

9.0 Lake Okeechobee CERP-Specific Conceptual Ecological Models and Performance Measures

The final draft of the *Monitoring and Assessment Plan (MAP), Part 2, 2006 Assessment Strategy for the MAP* (RECOVER 2006), referred to as the Assessment Strategy, presents six CERP-specific conceptual ecological models for Lake Okeechobee (**Figure 9-1**). These models provide a visual description of causal pathways described in hypotheses clusters. Each cluster and associated model focus on a key indicator for the lake: submerged aquatic vegetation (SAV), macroinvertebrates, phyto-plankton, native fish species, littoral emergent vegetation mosaic, and exotic vegetation.

The following sections briefly summarize descriptive text for hypotheses clusters and present conceptual ecological model diagrams along with how performance measures relate to them. Application of performance measures during evaluation (planning) and assessment processes, including the hypothesis-based approach, are discussed in more detail in Section 2. Full discussions of hypotheses clusters from the draft Assessment Strategy can be accessed from the CERP System-wide Performance Measures web page: http://www.evergladesplan.org/pm/recover/perf_low.aspx.

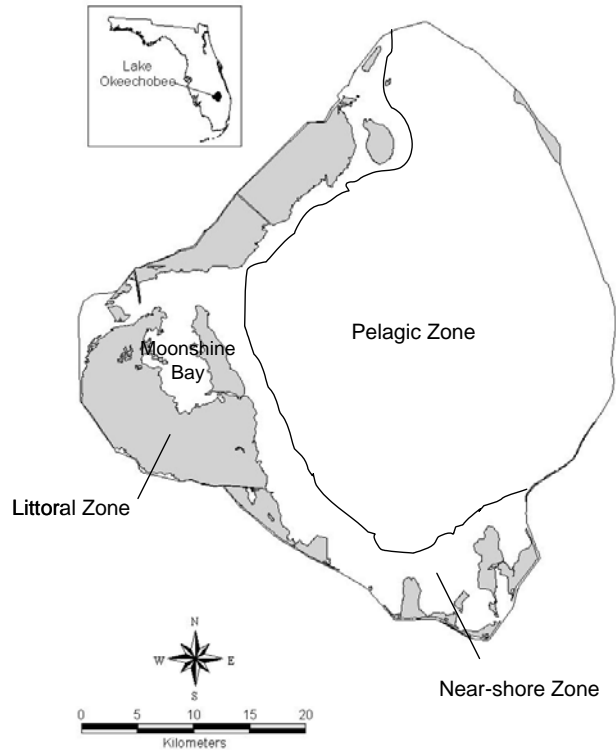


Figure 9-1. Lake Okeechobee

9.1 Submerged Aquatic Vegetation

Lake stage, major wind and wave events, nutrient concentrations, and extent of mud sediments all influence SAV in Lake Okeechobee (**Figure 9-2**). At higher lake stages, light penetration to the bottom is reduced and area capable of supporting dense SAV is smaller. Also, at higher lake stages, pelagic and littoral fringe zones (**Figure 9-1**) become hydrologically connected resulting in increased turbidity. Major wind and wave events can also increase turbidity and can result in large-scale destruction of SAV by direct physical tearing and uprooting. Elevated nutrient concentrations stimulate dense phytoplankton blooms, which in turn reduce light available for SAV growth. Under physical conditions that result in low light levels, the exotic SAV species hydrilla may have a competitive advantage over more desirable native SAV species. Changes in the extent of mud sediments in the littoral-pelagic fringe zone resulting from changes in nutrient loading and runoff influence potential area available for SAV colonization.

