Lake Okeechobee Performance Measure
Littoral Zone Emergent Vegetation Mosaic

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Acceptance Status: Accepted

1.0 Desired Restoration Condition

The Lake Okeechobee littoral marsh consists of approximately 40,000 hectares bounded by the Herbert Hoover Dike and the 3.05 m (10 ft) NGVD bathymetric contour. For ease of identification, the marsh is typically divided into three major units; 1) the southern region, including Kreamer, Torry, and Ritta Islands; 2) the western marsh north of Fisheating Bay (also referred to as the Indian Prairie Marsh); 3) the western marsh south of Fisheating Bay (Moore Haven Marsh including Moonshine Bay) and north of the southern islands (Figure 1).

The performance target will be achieved when areal coverage of the following key species or species groups resembles historic coverage based on the SFWMD survey of 1973 (Pesnell and Brown, 1976) and the University of Florida surveys conducted in 1989-1992 (Richardson and Harris, 1995). This target includes at least 10,000 hectares (ha) of beakrush (*Rhynchospora tracyi*) and/or spikerush (*Eleocharis cellulosa*), and at least 1900 ha of sawgrass (*Cladium jamaicense*). This target also includes at least 1900 ha of bulrush (*Schoenoplectus californicus*) below the 3.35 m (11ft) contour elevation. Willow (*Salix caroliniana*) is not to fall outside a range of 3000-5000 ha, respectively. Floating leaved plants, including, but not limited to, lily (*Nymphaea spp.*) and lotus (*Nelumbo spp,*), will not exceed 1500 ha above the 3.66 m (12 ft) contour elevation. Cattail (*Typha spp.)* will not exceed 8000 ha, torpedograss (*Panicum repens*) will not exceed 2000 ha of coverage, and other invasive/exotics will not occupy more than 25 ha. The areal coverage of woody vegetation, other than willow, should range from 500 – 1500 ha.

The distribution and composition of plant communities within a wetland or littoral area is primarily a function of water depth (Spence 1982, Van Der Valk 1994). Thus, targeting hydrologic conditions that would support an ecologically desirable mosaic of emergent vegetation and be beneficial for fish, birds and other wildlife should be a goal for lake managers. This performance measure has established areal coverage targets for many of the dominant plant communities found in Lake Okeechobee's littoral marsh. Based on years of monitoring and research, meeting these targets will enhance the ecological conditions for fish and other wildlife in this region of the lake.

1.1 Predictive Metric and Target

1.2 Assessment Parameter and Target

Table 1 identifies the primary littoral zone emergent vegetation targets. Achieving the desired areal coverage for each vegetative community results in a score of one. If the plant community is within 75% or 50% of the desired coverage, a score of 0.5 or 0.25 will be awarded, respectively. If the areal coverage of a plant community is less than 50% of the target coverage, a score of zero will be awarded. Scores are additive so that achieving the complete restoration target requires attaining a score of 9. The interim restoration goal is a score of 5, which is 56% of the full restoration target. The interim goal is higher than the highest recorded score since the 1973 Pesnell and Brown survey and hence should reflect progress towards attaining a desired restoration goal.

A complete mapping of the littoral marsh is recommended every three years with frequency dependent on available funding. However, for the years when data are not available to map the entire marsh, annual assessment scoring based on evaluating the plant communities at 24 representative sentinel sites distributed throughout the marsh will occur. Each sentinel site consists of 50 one-hectare grids. Most are arranged in a 5 X 10 grid pattern and all cover an area of 0.5 km^2 (Figure 1). The targeted areal coverages for the selected vegetative groups are shown in Table 1 (whole marsh map) and Table 2 (sentinel sites only). Examples of the scoring approach for the 2003 and 2007 and the 2015-16 vegetation maps are presented in Table 3.

Sentinel site mapping alone is not an adequate approach to assessing the ecological status of the emergent marsh since the sentinel site concept is dependent on the assumption that those sites are representative of the emergent vegetation mosaic in the entire marsh; this assumption could require confirmation, and possibly readjustment periodically based on whole marsh mapping results.

Figure 1 Lake Okeechobee littoral marsh showing the approximate geographic distribution of mapping units and the location of representative sentinel sites.

Table 1: Littoral zone emergent vegetation mosaic targets for whole marsh mapping:

Vegetation Target	Hectares
Bulrush	1,900 or greater
Beakrush/Spikerush	10,000 or greater
Sawgrass	1,900 or greater
Cattail	8,000 or less
Willow	3,000 – 5,000
Floating leaf	1,500 or less
Torpedograss	2,000 or less
Other Invasive Exotics	25 or less
Woody Vegetation, Not Willow	500 – 1,500

Table 2. Littoral zone emergent vegetation mosaic targets for sentinel sites (1,200 1-ha grids)

Vegetation Target	Hectares
Bulrush	60 or greater
Beakrush/Spikerush	300 or greater
Sawgrass	40 or greater
Cattail	240 or less
Willow	90 – 150
Floating leaf	45 or less
Torpedograss	60 or less
Other Invasive Exotics	0
Woody Vegetation, Not Willow	15 - 45

Table 3. Sample scoring based on the Lake Okeechobee 2003, 2007 and 2015-16 vegetation maps and sentinel site grids extracted from those maps.

