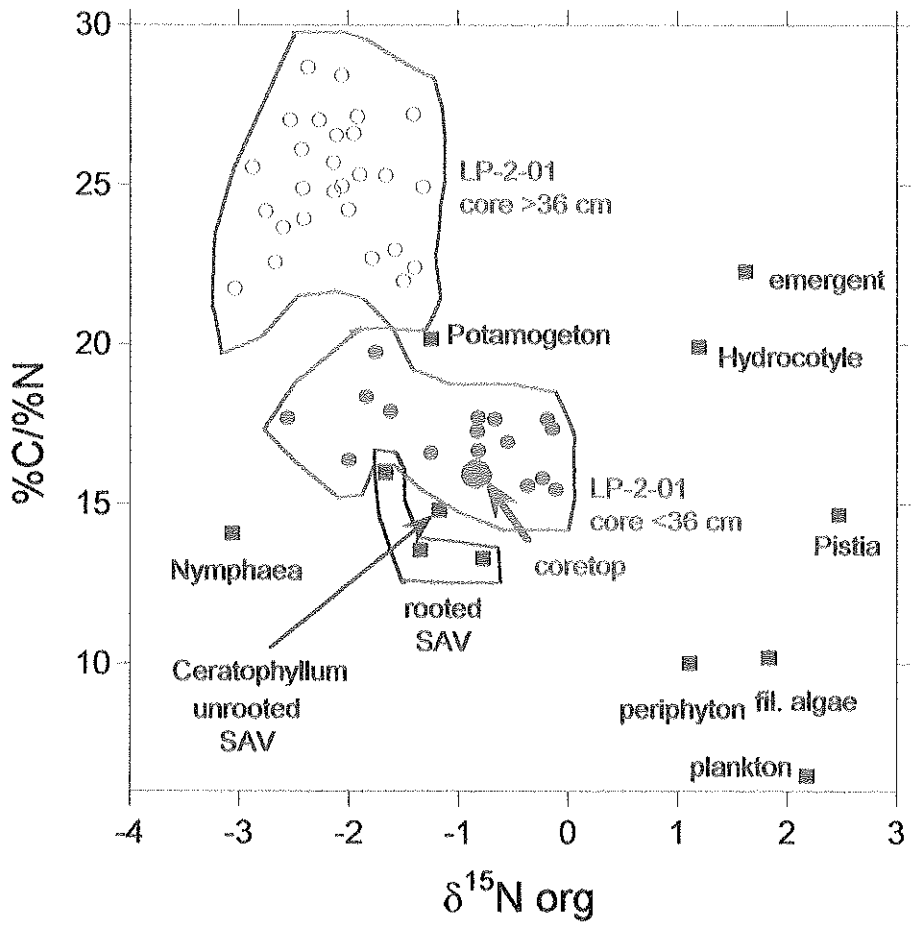

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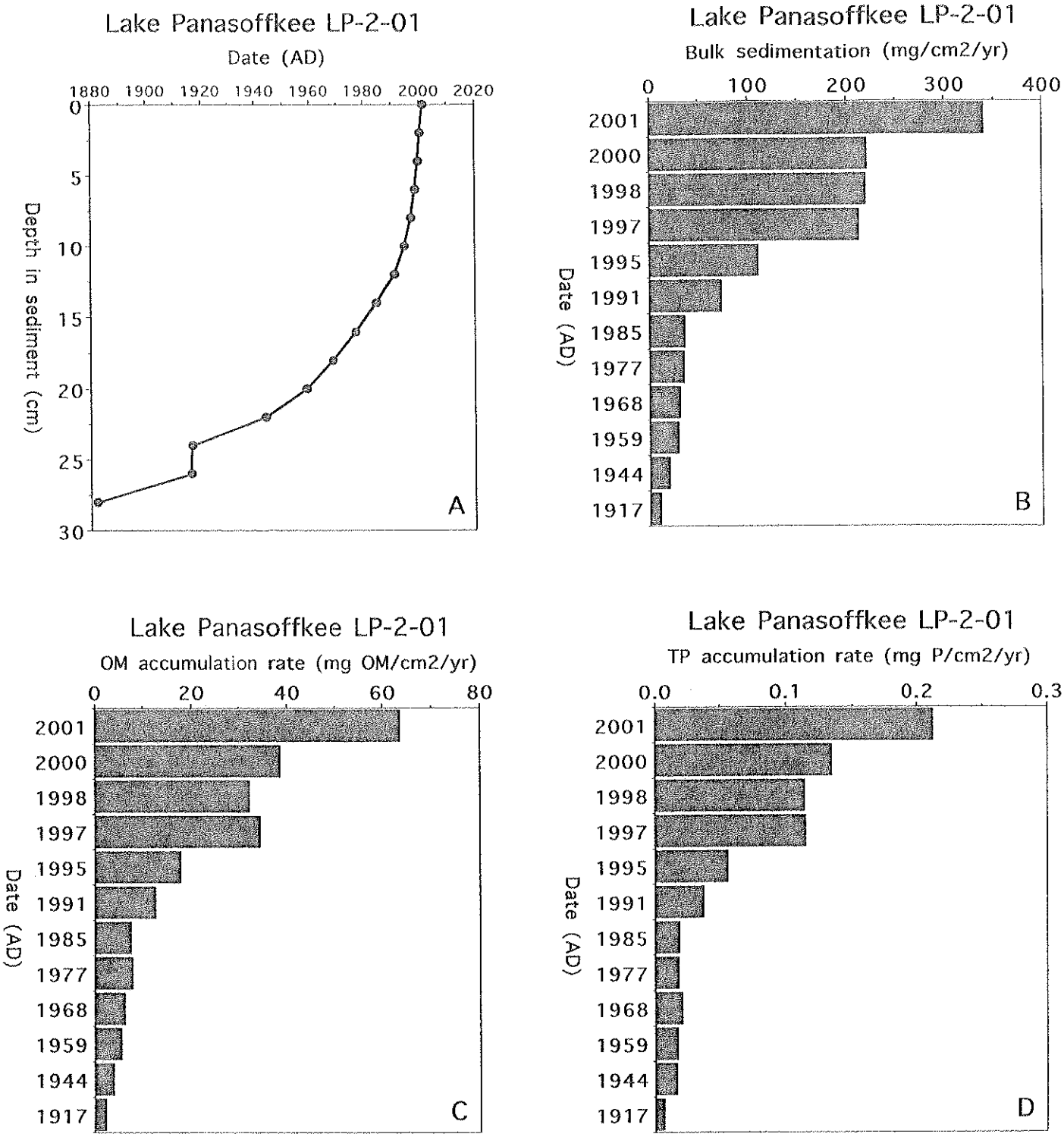

