Greater Everglades Performance Measure

Inundation Pattern in Greater Everglades Wetlands (previously GE-2)

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Acceptance Status: Accepted

1.0 Desired Restoration Condition

Restore Natural Systems Model (NSM) (version 4.62) envelopes throughout the Greater Everglades (GE) wetlands, except in areas where deviations from NSM have been deemed to be environmentally beneficial.

1.1 Predictive Metric and Target

The ecological target is the recovery of the predrainage patterns of multiyear hydroperiods. The NSM version 4.62 is used to develop envelopes for the number and duration of inundation events except where deviations from NSM are deemed ecologically beneficial (Water Conservation Area 1, Marl Marshes, and Corbett Wildlife Management Area). Number and duration of events are then used to calculate percent period of record (PPOR) of inundation by determining the total time inundated relative to the full period of record. This performance measure (PM) is applied in all Greater Everglades indicator regions (IR):

IR 100	Ridge and Slough	2000B2: 19 events, 94 weeks *
IR 101	Ridge and Slough	2000B2: 5 events, 372 weeks *
IR 102	Ridge and Slough	2000B2: 2 events, 935 weeks *
IRs 110-133 and 160-190	Ridge and Slough and Sawgrass Plains	NSM 4.62
IRs 140 and 141	Marl Marsh	24-34 weeks average duration with compatible number of events (30 weeks/55 ppor)
IR 143	Marl Marsh	8-16 weeks average duration with compatible number of events (13 weeks/ 23 ppor)
IR 144	Marl Marsh	16-20 weeks average duration with compatible number of events (19 weeks/34 ppor)
IR 145	Marl Marsh	20-24 weeks average duration with compatible number of events (23 weeks/ 42 ppor)
IR 146	Marl Marsh	28-32 weeks average duration with compatible number of events (32 weeks/ 58 ppor)
IR 147	Marl Marsh	26 weeks average duration with compatible number of events (26 weeks/ 46 ppor)
IR 148	Marl Marsh	32-34 weeks average duration with compatible number of events (hard targets for duration and ppor are waiting confirmation from the Marl Prairie expert panel) (35 weeks/64 ppor)
IRs 150 and 151	Mixed	2000B2

For marl marsh indicator regions, a specific target is provided (in parenthesis above) for duration and percent period of record (ppor) to provide clearer guidance on scoring alternative performance. Currently, due to the relatively high uncertainty associated with calculating the number of inundation events in marl prairies, number of events is not scored for these indicator regions. In order to score this PM for the Marl Prairie IRs it is necessary to consider PPOR while scoring inundation duration.

Currently, specific WCA-1 targets based on the 2000B2 condition are given to aid scoring. Previously target ranges were provided for this area. Ranges for IRs 100-102 were 9-22 events with ~74-222 weeks average duration, 2-9 events with ~222-962 weeks average duration, and 2-9 events with ~ 624-936 weeks average duration, respectively. These ranges are still provided for better understanding of acceptable conditions within WCA-1* (see notes for additional comments).

1.2 Assessment Parameter and Target

Targets are under development. The Everglades Depth Estimation Network (EDEN) is currently active and will be used for field assessments and comparisons to model projections. Previously, assessment targets were not set because the NSM update (comparing version 4.62 vs. Sens 4.0) was not completed.