Submerged Aquatic Vegetation Conceptual Ecological Model

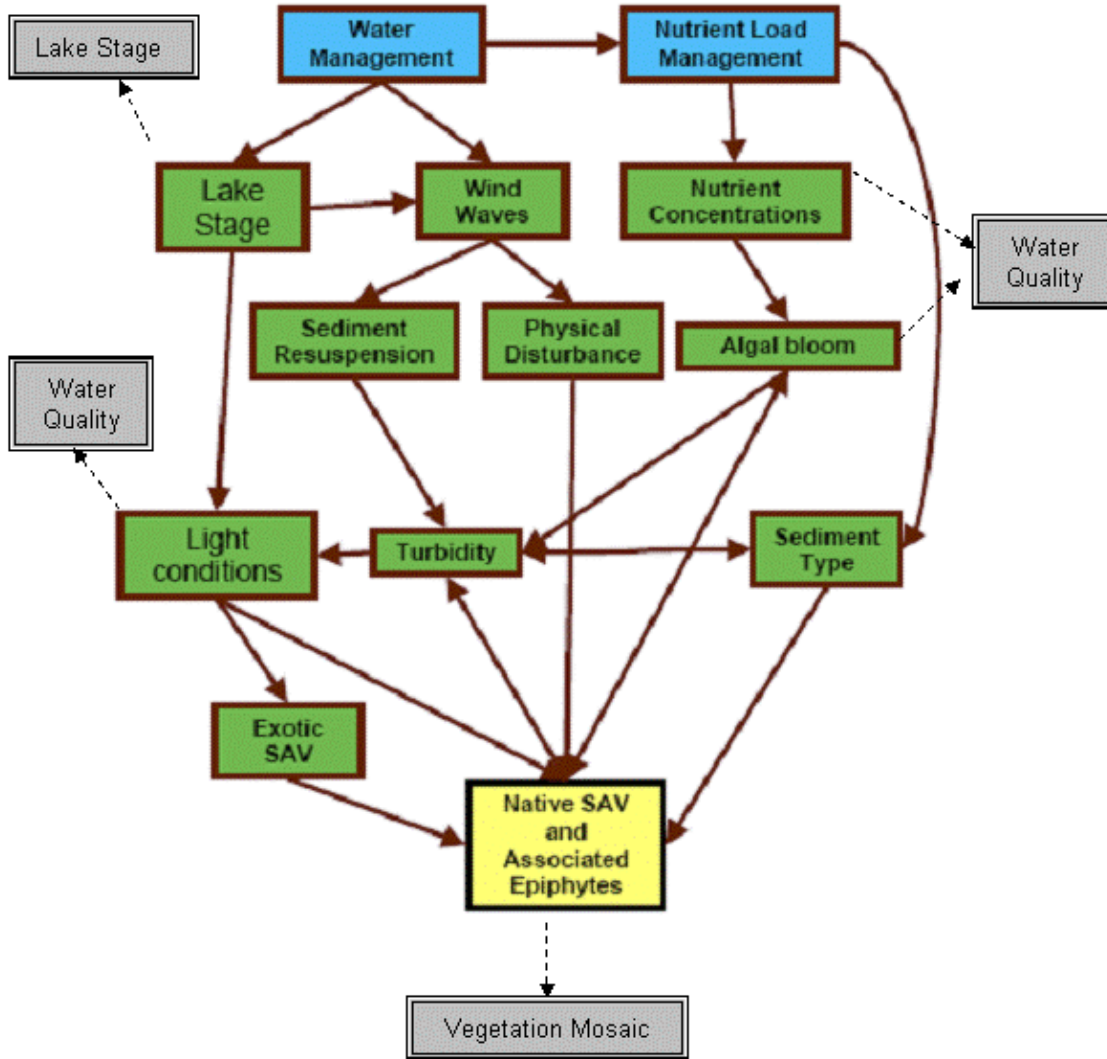


Figure 9-2. SAV Conceptual Ecological Model with associated performance measures

Several system-wide performance measures have been developed to assess and evaluate effects of CERP implementation on Lake Okeechobee SAV and pathways leading to it from water management and nutrient load management (**Figure 9-2**). A vegetation mosaic measure has been developed that includes SAV. A lake stage performance measure includes a target for high lake stage. The water quality performance measure includes nutrient concentrations, algal blooms and light conditions, all of which affect SAV in the lake.

