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Periphyton as an indicator of restoration in the Florida Everglades

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1 **Abstract**

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Periphyton communities dominate primary production in much of the Florida Everglades wetland and therefore contribute to soil production, ecosystem metabolism and secondary production as well as the composition of dependent communities. Decades of research in the Everglades have supported research findings from other wetland types that cumulatively show that periphyton communities respond very rapidly to alterations in the two dominant drivers of wetland structure and function – hydrology and water quality. Hydrology controls periphyton productivity and composition by regulating moisture availability, substrate types available for colonization and supply of nutrients. Nutrients, particularly the limiting nutrient in this system, phosphorus (P), control levels of production and community composition. Because periphyton communities are well-established to be related to hydrology and water quality, an indicator was developed based on three periphyton attributes: abundance, quality (i.e., nutrient content) and community composition. This assessment tool offers a qualitative assessment of ecosystem response to potential to changes in management activities at a time scale appropriate for active management. An example is provided of how the indicator can be used to assess the current water quality and hydrological conditions from high-density spatial surveys. Detected patterns of deterioration align with expectations derived from model predictions and known sources of nutrients and unnatural hydrologic regimes. If employed adaptively in ecosystem management, this tool can be used to both detect and react to change before the system has been irreparably altered.

Keywords: Periphyton, Everglades, Assessment, Algae, phosphorus

1 **I. Introduction**

2

3 Periphyton communities, comprised of algae, floating plants, and associated animals, are a
4 ubiquitous feature of Everglades' marshes. Periphyton is responsible for over half of the primary
5 production in the Everglades (Ewe et al., 2006) and is the primary food source for small fish,
6 crayfish, grass shrimp and other small consumers at the base of the food web. Therefore,
7 understanding changes in periphyton is critical to determine causes for alterations in
8 communities of charismatic megafauna (i.e., large fish, wading birds, alligators). In addition,
9 through interactions with the physiochemical environment and other biota, periphyton influences
10 many other features of the Everglades ecosystem including soil quality, concentration of
11 nutrients, and dissolved gasses. Periphyton responds predictably and quickly (days to weeks) to
12 changes in environmental conditions at a large range of spatial scales (meters to tens of
13 kilometers). It therefore serves as an excellent early responder and can be used as a warning of
14 impending change (Gaiser et al., 2005). Detecting change quickly in this system is important, as
15 the difficulty and cost of restoration increases with the duration of damage. For example, it is
16 much easier to stop an impending cattail invasion through diversion of eutrophic water than to
17 replace a large cattail stand with sawgrass.

18

19 Studies of variation in Everglades periphyton along naturally existing and experimentally created
20 gradients have found strong relationships between species composition, nutrient content,
21 structure (growth form), calcite content, and physiology (i.e., nutrient uptake and productivity) to
22 water quality and quantity (Browder et al., 1982; Swift and Nicholas, 1987; Grimshaw et al.,
23 1993; Raschke, 1993; Vymazal and Richardson, 1995; McCormick et al., 1996; McCormick and

1 O'Dell, 1996; McCormick et al., 1997; Cooper et al., 1999; Pan et al., 2000; McCormick et al.,
2 1998; Gaiser et al., 2006). The total phosphorus (TP) content of periphyton tissue is one of the
3 best measures of P load history (McCormick & Stevenson 1998; Gaiser et al., 2005, 2006).
4 While increases in water as well as soil P are only detectable after years of enhanced P loading
5 (because of rapid microbial and physical uptake), effects upon periphyton TP concentration are
6 immediate (Gaiser et al., 2004). Large-scale losses of periphyton throughout the system have
7 occurred in response to excessive P enrichment from canals (Gaiser et al., 2006) and these losses
8 have had cascading effects throughout the Everglades ecosystem (Gaiser et al., 2005). For this
9 reason, periphyton TP concentration and correlated variables (i.e., calcite content, species
10 composition) are now regularly monitored in most Everglades programs. Additionally, changes
11 in periphyton biomass and composition are apparent along spatial and temporal hydrologic
12 gradients, indicating that periphyton collections will improve detections of hydrologic changes as
13 well (Thomas et al., 2006a; Gottlieb et al., 2006).

14
15 The utility of periphyton to expose ecological ramifications of restorative or deconstructive
16 change is due to its bearing several of the most desirable features of a reliable ecological
17 indicator which include (1) being distributed throughout the system of study, and (2) having
18 rapid response to environmental change that is (3) quantifiable at several levels of biological
19 organization (individual, species, population and community) with (4) consequences to levels
20 above and below its placement in the food web (Karr 1999). Reliance on periphyton to indicate
21 environmental change is well justified by scientific research conducted in the Everglades
22 (McCormick and Stevenson 1998; Gaiser et al., 2006), which adds regional applicability to the
23 existing body of literature in aquatic sciences that supports the widespread employment of

1 periphyton monitoring in aquatic ecosystem management (Hill et al., 2000; Stevenson 2001).
2 We anticipate that patterns of periphyton production, nutrient content and composition among
3 and within mapping assessments will reliably indicate changes driven by hydrology and nutrient
4 enrichment. Alterations in periphyton attributes then cascade through the system to affect higher
5 organisms through changes in food composition and quality, concentration of gasses and
6 nutrients in the water column, and ecosystem structure (i.e., soil formation and quality, physical
7 habitat structure).