2.0 Justification

In the predrainage system, the inundation pattern supported an expansive system of freshwater marshes including longer hydroperiod sawgrass “ridges” interspersed with open-water “sloughs”, higher elevation marl prairies on either side of Shark River Slough, and forested wetlands in the Big Cypress marsh. Conceptual ecological models for the ridge and slough (Ogden 2005), southern marl prairies (Davis et al. 2005), and Big Cypress systems (Duever 2005) detail the fundamental role inundation patterns play in the formation and maintenance of the soils, vegetation patterns, animal use, and water quality characteristics of these landscape types. Throughout the predrainage Everglades, the depth, distribution and duration of surface flooding largely determined the vegetation patterns, as well as the distribution, abundance and seasonal movements, and reproductive dynamics of all of the aquatic and many of the terrestrial animals in the Everglades (Kushlan 1989, Davis and Ogden 1994, Holling et al. 1994, Walters and Gunderson 1994). Accretion of the peat soils typical of the ridge and slough landscape requires prolonged flooding, characterized by 10 to 12 month annual hydroperiods, and groundwater that rarely drops more than one foot below ground surface (Tropical BioIndustries 1990). Natural hydrologic patterns in marl wetlands support gradients of vegetation subtypes that are aligned sequentially along hydrologic gradients ranging from 1-2 month hydroperiods (*Schizachrium rhizomatum*-dominated) to 3-5 months (*Muhlenbergia filipes*-dominated) to 6-8 months (*Cladium jamaicense*-dominated) (RECOVER 2004). These communities are notable for the high floral species richness, which includes more than 100 herbaceous plant species (Olmstead and Loope 1984). Hydrologic patterns that maintain these community gradients also support higher-elevation tropical hammocks and pine forests that occur as islands within the marl wetlands. These forested communities contain a flora of West Indian origin that is unique in the Florida mainland and that includes the highest number of rare and threatened plant species in southern Florida (Gunderson 1994).

Water management practices that compartmentalized the Everglades to prevent flooding of and provide water supply to urban and agricultural areas also fragmented the landscape, exaggerated hydroperiods and depths, and reduced flows through natural sloughs. The result has been substantially altered plant community structures, reduced abundance and diversity of animals, and spread of exotic vegetation.

Altered inundation patterns are one of the most critical stressors on the ecology of the Everglades. Ecological consequences of operationally altered hydropatterns are numerous and widespread including flooding of alligator nests (Mazzotti and Brandt 1994) and apple snail egg clusters (Bennetts et. al. 1994), the adverse effects of water depth reversals on wading bird nesting and foraging (Bancroft et al. 1994), the adverse effects of dry season water deliveries on cape sable sparrow nesting, and flooding of tree islands (Brandt et al. 2000). In the marl prairies, shortened hydroperiod directly affects ecosystem food webs through 1) the decrease in the percent composition of diatoms and green algae associated with the periphyton mat, shifting near dominance by the blue-greens *Schizothrix* and *Scytonema* (Browder et al. 1994), 2) the reduced secondary production and altered species composition of marsh fishes and other aquatic fauna (Loftus and Eklund 1994, Loftus et al. 1990, Trexler and Loftus 2000, Turner et al. 1999), 3) the reduced population density and altered species composition of small herpetofauna, based on abundance in short hydroperiod habitats in relation to rainfall and water levels on Long Pine Key (Dalrymple 1987, Diffendorfer et al. in preparation, Dalrymple pers. comm.), 4) the loss of the potential for wading bird and wood stork foraging during the early dry season (Fleming pers. comm. in Ogden 1994), and 5) the decline in the American alligator population in the landscape where it was once abundant (Craighead 1968, Mazzotti and Brandt 1994). Shortened hydroperiod also directly affects plant community and habitat structure by enabling the invasion of nuisance native woody plants (e.g., willow) and exotics (e.g., Brazilian pepper and melaleuca) in a naturally herbaceous landscape (Armentano et al. 1995, Jones and Doren 1997), by altering the plant species composition of macrophyte vegetation toward more terrestrial plant species (Hilsenbeck et al. 1979, Hofstetter and Hilsenbeck 1980), and by altering the fire regime, resulting in hotter and more severe fires exacerbated by the prolonged dry season (Gunderson and Snyder 1994) that further alter herbaceous plant species composition and reduce plant community heterogeneity by burning out hardwood hammock tree islands (Loope and Urban 1980).

