APPENDIX 1
Public and Peer Review Panel Comments

Appendix 1-3
Authors Responses to Comments

Appendix 1-3b
Author's Response to Comments on Chapter 2

Chapter 2: Hydrological Needs: The Effects of Hydrology on the Everglades

Authors Responses to Comments on Chapter 2

Reviewer: Walter Dodds:

Author: Shili Miao

Comment: 1. p.2-31, Are Typha or Cladium mycorrhizal?

Response: I did not find any literature studying mycorrhizae of Typha and Cladium. However, I know of one ongoing study conducted by Dr. Jayachandran at FIU may suggest that sawgrass is mycorrhizal.

Comment: 2. p.2-31. What are the actual differences between these species in response to flooding stress?

Response: The text in chapter 2 has been edited to highlight more of the actual differences. However to clarify: Both species exhibit contrasting differences in flooding tolerance in aspects of internal gas transportation and root anatomy, morphology, and physiology. First, Pressurized gas flow to enhance root and soil oxygen concentration was discovered in *Typha* but not in *Cladium.* In *Cladium*, gas transportation is simply via molecula diffusion. It has been suggested that plants with the mechanism of presurrized gas flow are more flood tolerant in comparison with plants with diffusion mechanism.

Second, in 2000 report, we reported that both species exhibited different root anatomy. Recent results showed that shows that *Typha* responded more than *Cladium* to changes in soil moisture by increasing air space development in the root apex (**Figure 2-13**). Both species increase oxygen release to the sediments in response to flooding stress. However, oxygen release to the sediments from *Typha* roots greatly exceeded that from *Cladium* roots (**Figure 2-14**). As a result, *Typha* can maintain an oxidized rhizosphere under flood conditions in relation to *Cladium*.

Third, both species developed different root systems. Phosphorus loading and water depths had impacts on root development of both species (Mckee et al. In internal review). Typha produced an extensive and deep, fibrous root system (**Figure 2-15**). Within one month of transplantation, most plants had produced about 20 primary roots, and most primary roots had secondary lateral roots that were typically long and very thin. In contrast, *Cladium* produced only 2 primary roots, but some had produced 3 or 4 roots by the end of one month (**Figure 2-15**). *Typha* produces many more primary roots per plant than *Cladium* (24 vs 4 roots, respectively) ($P<0.0001$). The maximum root length of *Typha* (21-41 cm) is also greater than *Cladium* (3-18 cm) ($P<0.0001$). Thus, the soil volume exploited by *Typha* is several times greater than that of *Cladium*. *Typha* produces longer, finer lateral roots than *Cladium*, which increases the surface area per unit root mass for P absorption. Individual root elongation rates by *Typha* (0.71 cm d^{-1}) are significantly faster than *Cladium* (0.47 cm d^{-1}) ($P<0.0001$). Thus, the potential for P-acquisition through root interception may be greater for *Typha*.

Finally, root alcohol dehydrogenase activity (ADH) and ethanol concentration, indicators of alcoholic fermentation, were greater in *Cladium* than *Typha*, although both species showed increases. These results strongly suggest that *Cladium* is more subject to root oxygen deficiencies than *Typha*. Therefore, *Typha* is more flooding tolerant than *Cladium*. For example, a germination experiment (**Figure 1**) suggested that flooded treatment significantly inhibited the germination of cattail seeds and the survival of seedlingls (Miao et al., 2000).