8

9 *1.2. Factors that drive the use of periphyton indicators*

10

11 The following hypotheses relative to periphyton were formulated using data from descriptive and
12 experimental studies and are now being used to guide monitoring programs in the Greater
13 Everglades (RECOVER 2005).

14

15 *The proportion of floating, calcareous periphyton mats increase with longer hydroperiods, but*
16 *are replaced by epiphytic non-calcareous algal communities once water depths exceed ~1-2 m.*

17

18 *Supporting data:* Studies along transects in Everglades wetlands showed hydrologically-driven
19 gradients in periphyton mat structure (Gaiser et al., 2006). Sloughs and marl prairies were
20 dominated by thick, highly productive calcareous mats, but algal communities became non-
21 calcareous when water depths exceeded about 1.5 m. Other long-term studies showed that
22 calcareous mat productivity is highest in the short-hydroperiod wet prairie (Iwaniec et al., 2006;
23 Ewe et al., 2006) where benthic, sediment-associated mats predominate. Floating mats associated

1 with purple bladderwort, *Utricularia purpurea*, in slough sites are less productive but production
2 increases during the peak of the wet season (Gaiser et al., 2006).

3
4 *Nutrient enrichment elevates periphyton nutrient content, reduces the proportion of calcareous*
5 *floating and epiphytic periphyton mats, and replaces native species by non-mat forming*
6 *filamentous species.*

7
8 *Supporting data:* Throughout the Everglades, periphyton has been shown to rapidly and
9 accurately indicate water quality changes; periphyton responses were critical to establishing the
10 P criterion for freshwater sloughs (McCormick et al., 1996; Gaiser et al., 2004), indicated rates
11 of coastal salt water encroachment in mangroves (Ross et al., 2001; Gaiser et al., 2004) and
12 detected of nutrient enrichment in adjacent offshore seagrass beds (Frankovich et al., 2006).
13 Several studies have shown that periphyton not only responds to but also regulates water quality
14 (Thomas et al., 2006; Gaiser et al., 2006) by quickly and efficiently removing excess P from the
15 water column. Gaiser et al. (2005) recommends using periphyton P content, rather than water or
16 soil P, to measure P-enrichment history, because periphyton P content has repeatedly been
17 shown to more reliably indicate P load history. This has been adopted in most large-scale
18 monitoring programs in the Everglades (i.e., the EPA R-EMAP assessment).

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1 *1.3. Areas of the Everglades Covered by this Periphyton Indicator*

2

3 Periphyton covers virtually all of the Everglades freshwater wetlands and the southern estuarine
4 areas. The area this indicator covers includes the Greater Everglades, Florida Bay and southern
5 estuaries, Lake Okeechobee, and the Kissimmee River basin (see Fig. 1 in Doren et al., this
6 issue).

7

8 *1.4. Indicator History*

9

10 Periphyton has been studied extensively in the Everglades because of its utility as an early
11 warning indicator of impending ecosystem change and the significant consequences of altered
12 periphyton communities on the rest of the food web. Increased nutrient delivery to natural
13 Everglades marshes causes periphyton mats to disintegrate and collapse (Gaiser et al., 2006),
14 altering food availability to grazers at the base of the food web. Research shows periphyton
15 losses are initiated upon exposure to very low nutrient enhancements (>10 ppb TP; Gaiser et. al.,
16 2005). Models have been developed to determine the extent of periphyton losses driven by
17 nutrient enrichment of the Everglades ecosystem (Gaiser et al., 2006). Further, hydrologic
18 changes strongly affect the function and structure of periphyton. Sites that are dry for a majority
19 of the year have minimal production values, while sites that are flooded for >6 months are most
20 productive (Thomas et al., 2006; Gottlieb et al., 2005; Iwaniec et al., 2006). The timing of
21 reflooding of previously dried periphyton mats is also important, as dried periphyton releases
22 large quantities of nutrients into the water column upon reflooding that subsequently may
23 negatively affect downstream systems (Thomas et al., 2006).