3.0 Scientific Basis

3.1 Relationship to Conceptual Ecological Models

http://www.evergladesplan.org/pm/recover/recover_docs/et/pm_report/pm_rpt_4_3_ge_cem.pdf (RECOVER 2006)

In each of the hypothesis clusters and conceptual ecological models (CEMs), alternate terminology for inundation such as hydroperiod, water depth, or inundation pattern may be used. Inundation is an essential component in the following Conceptual Ecological Models:

Greater Everglades Regional Conceptual Ecological Models (RECOVER 2004b) by landscape type can be found at http://www.evergladesplan.org/pm/recover/cems.aspx

Everglades Ridge and Slough (Ogden 2005)
Southern Marl Prairies (Davis et al. 2005)

Big Cypress Regional Ecosystem (Duever 2005)

Simplified Conceptual Ecological Models (RECOVER 2006). The following list identifies which of the ten Greater Everglades simplified CEMs are directly related to dry down # and duration.

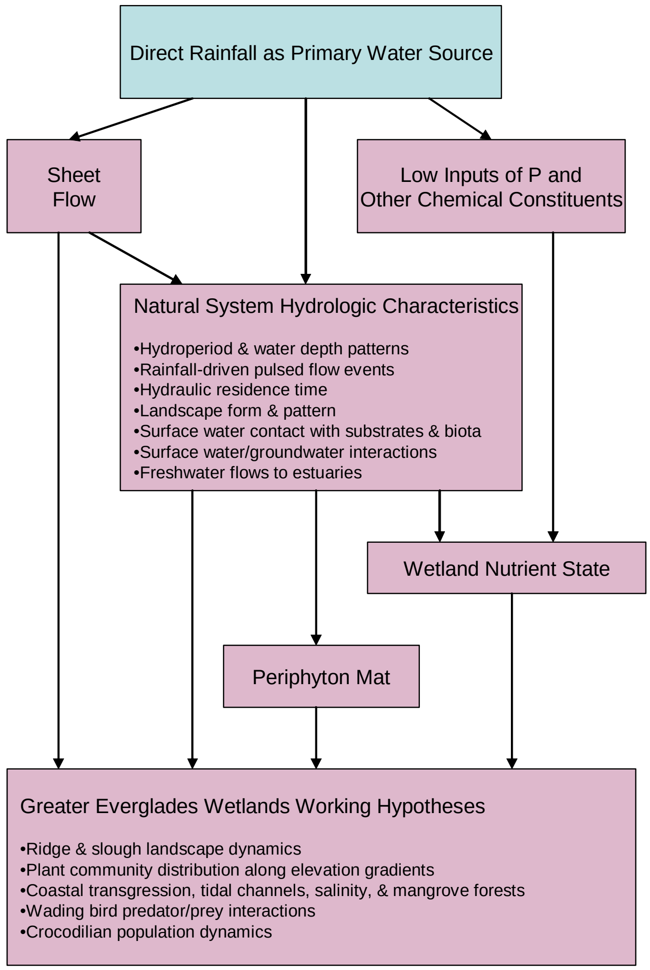
1) Integrated Hydrology and Water Quality Conceptual Ecological Model
2) Ridge and Slough Landscape Dynamics
3) Plant Communities along Elevation Gradients
4) Predator-Prey Interactions of Wading Birds and Aquatic Fauna Forage Base
5) Linkage of Periphyton to higher Trophic Levels
6) Everglades Crocodilian Populations

3.2 Relationship to Adaptive Assessment Hypothesis Clusters

For detailed information regarding each of the hypothesis, including additional CEM diagrams, please see the Map II. A subset of figures and hypothesis descriptions are provided below for justification and general theory *http://www.evergladesplan.org/pm/recover/recover_docs/et/060507_pm_report/hypothesis_clusters_ge.pdf*

<u>Integrated Hydrology and Water Quality Hypothesis Cluster (RECOVER 2006, Section 9.2.3)</u>