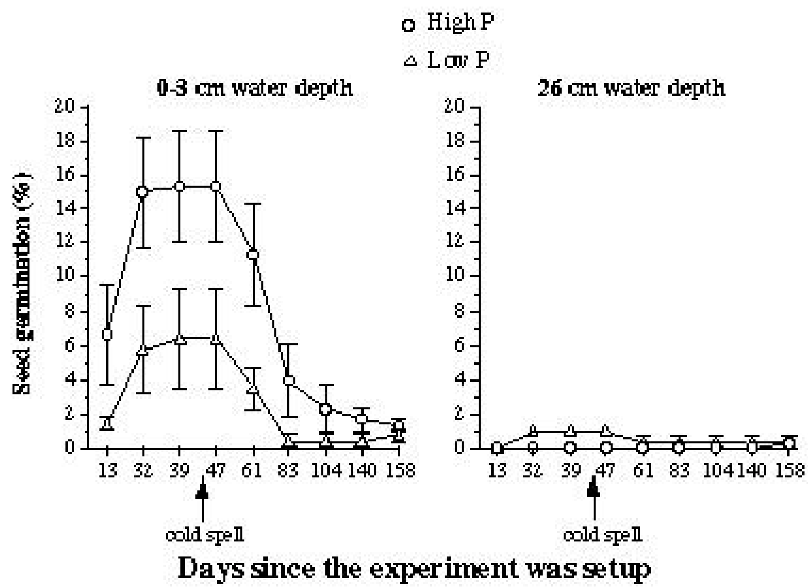

Figure 1. Germination percentage (mean±1SE) over time in tanks receiving cattail seed addition located outdoor in full sun, (a) at water depth of 0-3 cm and (b) at water depth of 26 cm.

Reviewer: Rebecca Sharitz:

Author: Fred Sklar

Comment: 1. A map is needed that shows structure locations and gauge loactions.

Response: All structures and levees such as L-67A and C-111 are shown in Figure 2-3 of the 1999 Everglades Interim Report. However, the rain gauges and water level recorders discussed in chapter 2 are not shown. A new figure showing these sites will be inserted into Chapter 2.

Comment: 2. The section on cattail and sawgrass needs clarification and better integration. The ability of phosphorus to alter the timing of plant life cycles was not demonstarted as claimed.

Response: These concerns are well founded. This section has been revised accordingly.

Comment: 3. Many aspects of the "applied science strategy" are not clear.

Response: The use of conceptual models in the Everglades restoration process is a complex discussion. The details of these models can be found in the documentation associated with the Comprehensive Everglades Restoration Plan and a white paper written by Ogden and Davis (June 29, 199) at the SFWMD.

Comment: 4. Pg 2-9, parag. 1

Response: The deeper water regulation schedule for WCA1 is based upon the need to manage for water fowl and the historical evidence that this area was once "lake-like" in hydrology.

Comment: 5. Pg 2-23, parag. 4, sent. 5

Response: These concerns are well founded. This sentence has been revised accordingly.

Comment: 6. Pg 2-29, 2-30 and 2-31

Response: All questions related to experiments on cattail and sawgrass are addressed in the modified text.

Comment:7. Pg 2-50. Why are the number of nests in the ENP still low?

Response: In the last decade, the proportion of Everglades wading birds that nest in ENP has declined while the proportion in the WCAs has increased. Currently the proportion of Everglades wading birds in ENP is about 7%. One hypothesis for the shift in nesting is that hydrologic conditions and food availability in ENP is lower relative to the WCAs. However, the precise mechanism driving those changes is still unknown. Research is underway at the SFWMD aimed at determining how hydrologic patterns make food available to different species of wading birds.

Comment: 8. Pg 2-52.

Response: Much has been informally said and some have been published on the significance of interannual hydrologic variation in relation to the general health of the Everglades. It seems that the NSM predicts greater differences between highs and lows than are currently measured. The diversity data suggest that such a variance can effect invertebrates. However, more spatial articulation is needed before such a conclusion is possible.

Comment: 9. Pg 2-57 and 2-58

Response: A list of conceptual models was added. Symbols used in Fig 28 are described in the figure caption.

Reviewer: Sujoy Roy and Steven Gherini, Tetra Tech, Inc.

Author: Christopher McVoy

Comment: 1. Our overview of the historical Everglades suggest the need for man-made, nutrient–enriched zones in the ridge & slough landscape as part of the restoration program.