9.2 Macroinvertebrates

Macroinvertebrate diversity will increase and presence of pollutant-tolerant species will decrease in Lake Okeechobee as water management and nutrient load management changes are made as CERP is implemented and macroinvertebrate habitat improves (**Figure 9-3**). As the lake is management for low and moderate stages and nutrient loads are reduced, density of SAV and emergent vegetation increases. Reduced nutrient loads are expected to reduce and/or cap mud sediments, and increase areas underlain by sand and peat sediments. Presence of dense SAV and emergent vegetation, sand and peat sediments, and low nutrient loads will provide habitat that will sustain a more diverse population of macroinvertebrate species with less pollutant-tolerant species.

A CERP system-wide performance measure has been developed for macroinvertebrates in Lake Okeechobee (**Figure 9-3**). Performance measures have also been developed for lake stage, water quality and vegetation mosaic, all of which affect macroinvertebrates in the lake.

Macroinvertebrate Conceptual Ecological Model

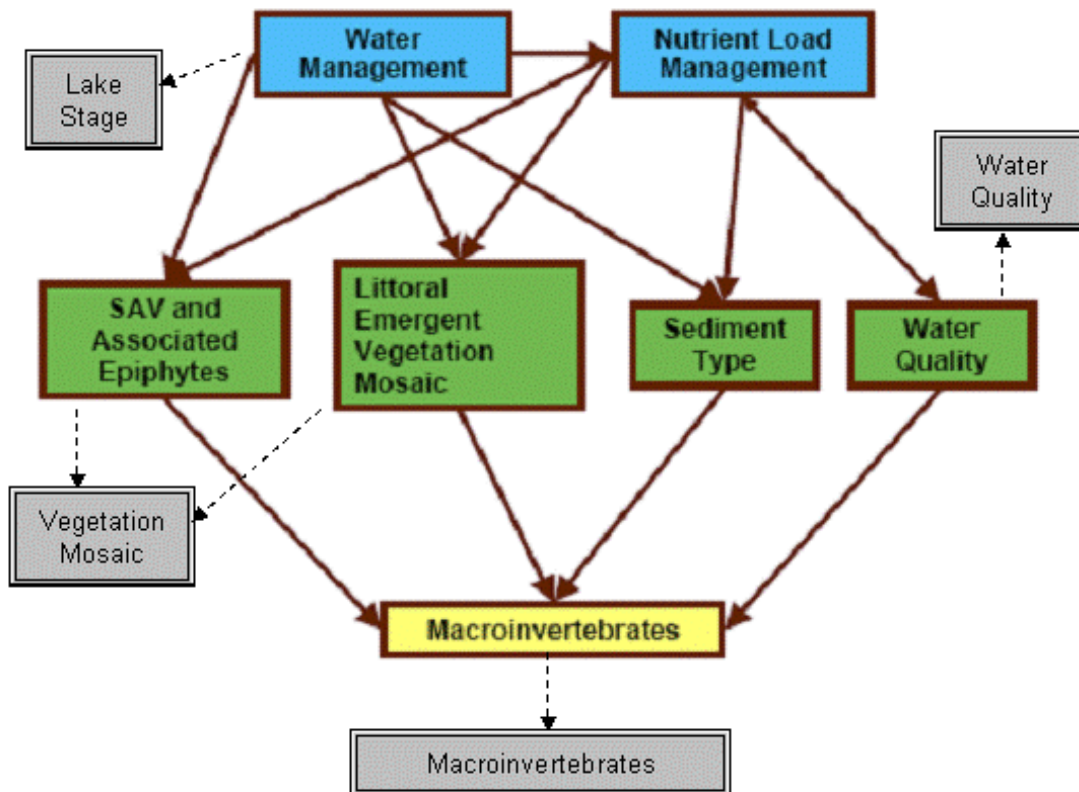


Figure 9-3. Macroinvertebrates Conceptual Ecological Model with associated performance measures

9.3 Phytoplankton

Phytoplankton in Lake Okeechobee is affected by lake water levels, nutrient concentrations, light level and SAV (Figure 9-4). At high lake stage, both sediment resuspension and horizontal mixing occur, resulting in increased turbidity and phosphorus levels. Under these conditions, phytoplankton growth rates and occurrence and intensity of algal blooms increase.