Integrated Hydrology and Water Quality Conceptual Ecological Model



Hypothesis 1: Rainfall and Sheet Flow as Determinants of Natural System Hydrologic Characteristics in the Everglades

The volume, timing, and distribution of sheet flow, in combination with direct rainfall, produced fundamental hydrologic and landscape characteristics of the pre-drainage Everglades that can be described by the following parameters:

- Hydroperiod and water depth patterns
- Rainfall-driven pulsed flow events

- Hydraulic residence time
- Landscape form and pattern
- Surface water contact with substrates and biota
- Surface water/groundwater interactions
- Freshwater flows supporting beneficial salinity patterns in the mangrove estuaries of Florida Bay and the Gulf of Mexico

Decompartmentalization, combined with resumption of natural volume, distribution, and timing of freshwater delivery is expected to restore sheet flow and pre-drainage hydrologic and landscape characteristics to an undivided ecosystem encompassing much of Water Conservation Area 3A, Water Conservation Area 3B, eastern Big Cypress, and Everglades National Park.

Rationale: Specific hydrologic restoration targets associated with the resumption of sheet flow and related hydrologic characteristics include:

- Multi-year hydroperiods in ridge and slough landscape
- Conditions conducive to peat formation in ridge and slough landscape
- Hydropatterns that sustain co-existing sloughs and sawgrass ridges in the ridge and slough landscape
- No distinct or persistent changes in water levels across boundaries such as canals, levees, or roads
- Large-scale surface water flow directions that follow the historic landscape directionality
- Hydropatterns that support the long-term stability of tree islands in ridge and slough landscape
- Hydroperiods from two months to less than one year conducive to marl formation and muhly grass (*Muhlenbergia filipes*) community persistence in Southern marl prairies
- Persistent pools of fresh to oligohaline water along the interface of the freshwater Everglades and the mangrove ecotone of Florida Bay and the Gulf of Mexico
- Dry season water recession patterns conducive to successful wading bird foraging
- Multi-year flood and drought cycles supporting formation of wading bird super-colonies
- Absence of harmful regulatory releases of excess fresh water to the Greater Everglades
- Freshwater flow discharges to Florida Bay and the Gulf estuaries that maintain a near shore salinity gradient characteristic of pre-drainage conditions.

Please note this performance measure is also directly related to Hypotheses 1-3 in the Wetland Landscape and Plant Community Dynamics hypothesis cluster of the Assessment Strategy (RECOVER 2006).

4.0 Evaluation Application

4.1 Evaluation Protocol

A table of values will be generated showing the number, duration (in weeks) and percent period of record (PPOR) of inundation events for NSM, Base conditions, and each alternative to be evaluated. The table is accompanied by box-and-whisker plots which represent the NSM v 4.62

(target) distributions for #, duration and PPOR for ridge and slough habitat. Calculations are made separately for the ridge and slough cells north (excluding WCA-1) and south of Tamiami Trail.

Values displayed on the whiskers represent the upper and lower 10 percent of the NSM distribution, while the remaining 80 percent of values make up the box. The box is divided into four categories, each encompassing a 20 percentile grouping of the cell values. The box-and-whiskers plots include labels or a legend off to the side indicating the percentage categories. A scale is included so that reviewers can see the percentage values that define the box-and-whisker areas. The mean and median values of the distribution are also calculated and shown (mean = x, median = y) at the top of the graph.

Scoring is accomplished by comparing the position of the indicator region value for each alternative on the box-and-whisker background to the position of the NSM (target) value for that indicator region. An "A" grade is assigned if the indicator region value for the alternative falls in the same 20 percentile category as predicted by NSM for the indicator region. A "B" grade is assigned if the indicator region value for the alternative falls in a 20 percentile category directly adjacent to the NSM target category. A "C" is assigned for performance two categories away, and a "D" for performance three categories away. Indicator region performance within or beyond the whiskers generally receives a failing grade. In some cases where the target falls on the whiskers or the edge of the box, further discussion may be necessary to justify scoring. The final score for an indicator region is represented by the combination of scores for # and duration of events. It should be noted that using PPOR provides insight into the total change in performance but PPOR alone does not provide independent information on the number and duration of dry events or the distribution and timing of these events, both of which are ecologically meaningful. Any scoring method used, including the method suggested above, should be consistently applied across alternatives and should reflect best professional judgment about what differences in performance are ecologically significant.

