Indicator 3.7 - Ridge and Slough Pattern

What is the desired restoration condition?

The desired restoration condition for ridge and slough pattern is to restore the ridge and slough landscape directionality and pattern by supporting natural soil forming processes, and the restoration of ridge and slough microtopography.

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

The pre-drainage ridge and slough landscape is characterized as expansive, long hydroperiod freshwater marsh with low velocity sheet flow, moderately deep organic soils, and alternating sawgrass ridge/open water slough communities (Davis et al. 1994, Gunderson 1994). These freshwater wetlands were important centers of primary production (e.g., periphyton, graminoids, and water lilies), secondary production (e.g., crayfish and grass shrimp), and supported wading birds, turtles, freshwater fish, and alligators. The spatial extent of this landscape has been reduced dramatically by urban and agricultural expansion and water management practices (Davis and Ogden 1994), resulting in landscape compartmentalization, reduced sheet flow, loss of organic soils, altered flow patterns, water depths, water and soil chemistry, and introduction of exotic species (RECOVER 2004).

Field and remotely sensed observations show that all of the remaining ridge and slough landscape has been altered significantly from pre-drainage conditions, either in diminished vertical cross-section or in degraded horizontal pattern or both. The original soil, topographic, and vegetative pattern was the direct result of water depth differences, with microtopographic variations in the peat surface maintained by processes associated with long, landscape-wide, and uninterrupted flow paths. Significant areas have already been converted to nearly monospecific stands of continuous sawgrass that support a substantially reduced fauna. These observed changes suggest that current water management practices are not able to sustain the ridge and slough landscape in its original, diverse form (Science Coordination Team 2003).

Comprehensive Everglades Restoration Plan (CERP) goals include improvements in soil forming processes, habitat, and plant and animal abundance and diversity. The heterogeneity of the ridge and slough landscape supports this diversity. The changes in the flow regime and water depths, associated with the CERP will help restore the soil forming processes and, consequently, the microtopography characteristic of the ridge and slough landscape.

How is the interim goal for this indicator predicted?

The South Florida Water Management Model (SFWMM) is used to calculate the ridge and slough habitat suitability index values for all model cells located within the remaining ridge and slough landscape. Index values are based on long-term average hydrology modeled for the scenario, and are the geometric mean of four subindices characterizing key aspects of water depth and flow. Although the ridge and slough landscape encompassed all three Water

Conservation Areas, particular CERP emphasis may be placed on the region comprised of Water Conservation Areas 3A and 3B, northeast Shark Slough, and Shark Slough. The other portion of remaining ridge and slough landscape, Water Conservation Area 1 (Arthur R. Marshall Loxahatchee National Wildlife Refuge) and Water Conservation Area 2, originally formed part of a separate flowway and may exhibit a different level of response to the CERP.

The habitat suitability index for ridge and slough pattern consists of four subindices, two each for water depth and for water flow (Tarboton et al. 2004). Together, the four attempt to capture the link between hydrology and landscape pattern. They are based on the assumption that conditions will be most suitable for maintaining or restoring the landscape when subindex levels are closest to their pre-drainage levels. The four subindices are average water depth, annual variation (rise and fall) in water depth, flow velocity, and flow direction.

Average Water Depth

Water depth is specified as a bell-shaped index curve with an optimum, in terms of slough water depths, at 2 feet, and minima at +/-1.5 feet relative to the optimum, the lower of which would turn the whole landscape into sawgrass, the higher all into slough (McVoy et al. in review).

Annual Variation in Water Depth

For the water depth variation index, an optimum difference of 2 feet was used as the difference between the average October water depth (i.e., maximum depth at the end of the wet season) and the average May water depth (i.e., minimum depth at the end of the dry season).

Flow Velocity

The flow velocity subindex was based simply on the assumption that flow velocities equal to or within +/- 20 percent of pre-drainage flow velocities would be optimal for maintaining/ restoring the landscape. Velocities lower than one-third pre-drainage or higher than twice pre-drainage are assumed to have zero suitability. As pre-drainage flow velocities were not available from the historical record, the grid cell velocities simulated by the Natural Systems Model (NSM) were used as a proxy estimate only.

Flow Direction

The directionality subindex was based upon the angular deviation between modeled flow direction and the original landscape directionality.