Phytoplankton Conceptual Ecological Model

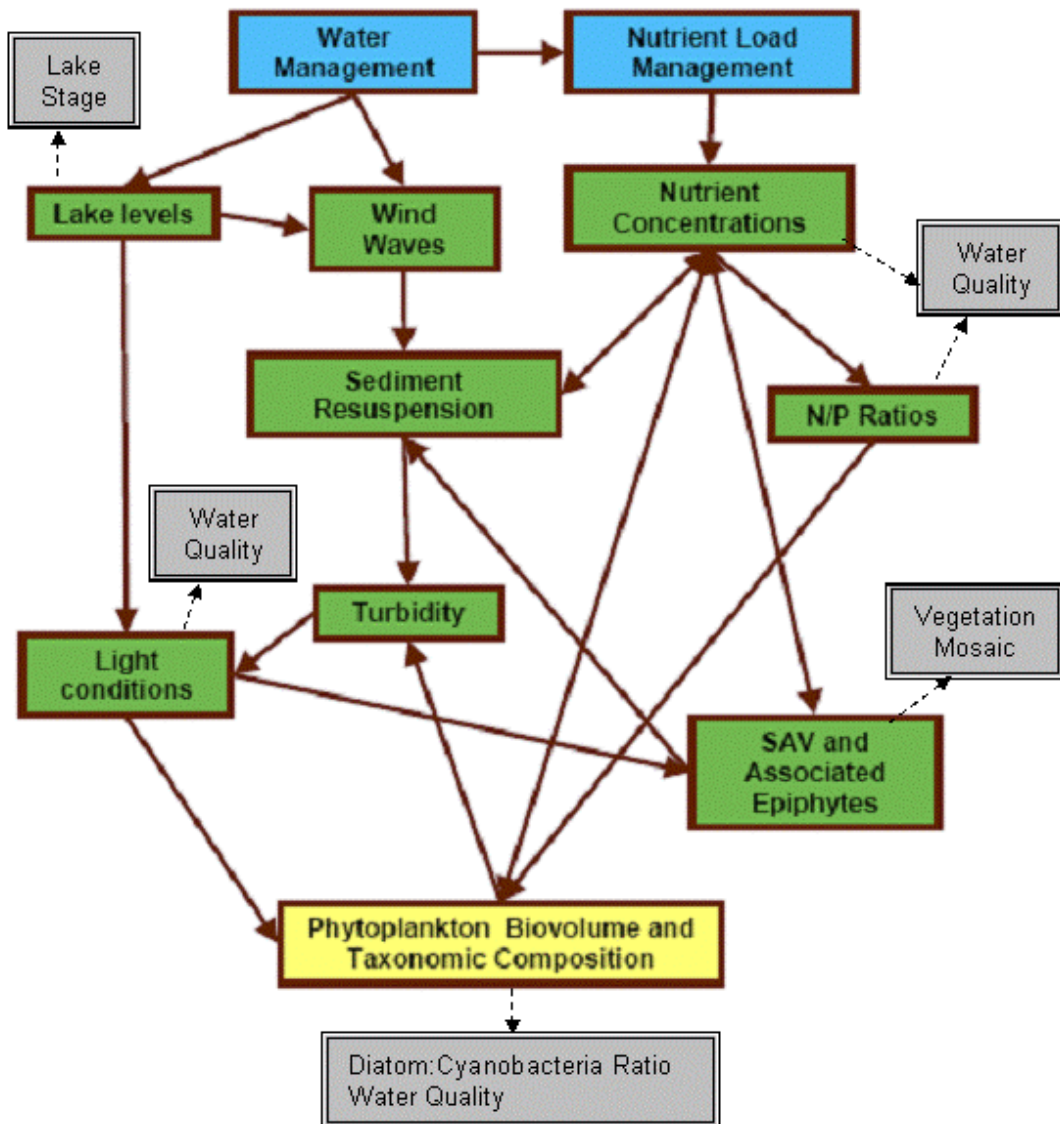


Figure 9-4. Phytoplankton Conceptual Ecological Model with associated performance measures

Nitrogen to phosphorus ratio (N:P) has been altered, shifting conditions from a phosphorus-limited to an nitrogen-limited system whenever the system is not light limited. Frequency of severe cyanobacterial blooms increase under phosphorus-limited conditions.

