Indicator 3.8 - Everglades Tree Islands

What are the desired restoration conditions?

The desired restoration conditions for Everglades tree islands are 1) improved health of Everglades tree islands considered to be stressed or degraded and maintain the status of healthy islands and 2) prevent areal reductions of tree islands except for islands that have expanded due to over drainage.

Why is the indicator important and why is it a good indicator of CERP restoration?

Tree islands are a small but important component of the mosaic of habitat types found in the Everglades ridge and slough landscape. They harbor high plant species diversity and provide essential upland habitat for a variety of wildlife. Tree islands occur throughout the Everglades marshes. However, large regions that were once "peppered" with islands are now completely devoid of them (e.g., Water Conservation Area 2A), while some areas have seen a reduction of 60 percent (e.g., Water Conservation Area 3). Historically, tree islands have supported diverse vegetative communities that provide essential foraging and sheltering habitat for wildlife, especially during periods of high water, and provide nesting sites for wading birds and herpetofauna (e.g., freshwater turtles). Tree islands are also archaeologically important and have significant cultural importance to both the Miccosukee Tribe of Indians and the Seminole Tribe of Florida. Several studies have shown that tree island vegetation is dependent upon hydrology (Heisler et al. 2002, Wu et al. 2002). Improvements in hydrology associated with the Comprehensive Everglades Restoration Plan (CERP) are likely to protect vegetation communities on intact tree islands and to restore those on degraded islands.

How is the interim goal for this indicator predicted?

Tree Island Habitat Suitability

The Tree Island Habitat Suitability Index is composed of three indices: a tree species richness index, a flooding stress index, and a drought stress index. It is assumed that hydropatterns predicted by the Natural System Model (NSM) include frequencies and durations of extreme depth conditions that would sustain appropriate species richness on elevated tree islands. The flooding and stress indices are based on the output from a dynamic model of tree island stress and recovery, and on parameters derived from the published literature and field observations (Wu et al. 1996, 1997, 2002).

Tree Species Richness Index. Analysis of data collected in Water Conservation Area 3 suggest that woody species richness on elevated tree islands is an indicator of negative impacts from both island flooding and prolonged low water conditions (Heisler et al. 2002). Therefore, species richness is used as a surrogate measure for hydrologic impacts to tree islands. In general, this index is founded on a statistical expression of the relationship between field data of tree island vegetation condition and hydrologic variables predicted by regional models. The specific metrics for the index are expected to change over time with improved knowledge of

hydrologic linkages to tree island vegetation condition. The current chosen hydrologic predictor variables are 1) the percent of weeks during the simulation that depths are less than -1.0 feet, and 2) the percent of weeks during the simulation that depths are greater than 2.0 feet relative to South Florida Water Management Model (SFWMM) version 3.5 grid cell ground elevation. The SFWMM period of record is for rainfall years 1979-1995. This index is described in detail in Heisler et al. (2004). Using these high and low depths from SFWMM output, a predicted species richness score is calculated for each model grid cell. A standardized measure of the deviation of the predictive hydrologic model from the NSM target is calculated and converted to a species richness suitability index.

Flood Index. The flood index is a cumulative accounting of the time that the survival of a generic tree island exceeds a threshold water depth and hydroperiod (continuous days of flooding) in the Everglades. This cumulative index is based upon a daily flood index, which is calculated from daily water depth data output from hydrologic simulations such as the SFWMM and NSM. The water depth threshold is 2 feet and is, in part, based upon Loveless (1959), who reported that tree islands range from 1.0-3.0 feet in elevation relative to the surrounding marsh. Duever (1984) has suggested that extreme flooding durations of 300 days are unsuitable even for willow islands. South Florida Water Management District field and staff scientists have observed tree island stress and loss of leaves occurring as early as sixty days under flooded conditions. Given these observances, the flood index assumes a logistic curve function between two extremes (60 and 300 days of flooding) such that tree island species begin to experience negative impacts after 60 days of flooding and mortality after 300 days of flooding.

This flood index has two basic assumptions: 1) all tree island are the same (differences in elevations make this a poor assumption), and 2) when there is a break in flooding, the index does not get reset back to zero (instead it takes twice as long to recover from this stress than it does to feel its impacts). Uncertainty resides within this index because the absolute rates of stress and recovery are undetermined, and would be expected to vary among different species and tree island community types. Thus, like any index, it is not the intent of the flood index to be an absolute measure. It is a tool to evaluate relative differences.

Drought Index. The drought index, also a relativistic tool, is at the other end of the hydrologic spectrum from the Flood Index. Soil oxidation and drought in the Everglades has led to extensive loss of peat soils both in the marshes and on tree islands, as well as to the destruction of tree island vegetation by peat fires (Loveless 1959, Schortemeyer 1980). Recently, specific changes to vegetation on tree islands associated with high drought frequencies in northern Water Conservation Area 3A have been detected. These include decreased species richness, reduced height and density of woody vegetation, and reduction of spatial extent.