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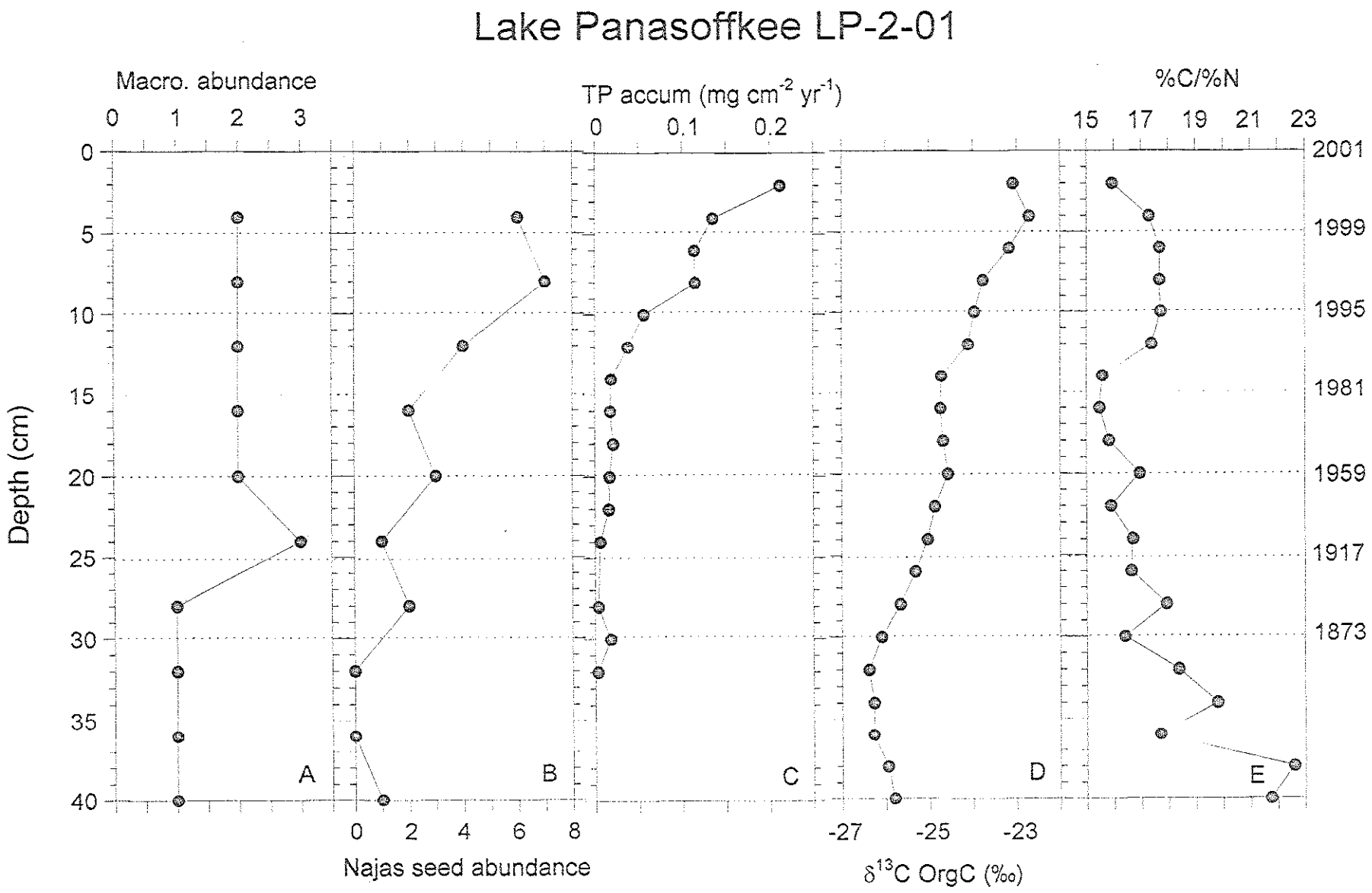

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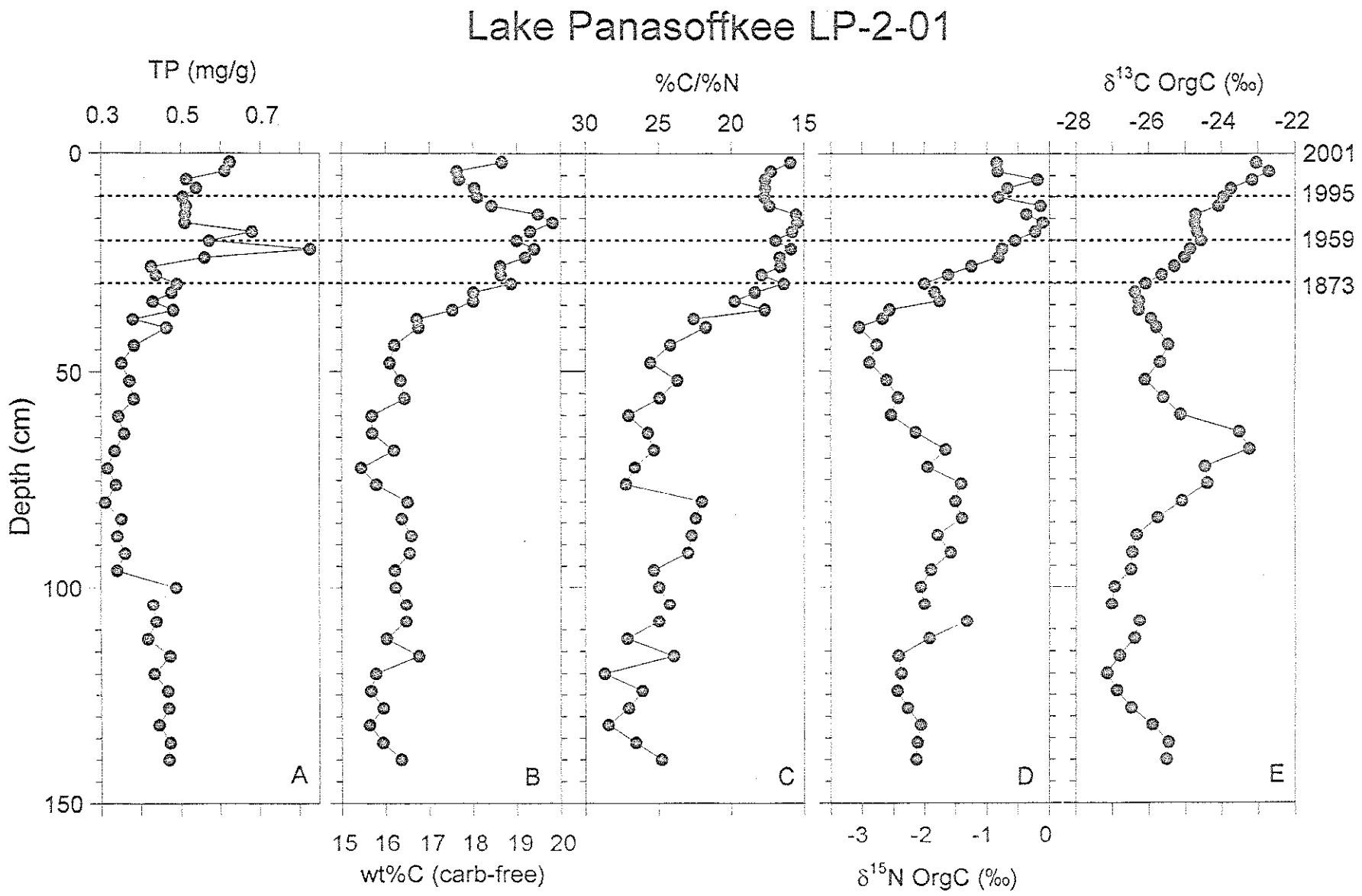

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Pollen Counts and Percentages by Depth (cm) for LP-1-01

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Pollen Counts and Percentages Listed by Depth (cm) for LP-2-01

Appendix I

Lake Panasoffkee (2001) Fieldnotes

Date: 30-May-2001
Mark Brenner
William Kenney
Jason Curtis
David Hodell
Binhe Gu

Date: 21-December-2001
Mark Brenner
William Kenney
Jason Curtis
David Hodell

Date: 30-May-2001
On lake at 0915 hours

Coring Site LP-2:
arrived 0950 hours
common plants are *Najas* and *Vallisneria*

28°47'09.4" N, 82°06'50.2" W

Core was sampled in the field at 2-cm intervals to 40 cm, and at 4-cm intervals thereafter to a depth of 140 cm.

Coring Site LP-1:
arrived 1150 hours
common plant is *Potamogeton*

28°48'46.9" N, 82°07'57.3" W
28°48'47.0" N, 82°07'57.6" W

Date: 30-May-2001
Site LP-3 (water/plant collection)

28°47'35.6" N, 82°07'01.2" W

Plant	Location	Lat/Long
Ceratophyllum	LP-3	28°47'35.6" N, 82°07'01.2" W
Bulrush (*Scirpus*)	TPFC	
Filamentous alga (*Cladophora*?)	near west shore	
Filamentous alga (*Cladophora*?)	LP-1	28°48'46.9" N, 82°07'57.3" W
Ceratophyllum	LP-2	28°47'09.4" N, 82°06'50.2" W
Hydrilla	LP-3	28°47'35.6" N, 82°07'01.2" W
Hydrilla	LP-2	28°47'09.4" N, 82°06'50.2" W
Hydrocotyle	TPFC	
Najas	LP-3	28°47'35.6" N, 82°07'01.2" W
Najas	LP-2	28°47'09.4" N, 82°06'50.2" W
Najas	LP-1	28°48'46.9" N, 82°07'57.3" W
Nymphaea mexicana	LP-3	28°47'35.6" N, 82°07'01.2" W
Nymphaea mexicana	LP-2	28°47'09.4" N, 82°06'50.2" W
Potamogeton	LP-1	28°48'46.9" N, 82°07'57.3" W
Potamogeton	LP-3	28°47'35.6" N, 82°07'01.2" W
Pokeberry	TPFC	
Pontederia	TPFC	
Potamogeton	---------	28°47'14.0" N, 82°06'50.0" W
Salix	TPFC	
Unknown	TPFC	
Typha	TPFC	
Vallisneria	near west shore	
Vallisneria	LP-2	28°47'09.4" N, 82°06'50.2" W
Vallisneria	LP-1	28°48'46.9" N, 82°07'57.3" W
Vallisneria	LP-3	28°47'35.6" N, 82°07'01.2" W
Vallisneria	LP-2	28°47'09.4" N, 82°06'50.2" W
Periphyton (on *Vallisneria*)	LP-3	28°47'35.6" N, 82°07'01.2" W
Periphyton (on *Vallisneria*)	LP-1	28°48'46.9" N, 82°07'57.3" W
Filamentous alga	LP-1	28°48'46.9" N, 82°07'57.3" W
Vallisneria	LP-2	28°47'09.4" N, 82°06'50.2" W