Response: On behalf of the Sugar Cane Growers Cooperative of Florida, Roy and Gherini of Tetra Tech, Inc., examined twelve pre-drainage or early post-drainage primary sources regarding Lake Okeechobee and the northern Everglades, as well as three secondary sources. Based on these sources, a radiocarbon dating study, and a computer modeling exercise, the authors developed a pre-drainage picture of the Okeechobee-Everglades system. From this pre-drainage picture, the authors conclude that creation of a man-made, nutrient-enriched zone along the northern edge of Water Conservation Area 2A would “develop some of the [lost] ecological niches” and “lead to a restoration that comes closer to providing the heterogeneity of habitats that was vital to the historical Everglades.” According to the authors, not creating a nutrient-enriched zone will lead to a sterile environment of homogeneous sawgrass. The authors also postulate that creation of an enriched zone in this particular location, northern WCA 2A is supported by what they believe to have been a former shoreline of Lake Okeechobee. Finally, the authors postulate that such a man-made enriched zone would remain stable, rather than expand southward as a continually “moving front.”

This approach--inference of ecological restoration goals from an understanding of the pre-drainage ecology--is certainly valid. Of course, such an approach depends critically on the accuracy of the pre-drainage understanding. Additionally, the picture must be accurate for the right reasons: causal mechanisms must be correctly identified. Roy and Gherini are correct in noting important spatial differences in wildlife abundance and vegetation type between different pre-drainage Everglades landscapes. However, Roy and Gherini are incorrect in concluding that the vegetation differences—which they associate with wildlife differences—were created by elevated phosphorus concentrations. Roy and Gherini’s analysis fails at two levels: (1) by assuming that correlation of spatial gradients implies causation; and (2) by inaccurately identifying the spatial gradients themselves. For these reasons, Roy and Gherini’s conclusions regarding the importance of establishing a nutrient (phosphorus) enriched zone must be rejected.

We look first at the spatial gradients, comparing Roy and Gherini’s picture with a picture developed from the sources listed chronologically in Table 1. Roy and Gherini discuss four gradients in the pre-drainage Everglades, extending from Lake Okeechobee southward through the Everglades:

Vegetation (N to S): custard apple, elderberry, and sawgrass zones;

Bird and wildlife abundancy and diversity, decreasing southward;

Soil (peat) thickness, decreasing southward; and a

Soil phosphorus concentration, decreasing southward.

Roy and Gherini’s central postulate is that a transition zone associated with the soil phorphorus concentration was responsible for creating the other three gradients. The reviewer agrees with the pre-drainage presence of downstream changes in all four of these variables. However, careful examination of the four spatial gradients indicates that the patterns in fact do not reflect monotonic declines with distance from the Lake. Reexamination of the sources used by Roy and Gherini, and comparison of the spatial patterns suggests more plausible, non-phosphorus-based causal mechanisms.

Wildlife and wading birds. Roy and Gherini state that the pre-drainage Everglades, “contained zones of higher productivity and greater wildlife abundance and diversity that were supported by elevated nutrient levels” (p. 3). They base this hypothesis on pre-drainage narratives which reported flocks of wading birds in the custard apple swamp adjacent to Lake Okeechobee, but little or no wildlife in the Sawgrass Plains south of the custard apple swamp. This comparison is likely correct, but incomplete. By extending the transect further south, through the Sawgrass Plains and into the Ridge and Slough landscape, an <u>increase</u> in wildlife would have again been found, particularly alligators, otters, large fish (Kersey 1975; Advisory Committee 1944), and, during the lower water time of the year, wading birds. The transect therefore included two peaks in wildlife abundance, one directly adjacent to the Lake and one more than 30 miles away, with an intervening zone of low abundance in the Sawgrass Plains.

The low abundance in the Sawgrass Plains likely was related to the uniformity of this landscape: a vast, almost perfectly flat area with neither elevated nor deeper spots. The dense, eight to twelve foot tall canopy greatly restricted both light penetration and physical access to the underlying water, and left no areas of open water. The relative abundance of wildlife in the Custard Apple Swamp and in the Ridge and Slough landscape is most likely related to the proximity, in both landscapes, of elevated areas with trees (roosts) next to open water areas, the latter containing both prey as well as accessible water depths (during part of year).