1
2 Periphyton biomass in the Everglades is significantly higher than occurs in other wetlands, with
3 dry mass values often exceeding plant biomass in many areas of freshwater marsh as well as
4 offshore marine seagrass beds (Ewe et al., 2006). This primary biomass supports the remainder
5 of the food web, including invertebrates, fish and wading birds (Williams and Trexler, 2006).
6 Periphyton grows on any substrate available in the marsh; as a result, substrate associations vary
7 throughout the Everglades. In the marl prairie, periphyton grows attached to the sediment or
8 bedrock and stems of emergent macrophytes, whereas deeper sloughs contain periphyton
9 communities that are primarily attached to floating macrophytes such as *Utricularia purpurea*
10 (Gaiser et al., 2006). Therefore, hydrology affects periphyton not only directly but also
11 indirectly, by affecting the substrate available for colonization.

12
13 Changes in the hydrologic regime (i.e., duration and timing of flooding, water depth) can greatly
14 influence periphyton community structure and function. During the dry season in short-
15 hydroperiod marshes, periphyton communities are dormant and unproductive (Thomas et al.,
16 2006). Following re-flooding, periphyton recovers within days, but not before large quantities of
17 nutrients have been released back into the water column (Thomas et al., 2006). In stagnant
18 situations, these nutrients may be re-sequestered by the community upon recovery but if water is
19 flowing, the released nutrients can affect downstream communities. Gottlieb et al. (2005)
20 showed that periphyton communities can quickly transition in composition and structure if
21 exposed to alternating hydrologic regimes. These fast responses to environmental changes
22 strongly advocates for the use of periphyton as an indicator for environmental monitoring in the
23 Everglades.

1
2 Across the hydrologic spectrum, periphyton has been shown to respond directly and quickly to
3 above-background concentrations of nutrients. The response is rapid and easily detected, as low-
4 level nutrient enhancements lead to a demise of the periphyton community altogether (Gaiser et
5 al., 2006). This has substantial consequences to the invertebrate and fish communities dependent
6 on this biomass for food (Turner et al., 1999; Gaiser et al., 2005). Periphyton mats have also
7 been shown to be extremely diverse, with more than 700 algal taxa having been documented
8 from the Florida Everglades thus far (see www.serc.edu/~periphyton and Slate and Stevenson,
9 2007). Taxonomic changes driven by changes in nutrient availability can be measured prior to
10 the collapse of the community itself. The history of nutrient loading to a particular site can be
11 interpreted with a high degree of accuracy from periphyton community composition (Gaiser et
12 al., 2005). A variety of models exist that accurately predict the nutrient status of water from
13 periphyton (Cooper et al., 1999; Gaiser et al., 2006), and these can be applied to monitoring and
14 paleoecological studies to determine trends in water quality over time (Slate and Stevenson,
15 2000).

16

17 *1.5. Significance of the Indicator to Everglades Restoration*

18

19 The periphyton indicator is *relevant* to the Everglades ecosystem because it responds to
20 variability at a scale that makes it applicable to the entire ecosystem or to large portions of the
21 ecosystem. Periphyton productivity and community structure are directly linked to hydrology.
22 Periphyton productivity (e.g., abundance and standing stock) is a performance measure in most
23 conceptual ecological models for the Comprehensive Everglades Restoration Program (CERP,

1 <http://www.evergladesplan.org>), including interim goals to assess the progress of CERP.

2 Periphyton performance measures identified by CERP include biomass and cover, community
3 composition in both short- and long-hydroperiod wetlands, and response to frequency and
4 duration of dry-downs.

5

6 The periphyton indicator is *feasible* to implement and is *scientifically defensible*. Periphyton
7 metrics such as abundance and community structure are statistically correlated to ecosystem
8 drivers in South Florida, resulting in reliable models that have been developed to determine the
9 impacts of water management on these communities (McCormick and Stevenson, 1998; Gaiser
10 et al., 2006).

11

12 The periphyton indicator is *sensitive to system drivers* (stressors). Key ecosystem drivers
13 (rainfall, water quantity, water quality) are statistically correlated with periphyton species
14 abundance and community composition (Cooper et al., 1999; Gaiser et al., 2006). Periphyton
15 biomass and community composition have been causally linked to hydrological factors (water
16 depth, days since last dry-down, and length of dry-down; Thomas et al., 2006). Finally, short-
17 and long-hydroperiod wetlands have distinct periphyton biomass and community composition
18 (Gottlieb et al., 2006).

19

20 The periphyton indicator is *integrative* (Fig. 1), as periphyton production is linked to fish and
21 macroinvertebrate production, which, in turn, is linked to wading bird nesting success (**this**
22 **issue**). In addition to CERP recognition of periphyton's food-web contributions, periphyton has
23 been identified as a relevant metric for landscape connectivity, or intactness of the system.

1 Ultimately, periphyton is integrative in that community responses are representative of
2 hydrological improvement (i.e., water management).