Date: 30-May-2001

Animal	Location	Lat/Long
grass shrimp	LP-2	28°47'09.4" N, 82°06'50.2" W
gastropods	LP-1	28°48'46.9" N, 82°07'57.3" W
gastropods	LP-2	28°47'09.4" N, 82°06'50.2" W

*TPFC = Tracy's Point Fish Camp

Filtered sample (on filter) *(precombusted quartz fiber)	Location	Lat/Long
Filtered sample	LP-1	28°48'46.9" N, 82°07'57.3" W
Filtered sample	LP-1	28°48'46.9" N, 82°07'57.3" W
Filtered sample	LP-1	28°48'46.9" N, 82°07'57.3" W
Filtered sample	LP-1	28°48'46.9" N, 82°07'57.3" W
Filtered sample	LP-3	28°47'35.6" N, 82°07'01.2" W
Filtered sample	LP-3	28°47'35.6" N, 82°07'01.2" W
Filtered sample	LP-3	28°47'35.6" N, 82°07'01.2" W
Filtered sample	LP-3	28°47'35.6" N, 82°07'01.2" W

Water samples	Location	time	Lat/Long
$\delta^{18}O$	LP-1	1317 hr	28°48'46.9" N, 82°07'57.3" W
$\delta^{18}O$	LP-2	1100 hr	28°47'09.4" N, 82°06'50.2" W
$\delta^{18}O$	LP-3	1420 hr	28°47'35.6" N, 82°07'01.2" W
$\delta^{13}C$-DIC (w $HgCl_2$)	LP-1	1317 hr	28°48'46.9" N, 82°07'57.3" W
$\delta^{13}C$-DIC (w $HgCl_2$)	LP-2	1100 hr	28°47'09.4" N, 82°06'50.2" W
$\delta^{13}C$-DIC (w $HgCl_2$)	LP-3	1420 hr	28°47'35.6" N, 82°07'01.2" W

Date: 21-December-2001

Coring Site LP-4 (near 1998 core site)
28° 46.876' N, 82° 06.689' W

water depth = 76 cm

LP4-21-XII-01 MWI-1
Upper section = 0-89 cm
Lower section =89-187 cm (not a full meter)

Plants samples:

1 *Ceratophyllum*
1 *Najas*
1 Filamentous algae (on *Najas*)
3 *Vallisneria* (roots, leaves, and mud on roots)

Dredge samples:

1 *Najas*
1 mud

Snails collected from *Najas* bed
2 filters POC collected for isotopes ~1.75 L filtered each (acidified with ~1N HCl)

2 POC @ 300 ml
2 PTN @ 200 ml

2 H_2O samples for DIC ($HgCl_2$ poisoned)
2 H_2O samples for $\delta^{18}O$

Collected emergent *Nymphaea* motoring away from LP4

Date: 21-December-2001

Coring Site LP-5 (near LP-2 station of May 30, 2001)
28°47'6.6" N, 82°06'47.2" W

water depth = 85 cm

LP5-21-XII-01-MW1
Upper section = 0-84 cm
Lower section =84-184 cm

Plants:

1 *Nymphaea*
1 *Vallisneria* leaves
1 *Vallisneria* roots
1 *Ceratophyllum*
1 *Najas*
1 *Hydrilla*
1 *Potamogeton*
1 Filamentous algae
1 *Nymphaea* with root/tuber

2 H_2O samples for DIC ($HgCl_2$ poisoned)
2 H_2O samples for $\delta^{18}O$

Filtered samples:

2 POC @ 300 ml
2 PTN @ 200 ml

2 filtered samples collected for $\delta^{13}C$ POC ~2.5 L each (acidified with ~1N HCl)

Snails collected in submerged macrophyte beds
2 surface (mud) sediments from dredge

Date: 21-December-2001

Station LP-6 (just off outlet)
28°48'26.3" N, 82°08'11.6" W

2 H_2O samples for $\delta^{13}C$ DIC ($HgCl_2$ poisoned)
2 H_2O samples for $\delta^{18}O$

Plants:

1 *Vallisneria* plant (root)
1 *Vallisneria* (leaves)
1 *Cladophora*

1 sediment dredge sample

2 POC @ 300 ml
2 PTN @ 200 ml

2 filtered samples collected for $\delta^{13}C$ POC (acidified with ~1N HCl)

LP-6 shore (near outlet)

Plants:

1 Bulrush root and leaves
1 *Typha*
1 *Pistia*
1 *Ceratophyllum*
1 *Hydrocotyle*
1 *Sagittaria*
1 *Najas*
1 *Potamogeton*

Snails

Date: 21-December-2001

Station LP-7

28°48'32.7" N, 82°08'6.8" W

Water depth = 2m

Plants:

1 *Vallisneria* leaves
1 *Vallisneria* root
1 *Najas*
1 surface sediment (dredge)
1 *Vallisneria* (periphyton)

2 H_2O samples for $\delta^{13}C$ DIC ($HgCl_2$ poisoned)
2 H_2O samples for $\delta^{18}O$

Station LP-8

28°48'40.0" N, 82°07'54.2" W

Water depth = 1.2 m

Plants:

Vallisneria epiphyte
Vallisneria root
Vallisneria leaves
Najas
Potamogeton

Station LP-9

28°48'40.4" N, 82°07'54.8" W

2 H_2O samples for $\delta^{18}O$

Potamogeton with seed head

Date: 21-December-2001

Station LP-10

28°48'35.8" N, 82°07'17.7" W

Water depth = 80 cm

2 H_2O samples for $\delta^{18}O$

snail

Plants:

1 *Potamogeton*
1 *Vallisneria* root
1 *Vallisneria* leaves
1 *Vallisneria* periphyton
1 *Najas*

sediment (dredge)
sediment (for ostracods)

Station LP-11

28°48'24.8" N, 82°07'4.10" W

Water depth = 40 cm

Plants:

1 *Najas*
1 *Nymphaea* leaves
1 *Nymphaea* roots

2 H_2O samples for $\delta^{18}O$
sediment for ostracods

Date: 21-December-2001
Station LP-12

28°48'08.5" N, 82°07'7.9" W

Plants:

1 *Ceratophyllum*
1 *Vallisneria* leaves
1 *Vallisneria* roots
1 *Potamogeton*
1 *Naja*
1 *Vallisneria* epiphyte
1 Aufwuchs (epiphytic material on macrophytes)

snails

Appendix II
Isotopic and Elemental Results on Vegetation

Site	Taxa	Date collected	$\delta^{15}N$ org	$\delta^{13}C$ org	%N	%C	C/N
Tracy Point Fish Camp	Bulrush (Scirpus)	30-V-01	-0.61	-28.02	1.67	46.18	27.7
LP-6-01	Bulrush Leaves	21-XII-01	0.35	-26.71	2.88	47.03	16.3
LP-6-01	Bulrush Root	21-XII-01	0.32	-26.20	1.35	46.00	34.1
Tracy Point Fish Camp	Pontederia	30-V-01	2.06	-26.92	2.31	46.95	20.3
LP-6-01	Sagittaria	21-XII-01	0.87	-28.45	3.13	46.55	14.9
Tracy Point Fish Camp	Salix	30-V-01	3.57	-27.28	2.49	53.32	21.4
Tracy Point Fish Camp	Typha	30-V-01	-0.33	-26.55	1.67	49.60	29.7
LP-6-01	Typha	21-XII-01	1.61	-26.18	1.49	47.13	31.6
Tracy Point Fish Camp	Unknown terrestrial	30-V-01	6.72	-26.67	2.47	51.07	20.7
		Average	1.62	-27.00	2.16	48.20	22.3
		St.Dev	2.31	0.79	0.64	2.55	
Tracy Point Fish Camp	pokeberry (outlier)	30-V-01	1.95	-12.52	4.58	42.63	9.3
LP-2-01	Ceratophyllum	30-V-01	-1.89	-19.53	3.17	47.02	14.8
LP-3-01	Ceratophyllum	30-V-01	-2.99	-16.96	3.16	48.16	15.2
LP-4-01	Ceratophyllum	21-XII-01	-1.08	-22.56	3.14	44.56	14.2
LP-5-01	Ceratophyllum	21-XII-01	-1.35	-21.52	2.83	42.17	14.9
LP-6-01	Ceratophyllum	21-XII-01	1.06	-18.96	3.62	41.85	11.6
LP-7-01	Ceratophyllum	21-XII-01	-2.71	-21.52	2.88	46.21	16.0
LP-12-01	Ceratophyllum	21-XII-01	0.73	-20.78	2.37	43.78	18.5
		Average	-1.18	-20.26	3.02	44.82	14.8
		St.Dev	1.57	1.91	0.39	2.41	
LP-6-01	Cladophora	21-XII-01	1.64	-19.94	5.76	44.41	7.7
TP FC	Cladophora	21-XII-01	3.11	-23.05	4.98	43.61	8.8
LP-6-01	Cladophora (other collection)	21-XII-01	2.18	-21.50	6.91	47.29	6.8
LP-1-01	Filamentous Algae	30-V-01	-0.26	-16.03	2.77	43.71	15.8
West shore	Filamentous Algae	30-V-01	1.07	-14.05	3.44	38.36	11.2
LP-4-01	Filamentous Algae	21-XII-01	-0.41	-15.80	2.89	44.46	15.4
LP-5-01	Filamentous Algae	21-XII-01	0.43	-19.08	3.58	42.65	11.9
		Average	1.11	-18.49	4.33	43.50	10.0
		St.Dev	1.30	3.30	1.58	2.69	

Site	Taxa	Date collected	$\delta^{15}N$ org	$\delta^{13}C$ org	%N	%C	C/N
LP-2-01	Hydrilla	30-V-01	-1.72	-11.77	3.62	44.45	12.3
LP-3-01	Hydrilla	30-V-01	-1.84	-10.81	3.19	44.12	13.8
LP-5-01	Hydrilla	21-XII-01	-0.50	-15.82	2.88	42.85	14.9
		Average	-1.35	-12.80	3.23	43.81	13.6
		St.Dev	0.74	2.66	0.37	0.84	
Tracy Point Fish Camp	Hydrocotyle	30-V-01	2.28	-27.29	2.56	47.54	18.6
LP-6-01	Hydrocotyle	21-XII-01	0.11	-26.83	2.22	47.70	21.5
		Average	1.20	-27.06	2.39	47.62	19.9
		St.Dev	1.53	0.33	0.24	0.11	
LP-4-01	Dredge Najas	21-XII-01	-2.31	-18.64	3.35	43.17	12.9
LP-3-01	Naja	30-V-01	0.81	-10.87	3.14	45.35	14.4
LP-1-01	Najas	30-V-01	2.03	-12.75	2.54	44.72	17.6
LP-2-01	Najas	30-V-01	-2.14	-12.40	2.69	44.90	16.7
LP-4-01	Najas	21-XII-01	-0.60	-17.70	2.95	42.44	14.4
LP-5-01	Najas	21-XII-01	-1.54	-17.60	2.97	42.68	14.4
LP-6-01	Najas	21-XII-01	0.97	-19.93	3.36	40.42	12.0
LP-7-01	Najas	21-XII-01	-0.60	-16.61	1.84	42.07	22.9
LP-8-01	Najas	21-XII-01	-4.42	-13.40	2.26	43.73	19.3
LP-10-01	Najas	21-XII-01	-7.11	-15.14	2.68	44.29	16.5
LP-11-01	Najas	21-XII-01	-4.09	-17.72	2.81	43.39	15.4
LP-12-01	Najas	21-XII-01	-0.99	-18.02	1.86	41.65	22.4
		Average	-1.67	-15.90	2.70	43.23	16.0
		St.Dev	2.58	2.90	0.51	1.46	
LP-5-01	Nymphaea and Root	21-XII-01	-1.12	-24.25	1.75	43.34	24.8
LP-2-01	Nymphaea mexicana	30-V-01	0.28	-24.72	3.41	47.63	14.0
LP-3-01	Nymphaea mexicana	30-V-01	-0.64	-24.16	2.86	45.77	16.0
LP-4-01	Nymphaea mexicana	21-XII-01	-4.41	-25.96	3.59	46.89	13.1
LP-5-01	Nymphaea mexicana	21-XII-01	-6.00	-25.82	4.65	47.89	10.3
LP-11-01	Nymphaea mexicana	21-XII-01	-6.51	-25.44	3.46	46.33	13.4
		Average	-3.07	-25.06	3.29	46.31	14.1
		St.Dev	2.94	0.79	0.95	1.65	

Site	Taxa	Date collected	$\delta^{15}N$ org	$\delta^{13}C$ org	%N	%C	C/N
LP-5-01	Nymphaea and Root	21-XII-01	-1.12	-24.25	1.75	43.34	24.8
LP-2-01	Nymphaea mexicana	30-V-01	0.28	-24.72	3.41	47.63	14.0
LP-3-01	Nymphaea mexicana	30-V-01	-0.64	-24.16	2.86	45.77	16.0
LP-4-01	Nymphaea mexicana	21-XII-01	-4.41	-25.96	3.59	46.89	13.1
LP-5-01	Nymphaea mexicana	21-XII-01	-6.00	-25.82	4.65	47.89	10.3
LP-11-01	Nymphaea mexicana	21-XII-01	-6.51	-25.44	3.46	46.33	13.4
		Average	-3.07	-25.06	3.29	46.31	14.1
		St.Dev	2.94	0.79	0.95	1.65	
LP-6-01	Pistia	21-XII-01	2.47	-25.03	3.06	44.91	
LP-1-01	Potamogeton	30-V-01	-6.39	-12.68	3.14	46.22	14.7
LP-3-01	Potamogeton	30-V-01	-2.11	-11.38	3.05	47.26	15.5
28 by 82 degrees	Potamogeton	30-V-01	1.12	-10.75	2.34	46.56	19.9
LP-5-01	Potamogeton	21-XII-01	2.27	-18.66	2.70	43.91	16.3
LP-6-01	Potamogeton	21-XII-01	1.62	-13.23	2.17	43.06	19.8
LP-8-01	Potamogeton	21-XII-01	-0.52	-12.46	1.89	44.77	23.7
LP-9-01	Potamogeton	21-XII-01	-0.15	-10.68	1.12	44.44	39.7
LP-10-01	Potamogeton	21-XII-01	-3.57	-13.21	1.65	45.31	27.5
LP-12-01	Potamogeton	21-XII-01	-3.49	-15.74	1.99	42.94	21.6
		Average	-1.25	-13.20	2.23	44.94	20.2
		St.Dev	2.86	2.57	0.66	1.53	