Vegetation. As noted above, Roy and Gherini assume that the presence of the Custard Apple Swamp was due to elevated nutrients, particularly phosphorus. This ignores two other important aspects of the custard apple area, both of which have been associated with the custard apple presence, namely soil type and elevation. The soil directly adjacent to the southern border of the Lake (as far west as the present Clewiston), known as “custard apple muck,” was early recognized as being distinct from the sawgrass peat soil further south (e.g., Baldwin and Hawker 1915, Forsaith 1916; Allison *et al*. 1927). The most obvious difference was that the custard apple soil included as much as 50% mineral matter, whereas the sawgrass peat was predominantly organic, with only 10% mineral matter. Aluminum, iron, and silicon were all much higher in the custard apple soils (Hammar 1929). After clearing for agriculture, the custard apple soils were found to more easily support crops, whereas addition of the micronutrient copper was required for crop production on the sawgrass soil (Allison *et al*. 1929). The impression of differing fertility of the two soils appears to have arisen out of their initial ability to grow crops, and the need for additional micronutrients in the sawgrass soil.

Southward from Lake Okeechobee, the land surface sloped downward, so prior to post-drainage subsidence, the custard apple area adjacent to the lake was the most elevated portion of the Everglades. It is possible that the custard apple area formed a slightly elevated rim. Whether actual rim, or simply peak, the elevation of the custard apple area likely resulted in distinct hydrology. The explanation for the pre-drainage location of the custard apple swamp most likely lies in the combination of relative elevation and mineral soil type.

It is important to note that the custard apple swamp did not encircle all of the outflowing portions of Lake Okeechobee. In fact, along a 20 mile shoreline extending from Clewiston around the SW corner to Fisheating Creek, the “Great Okeechobee Marsh” of sawgrass (Herr 1943) bordered the Lake directly, with no intervening band of custard apple (see also Kraemer 1892). Outflow from Lake Okeechobee through part of this sawgrass marsh contributed to the headwaters of the Caloosahatchee River.

Peat thickness. It is well known that pre-drainage peat thickness decreased from Lake Okeechobee southward through the Everglades. Roy and Gherini associate greater peat thickness with denser vegetation growth due to elevated phosphorus levels (p. 28). No evidence of spatially differing peat formation rates was presented, in fact, elsewhere the authors refer to a “paucity of data” (p. 12). There actually is important information availablein one of the sources cited by Roy and Gherini. Dachnowski-Stokes (1930) analyzed numerous soil cores within the present Everglades Agricultural Area, measuring both the core contents and the elevation of the core above sea level. In essentially all cores he found a uniform layer of more decomposed peat at about elevation 14 feet, which he ascribed to a period of altered climate. This strongly suggests a pattern of spatial uniform accumulation of sawgrass peat. The reviewer believes that final sloped surface of the accumulated peat reflects a decomposition equilibrium controlled by water elevations. The water elevations were in turn sloped due to the southward slope of the sand rims border the eastern and western sides of the Everglades, i.e., a physical mechanism that had little to do with possible nutrient gradients.

Soil Phosphorus. Roy and Gherini state that "the soils south of the lake were naturally highly enriched in phosphorus" (p. 24), citing Hammar (1929). Let us note what this author himself said about the custard apple soils directly adjacent to the lake, and the sawgrass soils further south: "*The content of phosphorus does not vary to any marked degree from one type to another.*" (italics added). It is not clear why Roy and Gherini chose to ignore this statement, particularly as it is consistent with Hammar's data.