3

4 **2. Communicating the Periphyton Indicator**

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6 *2.1. Indicator Performance Measures and Metrics*

7

8 Several metrics provide reliable measure of periphyton response to hydrologic and water quality
9 changes in this system. They can be broadly grouped into three categories: abundance, quality
10 and community composition. Within these categories, at least three measures are recorded within
11 the context of the CERP assessment. These include, for abundance, wet biovolume (ml m^{-2}), dry
12 biomass (g m^{-2}) and ash-free dry biomass (g m^{-2}); for quality, organic content ($\mu\text{g dry g}^{-1}$),
13 chlorophyll *a* content ($\mu\text{g dry g}^{-1}$) and total phosphorus content ($\mu\text{g dry g}^{-1}$); and, for community
14 composition, algal and diatom composition measured using similarity metrics in multi-
15 dimensional ordination space and substrate affiliation (percent cover by substrate type).

16

17 Within each of the categories, all of the parameters respond in the same direction (positive or
18 negative) to changes in water quality as well as hydrologic conditions, including water depth,
19 duration, timing, and spatial extent (Gaiser et al., 2006). The periphyton biomass metrics of wet
20 biovolume, dry biomass and ash-free dry biomass are correlated and all decline with increasing
21 water depth and hydroperiod as well as with increasing availability of phosphorus (Gaiser et al.,
22 2006; Ewe et al., 2006). The periphyton quality metrics of organic, chlorophyll *a*, and total
23 phosphorus content are correlated and increase with increasing water depth and hydroperiod and

1 with increasing phosphorus availability (Gaiser et al., 2005, 2006). The community metrics are
2 based on compositional similarity to expected community structure, established from collections
3 at reference locations (according to Gaiser et al., 2006). The metric for periphyton cover by
4 substrate type is also multivariate, where optima and tolerances are calculated for each substrate
5 type along each gradient, and then site water quality predictions are based on those optima
6 weighted by relative cover.

7

8 *2.2. Stoplight Report Card System Applied to Periphyton*

9

10 The stoplight system for periphyton involves first calibrating the tri-color code by the deviation
11 of values for each metric from an expected baseline condition for each sampling point. Triplicate
12 samples from Principal Sampling Units (PSU's, randomly selected locations within Landscape
13 Sampling Units, LSU's) visited annually in the mid-wet season are analyzed for each periphyton
14 metric. PSU means are then compared to expected values for background conditions defined for
15 the respective LSU. Background conditions are defined from data collected or inferences made
16 from locations within the LSU that are considered un-impacted by human activities and are not
17 static; that is, ranges of acceptable conditions may change depending on modifications by
18 external drivers not under our control (i.e., climate variability) and advancements in the
19 understanding of the ecosystem. Development of a consistent baseline necessitates long-term
20 data, so we do expect targets to evolve as the duration of monitoring programs grow. However,
21 any changes in baseline expectations will be documented and then hindcast through the stoplight
22 system to re-calibrate former values.

23

1 2.3. *Determining Thresholds for Periphyton Success (Green), Caution (Yellow) or Failure (Red)*

2

3 Once baseline expectations for each of the 9 variables are established, color codes are assigned to
4 each PSU based on deviation from that expectation. If the value is within one standard error of
5 the mean, it is designated green (natural), within two standard errors is designated yellow
6 (caution) and beyond three standard errors is designated red (altered). The PSU is then assigned
7 a color for biomass, quality and community composition. The distribution of color designations
8 can then be mapped by PSU for each of these three performance measures. The final color
9 designation for each LSU is then based on the percentage of yellow and red sites. An LSU is
10 given a final yellow designation if more than 25% of sites are coded yellow or red and a red
11 designation if more than 50% of the sites are red, with these cut-offs being based on variability
12 determined within unimpacted background sites (Gaiser et al., 2006).

13

14 Baseline expectations for periphyton TP content, ash-free dry biomass and composition for some
15 LSU's are fairly well-defined and so we provide an example using those data. The expected
16 ranges for these variables for un-impacted conditions for WCA-1A, WCA-3A, SRS and TS were
17 defined by transect surveys conducted in these areas in 1999 by Gaiser et al., (2006). This study
18 did not find un-impacted conditions in WCA-2A, but because this is an important wetland of
19 considerable management interest, we estimated the un-impacted condition for this wetland to be
20 close to that defined for periphyton-dominated areas of SRS. This contention is supported by the
21 work of McCormick and O'Dell (1998) who found the abundance and composition of periphyton
22 in the interior of this wetland to resemble that described for SRS. Establishment of appropriate
23 baseline expectations is a challenging process, since it involves choosing targets based on values

1 observed a selected temporal or spatial distance from perceived unnatural perturbations.
2 Effective targets also encompass the range of natural variability experienced by a system,
3 requiring long-term datasets that are rarely available. We expect this to be an area of rapid
4 development as new, large-scale surveys generate applicable data. The Gaiser et al., (2006)
5 provides a starting point, however, and Figure 2 shows how each basin has unique ranges of
6 acceptable values and how each attribute scales differently. Data from 2005 and 2006 CERP
7 Mapping surveys were plotted on these graphs to show the proportion of sites falling in each of
8 the colored regions.