Site	Taxa	Date collected	$\delta^{15}N$ org	$\delta^{13}C$ org	%N	%C	C/N
LP-1-01	Vallisneria	30-V-01	4.60	-12.31	2.24	44.14	19.7
LP-2-01	Vallisneria	30-V-01	1.74	-13.38	2.46	44.27	18.0
LP-3-01	Vallisneria	30-V-01	1.85	-12.82	2.42	43.09	17.8
West shore	Vallisneria	30-V-01	-0.15	-12.24	2.63	45.21	17.2
LP-2-01	Vallisneria #2	30-V-01	2.61	-12.05	3.00	45.00	15.0
LP-4-01	Vallisneria Leaves	21-XII-01	-0.97	-15.47	1.54	18.50	12.0
LP-5-01	Vallisneria Leaves	21-XII-01	-2.83	-17.52	2.82	42.20	15.0
LP-6-01	Vallisneria Leaves	21-XII-01	0.18	-15.16	2.71	45.47	16.8
LP-7-01	Vallisneria Leaves	21-XII-01	-0.61	-15.55	3.05	45.05	14.8
LP-8-01	Vallisneria Leaves	21-XII-01	2.55	-13.00	2.19	44.25	20.2
LP-10-01	Vallisneria Leaves	21-XII-01	-2.57	-12.67	2.76	44.83	16.2
LP-12-01	Vallisneria Leaves	21-XII-01	0.38	-15.88	2.71	43.47	16.0
LP-4-01	Vallisneria Root	21-XII-01	-5.93	-17.52	4.48	44.50	9.9
LP-5-01	Vallisneria Root	21-XII-01	-2.36	-16.48	3.73	39.74	10.7
LP-6-01	Vallisneria Root	21-XII-01	-2.01	-15.65	4.09	45.12	11.0
LP-7-01	Vallisneria Root	21-XII-01	-4.54	-17.68	5.26	44.96	8.5
LP-8-01	Vallisneria Root	21-XII-01	0.86	-14.50	4.06	45.08	11.1
LP-10-01	Vallisneria Root	21-XII-01	-2.74	-17.51	5.06	46.87	9.3
LP-11-01	Vallisneria Root	21-XII-01	-4.56	-24.70	2.79	47.46	17.0
LP-12-01	Vallisneria Root	21-XII-01	-1.08	-17.24	5.00	45.97	9.2
		Average	-0.78	-15.47	3.25	43.26	13.3
		St.Dev	2.72	2.95	1.07	6.05	
LP-1-01	Vallisneria Periphyton	30-V-01	1.56	-13.04	3.46	37.27	10.8
LP-3-01	Vallisneria Periphyton	30-V-01	2.51	-29.69	4.21	40.03	9.5
LP-8-01	Vallisneria Periphyton	21-XII-01	0.76	-17.71	3.84	40.78	10.6
LP-10-01	Vallisneria Periphyton	21-XII-01	0.38	-20.48	4.24	40.10	9.5
LP-7-01	Vallisneria Epiphyton	21-XII-01	1.85	-20.22	3.65	34.63	9.5
LP-12-01	Vallisneria Epiphyton	21-XII-01	3.96	-20.30	2.81	33.74	12.0
		Average	1.84	-20.24	3.70	37.76	10.2
		St.Dev	1.18	4.96	0.49	2.77	
LP-12-01	Epiphytic Aufwuchs	21-XII-01	3.52	-23.42	3.42	35.00	10.2

Appendix III
Isotopic and Elemental Results on Filtered Plankton Samples

Site	Replica #	Date collected	$\delta^{13}C$ org	$\delta^{15}N$ org	%C/%N
LP-3-01	1	30-V-01	-23.78	1.06	7.18
LP-3-01	2	30-V-01	-23.60	1.04	
LP-3-01	3	30-V-01	-23.56	0.78	
LP-3-01	4	30-V-01	-23.76	0.54	
		mean	-23.67	0.86	
LP-1-01	1	30-V-01	-20.76	3.55	5.54
LP-1-01	2	30-V-01	-21.00	2.34	6.75
LP-1-01	3	30-V-01	-21.04	3.28	
LP-1-01	4	**30-V-01**	-20.98	3.32	
		mean	-20.95	3.12	
LP-4-01	1	21-XII-01	-17.53	2.03	7.95
LP-4-01	2	21-XII-01	-18.10	2.21	
		mean	-17.82	2.12	
LP-5-01	1	21-XII-01	-21.57	2.63	5.98
LP-5-01	2	21-XII-01	-22.21	2.52	
		mean	-21.89	2.58	
LP-6-01	1	21-XII-01	-26.37	2.00	6.08
LP-6-01	2	21-XII-01	-26.78	1.88	
		mean	-26.58	1.94	
LP-7-01	1	21-XII-01	-25.62	2.48	5.76
LP-7-01	2	21-XII-01	-26.33	2.39	
		mean	-25.98	2.44	

Appendix IV

Carbon Isotope Results of Dissolved Inorganic Carbon (DIC) and Oxygen Isotope Results of Water Samples from Lake Panasoffkee

Date collected	Station		$\delta^{13}C_{DIC}$ (‰ PDB)	$\delta^{18}O_{H2O}$ (‰ SMOW)
5/30/01	LP1			2.53
5/30/01	LP1			2.48
		average		2.51
5/30/01	LP2		-6.21	0.85
5/30/01	LP2		-6.59	0.52
		average	-6.40	0.68
5/30/01	LP3		-4.73	2.27
				2.25
		average		2.26
12/21/01	LP4		-3.41	
12/21/01	LP4		-3.55	
		average	-3.48	
12/21/01	LP5		-3.07	
12/21/01	LP5		-2.94	
		average	-3.01	
12/21/01	LP6		-2.26	
12/21/01	LP6		-1.86	
		average	-2.06	
12/21/01	LP7		-1.20	
12/21/01	LP7		-2.09	
		average	-1.65	
12/21/01	LP8		-1.87	
12/21/01	LP8		-1.38	
		average	-1.63	

Appendix V

Density, Loss-on-Ignition, Total Phosphorus and Radiometric Dating Results from Core LP-1-01

Depth Bot (cm)	Depth Mid (cm)	g dry/cc wet	g/cm2	LOI (proportion)	LOI (%)	TP (mg/g)	Pb-210	Ra-226	Cs-137
							-------- dpm/g dry ---------		
4	2	0.096	0.4	0.198	19.8	0.477	7.76	2.54	0.25
8	6	0.101	0.8	0.226	22.6	0.518	8.57	2.40	0.62
12	10	0.140	1.4	0.184	18.4	0.449	4.83	2.48	0.72
16	14	0.181	2.1	0.235	23.5	0.373	2.14	2.15	0.36
20	18	0.280	3.2	0.197	19.7	0.258	1.56	2.41	0.14
24	22	0.368	4.7	0.176	17.6	0.371	1.24	2.13	0.00
28	26	0.405	6.3	0.071	7.1	0.281	1.29	2.38	0.00
32	30	0.412	7.9	0.068	6.8	0.351	1.95	2.38	0.02
36	34	0.373	9.4	0.070	7.0	0.415	1.96	1.92	0.05
40	38	0.452	11.2	0.066	6.6	0.256	1.92	2.28	0.00
44	42	0.367	12.7	0.091	9.1	0.229	2.44	2.17	0.00
48	46	0.390	14.3	0.082	8.2	0.231	2.53	2.27	0.00
52	50	0.280	15.4	0.100	10.0	0.238			
56	54	0.444	17.2	0.077	7.7	0.273			
60	58	0.371	18.6	0.088	8.8	0.270			
64	62	0.361	20.1	0.088	8.8	0.296			
68	66	0.468	21.9	0.072	7.2	0.317			
72	70	0.404	23.6	0.080	8.0	0.374			
76	74	0.458	25.4	0.065	6.5	0.367			
80	78	0.472	27.3	0.083	8.3	0.398			
84	82	0.402	28.9	0.081	8.1	0.419			
88	86	0.414	30.5	0.084	8.4	0.370			
92	90	0.497	32.5	0.079	7.9	0.038			
96	94	0.428	34.2	0.089	8.9	0.360			
100	98	0.437	36.0	0.086	8.6	0.373			
104	102	0.460	37.8	0.076	7.6	0.036			

Depth Bot (cm)	Depth Mid (cm)	g dry/cc wet	g/cm2	LOI (proportion)	LOI (%)	TP (mg/g)
108	106	0.427	39.5	0.094	9.4	0.356
112	110	0.425	41.2	0.097	9.7	0.661
116	114	0.443	43.0	0.083	8.3	0.435
120	118	0.494	45.0	0.083	8.3	0.335
124	122	0.544	47.2	0.055	5.5	0.338
128	126	0.504	49.2	0.073	7.3	0.331
132	130	0.398	50.8	0.085	8.5	0.298
136	134	0.388	52.3	0.087	8.7	0.272

Appendix VI

Density, Loss-on-Ignition, Total Phosphorus and Radiometric Dating Results from Core LP-2-01