For areas with NSM envelope targets, a failing grade indicates that the alternative would not be expected to support a sustainable natural Everglades landscape within the range of the landscape type. Any "passing" grade of A-D indicates that the alternative produces conditions within the indicator region that may be expected to support a sustainable natural Everglades landscape within the range of the landscape type. Higher grades indicate the alternative is expected to support a sustainable natural Everglades landscape closer to that found in the indicator region area historically.

Calculations of average depth and average and total duration of inundation events are calculated as follows:

1) Period of record (POR) = 1965-2000 simulation period

a) Non-Leap Years -> last eight days of calendar year used for weekly average

b) Leap Years -> last nine days of calendar year used for weekly average

2) The average depth for a given week in a given year is calculated for each grid cell within an indicator region and these values are averaged over the cells within the indicator region to obtain an average depth for the indicator region for that week.

3) An inundation event (IE) is calculated as a discrete segment of time from the point at which water levels rise above ground surface, providing they exceed 0.2 feet, until the time they fall below ground. When water levels rise above 0.2 feet, then the IE is counted as beginning when water levels first rose above ground.

4) Average inundation duration (weeks per event) is the average number of sequential weeks in an IE for the period of record: average inundation duration = sum[duration of each IE in weeks] / (number of IE)

4.2 Normalized Performance Output

Normalization of output is currently being discussed by the Greater Everglades Subteam and Module Team.

4.3 Model Output

4.4 Uncertainty

Because of the relatively high uncertainty associated with the calculating the number of inundation events in marl prairies, the number of events is not scored for these indicator regions. 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). (http://www.evergladesplan.org/pm/recover/recover_docs/et/052402_mrt_uncertainty_report.pdf).

5.0 Monitoring and Assessment Approach

5.1 MAP Module and Section

See CERP Monitoring and Assessment Plan: Part 1 Monitoring and Supporting Research - South Florida Hydrology Monitoring Network Module sections 3.5.3.1 - 3.5.3.3 (RECOVER 2004a)

See The RECOVER Team's Recommendations for Interim Goals and Interim Targets for the Comprehensive Everglades Restoration Plan – Interim Goal 3.3 Hydropattern (RECOVER 2005).

5.2 Assessment Approach

6.0 Future Tool Development Needed to Support Performance Measure

6.1 Evaluation Tools Needed

Further work to increase the sensitivity of this performance measure is needed. Current methods counting the number and duration of extreme events over the 36-year period of record lack information on the timing and distribution of these events. Continued discussion on how to best consolidate and present information on timing and distribution of inundation events is ongoing within the sub-team. Updates to the PM output will follow sub-team recommendations.

6.2 Assessment Tools Needed

7.0 Notes

Currently, the Greater Everglades Sub-team is reviewing a proposed update to the marl prairie portion of this performance measure. The updated wet prairie performance measure focuses on the hydroperiod distribution identified by Ross and Sah (Ross et al. 2004, 2006).

* It should be noted that some of the WCA-1 target ranges previously provided fall outside the 36 year period of record used in the SFWMM calculation of this PM. The upper end of the ranges while still providing guidance and ecological context, are not directly comparable to the current version of SFWMM output that uses a 36 period of record. This is particularly so in IR 102.

This performance measure supersedes and addresses GE-2 Inundation Pattern in Greater Everglades wetlands (Last Date Revised: November 22, 2005).

8.0 Working Group Members

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