In deeper, more turbid pelagic region, light is the limiting factor, and favors proliferation of low-light adapted non-bloom forming species. SAV and associated epiphytes can reduce water column phosphorus concentrations and stabilize sediment preventing resuspension of phosphorus back into the water column. These conditions inhibit phytoplankton growth and algal bloom frequency and intensity when nutrient concentrations are high.

A diatom-cyanobacteria ratio system-wide performance measure has been developed to assess biovolume ratio of the two types of phytoplankton as CERP is implemented (**Figure 9-4**). The water quality performance measure includes targets for algal blooms (chlorophyll *a*), along with targets for nitrogen-phosphorus ratios and light conditions, which both affect phytoplankton biovolume and taxonomic composition. High lake stage, which also affects this attribute, is tracked by the lake stage performance measure.

9.4 Native Fish Species

Native fish species are affected by SAV, nutrient loads, sediment composition, exotic animal species and lake levels (**Figure 9-5**). Increases in SAV density, biomass and aerial coverage improve fish habitat and fish foraging opportunities and improve desirable native fish abundance and diversity. Reduced nutrient loads and improved water quality will result in increased fish diversity and a shift from less desirable rough fish to more desirable game fish. Competition from introduced exotic fauna exerts negative pressure on desirable native fish. Reduction in mud sediment as a consequence of water management will improve macroinvertebrate species diversity resulting in a positive impact on the food web and in an increase in desirable fish species. Prolonged low lake stage, especially during breeding season, removes large areas of fish foraging and spawning habitat from use and negatively impacts recruitment and fish abundance. Elevated nutrient loads and high lake levels favor development of dense algal blooms. These algal blooms can result in fish kills and negative impacts on other wildlife either through the development of anoxic conditions when blooms senesce and decay or through direct effects of cyanotoxin production.

A CERP system-wide performance measure has been developed for fish population density, age structure and condition in Lake Okeechobee (**Figure 9-5**). Performance measures have also been developed for lake stage, water quality, diatom-cyanobacteria ratio, vegetation mosaic and macroinvertebrates, which all affect fish in the lake.