9
10 For annual assessments, a map of the distribution of the periphyton TP indicator is displayed
11 (Fig. 3) to show within and among-region pattern. Because of inter-basin differences in targets,
12 areas showing high values (dark shading) do not necessarily indicate altered conditions (red
13 coding) unless they exceed the range acceptable for that region. Pattern and suspected causes are
14 displayed in the “summary” and “key findings” sections (Fig. 4). Each basin is then assigned a
15 value using the green-yellow-red coding, based on the proportion of sites falling into these
16 ranges (explained above). Explanation is then provided for causes of current conditions and
17 prospects for the next two years if water management remains the same (Fig. 4).

18

19 **3. Discussion**

20

21 Conversions of large areas of short-hydroperiod wetlands (marl prairies) east of Everglades
22 National Park and the Water Conservation Areas into agricultural and urban uses has resulted in
23 a large loss of the spatial area once inhabited by periphyton and associated populations of fish

1 and macroinvertebrates. These irreversible land-use changes have had a major impact on both the
2 abundance and structure of these communities.

3
4 Periphyton cover, biomass, productivity and composition are affected by the duration and
5 frequency of droughts. The reduction of hydroperiod resulting from long-term water
6 management changes has limited the production period for periphyton in Everglades' wetlands
7 for many decades (Davis et al., 2006). Increases in duration of flooding and depth of water in the
8 southern Everglades (eastern portions of Everglades National Park) that were over-drained for
9 many decades have allowed periphyton to recover, with subsequent improvements in fish and
10 macroinvertebrate populations (Trexler et al. 2005). Further improvement in water management
11 is needed. Additional hydrological restoration is expected to improve habitat for periphyton
12 production in both long and short hydroperiod wetlands. In long-hydroperiod wetlands,
13 improvements in water management should reduce the incidence and severity of drying, further
14 lengthening the production period and primary biomass available to the food chain. In short-
15 hydroperiod wetlands, improved water management should encourage more prolific periphyton
16 growth, including more edible taxa (Gottlieb et al., 2006; Geddes and Trexler, 2003), and
17 facilitate recovery of dependent macroinvertebrates and fish.

18
19 This periphyton-based tool effectively indicates departures in the system from the natural un-
20 impacted state. Because periphyton responds over short time scales to manipulations in the
21 system, it is likely that year-to-year patterns in ecosystem response to management will be
22 observed. This is particularly true in the case of water quality variables (TP content) which
23 respond very directly to P supply and more quickly than P in other system components like the

1 water column, soils or plants (Gaiser et al., 2005). Responses to hydrologic manipulation may
2 take longer to be detected in periphyton, particularly because the variability in response to
3 hydrologic change is greater than for water quality. As the availability of experimental and
4 observational data on periphyton response to hydrology expands, predictions will be enabled at
5 smaller spatial scales that may be more sensitive to change.

6

7 **4. Longer-Term Science Needs**

8

9 The productivity and composition of periphyton mats throughout the Everglades is fairly well
10 understood. Models of periphyton response to hydrology and water quality are also being
11 developed, but few studies have examined the combination of these effects on periphyton and the
12 rest of the food web. Models that operate on smaller scales than the landscape units presented
13 here need to be employed as it is widely recognized that periphyton exhibits unique natural
14 qualities at different points along the Everglades gradient. In addition, longer-term effects of
15 alterations in periphyton composition and function are necessary to determine consequences to
16 the food web and to soil formation. Paleoecological studies, where possible, would also provide
17 baseline information about past water quality and hydrology, to provide a better guide to
18 restoration.

19

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9

1 **Figure Legends:**

2

3 Figure 1. Conceptual model developed by the CERP RECOVER team that links the two primary
4 drivers (water quality and hydrology), manipulated through restorative projects, to periphyton.
5 Cascading effects of changes in periphyton biomass, structure and composition upon the
6 Everglades food web are also shown.

7

8 Figure 2. Distribution of values for periphyton TP, ash-free dry mass and compositional
9 similarity for surveys in 2005 and 2006 in Water Conservation Areas 1A (WCA-1A), 2A (WCA-
10 2A) and 3A (WCA-3A), Shark River Slough (SRS) and Taylor Slough (TS). Green coding was
11 used to define acceptable ranges defined by the mean values of unimpacted sites +/- 1 standard
12 error of that mean, yellow for values between 1-2 standard errors and red for sites departing
13 more than 2 standard errors from mean values of sites surveyed in the same basins in 1999
14 (Gaiser et al., 2006). Compositional assessments for 2006 have not yet been completed.

