**Comparative Effects of Carbon Dioxide Enrichment and pH Change on
Phytoplankton Communities in SRS Carolina bay Restoration Efforts.**

**Progress Report
for
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GENERAL PROJECT BACKGROUND:

Impacts of land-use activities on wetland ecosystems, their resiliency, restoration, and related topics continue to be front-page issues for environmental planners, conservation groups, and government agencies. Among the abundant wetland systems within the United States Department of Energy (DOE) Savannah River Site (SRS) are unique aquatic environments known as Carolina bays. Carolina bays represent especially critical habitat areas because they are the only naturally occurring aquatic systems above the floodplain in otherwise dry upland areas. Previous DOE-funded wetlands research at SCSU has produced results concerning important relationships between phytoplankton (part of the food-web base), water chemistry, and higher food chain levels in Carolina bay wetlands at SRS.

Developing a clear understanding of the functional roles of phytoplankton and their responses to water chemistry is essential if natural ecosystem integrity is to be maintained through Carolina bay conservation and restoration efforts. These efforts take on added significance since the high ecological value of wetlands to the nation has been emphasized by the federal policy of no net loss of wetlands. Valuable specific ecosystem roles of Carolina bays would include: 1) critical reproductive and nursery sites for amphibians in upland areas, 2) waterfowl and wildlife habitat, 3) important primary and secondary productivity and 4) habitat for plant and animal species under consideration for "threatened or endangered" species status (Bennett and Nelson, 1991). With greater than 150 larger Carolina bays within its borders (Shields, *et al.*, 1982) the SRS National Environmental Research Park (NERP) potentially provides protection to one of the greatest concentrations of relatively undisturbed Carolina bays in the nation. SRS bays take on special significance considering the description of Carolina bays within South Carolina as "relatively endangered systems" with only 4,000 bays existing in the State (Bennett and Nelson, 1991).

The Year One research efforts summarized in this report will be valuable to projecting the success of SRS Carolina bay restoration efforts in reestablishing natural ecosystem functions. As a newly restored Carolina bay progresses through wetland successional stages to the dystrophic conditions (Schalles and Shure, 1989) typical of established bays, changes in CO₂ and pH will occur. Determining the effects of these CO₂ and pH changes on bay phytoplankton community succession is important since previous studies have shown dramatic changes in species abundance can result from CO₂ and pH alterations (Goldman, 1973; Talling, 1976; Yan and Stokes, 1978).

Project Year One Developments:

These Year One efforts focused on population changes produced by effects of changes in pH and CO₂ resulting from simulated aquatic ecosystem successional processes. Results are being compared with the phytoplankton changes induced by added nutrients studied previously. CO₂ and pH effects were quantified to more accurately assess the impacts of fertilizing in contrast to natural lake aging processes.

Additional benefits resulting from this continued research by SCSU included the training of minority students (especially minority females) in environmental sciences and maintaining linkages between South Carolina's largest HBCU and SREL and DOE-SRS. During this past project year (1994 to 1995), four different SCSU undergraduate and graduate students worked as research assistants. Additional contributions of these student assistants included instructing middle school and high school students in our research methods during this year's South Carolina Junior Academy of Sciences Winter Conference at SCSU. (See attached letter of appreciation).

Our project results have also proven valuable to Westinghouse-SCUREF research being conducted at USC-Aiken by Dr. Harold Ornes on macrophyte successional changes in the Lost Lake restoration project. USC-Aiken has requested use of our water chemistry data for Lost Lake and informed us that our water chemistry research data base is the primary information available for restoration changes in Lost Lake.

An additional accomplishment in Year One was to continue the measurement of patterns of phytoplankton community dynamics and changes in water chemistry in Flamingo Bay and Lost Lake for comparison with previous years. These results will further assist the evaluation of Lost Lake restoration efforts.

SUMMARY STATUS OF RENEWAL YEAR ONE OBJECTIVES:

OBJECTIVES FOR QUESTION 1: What are the main effects and combined effect of CO₂ and pH on phytoplankton communities in restored and natural Carolina bays?

OBJECTIVE 1:

1) Determine the main effect of CO₂ concentration on phytoplankton community dynamics for different nutrient conditions under controlled pH.

Status: All CO₂ treatment field and laboratory experiments have been completed and water chemistry and phytoplankton analyses conducted. Experiments were initiated on May 31

and June 13, 1994, with Flamingo Bay water and on May 31, June 13, July 13, and August 24, 1994 with Lost Lake water.

The computer data base has been created, but is still undergoing final editing as some phytoplankton samples are being recounted to assure quality control. Following this, final statistical analyses will be conducted and manuscripts developed. Preliminary results are described below.

OBJECTIVE 2:

2) Determine the main effect of pH on phytoplankton community dynamics for different nutrient conditions under controlled CO₂ levels.

Status: All pH treatment field and laboratory experiments for ambient nutrient levels have been completed and water chemistry and phytoplankton analyses conducted. pH changes were produced through HCl and NaOH additions. Experiments were initiated on June 22 and October 13, 1994 with Flamingo Bay water and with Lost Lake water.

The computer data base for these results has been created, but is still undergoing final editing as some phytoplankton samples are being recounted to assure quality control. Additional experimental treatments with the elevated nutrient conditions are still ongoing. Following these additional experimental replications, final statistical analyses will be conducted and manuscripts developed. Preliminary results are described below.

OBJECTIVE 3:

3) Analyze changes in algae species abundance and community diversity for each of the CO₂ and pH treatments.