Depth Bot (cm)	Depth Mid (cm)	g dry/cc wet	g/cm2	LOI (proportion)	LOI (%)	TP (mg/g)	Pb-210	Ra-226	Cs-137
							-------- dpm/g dry ---------		
2	1	0.071	0.1	0.187	18.7	0.624	5.23	4.02	0.01
4	3	0.097	0.3	0.175	17.5	0.612	5.17	3.34	0.07
6	5	0.136	0.6	0.146	14.6	0.515	4.66	2.89	0.13
8	7	0.136	0.9	0.162	16.2	0.540	5.12	3.36	0.00
10	9	0.139	1.2	0.161	16.1	0.506	6.43	3.24	0.15
12	11	0.134	1.4	0.173	17.3	0.514	7.14	2.75	0.12
14	13	0.117	1.7	0.206	20.6	0.512	8.96	1.42	0.20
16	15	0.133	1.9	0.221	22.1	0.511	8.61	2.40	0.49
18	17	0.132	2.2	0.200	20.0	0.681	8.41	2.80	0.36
20	19	0.143	2.5	0.190	19.0	0.572	7.59	3.15	0.55
22	21	0.145	2.8	0.200	20.0	0.827	6.74	2.25	0.66
24	23	0.142	3.1	0.207	20.7	0.561	6.55	2.03	1.09
26	25	0.174	3.4	0.187	18.7	0.427	2.00	1.96	0.79
28	27	0.143	3.7	0.196	19.6	0.439	6.09	3.91	1.08
30	29	0.169	4.0	0.189	18.9	0.492	4.30	4.07	0.54
32	31	0.180	4.4	0.171	17.1	0.478	4.43	3.88	0.09
34	33	0.200	4.8	0.173	17.3	0.431	4.83	3.91	0.09
36	35	0.201	5.2	0.154	15.4	0.482	4.69	4.71	0.00
38	37	0.251	5.7	0.120	12.0	0.380	4.68	3.55	0.04
40	39	0.227	6.1	0.126	12.6	0.465	1.93	3.86	0.00
44	42	0.248	7.1	0.118	11.8	0.384			
48	46	0.290	8.3	0.104	10.4	0.351			
52	50	0.299	9.5	0.111	11.1	0.372			
56	54	0.277	10.6	0.116	11.6	0.383			
60	58	0.352	12.0	0.090	9.0	0.343			
64	62	0.334	13.3	0.090	9.0	0.358			
68	66	0.321	14.6	0.101	10.1	0.334			
72	70	0.459	16.5	0.067	6.7	0.315			
76	74	0.354	17.9	0.093	9.3	0.337			
80	78	0.325	19.2	0.113	11.3	0.310			
84	82	0.323	20.5	0.102	10.2	0.352			
88	86	0.349	21.9	0.116	11.6	0.341			
92	90	0.283	23.0	0.116	11.6	0.361			
96	94	0.335	24.3	0.110	11.0	0.341			

Depth Bot (cm)	Depth Mid (cm)	g dry/cc wet	g/cm2	LOI (proportion)	LOI (%)	TP (mg/g)
100	98	0.353	25.7	0.103	10.3	0.489
104	102	0.385	27.3	0.107	10.7	0.432
108	106	0.356	28.7	0.112	11.2	0.440
112	110	0.408	30.3	0.093	9.3	0.419
116	114	0.349	31.7	0.124	12.4	0.474
120	118	0.445	33.5	0.089	8.9	0.434
124	122	0.383	35.1	0.104	10.4	0.468
128	126	0.399	36.6	0.093	9.3	0.470
132	130	0.442	38.4	0.086	8.6	0.445
136	134	0.378	39.9	0.098	9.8	0.473
140	138	0.391	41.5	0.109	10.9	0.470

Appendix VII
Geochemical Data for Core LP-1-01

Core	Depth	$\delta^{13}C$ Tryonia	$\delta^{18}O$ Tryonia	$\delta^{15}N$ OrgC	$\delta^{13}C$ OrgC	$\delta^{13}C$ ostra.	$\delta^{18}O$ ostra.	%N	%C	%C/%N	$\%CaCO_3$
	cm	PDB, permil	PDB, permil	AIR, permil	PDB, permil	PDB, permil	PDB, permil	Acidified	Acidified		
LP-1-01	4			0.48	-22.91			1.06	18.62	17.61	78.86
LP-1-01	8			-0.02	-24.54	-3.79	-0.73	1.15	19.35	16.81	75.09
LP-1-01	12			-0.38	-25.15			1.17	19.48	16.71	80.86
LP-1-01	16	-4.05	-2.05	-1.51	-26.16			0.82	17.51	21.34	80.83
LP-1-01	20	-4.55	-2.09	-2.31	-26.46	-2.96	-0.47	0.66	16.25	24.80	83.78
LP-1-01	24	-4.98	-1.62	-2.31	-26.35	-3.68	0.04	0.56	15.62	27.68	87.60
LP-1-01	28	-5.14	-2.14	-2.32	-26.21	-2.00	-1.59	0.45	14.56	32.55	90.88
LP-1-01	32	-5.25	-1.92	-1.87	-25.08	-3.55	-1.39	0.65	15.67	24.22	90.31
LP-1-01	36	-5.25	-2.30	-1.72	-24.10	-2.86	-0.81	0.51	15.20	29.96	89.16
LP-1-01	40	-5.14	-1.84	-1.21	-24.34	-1.97	0.49	0.55	15.17	27.61	90.42
LP-1-01	44	-2.98	-1.44	-1.06	-24.43	-4.62	0.45	0.61	15.85	26.19	89.55
LP-1-01	48	-1.85	-0.98	-1.48	-25.03	-1.70	0.60	0.58	15.55	26.58	83.33
LP-1-01	52	-5.00	-1.79	-1.24	-25.90	-2.23	0.18	0.70	16.25	23.05	88.11
LP-1-01	56	-3.87	-1.20	-1.64	-26.28	-2.97	0.05	0.54	15.32	28.30	89.91
LP-1-01	60	-3.52	-1.35	-1.94	-26.77	-2.74	0.51	0.59	15.65	26.51	87.54
LP-1-01	64	-3.42	-1.79	-2.25	-27.13	0.91	-0.31	0.50	15.31	30.37	89.43
LP-1-01	68	-3.93	-1.38	-2.27	-27.21	-1.42	-0.02	0.48	15.22	31.82	88.84
LP-1-01	72	-3.86	-1.06	-1.99	-26.69	-3.92	0.54	0.53	15.46	29.29	89.47
LP-1-01	76	-5.31	-1.48	-2.20	-27.14	-2.31	0.46	0.53	15.14	28.74	89.88
LP-1-01	80	-3.77	-1.85	-2.15	-26.74	-1.17	0.99	0.53	15.42	29.07	88.00
LP-1-01	84	-3.58	-1.69	-1.94	-25.89	-2.20	0.06	0.49	15.52	31.99	88.58
LP-1-01	88	-4.22	-1.57	-1.88	-25.38	-1.35	-0.64	0.47	15.28	32.74	88.25
LP-1-01	92	-1.88	-1.18	-1.70	-25.46	-4.01	-0.12	0.46	14.81	31.86	89.45

Core	Depth	$\delta^{13}C$ Tryonia	$\delta^{18}O$ Tryonia	$\delta^{15}N$ OrgC	$\delta^{13}C$ OrgC	$\delta^{13}C$ ostra.	$\delta^{18}O$ ostra.	%N	%C	%C/%N	$\%CaCO_3$
	cm	PDB, permil	PDB, permil	AIR, permil	PDB, permil	PDB, permil	PDB, permil	Acidified	Acidified		
LP-1-01	96	-3.09	-0.70	-1.66	-25.43	-3.87	-0.68	0.50	15.21	30.28	89.09
LP-1-01	100	-3.69	-0.69	-1.94	-26.19	-3.07	-0.59	0.56	15.55	27.93	88.08
LP-1-01	104	-3.79	-1.50	-2.30	-26.23	-2.84	0.24	0.51	15.15	29.81	88.30
LP-1-01	108	-2.41	-1.02	-1.74	-25.74	-1.50	-0.19	0.50	15.47	31.02	87.85
LP-1-01	112	-3.80	-1.83	-1.40	-24.90	-1.52	0.55	0.59	15.89	27.07	86.23
LP-1-01	116	-3.97	-1.33	-2.08	-25.30	-0.98	-0.21	0.47	15.36	32.96	87.28
LP-1-01	120	-3.51	-1.25	-2.54	-25.52	-1.90	-1.24	0.45	15.11	33.59	88.97
LP-1-01	124	-4.62	-1.40	-2.45	-24.30	-2.74	0.65	0.46	14.95	32.44	91.46
LP-1-01	128	-0.23	-0.69	-1.98	-24.30	-1.34	-0.13	0.48	15.26	31.57	85.12
LP-1-01	132	-3.19	-0.76	-1.98	-24.94	0.42	-0.39	0.53	15.50	29.24	90.07
LP-1-01	136	-2.01	-1.73	-2.22	-24.47	0.95	-0.63	0.47	15.12	32.25	82.24
LP-1-01	140	-1.47	-1.42	-2.20	-24.43	2.51	0.94				