15

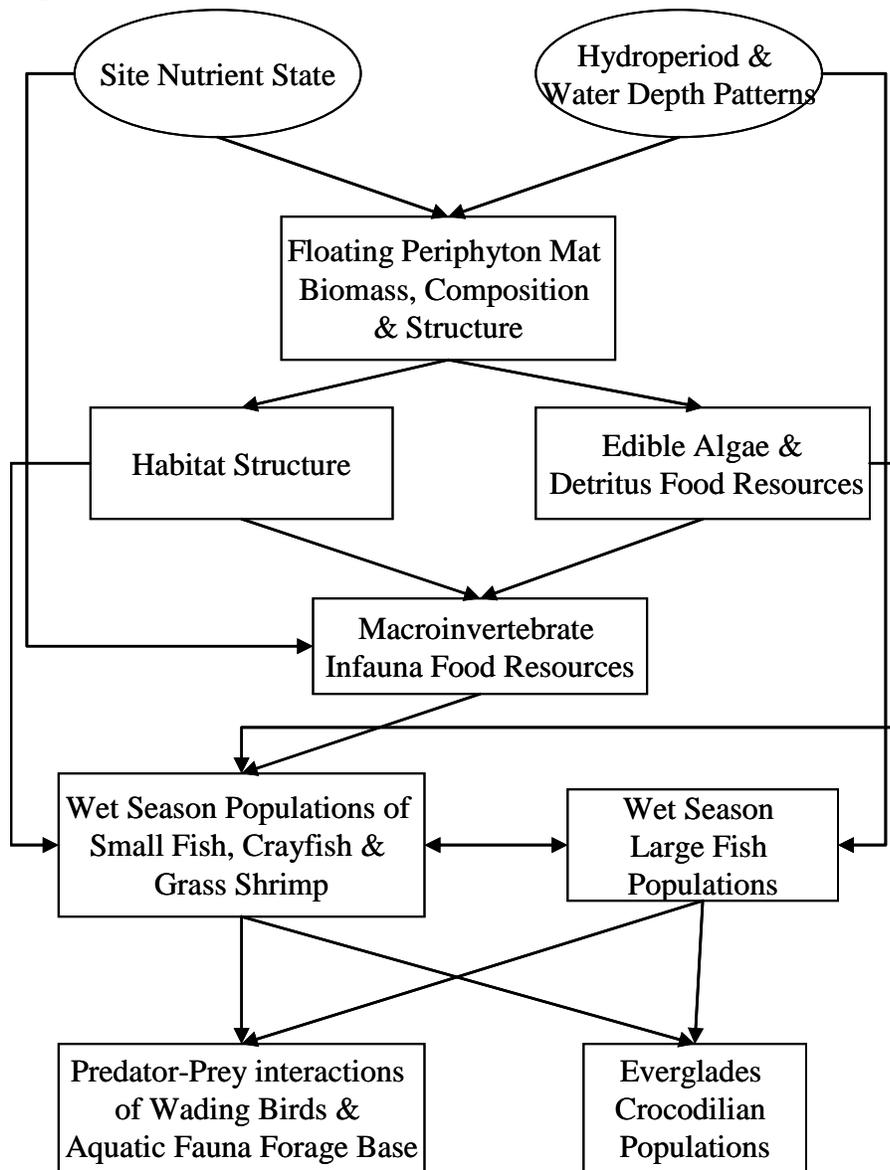
16 Figure 3. Example of system assessment report based on periphyton. Map depicts color
17 assignments based on departure from un-impacted marsh conditions. Summary and key findings
18 sections explain observed patterns.