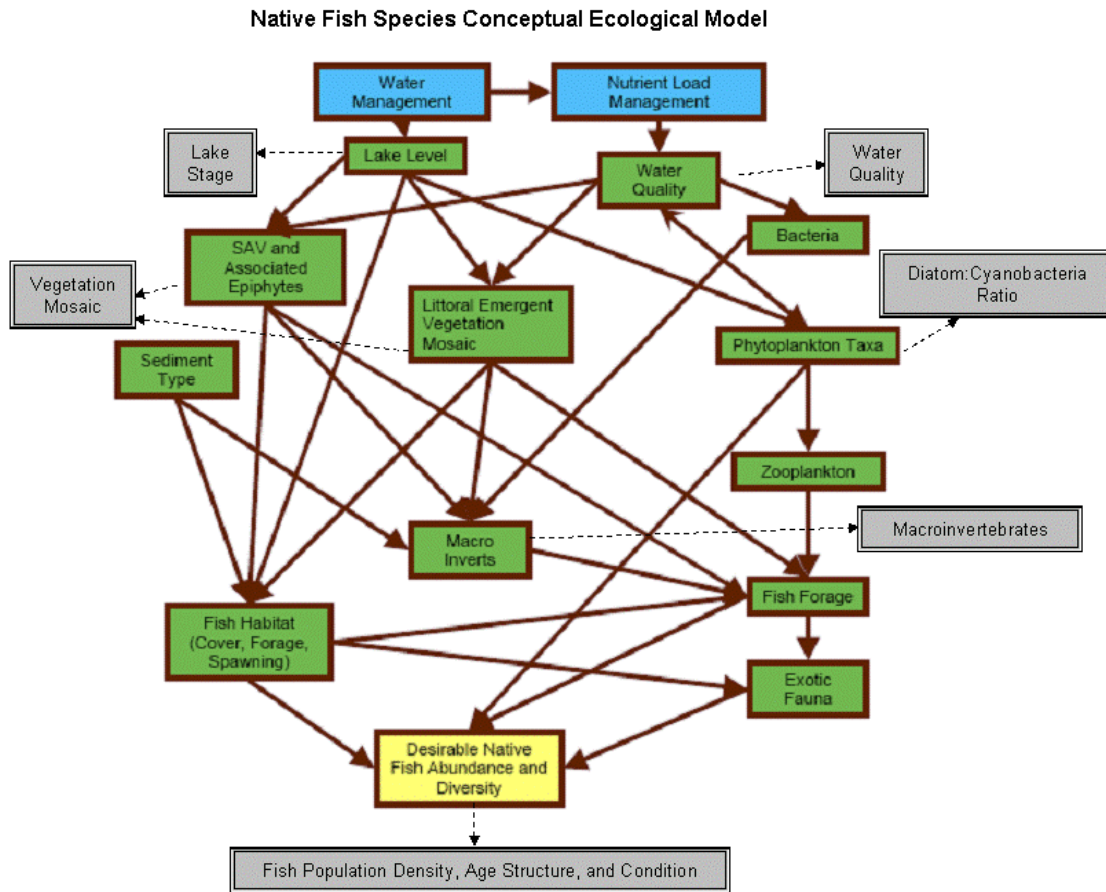


Figure 9-5. Native Fish Species Conceptual Ecological Model with associated performance measures

9.5 Littoral Zone Emergent Vegetation Mosaic

Lake stage and exotic vegetation management affects the littoral zone emergent vegetation mosaic (**Figure 9-6**). High lake stage can 1) cause uprooting of desirable native shoreline vegetation by wind-driven waves, 2) transport pelagic water with high phosphorus concentrations into interior regions of the marsh, 3) cause physiological stress in rooted emergent macrophytes resulting in plant death, 4) prevent seed germination of some desirable species, and 5) enhance wind-driven transport of floating exotics, which form mats and can cause extensive physical damage through uprooting or breaking emergent plant stems. Operating Lake Okeechobee at lower overall lake stages and providing periodic recession events will reverse these trends and encourage expansion of desirable native emergent vegetation. On the other hand, low water events can accelerate spread of exotic and nuisance invasive vegetation such as torpedograss, melaleuca and cattail. However, low water events will stimulate germination of desirable native vegetation and encourage occurrence of fire, which may help control undesirable exotic and invasive species. Exotic vegetation management activities can kill desirable native plants in addition to the target plant.

The Lake Okeechobee vegetation mosaic system-wide performance measure includes targets for assessing native littoral emergent vegetation response to CERP implementation (Figure 9-6). This measure includes reduction in exotic vegetation in its restoration expectation. The water quality performance measure has targets for light conditions and nutrient concentrations, which both affect littoral vegetation. The lake stage performance measure has targets for both low and high stage events and recession.

