

## 1.0 Performance Measure Title

### Wetland Landscape Patterns – Freshwater and Estuarine Vegetation Mosaics

Last Date Revised: March 2, 2007

## 2.0 Justification

Everglades landscapes have lost and continue to lose pattern and directionality due to altered patterns of flow, hydroperiod and water depth. Sediments and the vegetation of surrounding landscapes have filled in open watercourses of sloughs and tidal creeks to the point that they have disappeared entirely or have lost their former directional orientation. The number of tree islands has decreased by 60% in Water Conservation Area 3 and more than 90% in Water Conservation Area 2 due to a combination of destructive fires during low-water periods and flooding during high-water periods. Cattail has replaced the mosaic of wetland plant communities in extensive areas of the ridge and slough landscape that have received high-phosphorus runoff water. The “white zone” and dwarf mangrove interface between estuarine and freshwater conditions have moved inland into the southern Everglades. Vegetation patterns along hydrologic gradients have shifted toward shorter-hydroperiod communities in drained areas and toward longer-hydroperiod communities in pooled areas throughout much of the freshwater wetland landscape.

Increasing seasonal freshwater sheet flow to the lower Everglades is expected to provide a broader zone of salinity gradients in the lower Everglades and coastal wetlands and should, in the short term, re-establish an oligohaline zone in the coastal wetlands

## 3.0 Relationship to CEMs and Adaptive Assessment Hypotheses

Everglades Ridge and Slough (Ogden 2005), Southern Marl Prairies (Davis et al. 2005a), Everglades Mangrove Estuaries (Davis et al. 2005b), and Big Cypress Regional Ecosystem (Duever 2005) Conceptual Ecological Models attribute

**Ecological Premise:** (RECOVER 2004) The loss of pattern and directionality in Everglades wetland landscapes has been caused by altered hydrologic conditions in combination with eutrophication. Sheet flow interacts with hydroperiod, water depth, fire, and nutrient dynamics to maintain organic soil accretion and loss in a state of dynamic equilibrium. The dynamic equilibrium involves a balance of particulate organic matter transport, and the accumulation, oxidation, and combustion of organic soil. Altered magnitude, duration, and direction of sheet flow causes disequilibrium of accretion and loss processes. The disequilibrium is exacerbated by eutrophication. Disequilibrium of accretion and loss processes causes a degradation in the ridge, slough, and tree island micro-topography toward a flattening of the landscape.

Degradation of micro-topography interacts with hydroperiod, water depth, eutrophication, fire, and exotic plants to reduce the diversity and stability of habitats which were previously long-term, large-scale features of the ridge and slough landscape. Decline in ridge and slough habitat diversity and stability includes expansion of sawgrass into sloughs and wet prairies, tree island drowning, tree island burn-out, conversion to cattail under eutrophic conditions, and takeover by exotic species, such as, *Melaleuca quinquenervia* and *Lygodium microphyllum*.

The composition and distribution of plant communities along elevation gradients are determined by patterns of hydroperiod, water depth, nutrient dynamics, and fire patterns throughout freshwater wetlands of the Greater Everglades. The dynamic equilibrium of the vegetation mosaic in relation to elevation gradients is maintained if biogeochemical processes in the soil support the physiological requirements of the vegetation. The dynamic equilibrium is altered if water depths or hydroperiods decrease or increase. Anthropogenic disturbances (i.e. past 100+ years) of hydroperiods, water depths, eutrophication, fire patterns, land use change, and the spread of exotic plants and animals have shifted the vegetation mosaic away from the historic dynamic equilibrium. These hypotheses are designed to focus monitoring and modeling at the ecotone boundaries between vegetation types which may be an early location of change.

In most of the greater Everglades wetlands where hydroperiods and water depths have decreased, the hydrologic tolerances of the surviving plant communities are adapted to greater hydroperiods and water depths than are currently maintained. For example, with regional drainage and altered fire regimes in the Big Cypress region there has been a gradual shift in landscape patterns, resulting in an increase in mesic rather than hydric-dominated communities.

Vegetation gradients between higher elevation marl prairies and lower elevation ridge and slough communities are of particular concern in the southern Everglades. Although a potential trade-off exists between ridge and slough habitat restoration and the extent and quality of habitat in adjacent marl prairies. Sheet flow in the southern Everglades prior to drainage produced prolonged pooling of fresh water upstream of the mangrove ecotones and prolonged patterns of freshwater inflow into the mangrove ecotones. The freshwater pooling and inflow supported a wide salinity gradient, including a broad oligohaline zone, in the mangrove estuary. A combination of historical reduced freshwater inflow and increased relative sea level rise has resulted in higher salinities in the former estuarine mangrove ecotones and significant saline intrusion into former freshwater marshes of the lower Everglades.