19

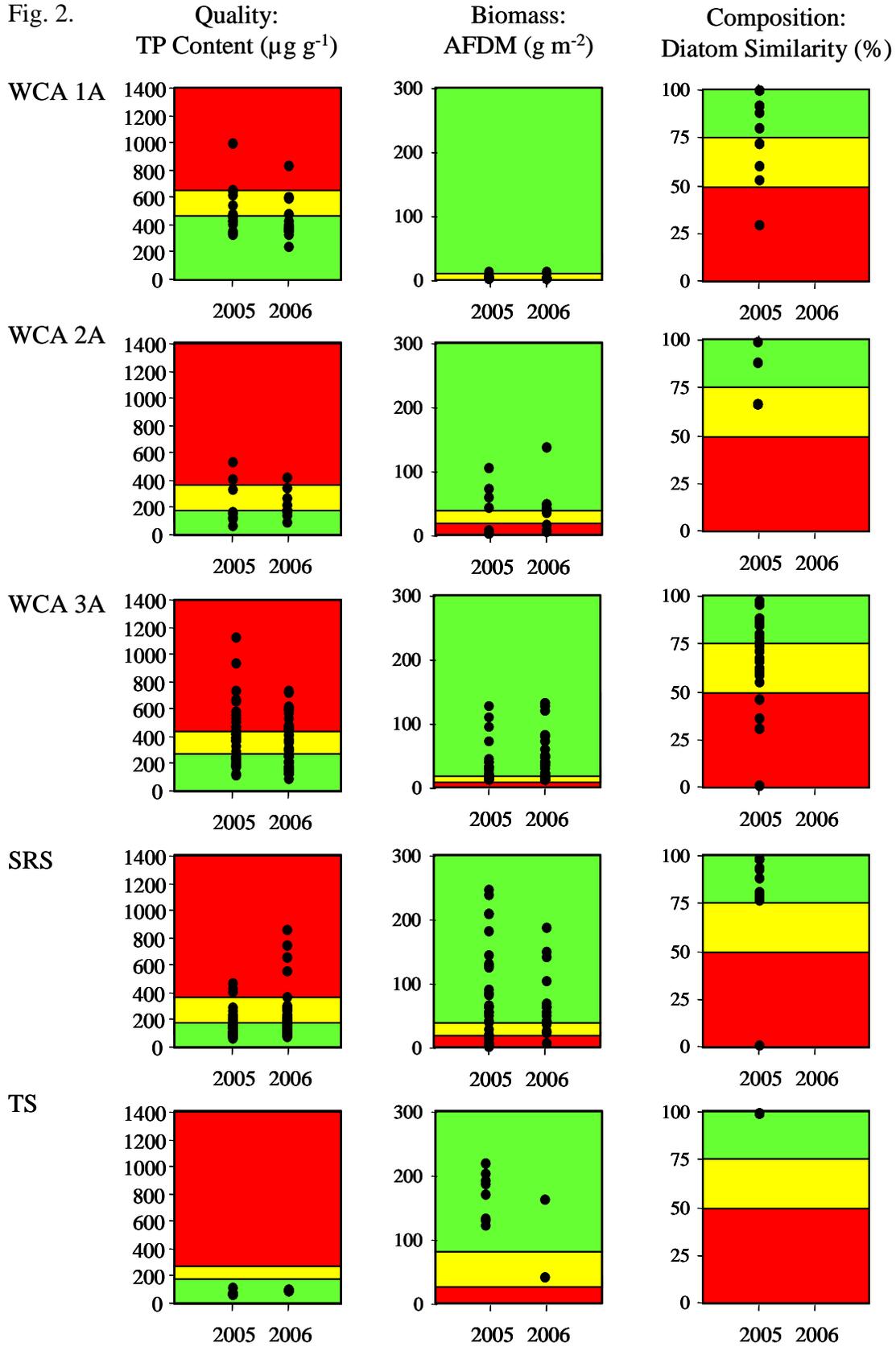
20 Figure 4. Example of system assessment report based on periphyton. Each wetland basin with
21 significant background data is scored with a red, yellow or green symbol for each indicator,
22 based on the proportion of sites falling within these categories in assessment. In this case,
23 biomass = ash-free dry mass (g m^{-2}), quality = total phosphorus content ($\mu\text{g g}^{-1}$) and community

- 1 composition = diatom similarity (%). Trends in current status are explained and prospects for
- 2 conditions in 2-years are projected based on the assumption of no change in water management.