Appendix VIII
Geochemical Data for Core LP-2-01

Core	Depth	$\delta^{13}C$ Tryonia	$\delta^{18}O$ Tryonia	$\delta^{15}N$ OrgC	$\delta^{13}C$ OrgC	$\delta^{13}C$ ostra.	$\delta^{18}O$ ostra.	%N	%C	%C/%N	$\%CaCO_3$
	cm	PDB, permil	PDB, permil	AIR, permil	PDB, permil	PDB, permil	PDB, permil	Acidified	Acidified		
LP2-01	2			-0.84	-23.07			1.17	18.66	16.01	69.33
LP2-01	4	-3.80	-2.15	-0.83	-22.71			1.02	17.63	17.23	78.02
LP2-01	6	-6.44	-2.42	-0.19	-23.17			1.00	17.68	17.63	86.22
LP2-01	8	-6.92	-1.38	-0.67	-23.76			1.02	18.03	17.72	80.23
LP2-01	10			-0.82	-23.96			1.02	18.08	17.79	79.93
LP2-01	12	-6.71	-2.59	-0.14	-24.10	-3.84	-1.74	1.06	18.42	17.37	78.10
LP2-01	14			-0.37	-24.72	-5.70	-1.52	1.25	19.48	15.64	75.06
LP2-01	16			-0.11	-24.74			1.28	19.81	15.47	72.57
LP2-01	18	-8.20	-3.91	-0.23	-24.68	0.20	0.40	1.22	19.30	15.82	77.20
LP2-01	20	-7.44	-1.59	-0.55	-24.57	-3.64	-0.84	1.12	18.99	16.90	76.53
LP2-01	22	-4.64	-2.44	-0.76	-24.87	-1.54	-0.04	1.22	19.39	15.85	73.71
LP2-01	24	-4.11	-1.68	-0.82	-25.03	-6.15	-3.22	1.15	19.19	16.76	75.69
LP2-01	26	-4.40	-2.68	-1.25	-25.31	-1.79	0.46	1.12	18.62	16.70	75.55
LP2-01	28	-4.65	-2.18	-1.63	-25.66	-3.21	-0.31	1.04	18.63	17.94	74.15
LP2-01	30	-5.81	-2.77	-2.00	-26.09	-3.18	-0.12	1.15	18.86	16.43	76.37
LP2-01	32	-4.62	-2.38	-1.84	-26.38	-3.24	0.05	0.98	18.00	18.37	78.96
LP2-01	34	-4.75	-1.87	-1.76	-26.27	-4.04	0.10	0.91	18.00	19.68	75.85
LP2-01	36	-4.60	-2.58	-2.56	-26.28	-4.29	0.33	0.99	17.52	17.66	82.56
LP2-01	38	-5.87	-2.13	-2.67	-25.95	-2.43	0.37	0.74	16.71	22.52	83.69
LP2-01	40	-3.87	-1.83	-3.04	-25.80	-3.62	0.10	0.77	16.75	21.68	84.16
LP2-01	44	-3.75	-1.75	-2.76	-25.47	-3.01	0.40	0.67	16.20	24.29	85.61
LP2-01	48	-4.61	-1.93	-2.88	-25.70	-1.74	-0.51	0.63	16.10	25.74	80.53
LP2-01	52	-5.12	-2.17	-2.60	-26.11	-2.00	0.86	0.69	16.34	23.58	91.27
LP2-01	56	-4.14	-2.00	-2.42	-25.61	-2.83	-0.29	0.66	16.43	24.95	86.09
LP2-01	60	-3.84	-1.95	-2.53	-25.13	-3.97	-0.51	0.58	15.68	27.21	83.41
LP2-01	64	-3.61	-2.05	-2.14	-23.52	-2.28	-0.37	0.61	15.69	25.85	88.19
LP2-01	68	-4.42	-1.79	-1.66	-23.24			0.64	16.19	25.21	88.47
LP2-01	72	-1.85	-2.19	-1.95	-24.47			0.58	15.44	26.54	90.70
LP2-01	76	-4.71	-2.71	-1.41	-24.40	-2.24	-0.90	0.58	15.79	27.14	79.62

Core	Depth	$\delta^{13}C$ Tryonia	$\delta^{18}O$ Tryonia	$\delta^{15}N$ OrgC	$\delta^{13}C$ OrgC	$\delta^{13}C$ ostra.	$\delta^{18}O$ ostra.	%N	%C	%C/%N	$\%CaCO_3$
	cm	PDB, permil	PDB, permil	AIR, permil	PDB, permil	PDB, permil	PDB, permil	Acidified	Acidified		
LP2-01	80	-4.75	-1.66	-1.50	-25.09	0.36	1.07	0.75	16.50	21.88	76.24
LP2-01	84	-5.05	-1.78	-1.40	-25.76	-0.02	-0.97	0.73	16.37	22.37	91.18
LP2-01	88	-4.75	-1.26	-1.79	-26.34	-3.08	-0.74	0.73	16.58	22.57	85.75
LP2-01	92	-4.23	-1.78	-1.58	-26.46	-0.58	0.21	0.72	16.54	22.93	85.24
LP2-01	96	-3.34	-2.05	-1.90	-26.50	-2.28	0.68	0.64	16.21	25.29	84.54
LP2-01	100	-3.38	-1.23	-2.06	-26.94	-2.17	0.00	0.65	16.23	25.10	85.34
LP2-01	104	-2.59	-1.46	-2.00	-27.02	-2.24	0.37	0.68	16.47	24.25	71.63
LP2-01	108	-3.49	-1.04	-1.32	-26.26	-2.98	0.06	0.66	16.47	24.88	88.64
LP2-01	112	-5.40	-1.25	-1.93	-26.39	-2.12	-0.55	0.59	16.02	27.32	81.36
LP2-01	116	-1.50	-1.08	-2.41	-26.81			0.70	16.76	23.99	81.09
LP2-01	120	-2.43	-0.51	-2.37	-27.14	-2.83	0.45	0.55	15.78	28.61	85.19
LP2-01	124	-3.19	-1.10	-2.43	-26.87	-1.82	1.19	0.60	15.67	26.32	86.06
LP2-01	128	-3.76	-1.61	-2.27	-26.49	-2.49	0.27	0.59	15.95	27.21	88.40
LP2-01	132	-4.08	-2.03	-2.06	-25.90	-2.56	-0.20	0.55	15.64	28.52	88.02
LP2-01	136	-1.35	-1.20	-2.11	-25.46	-1.43	-0.50	0.60	15.94	26.57	88.54
LP2-01	140	-4.07	-0.86	-2.13	-25.52	-1.64	-0.60	0.66	16.36	24.88	86.88

Appendix IX
Macrofossil Results from Cores LP-01-01 and LP-2-01

LP-1-01	sample size (cc)	overall abund.	vegetative Cerato-phyllum	tubular	strands flat	black	node	anther	other stem	floral head minute	leaf frag.	seeds Najas	Vallisneria
4	3	*	*	*	*	*	6	1					
8	9	**	*	**		*	4						
12	13	**	*	**	*	*	2						
16	14	**	*	**			1						
20	14	*	*	**		*							
24	10	*	*	*		*			*	1		1	1
28	9	*	*	*				1					
32	17	**	*	*	*	*							
36	17	***	*	**	*	*			*				
40	16	***	*	**	*		3						
LP-2-01													
4	2	**	*	*		*			*			6	
8	5	**	*	*	*	*			*			7	1
12	7	**	*	*	*	*	4		*			4	
16	4	**	*	*		*	4					2	
20	7	**	*	*	*		3				1	3	
24	7	***	*	*		*	2					1	1
28	7	*	*	*			1					2	
32	9	*	*	*	*								1
36	7	*	*	*									
40	12	*		*								1	