Although surface water salinities fluctuate laterally through the wet and dry seasons, saline groundwater intrusion has moved and remains further inland of its position at the turn of the last century. The freshwater/saltwater interface in the shallow aquifer is slower to respond. The response or movement of the interface depends on the intensity and duration of no freshwater inflow to the lower Everglades during the dry season. Over a long-term period, rising sea level is expected to result in high tides overtopping coastal marl ridges and saline waters penetrating more deeply into tidal channels and mangrove forests, forcing the areas of fresh and lower salinity waters further inland.

Production and organic soil accretion in the mangrove forests of the coastal Everglades are controlled by phosphorus availability, with relatively high inputs from marine sources and low inputs from freshwater sources. Phosphorus availability, mangrove production, and soil elevation are thus driven by the opposing influences of sea level and sheet flow from the Everglades. Aboveground biomass and production in the mangrove forests of Shark River Slough and other Gulf estuaries increase from the ecotone toward the Gulf of Mexico, reflecting the direct connection of these systems to the marine phosphorus source. Trees in the forests near the Gulf are able to allocate more biomass to aboveground growth. The dwarf mangrove forests along the northern margin of Florida Bay reflect suppressed levels of aboveground productivity, as influenced by minimal P supply from either the oligotrophic marshes of the southern Everglades or Florida Bay. High belowground production rates in the dwarf mangrove forests appear to be a biomass allocation phenomenon in which mangroves in the oligotrophic southern Everglades are foraging for nutrients. The counter-intuitive expectation is that maintenance of oligotrophic conditions in the southern Everglades (by increased freshwater inflows) may promote peat accretion in these mangrove forests.

Resilience of the coastal Everglades mangrove forests after disturbance is dependent on hydrologic flushing by either fresh or saline water, which is driven by sea level and sheet flow from the Everglades. Resilience also varies with soil fertility. An important feature for maintenance of an existing wetland environment, its recovery following disturbance events such as hurricanes, freezes, fires, or salinity changes, or the successful shift from one wetland type to another is maintenance of good flushing by either fresh or saline waters. Where flow and flushing diminish, wetland communities collapse. This is true for long-term maintenance of mangrove communities and for mangrove communities transitioning into former sawgrass wetlands.

## 9.2.5 Wetland Landscape and Plant Community Dynamics (RECOVER 2006)

(See diagram below.)

### Hypothesis 2: Everglades Ridge and Slough Landscape Pattern in Relation to Micro-topography

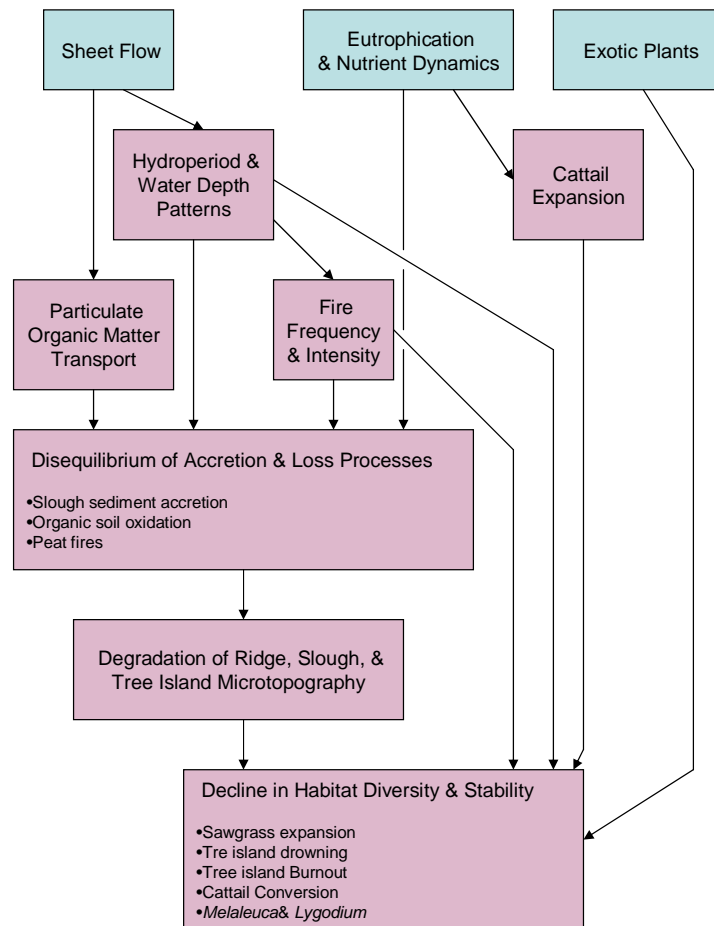
Degradation of micro-topography, changes in hydroperiod, water depth, eutrophication, fire, and vegetation, especially nonnative and invasive species, can reduce the diversity and stability of habitats which were previously long-term, large-scale features of the ridge and slough landscape.

**Rationale:** Decline in ridge and slough habitat diversity and stability includes expansion of sawgrass into sloughs and wet prairies, tree island drowning, tree island burn-out, conversion to cattail under eutrophic conditions, and

takeover by exotic species, such as, *Melaleuca quinquenervia* and *Lygodium microphyllum*.