What are the predictions for five-year increments?

This index has depth and flow thresholds based upon historical surveys and an ecological logic designed to maximize the creation of a ridge and slough habitat. Based upon this logic, even the NSM can do better and only the Shark Slough has a good score (Table 3.7.1). Due to the assumptions built into this index and the uncertainty in the NSM with respect to topography and flow velocity, values should be used to evaluate relative trends and not absolute suitability.

Table 3.7.1. Mean ridge and slough pattern index for all indicator regions for each area of the Everglades. Values range from 0 to 1, with 1 being the best. Indicator regions are averaged within each area.

Area	NSM	1995BSR	2050BSR	D13R	2010	2015
Arthur R. Marshall Loxahatchee National Wildlife Refuge	0.51	0.21	0.26	0.23	0.23	0.23
Water Conservation Area 2	0.54	0.38	0.35	0.34	0.35	0.34
Water Conservation Area 3A North	0.54	0.45	0.52	0.57	0.57	0.57
Water Conservation Area 3A South	0.52	0.59	0.62	0.67	0.66	0.66
Water Conservation Area 3B	0.52	0.34	0.48	0.36	0.65	0.66
Shark Slough	0.82	0.43	0.55	0.71	0.71	0.74

According to this index, the best ridge and slough condition can be found in the Shark Slough when experiencing NSM hydrology. It is critical to note that both the 1995BSR (base line) and the 2050BSR (2050 without CERP) indicate a significant decline in suitability in Shark Slough with current conditions and without project conditions, respectively. The 2010, 2015, and D13R (full CERP implementation) Shark Slough runs are all significant improvements, although a trend is difficult to see. A significantly improved ridge and slough hydrology in Water Conservation Area 3B is expected by 2010, as the index goes from 0.34 to 0.65. On the other hand, Water Conservation Area 3B may show signs of ridge and slough pattern deterioration by 2050.

The suitability of the hydrology in Water Conservation Area 3 for ridge and slough increases by 12 percent in the south and by 27 percent in the north by the year 2010. These improvements are sustained by D13R until 2050 and, to some degree, may be due to non-CERP projects. Finally, an examination of the ridge and slough indices for Water Conservation Area 1 and Water Conservation Area 2 indicate no improvement compared to current and future without project conditions. The 1995BSR has a similar index as the 2010, 2015, and D13R indices because CERP does not require high water depth variations, levee removals, or any sheet flow enhancements in these regions.

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

In addition to plant community, soil, and topography monitoring (in transects), the ridge and slough pattern will also be observed using aerial photographs as described in the *CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research* (RECOVER 2004). A relatively new method for analysis of aerial photographs is available. Slough shape is characterized by the length and width of the slough. The landscape as a whole can be characterized by the spacing of the sloughs and the percent that is open slough compared to the percent that is covered by emergent sawgrass.

The proposed assessment method combines an analysis of lacunarity (related to the shape of the ridges and sloughs), percent area, mean distance/gap between ridges, and straight slough flow length. This analysis produces a pattern complexity value for regions of the ridge and slough habitat.

The Ridge and Slough Pattern Analysis Tool (RASPAT) has established a set of criterions and thresholds of “natural”, “deteriorating”, and “deteriorated” patterns of ridge slough landscape in the Everglades based on analysis of historic aerial photographs. The RASPAT will first be used to estimate the current spatial complexity of ridge and slough in Water Conservation Area 3 and Everglades National Park. It will then be used every five years to measure actual spatial complexity in these areas (based upon new aerial photographs).

What additional work is needed to improve this interim goal?

Ideally, a predicted interim goal would also be observable in the field. At this time, the suitability index, while not observable in the field, is the best tool for predicting the condition of the ridge and slough habitat.

With improved understanding of the relationship between flow velocities and sediment movement and the indirect effects of canals, the RASPAT method may be developed into a predictive tool called the Ridge and Slough Pattern Simulation Model. If this tool is considered preferable to the existing suitability index, the interim goal will be revised.

Another important area of work is in understanding the processes that maintain the characteristic microtopography. This would include studies of biomass production and soil accretion as well as organic matter decomposition and other factors. Understanding the complicated interaction between these processes may eventually result in a dynamic model that can precisely predict topographic changes.

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