				2003		2007		2015-2016	
Lakewide Vegetation Target	**Target (ha)**	**75% Range (ha)**	**50% Range (ha)**	ha	Score	ha	Score	Ha	Score
Bulrush	≥ 1,900	1425-1,899	950-1,424	145	0	0	0	670	0
Beakrush/Spikerush	≥ 10,000	7,500-9,999	5,000-7,499	826	0	7,546	0.5	3,085	0
Sawgrass	≥ 1,900	1425-1,899	950-1,424	522	0	1,787	0.5	981	0.25
Cattail	≤ 8,000	8,001-10,000	10,001-12,000	6,992	1	1,413	1	11,473	0.25
Willow	3,000 – 5,000	2,250-2,999 or 5,001-6,250	1,500-2,999 or 6,251 7,500	2,970	0.5	4,717	1	5,040	0.5
Floating leaf (above 3.7m or 12 ft. elev.)	≤ 1,500	1,501-1,875	1,876-2,250	3,203	0	238	1	2,283	0
Torpedograss	2,000 or less	2,001-2,500	2,501-3,000	3,493	0	3,658	0	2,648	0.25
Other Invasive Exotics	≤ 25	26-32	33-38	47	0	126	0	5	1
Woody, Not Willow	500 – 1,500	375-499 or 1,501-1,875	250-374 or 1,876 - 2,250	1,188	1	3,636	0	3483	0
Cumulative Score					2.5		4		2.25

				2003		2007		2015-2016	
Sentinel Vegetation Target	**Target(ha)**	**75% Range (ha)**	**50% Range (ha)**	ha	Score	ha	Score	ha	Score
Bulrush	≥ 60	45 - 59	30-44	9	0	0	0	33	0.25
Beakrush/Spikerush	≥ 300	301- 375	376- 450	48	0	112	0	114	0
Sawgrass	≥ 40	30 - 39	20 - 29	33	0.5	13	0	19	0
Cattail	≤ 240	241- 300	301- 360	166	1	93	1	275	0.5
Willow	90 – 150	68-89 or 151-187	45-67 or 188-225	28	0	35	0	32	0
Floating leaf (above 3.7m or 12 ft. elev.)	< 45	56	68	188	0	3	1	226	0
Torpedograss	≤ 60	61-75	76-90	242	0	87	0.25	127	0
Other Invasive Exotics	0	0	0	0	1	0	1	0	1
Woody, Not Willow	15- 45	11-14 or 46- 57	7-10 or 58- 68	19	1	84	0	20	1
Cumulative Score					3.5		3.25		2.75

2.0 Justification

Landscapes that consist of a moderately diverse mosaic of native and non-invasive emergent and submerged plants in Lake Okeechobee's littoral and nearshore zones provide important habitat for wading birds, fish, and other wildlife. Over the past 10 years, our understanding of the relationship between hydrology and vegetation distribution has increased, and our ability to predict how plant communities respond to hydrologic conditions has improved making it possible to refine the previous version of this performance measure in a meaningful way.

The Pesnell and Brown (1976) and Richardson and Harris (1995) vegetation studies were chosen for this project. The restoration targets were established from these projects because they provide the most complete spatially explicit vegetation maps for the Lake Okeechobee littoral zone. The Pesnell and Brown (1976) map was prepared after the Herbert Hoover Dike was completed (circa 1969) during a period of moderate lake levels that were similar to the LORS 2008 schedule. The annual maps developed by Richardson and Harris included the period 1989-1992.

In the early 1970s, there were more than 12,575 ha of spikerush and beakrush in Lake Okeechobee's littoral zone. During the past 30 years, about 80% of this native open water marsh habitat was replaced by dense stands of exotic torpedograss in the upper marsh and less desirable monotypic stands of floating leaf plants and cattail in Moonshine Bay. The altered habitat greatly reduced important wildlife habitat selectively used by wading birds and sport fish. Historically, dense bands of bulrush also were common along the lakeside edge of the emergent marsh located in the north and west regions of the lake. (Richardson and Harris 1995). The bulrush provided important habitat for fish and wildlife and helped reduce turbidity along the outer edge of the marsh by stabilizing bottom sediments. In addition, thick bands of bulrush protected other desirable vegetation by diminishing potentially damaging wave energy that otherwise may have uproot aquatic vegetation. Unfortunately, more than 50% of the bulrush community was lost during the 1990s and has not recovered. The loss of bulrush occurred in conjunction with prolonged periods of high lake stages that often exceeded 4.88 m (16 ft).

Prolonged periods (> 3 months) of extreme low lake stage (< 3.35 m or 11 ft.) can also lead to undesirable changes in the marsh landscape. Important herbaceous wetland plant communities disappear and tend to be replaced by woody vegetation and other less productive terrestrial species in regions of the marsh where sediments are exposed. Maximization of important wildlife habitat will be achieved if restoration targets are met for the entire Lake Okeechobee emergent vegetation mosaic.