Resumption of sheet flow and related patterns of hydroperiod, water depth, water quality, and fire will significantly restore and sustain the microtopography, directionality, and spatial extent of ridges and sloughs and improve the health of tree islands in the ridge and slough landscape.

**Ridge & Slough Landscape Dynamics  
Conceptual Ecological Model**



**4.0 Restoration Expectation**

Resumption of sheet flow and related patterns of hydroperiod, water depth, water quality, and fire will significantly restore and sustain the micro-topography, directionality, and spatial extent of ridges and sloughs and improve the health of tree islands in the ridge and slough landscape, without significantly infringing on adjacent marl prairies, where short-hydroperiod, tussock growth habitats will persist. Improved freshwater inflow and flushing through the lower Everglades and coastal wetlands (through both channel and sheet flow) are expected to aid in recovery of wetlands from catastrophic setbacks (from hurricanes, fire, freeze, and salinity changes). Increased freshwater sheet flow caused by implementation of CERP projects is expected to maintain low nutrient conditions in the southern Everglades mangrove estuaries and in the oligohaline forests of the western mangrove estuaries. These low nutrient conditions are expected to enhance belowground productivity by mangroves, which will maintain peat production and soil elevation increases—ultimately enhancing the maintenance of these low salinity forests against sea level rise. The maintenance of oligotrophic conditions in the southern Everglades (by increased freshwater inflows) may promote peat accretion in these mangroves.

<b>4.1 Predictive Metric and Target</b>
Predictive metric and target are not available at this time.
<b>4.2 Assessment Parameter and Target</b>
<b>5.0 Evaluation Application</b>
<b>5.1 Evaluation Protocol</b>
Predictive models to evaluate this performance measure are still under development and refinement. At this time, this performance measure should not be used to conduct evaluations.
<b>5.2 Normalized Performance Output</b>
<b>5.3 Model Output (example attached)</b>
<b>5.4 Uncertainty</b>
Recognition of model uncertainty is needed when interpreting the ecological significance of model output. The Model Uncertainty Workshop Report provides guidance on the potential implications of uncertainty on model output interpretation (RECOVER 2002).
<b>6.0 Monitoring and Assessment Approach</b>
See CERP Monitoring and Assessment Plan: Part 1 Monitoring and Supporting Research - Greater Everglades Wetlands Module section 3.1.3.4 (RECOVER 2004) See 2006 Assessment Strategy for the Monitoring and Assessment Plan. Final Draft. (RECOVER 2006).
<b>7.0 Future Tool Development Needed to Support Performance Measure</b>
<b>7.1 Evaluation Tools Needed</b>
Predictive models to evaluate this performance measure are still under development and refinement.
<b>7.2 Assessment Tools Needed</b>
Accessibility to the various data sources through an integrated database is needed for the complete evaluation of these hypotheses and for parameter refinement.
<b>8.0 Notes</b>

<b>9.0 Working Group Members</b>	
Patty Goodman, SFWMD Andy Gottlieb, EPJV Jana Newman, SFWMD	
<b>10.0 Acceptance Status</b>	
GE Working Group	November 22, 2005
ET	
AT	
Public Review	
Final Acceptance Date	
<b>11.0 References</b>	
<p>Davis, S.M., W.F. Loftus, E.E. Gaiser, and A.E. Huffman. 2005a. Southern marl prairies conceptual ecological model. <i>Wetlands</i> 25(4):821-831.</p> <p>Davis, S.M., D.L. Childers, J.J. Lorenz, and T.E. Hopkins. 2005b. A conceptual model of ecological interactions in the mangrove estuaries of the Florida Everglades. <i>Wetlands</i> 25(4):832-842.</p> <p>Duever, M.J. 2005. Big Cypress regional ecosystem conceptual ecological model. <i>Wetlands</i> 25(4):843-853.</p> <p>Ogden, J.C. 2005. Everglades ridge and slough conceptual ecological model. <i>Wetlands</i> 25(4):810-831.</p> <p>RECOVER 2002. Model Uncertainty Workshop Report: Quantifying and Communicating Model Uncertainty for Decision Making in the Everglades, Restoration Coordination and Verification Program (RECOVER), United States Army Corps of Engineers, Jacksonville District, Jacksonville, Florida, and South Florida Water Management District, West Palm Beach, Florida.</p> <p>RECOVER. 2004. CERP Monitoring and Assessment Plan: Part 1 Monitoring and Supporting Research. Restoration Coordination and Verification Program, c/o United States Army Corps of Engineers, Jacksonville District, Jacksonville, Florida, and South Florida Water Management District, West Palm Beach, Florida.</p> <p>RECOVER. 2006. 2006 Assessment Strategy for the Monitoring and Assessment Plan. Final Draft. c/o United States Army Corps of Engineers, Jacksonville District, Jacksonville, Florida, and South Florida Water Management District, West Palm Beach, Florida.</p>	