1 Fig. 1.
2



1 Fig. 2.
2



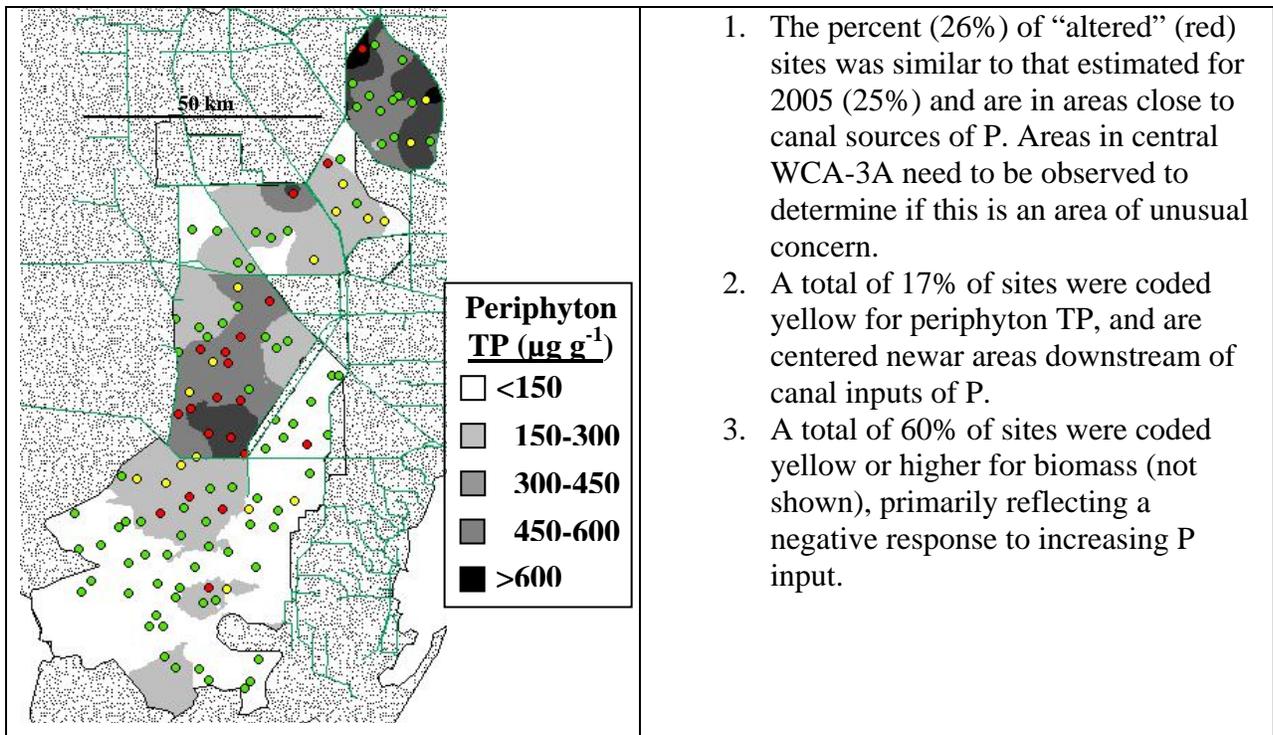
1 Fig. 3.

2006 PERIPHYTON ASSESSMENT

2

3 **SUMMARY FINDINGS:** Many of the sites coded as “altered” (red) are near the peripheral
4 canals surrounding the wetlands, or in drainages downstream of canal inputs. In WCA-1A,
5 canals deliver above-ambient concentrations of both nutrients and calcium carbonate, both
6 causing changes in periphyton quality, including increased TP from nutrient enrichment and
7 reduced organic content from calcium carbonate inputs. In WCA-2A, long-term delivery of
8 above-ambient P in canal inputs have caused enrichment cascades throughout most of the
9 system. This is most severe in the northeast portion of this wetland, where monospecific cattail
10 stands predominate, precluding periphyton sampling. The central slough of WCA-3A appears to
11 be enriched, a trend that continues downstream of water control structures in SRS. TS has
12 remained relatively free of enrichment or hydrologic modifications that would influence
13 periphyton composition.

14



15

16 4. Continued input of above-ambient P concentrations will both increase severity of
17 enrichment effects near canals and cause these effects to continue to cascade downstream
18 of inputs.

19 5. Increased input of water through restorative projects may increase periphyton
20 development in areas formerly dry, but if accompanied by above-ambient P
21 concentrations, cascading P effects are expected.

22

23

24

1 Fig. 4.

PERFORMANCE MEASURE	LAST STATUS	CURRENT STATUS ^a	2-YEAR PROSPECTS ^b	CURRENT STATUS ^a	2-YEAR PROSPECTS ^b
WCA 1A					
Biomass	●	●	●	Periphyton shows evidence of enrichment near canals and calcareous mat biomass has increased due to calcite input from canals	If canal inputs remain low, status should remain same; increased inputs may cause further enrichment and mat change
Quality	●	●	●		
Composition	●	○	○		
WCA 2A					
Biomass	●	●	●	Periphyton TP has increased near canal inputs; composition and biomass reflect this long-term input of above ambient P	If canal P inputs remain above ambient, more sites will be enriched, further changing periphyton biomass and structure
Quality	●	●	●		
Composition	●	○	○		
WCA 3A					
Biomass	●	●	●	This area has received some low level P enrichment, reflected in periphyton biomass and quality	If canal P inputs remain above the protective criterion, status will remain similar or perhaps worsen over time
Quality	●	●	●		
Composition	●	○	○		
SRS					
Biomass	●	●	●	SRS has received low-level P enrichment for decades, reflected in periphyton biomass and quality	Increased flow through S-12 structures may encourage periphyton in dry areas, but above ambient P inputs will cause negative change
Quality	●	●	●		
Composition	●	○	○		
TS					
Biomass	●	●	●	TS has remained relatively unimpacted due to low levels of disturbance and low P inputs	Periphyton should remain the same if conditions continue as they have
Quality	●	●	●		
Composition	●	○	○		

2
3 ^aData in the Current Status column for the periphyton indicator reflect data inclusive of calendar
4 year 2006. Open circles indicate no data available.

5 ^bThe assumption being used for the 2-Year Prospects Column is: There will be no changes in
6 water management from the date of the current status assessment.

7