Any conclusions about a phosphorus gradient with distance south of Lake Okeechobee must also carefully consider locations of the soil samples used by Roy and Gherini. Both Rose (1912; 1919) and Hammar (1929) were agricultural scientists, interested in the agricultural potential of the Everglades, not pre-drainage ecological conditions. In addition, access into the Everglades was still difficult, with canals providing the primary entry points. As a result, we find that 12 out of 24 of Hammar's samples were taken within 75 to 100 feet of one of the four major canals, and that all of Rose's samples were taken along canals. As these canals were known to overflow (Elliot 1927; 1929; Parker *et al.* 1955), the chemistry of these samples bears an unknown relation to the original pre-drainage chemistry. Additionally, 21 out of 24 of Hammar's samples were taken from fields actually under cultivation, making their chemistry even more uncertain.

In summary, Roy and Gherini are correct in noting that different pre-drainage Everglades landscapes supported different vegetation, different microtopography, and different wildlife abundance. However, the evidence presented by Roy and Gherini for a southward phosphorus gradient is weak. The evidence presented for a phosphorus gradient being the cause of the landscape differences is also weak. Other, non-phosphorus-based causal mechanisms provide more plausible explanations.

Table 1. Sources of information concerning the vegetation, soils and water levels along the shore of southern half of Lake Okeechobee.

Year	Type	Veg	Soil	Hyd	Spa.	Chg	Fire	Citation
1842	Military	x	x	x				Prebles
1857	Military	x	x	x				Canova (1895)
1871	U.S. Land Survey	x						Tannehill (1871)-T42 R30
1871	U.S. Land Survey	x						Tannehill (1871)-T42 R31
1874	Sportsmen	x	x	x	x			Ober (1874a,b)
1879	Drainage	x	x	x				Meigs (1879)
1882	Develop./Expl.	x		x				Times-Dem
1882 ?	Drainage		x					Menge in Stewart (1907)
1883	Transport.			x				Hanna & Hanna (1948)
1884	Drainage	x	x	x				Harney (1884)
1884	Develop./Expl.	x	x	x				Hopkins in Stewart (1907)
1884	Develop./Expl.	x	x	x	x	x	x	Hendry in Stewart (1907)
1887	Geologic	x	x	x				Heilprin (1887)
1880s	Drainage	x	x	x		x		TIIF reports
1891	Agric. & Drainage	x	x	x	x			Wiley (1891)
1892	Agric. Mapping	x	x		x			Kraemer (1892)
1906?	Surveying	x	x	x			x	Lupfer (1906)
1907	Develop./Expl.	x			x			Stewart (1907)
1907	Drainage			x		x		Clark (1907)
1910	Surveying	x		x				Dickey (1910)
1911	Overview							Senate Doc. 89 (1911) p187
1912	Overview	x			x	x		Wright (1912)
1913	Ecological Survey	x			x			Harshberger (1913)
1913	Canal Survey		x	x				Hills (1931)
1913	Soil Survey	x	x	x	x	x		Baldwin & Hawker (1915)
1913	Botanical Coll.	x	x	x	x			Small (1914)
1914	Alligator Hunting	x			x	x		Storter (2000)
1915	Drainage			x		x		Elliot (1927)
1916	Botanical / Soil		x					Forsaith (1916)
1917	Botanical / Soil		x					Forsaith (1917)
1917	Botanical Coll.	x	x	x		x	x	Small (1918)
1918	Naturalist Trip	x		x		x		Blatchely (1932)
1919	Geological			x		x		Sellards (1919)
1913	Lakeshore Survey							Anonymous (1921)
1920	Botanical Coll.	x	x			x	x	Small (1922)
1922	Botanical Coll.					x		Small (1927)
1924	Land buying					x	x	Whitney (1924)
1927	Soil Research	x	x		x	x	x	Allison et al. (1927)
1928	Soil Research							Waksman et al. (1928)

1929	Soil Research	x	x		x	x		Hammar (1929)
1929	Soil Research							Waksman et al. (1929)
1930	Soil Research							Dachnowski-Stokes (1930)
1930	Drainage		x	x		x	x	Interbureau Comm. (1930)
1932	Soil Research	x	x	x		x		Allison & Dachnowski (1932)
1936	Soil Research	x	x	x	x	x	x	Clayton (1936)
1942	Soil Research		x	x		x	x	Clayton et al. (1942)