Littoral Zone Emergent Vegetation Conceptual Ecological Model

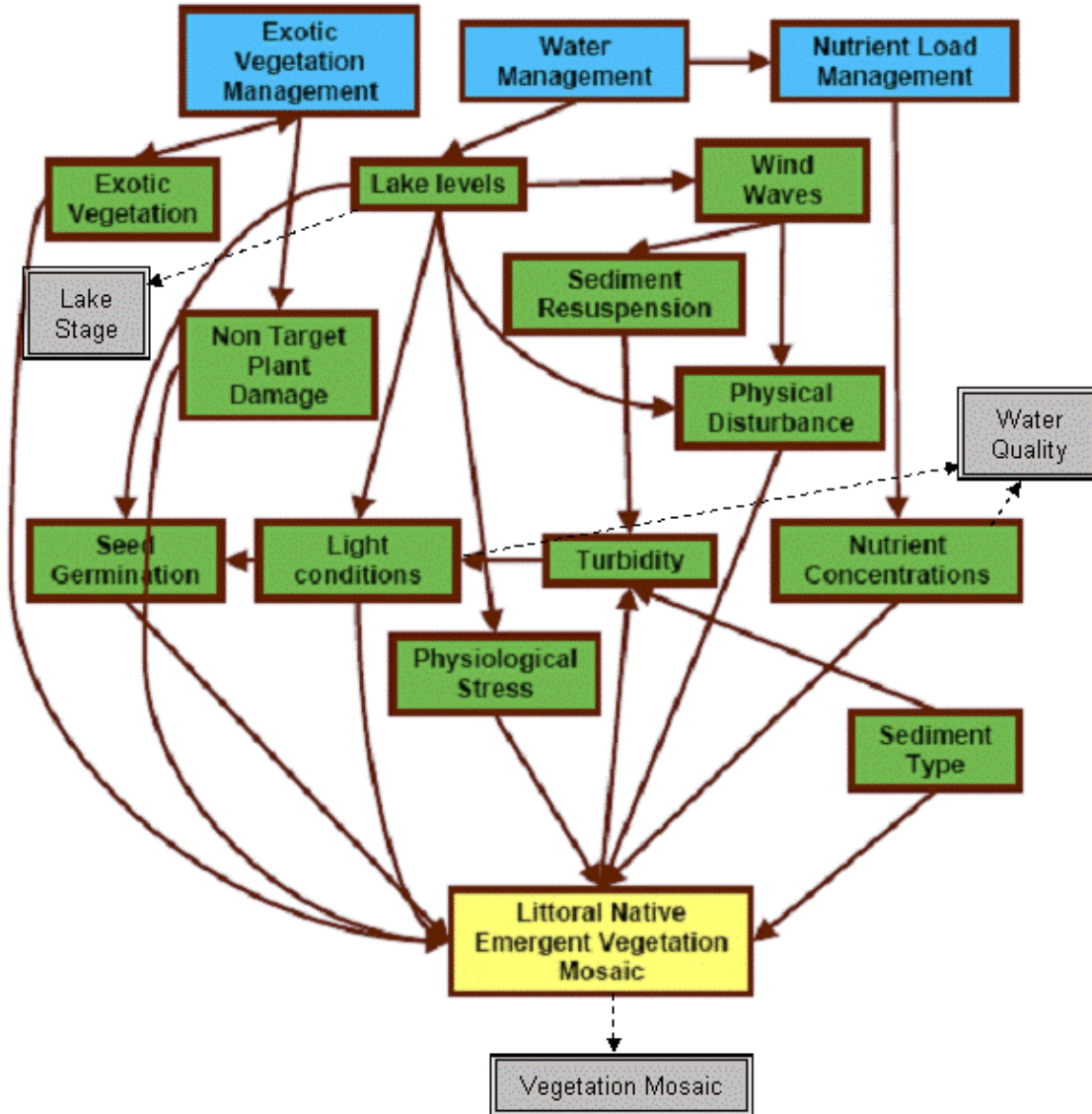


Figure 9-6. Littoral Zone Emergent Vegetation Mosaic Conceptual Ecological Model with associated performance measures

9.6 Exotic Vegetation

The littoral zone emergent vegetation mosaic is affected by expansion of exotic and undesirable species and vegetation management activity (**Figure 9-7**). Vegetation management activities, while effectively controlling exotic and invasive plants, have also killed desirable, native species. During high lake stages, pelagic water with high phosphorus concentrations is transported into the interior marsh resulting in loss of desirable species and an expansion of cattail and other undesirable species.

The Lake Okeechobee vegetation mosaic system-wide performance measure includes reduction of exotics in its restoration expectation (**Figure 9-7**). Targets for nutrient load to the lake are included in the water quality performance measure. The lake stage performance measure includes targets for high lake stage.