Status: All phytoplankton samples have been counted, however, high variability between some of the different observers has required the recounting of several samples. The computer data base has been created, but is still undergoing final editing until these counts have been completed. Following this, final statistical analyses will be conducted and results developed for manuscripts. Preliminary results are described below.

OBJECTIVE 4 and OBJECTIVE 5:

4) Relate experimental results to actual pH and CO₂ conditions in undisturbed Carolina bays and previously determined natural phytoplankton dynamics.

5) Compare the relative magnitude of changes in phytoplankton due to CO₂, pH, and nutrients and relate these results to projected effects of ecological succession in wetlands restoration projects.

Status: The ongoing work of final data base editing and statistical analysis will have to be completed before these two objectives can be completed to produce final conclusions. Preliminary results for pH changes in nature are described below along with conditions of temperature and water depth at the sampling sites.

PRELIMINARY RESULTS:

Water depth and temperature varied in a similar pattern at both the Flamingo Bay and Lost Lake study sites (Figures 1 and 2). The Flamingo Bay site was located in deeper water due to the extensive aquatic plant cover surrounding the open water pond here compared to Lost Lake. A major difference between Flamingo Bay and Lost Lake was the higher pH in Lost Lake (Figure 1 and 2). Causes for the general alkaline conditions in Lost Lake are not known and should be assessed by the restoration project.

During the May 31, 1994 Flamingo Bay experiment, *Chlamydomonas* sp. continued to represent the greatest percentage of cells present in the medium CO₂ treatment compared to the initial water sample (Figure 3a.). However, *Scenedesmus* sp. had become more frequent in the high CO₂ sample (Figure 3a.). The pH of the control treatment remained similar to the initial water sample (Figure 3b.). The lower initial pH in the medium and high CO₂ treatments was due to the effects of carbonic acid formation, while the rise in pH for these two treatments during the course of the experiment was likely due to CO₂ uptake during photosynthesis (Figure 3b.).

During the May 31, 1994 Lost Lake experiment, *Chlamydomonas* sp. increased in relative percentage of cells present in the medium and high CO₂ treatments compared to the initial water sample (Figure 4a.). Additionally, *Scenedesmus* sp. had become less frequent in the medium CO₂ treatment and more frequent in the high CO₂ treatment compared to the control (Figure 4a.). As in the Flamingo Bay treatments, the pH of the control treatment remained similar to the initial water sample (Figure 4b.). The lower initial pH in the medium and high CO₂ treatments was due to the effects of carbonic acid formation, while the rise in pH for these two treatments during the course of the experiment was likely due to CO₂ uptake during photosynthesis (Figure 4b.). During the June 13, 1994 experiment, *Scenedesmus* sp. increased dramatically in percent relative to the initial water for Flamingo Bay CO₂ treatments (Figure 5.).

Scenedesmus sp. remained high in occurrence for all Flamingo Bay control and pH treatments during the June 22, 1994 pH experiment (Figure 6a.). *Scenedesmus* sp. was also common in the Lost Lake treatments, however several other species increased in relative abundance, while *Chlamydomonas* sp. declined in occurrence (Figure 6b.).

Figure 1. Changes in pH, temperature, and water depth in Flamingo Bay during the 1994 experimental period

Figure 2. Changes in pH, temperature, and water depth in Lost Lake during the 1994 experimental period

Figure 3a. Variations in phytoplankton species composition for the different Flamingo Bay treatments during the May 31 to June 9, 1994 experimental period.

Figure 3b. Variations in initial and final pH for the different treatments with Flamingo Bay water during the May 31 to June 9, 1994 experimental period.

Figure 4a. Variations in phytoplankton species composition for the different Lost Lake treatments during the May 31 to June 9, 1994 experimental period.

Figure 4b. Variations in initial and final pH for the different treatments with Lost Lake water during the May 31 to June 9, 1994 experimental period.

Figure 5a. Variations in phytoplankton species composition for the different Flamingo Bay treatments during the June 13 to June 22, 1994 experimental period.

Figure 5b. Variations in phytoplankton species composition for the different treatments with Lost Lake water during the June 13 to June 22, 1994 experimental period.

Figure 6a. Variations in phytoplankton species composition for the different Flamingo Bay treatments during the June 22 to June 29, 1994 experimental period.

Figure 6b. Variations in phytoplankton species composition for the different treatments with Lost Lake water during the June 22 to June 29, 1994 experimental period.

Figure 7. Variations in phytoplankton species composition for the different Lost Lake treatments during the July 13 to July 20, 1994 experimental period.

Figure 8. Variations in phytoplankton species composition for the different Lost Lake treatments during the August 24 to August 29, 1994 experimental period.

Figure 9a. Variations in phytoplankton species composition for the different Flamingo Bay treatments during the October 13 to October 20, 1994 experimental period.

Figure 9b. Variations in phytoplankton species composition for the different Lost Lake treatments during the October 13 to October 20, 1994 experimental period.

Chlorella sp. increased in frequency in the control and CO₂ treatments during the July 13, 1994 experiment with Lost Lake water (Figure 7.). *Chlorella* sp displayed a similar pattern in the August 24, 1994 replication of the CO₂ experiment, however *Scenedesmus* sp. increased sharply in the medium CO₂ treatment (Figure 8.).

During the October 13, 1994 pH experiment, *Chlamydomonas* sp. was most abundant in both the Flamingo Bay and Lost Lake treatments (Figure 9a. and b.). The other phytoplankton species in the experimental pH treatments also did not change dramatically from the initial and control samples (Figure 9 a. and b.).

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