LP-1-01	size (cc)	Pota-mogeton	Eleocharis	Cheno-podium	Asteraceae striate type	Asteraceae smooth type	large warty	Arabis type	black bean 1	black bean 2	caddisfly	egg	pod-like
4	3							2			*	*	
8	9										*		
12	13										*	*	
16	14								1			*	
20	14										*		*
24	10					1					*	*	**
28	9										*		**
32	17												**
36	17												**
40	16	1						1			*	*	*
LP-2-01													
4	2							2			*		
8	5				2	1		3			*	*	
12	7				2		1	1			*	*	
16	4										*		
20	7				3						*		
24	7										*		
28	7												
32	9			2						2			
36	7					1							
40	12		1										*

Appendix X
Pollen Counts and Percentages by Depth (cm) for LP-1-01

	4	8	12	16	20	24	28	32	36	40
Pinus	22.3	25.9	25.4	27.6	29.9	29.1	30.9	34.2	31.8	32.5
Quercus	35.5	32.4	26.3	19.9	15.0	12.2	17.9	16.0	18.2	16.4
Taxodium-type	16.9	11.3	15.3	18.4	30.8	32.3	26.0	22.7	26.0	26.2
Liquidambar	2.1	2.0	2.1	2.3	1.4	2.9	2.0	2.1	1.8	1.2
Fraxinus	1.5	0.9	0.8	2.5	1.5	1.0	1.1	1.8	1.0	0.8
Carya	0.8	0.7	1.5	0.9	1.3	1.3	1.0	1.2	1.5	1.1
Carpinus/Ostrya	0.6	1.1	0.5	0.6	0.6	0.5	0.6	1.2	0.6	1.0
Myrica	1.5	2.0	3.9	3.4	1.0	1.7	1.5	1.1	1.1	0.4
Nyssa	0.2	0.0	0.0	0.0	0.1	0.2	0.3	0.0	0.0	0.2
Fagus	0.0	0.5	1.0	0.3	0.1	0.0	0.0	0.0	0.4	0.0
Ulmus	1.0	1.4	1.6	2.0	0.8	0.2	0.9	1.1	0.5	0.6
Salix	0.0	0.0	0.2	0.0	0.1	0.3	0.0	0.2	0.0	0.1
Acer	0.4	0.5	0.3	0.6	0.1	0.0	0.0	0.3	1.0	0.2
Alnus	0.0	0.0	0.2	0.2	0.1	0.2	0.1	0.2	0.1	0.1
Ericaceae	0.0	0.2	0.0	0.2	0.1	0.2	0.1	0.0	0.1	0.0
Poaceae	2.3	1.8	2.3	1.4	1.4	1.0	1.9	2.7	1.2	1.9
Cyperaceae	1.5	1.1	2.9	2.8	1.8	1.7	1.0	1.8	1.7	2.6
Chenopodiaceae-Amaranthaceae	8.8	13.2	9.4	12.3	9.6	13.3	12.4	9.0	11.0	12.6
Asteraceae	3.5	4.3	4.8	3.7	2.8	0.6	0.9	0.8	0.6	1.2
Sagittaria	0.4	0.0	0.0	0.2	0.3	0.1	0.1	0.3	0.5	0.2
Potamogeton	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Lemna	0.2	0.5	1.0	0.5	1.0	0.9	0.8	1.2	0.2	0.4
Nymphaea	0.2	0.0	0.0	0.0	0.0	0.0	0.1	2.0	0.0	0.1
Typha	0.2	0.2	0.6	0.2	0.0	0.1	0.3	0.2	0.4	0.2
Algal 1	0.2	0.0	0.0	0.0	5.1	3.6	2.8	1.2	0.0	0.3
Algal 2	0.4	0.5	0.8	2.0	1.4	2.1	3.7	6.1	3.3	0.8
Pediastrum	10.7	16.3	12.8	7.8	4.0	1.3	1.0	0.8	0.4	0.7
Eucalyptus spike	94	82	83	61	68	51	99	102	94	105
Aquatic Algae	11.3	16.8	13.6	9.8	10.5	6.9	7.5	6.1	3.7	1.8
Herbs	16.1	20.4	19.4	20.2	15.6	16.6	16.2	14.3	14.5	18.3
Aquatic Macrophytes	1.2	0.7	1.6	0.8	1.3	1.1	1.3	3.7	1.3	0.9
Trees and Shrubs	82.7	78.9	79.0	79.0	83.1	82.2	82.5	82.0	84.1	80.8
Pollen Sum	521	441	619	642	782	872	784	657	818	1004

Appendix XI
Pollen Counts and Percentages Listed by Depth (cm) for LP-2-01

	4	8	12	16	20	24	28	32	36	40
Pinus	13.5	20.5	23.4	22.8	21.2	26.3	25.8	26.7	33.3	35.3
Quercus	50.7	50.2	42.7	38.4	39.5	31.3	24.0	21.9	18.6	16.1
Taxodium-type	6.4	4.7	5.8	7.8	7.3	7.0	9.0	13.0	16.1	18.0
Liquidambar	2.4	2.5	2.9	2.2	1.8	3.0	2.0	1.2	1.5	1.9
Fraxinus	1.3	3.2	0.9	3.3	2.2	2.0	2.4	2.6	1.2	2.5
Carya	0.5	0.6	0.6	1.7	1.6	0.7	1.5	1.5	0.7	1.3
Carpinus/Ostrya	1.1	0.6	0.9	0.8	0.6	0.5	0.7	1.1	1.1	0.6
Myrica	4.2	2.8	2.3	1.9	2.6	3.8	2.2	3.5	2.5	1.6
Nyssa	0.8	0.0	0.3	0.3	0.4	0.0	0.3	0.0	0.5	0.2
Fagus	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.2	0.0
Morus	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.4	0.2
Ulmus	1.3	1.6	1.2	1.7	0.4	1.2	0.6	1.1	0.6	0.9
Salix	0.3	0.0	0.0	0.6	0.6	0.3	0.3	0.2	0.2	0.2
Acer	1.3	0.6	0.0	0.0	0.2	0.2	0.6	0.0	0.4	0.2
Alnus	0.0	0.3	0.0	0.0	0.2	0.0	0.3	0.0	0.1	0.2
Ericaceae	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0
Poaceae	3.4	2.5	3.5	2.5	2.6	3.0	1.4	1.8	0.5	1.7
Cyperaceae	0.8	0.6	2.0	2.2	2.4	1.7	1.8	1.5	1.6	1.1
Chenopodiaceae-Amaranthaceae	6.1	4.7	6.1	8.9	10.5	14.1	19.5	19.0	16.1	16.9
Asteraceae	4.5	3.5	6.4	4.2	5.0	4.0	5.8	3.6	2.7	0.9
Sagittaria	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.2	0.0	0.2
Potamogeton	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lemna	0.0	0.6	0.0	0.0	0.2	0.0	0.6	0.6	0.9	0.0
Nymphaea	0.0	0.3	0.0	0.0	0.2	0.3	0.6	0.2	0.0	0.0
Typha	1.1	0.0	0.3	0.3	0.2	0.2	0.1	0.2	0.5	0.2
Algal 1	0.0	0.3	0.0	0.0	0.8	0.0	0.6	0.8	1.2	0.2
Algal 2	0.0	0.0	0.0	0.0	0.2	0.2	0.3	0.3	1.6	2.2
Pediastrum	8.0	11.7	6.7	15.0	14.5	5.1	9.0	2.6	1.4	0.9
Algal Types	8.0	12.0	6.7	15.0	15.5	5.3	9.8	3.6	4.2	3.3
Herbs	14.9	11.4	18.1	17.8	20.6	22.7	28.5	26.0	20.9	20.7
Aquatic Macrophytes	1.1	0.9	0.9	0.6	0.8	1.0	1.3	1.4	1.5	0.3
Trees and Shrubs	84.1	87.7	81.0	81.6	78.6	76.3	70.2	72.7	77.6	79.0
Pollen Sum	377	317	342	359	496	604	712	662	807	634