To prevent significant harm to the water resources as indicated by loss of peat soils and associated wetland plant communities, a 1-foot minimum water level criteria was set by the South Florida Water Management District (SFWMD 2000). This rule stipulated that for peat-forming areas of the Everglades, water levels should not fall 1.0 feet or more below ground level for more than 30-days duration. The drought index proposed here is a dual-purpose tool, because it can serve both as an index for assessing potential tree island impacts from drought,

and as a stand alone performance measure for evaluating the risk of peat-consuming wildfires in the overall ridge and slough.

The drought index is a time-dependent function of two variables: water depth and cumulative drought duration. Cumulative drought duration is defined as the number of sequential days during which depths are below -1.0 foot. Note, where water depth on any single day is greater than or equal to 0.0 feet then it is assumed to "break" the drought and the number of sequential days of drought is reset to zero. The drought index decreases as ground water recedes further below the surface; this feature of the index is intended to mimic the increased risk of intense and damaging muck fires when the soil has dried to greater depths.

A key assumption of the drought index is that once the water depth is greater than or equal to 0.0 feet then the number of sequential days counter for the drought is reset to 0, regardless of the number or duration of days of previous drought intervals. This prevents the index from addressing the effects of progressive deterioration of tree islands as a result of repeated soil oxidation and the cumulative risk of severe fire. In other words, it assumes that there is no "point of no return" from which recovery may be impossible. As with the flood index, the uncertainty introduced by the hydrological simulation of daily water depth output and the elevation difference between marsh elevation and tree island elevation should be noted.

Tree Island Extent

The number and aerial extent of tree islands in Water Conservation Areas 2 and 3 is quantified as a function of competition with surrounding habitats in relation to drought, fire, hydroperiod, and water depth. The Everglades Landscape Vegetation Model (ELVM) predicts the competitive interaction between a generic tree island and the surrounding ridge and slough as a function of past and present habitat condition. The ELVM predicts landscape-scale changes in the aerial extent of tree islands (Wu et al. 2002). It simulates the establishment, growth, and competition of individual community types at a grid cell resolution of 100 by 100 meters. This high spatial resolution gives ELVM more control over seed distribution, rhizome extension, exotic species invasion, and succession. Vegetation growth and competition in the model were controlled by subsets of environmental factors that include hydroperiod, nutrients, salinity, elevation, precipitation, fire, hurricanes, and freezes. Five vegetation community types - cattail, sawgrass, wet prairies, sloughs, and tree islands - compete with one another for nutrients, water, and space. The life cycle of each community type within a cell is simulated including establishment, growth, expansion, mortality, and succession. Life cycles of each community type are simulated based on growth strategies (e.g., seed germination versus vegetative expansion). These competition and colonization growth strategies can cause a shift in dominance to another community within the cell. The details and mechanism of each function (e.g., succession, growth, mortality, disturbance, hydrology, and elevation) in the ELVM are described in Wu et al (2002). The model results will be displayed using maps of tree island size and location plotted over the applicable regions of the Everglades and summarized in a time-series table by basin.

What are the predictions for five-year increments?

Tables 3.8.1 to 3.8.3 summarize simulation results for three components of the tree island habitat suitability index: drought, flood, and species richness. The tables present the mean index for all indicator regions within each area of the Everglades for the pre-drainage (NSM), the baseline (1995BSR), full CERP implementation (D13R), two intervals during CERP implementation (2010 and 2015), and 2050 without CERP implementation (2050BSR). Index values range from 0 to 1, with 1 being the best. The species richness index has no NSM column because this index is normalized to NSM output (i.e., a value of 1 is equivalent to NSM). Like any index, values should be viewed relative to one another.

Table 3.8.1. Drought index summary

Indicator Region Average	NSM	1995BSR	D13R	2010	2015	2050BSR
Arthur R. Marshall Loxahatchee National Wildlife Refuge	0.88	0.92	0.91	0.90	0.91	0.83
Water Conservation Area 2	0.83	0.78	0.79	0.79	0.80	0.77
Water Conservation Area 3A North	0.79	0.60	0.76	0.74	0.74	0.73
Water Conservation Area 3A South	0.82	0.88	0.92	0.86	0.90	0.80
Water Conservation Area 3B	0.88	0.92	0.95	0.85	0.87	0.86
Shark Slough	0.98	0.76	0.94	0.81	0.84	0.81