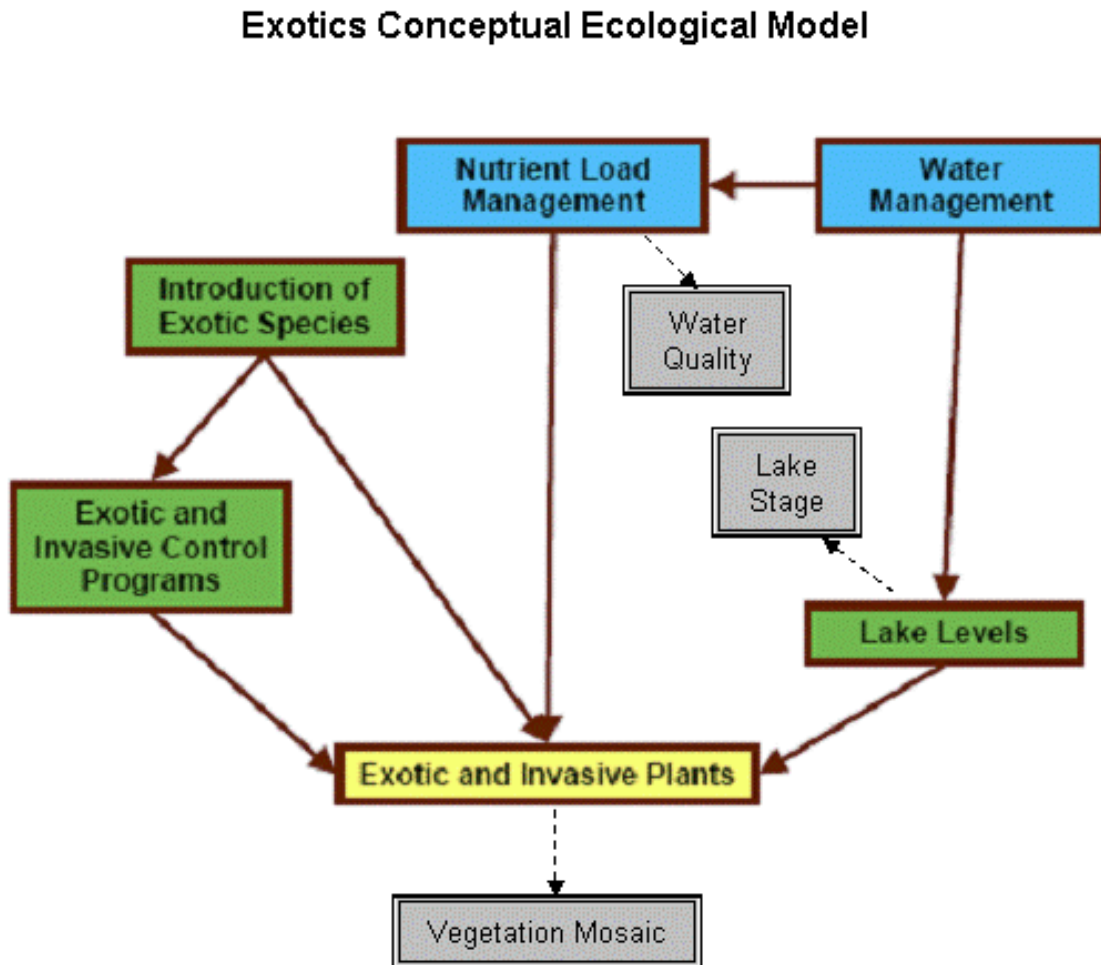


Figure 9-7. Exotic Vegetation Conceptual Ecological Model with associated performance measures

9.7 Lake Okeechobee Performance Measures

CERP System-wide performance measures that relate to Lake Okeechobee are as follows:

- Lake Okeechobee Stage
- Lake Okeechobee Water Quality
- Lake Okeechobee Diatom-Cyanobacteria Ratio
- Lake Okeechobee Vegetation Mosaic
- Lake Okeechobee Fish Population
- Lake Okeechobee Macroinvertebrates

Documentation sheets can be accessed from the Lake Okeechobee Performance Measures web page: http://www.evergladesplan.org/pm/recover/perf_low.aspx.

9.8 References

RECOVER. 2006. Monitoring and Assessment Plan (MAP), Part 2, 2006 Assessment Strategy for the MAP, Final Draft. Restoration Coordination and Verification Program, c/o United States Army Corps of Engineers, Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL. December 2006.
http://www.evergladesplan.org/pm/recover/recover_map.aspx