3.0 Scientific Basis

3.1 Relationship to Conceptual Ecological Models

The indicator for this performance measure is an ecological attribute (Vegetation) in the Lake Okeechobee conceptual ecological model. The relationships between the spatial and temporal parameters of the preferred stage envelope, the impacts of prolonged excessive high and low lake stages, eutrophication, and exotic and/or invasive vegetation are all presented as linkages in the model although specific areal coverage targets are not provided.

<u>Regional Models</u>

This performance measure is not compatible with any regional model since it is a tool for assessing monitoring results only and cannot evaluate regional model output.

<u>Ecological Model for Hypothesis Clusters</u>

Ecological Communities and Effects of Water Stages Conceptual Ecological Model

3.2 Relationship to Adaptive Assessment Hypothesis Clusters

Ecological Premise: Lake levels outside the temporal and spatial bounds of the preferred stage envelope, coupled with nutrient enrichment and the introduction of invasive exotic species resulted in the degradation of the littoral vegetative community in Lake Okeechobee.

CERP Hypotheses:

1) Providing a reduction in the frequency of extreme high-water levels (never to exceed lake stage 5.18 m (17 ft.) or stage >4.57 m (15 ft.) for more than 12 consecutive months) and extreme low water levels (never less than lake stage 3.05 m (10 ft.) or less than stage <3.66 m (12 ft.) for more than 12 consecutive months) and an increase in the frequency of spring recessions (yearly stage decline from near 4.72 m (15.5 ft.) in January to near 3.81 m (12.5 ft.) in June, with no reversal >0.15 m (0.5 ft.)) will result in an increase in spatial extent of bulrush along the western outside edge of the littoral zone and increased spatial extent of spikerush, beakrush, and other native plants in the littoral zone.
2) Reductions in Nitrogen and Phosphorus concentrations will further contribute to control of cattail.
3) Irrespective of operational or restoration improvements, an ongoing invasive nuisance and exotic vegetation control program will continue to be a component of maintaining a desirable emergent vegetation mosaic in the Lake Okeechobee littoral marsh due to the inexhaustible exotic/nuisance vegetation propagule bank that exists in the surrounding watershed.

4.0 Evaluation Application

4.1 Evaluation Protocol

There is no evaluation protocol for this PM because lake stage data generated as regional model output do not provide the specific input data required by the performance measure to generate scores which are used for evaluation.

4.2 Normalized Performance Output

4.3 Model Output - None

5.0 Monitoring and Assessment Approach

5.1 MAP Module and Section

See CERP Monitoring and Assessment Plan: Part 1 Monitoring and Supporting Research – Lake Okeechobee Module section 3.4.3.2 (RECOVER 2004a). Monitoring will be accomplished by producing a spatially, and technically accurate vegetation map of Lake Okeechobee's littoral zone (emergent marsh) using color infrared (CIR) aerial georectified stereoscopic photographs. Since a comprehensive yearly map of the entire littoral zone is both time and cost intensive, vegetation maps

will be created for three geographically separate areas of the lake, 1) Kreamer, Torry, and Ritta Islands in the south; 2) western marsh north of Fisheating Bay (Indian Prairie Marsh); 3) the western marsh south of Fisheating Bay (Moore Haven Marsh). Each region will be mapped at least once in every three-year period so as to be able to compile a full map of the entire vegetated Lake Okeechobee Marsh once every three years. This map will be used to determine if performance measures are achieved as well as to guide vegetation restoration and control activities. Directly comparable maps indicating the distribution and areal coverage of vegetation in the western marsh were produced in 1973, 1996, 2003, 2007, and in 2016 when a composite map of 2015 and 2016 data was created. However only data from the 2003, 2007 and 2016 maps reflected the areas surveyed by Pesnell and Brown closely enough to be scored by the performance measure. In the future, whole marsh and sentinel site field mapping will be done in such a way as to ensure that the results can be scored using the performance measure.

For yearly monitoring between 3-year intervals, 24 sentinel sites (1,200 1-ha grids) representing a subset of the marsh will be used to detect temporal changes in the marsh landscape. This will allow for yearly detection of any major community shifts that may need attention between 3 year mapping efforts.

5.2 Assessment Approach

Every three years, provided available funding for the collection of the required aerial imagery is available, the complete areal distribution (ha) of focal species will be compared to performance measure targets. On a yearly basis, sentinel grids will be used to detect annual changes that occur in response to environmental conditions and/or management actions.

Scoring will be conducted as described in section 1.2 above.

6.0 Future Tool Development Needed to Support Performance Measure

6.1 Evaluation Tools Needed – Not applicable.

6.2 Assessment Tools Needed – Yearly sentinel site monitoring and the entire littoral zone mapped every three years.

7.0 Notes

8.0 Working Group Members

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9.0 References

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