Table 3.8.2. Flood index summary

Indicator Region Average	NSM	1995BSR	D13R	2010	2015	2050BSR
Arthur R. Marshall Loxahatchee National Wildlife Refuge	1.00	0.61	0.66	0.66	0.66	0.68
Water Conservation Area 2	1.00	0.98	0.91	0.90	0.91	0.84
Water Conservation Area 3A North	1.00	0.70	0.67	0.69	0.76	0.73
Water Conservation Area 3A South	0.98	0.24	0.53	0.41	0.50	0.37
Water Conservation Area 3B	0.45	0.09	0.05	0.00	0.00	0.00
Shark Slough	0.38	0.73	0.38	0.33	0.35	0.76

Table 3.8.3. Species richness index summary

Indicator Region Average	1995BSR	D13R	2010	2015	2050BSR
Arthur R. Marshall Loxahatchee National Wildlife Refuge	0.95	0.93	0.95	0.93	0.94
Water Conservation Area 2	0.80	0.70	0.78	0.74	0.84
Water Conservation Area 3A North	0.60	0.83	0.75	0.78	0.64
Water Conservation Area 3A South	0.87	0.83	0.99	0.89	0.89
Water Conservation Area 3B	0.51	0.66	0.51	0.54	0.42
Shark Slough	0.44	1.00	0.60	0.73	0.70

According to the tree island drought index (Table 3.8.1), the Arthur R. Marshall Loxahatchee National Wildlife Refuge will degrade without CERP implementation. With implementation, tree islands will improve 10 percent during droughts. This is the only type of improvement expected in the refuge because the flooding and richness indices for this region appear unaffected by the CERP. All regions of the Everglades were found to have a reduced drought stress of 1 to 3 percent by 2015. The largest reduced drought stress occurred in Shark Slough, with a 16 percent improvement for D13R in comparison to the 2050BSR.

According to the tree island flood index (Table 3.8.2), the Shark Slough and Water Conservation Area 3B are expected to get worse as a result of CERP implementation. One must view this result with a large amount of caution because tree islands in this region may be significantly higher than the 2-foot flooding stress threshold. This is suggested by the fact that these two regions do very poorly even when simulated with NSM conditions (0.38 and 0.45, respectively). When we adjusted this threshold up to 3 feet for the indicator regions in Everglades National Park, all alternatives had a flooding stress index of 1.0 and all alternatives were equally good for tree islands. Despite this uncertainty, it is important to realize that current conditions and future without CERP (2050BSR) can result in flooding stress for tree islands in Water Conservation Area 2A and the southern region of Water Conservation Area 3A. A 4-8 percent improvement is expected in these regions by 2015.

The species richness index is designed to be sensitive to both flood and drought (relative to the NSM); therefore, it is a good summary of the effects of flooding and drought. According to this index CERP implementation will have no effect on the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Table 3.8.3). However, the refuge has a strong hydrological gradient from north to south, and the dry northern regions are expected to see a 33 percent improvement in species richness by 2015. The tree islands in Water Conservation Area 2A are not expected to improve according to this index, and the few that remain may actually degrade (e.g., the 2050BSR is 20 percent higher than D13R for Water Conservation Area 2A). The other region that showed little improvement over the long-term was southern Water Conservation Area 3A. This region is expected to be "perfect" for tree species by 2010, but then declines to a value of 0.83 by full CERP implementation (D13R), an index equivalent to the 2050BSR. As above, this too must be viewed with caution. The trends in Water Conservation Area 3B and Shark Slough indicate similar improvements with time. Compared to the 2050BSR, Water Conservation Area 3B will see a 21 percent improvement by 2010 and a 57 percent improvement by full CERP implementation (D13R). Similarly, Shark Slough will see a 4 percent improvement by 2015 and a 43 percent improvement by full CERP implementation (D13R).

How will we track whether the interim goals established for the indicator have been achieved?

The tree island interim goal will be assessed by analysis of aerial photos every five years. Tree island native canopy density and diversity, understory composition and structure, exotic plant density, and tree growth will be measured as described in the *CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research* (RECOVER 2004).

What additional work is needed to improve this interim goal?

Tree Islands Species Richness

Additional information is needed to cross-validate the species richness suitability index for possible application outside of Water Conservation Area 3. This information would include evaluation of correlations between species richness and existing data on tree island species richness for islands outside Water Conservation Area 3, followed by modification of the index's depth criteria and/or weighting coefficients as needed.

Because the temporal lag in the response of species richness to hydrology is unknown, this index is not intended to predict actual species richness changes over time, but rather the suitability of hydrology for tree island vegetation. However, collection of data needed to evaluate the tree island extent indicator along with field hydrologic data should permit the eventual development of a single index for combining the prediction and evaluation of tree island vegetation change over time.

Tree Island Extent

Field data that is needed to improve the EVLM and make it applicable to the Arthur R. Marshall Loxahatchee National Wildlife Refuge and Everglades National Park include distribution of 1) tree island elevations, 2) tree island types, and 3) peat depths on tree islands.

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