FINAL PEER REVIEW REPORT

ENVIRONMENTAL PEER REVIEW OF THE SCIENTIFIC AND TECHNICAL BASIS FOR MANAGEMENT DECISION-MAKING AS DESCRIBED IN THE DRAFT KISSIMMEE CHAIN OF LAKES LONG-TERM MANAGEMENT PLAN [DRAFT DATED JUNE 18, 2007]

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Executive Summary

Undertaking the development of a long-term management plan is a difficult process due to multiple management agencies (stakeholders), diverse user groups, and complex management issues, such as rapidly expanding human populations, existing alterations in lake hydrology, and managing non-native taxa like *Hydrilla*. The KCOL LTMP report is an important first step in developing an effective management plan because it initiated the process of agencies working together to solve management issues from a broader perspective than any single agency's charge (e.g., fish and wildlife, water quality) and it identified attributes that will be useful in defining lake health as core components of a monitoring and assessment program. Overall, the panel commends the authors on progress to date; the report provides a firm foundation for the continuing development of a comprehensive management plan.

In part because it was still incomplete, the KCOL LTMP report falls short of being a comprehensive management plan. Consequently, the review panel focused on ways to improve the development process for a management plan and one of its key ingredients, a monitoring and assessment plan. The KCOL LTMP report deals almost exclusively with describing lake attributes and the proposed targets for these attributes. It contains little or no discussion of 1) how the data collected will be analyzed and synthesized to provide decision makers with the information needed to make management decisions, 2) how management decisions will be made, 3) what management actions will be taken (i.e., what are the primary tools in the managers' toolbox), and 4) what are the uncertainties that the management plan would seek to reduce in order to improve future management and thus improve KCOL natural resources. Here we summarize and highlight our core recommendations to improve the Long-Term Management Plan. We encourage managers, agency scientists, and members of the public to read our full report. That report includes the rationales for all our recommendations and, equally important, other thoughts and comments that can save time and focus the energies of all involved in producing and implementing a successful management plan.

Overall Recommendations to Improve the LTMP

- **Explicitly define terms such as health and sustainability to ensure they are clearly understood by all users of the management plan. Without a clearly framed conceptual foundation and definition of terms, it will be difficult, even impossible, to provide specific criteria for judging whether a lake is healthy or not, and why. (See Section 5 for our suggested definitions.)**

- **The goal of the KCOL LTMP to "improve, enhance, and/or sustain lake ecosystem health." is too ambiguous. Specific criteria (using more precisely characterized and rigorously evaluated indicators) should be defined for each lake or lake group to judge whether or not each lake or lake group is healthy. In addition, objective criteria should distinguish whether the management goal for each lake is to improve, to enhance, or to sustain.**

- **Increasing human population size and associated increases in resource consumption present major challenges to the management of the lakes today and in the future. More specific goals should be formulated (1) to accommodate current and future development in ways that minimize adverse impacts on the lakes, and (2) to preserve and protect the key natural resources (native species and ecosystems) that are valued by both residents and visitors to the KCOL region.**

- **Expand the community engaged to define lake health generally and specifically for each lake or lake group to include local citizen groups and government entities in the KCOL region**.

- **In addition to engaging a broader array of KCOL stakeholders in defining health within the KCOL lakes, examine what is meant by health in research and management of other aquatic systems. We suggest that using definitions similar to those proposed in Section 5 of this report will aid in evaluation and ranking of proposed measures.**

- **The report should be very clear about whether the lakes are currently considered to be "healthy." Users of the LTMP will need to know whether the objectives of the management plan for a lake are to (1) maintain the status quo, or (2) alter the lake's current condition to a different, more healthy state. Cases where the former or latter are true should be identified explicitly in the LTMP. Two important questions should be answered for each lake: Do you want the lake to be different than it is now? What direction do you want it to go? If this is specified clearly in the LTMP, all groups using the plan will have a clear vision of the management needs in the future.**

- **The introductory material presents distinct lake groups, yet the APMs that follow are not described using these same groupings. The lake groups should be discussed in all sections of the LTMP, and the report should identify cases where no information exists for specific lake groups.**

- **Because lake health is closely linked to the condition of its watershed, more attention needs to be paid to developing attributes that describe the condition of each lake or lake group's watershed.**

- **The report fails to describe how management decisions will be made via the interagency team, a gap that if not rectified will compromise the success of the LTMP. Develop and define a clear framework for how this will be done. We describe an example of the management process that could be used as a template.**

- **We recommend that a suitable framework for developing and evaluating monitoring programs be adopted that takes into account the whole information cycle needed for effective management.**

- **The conceptual ecological model (CEM) in its current form should be deleted from the KCOL LTMP report because it is not used as a guide in the later sections of the LTMP. We suggest that the current conceptual model be replaced with a schematic of the proposed management process as it is envisioned in Chapter 7 (Agency Action Plans). This schematic should identify how management decisions will be made, what the highest priority performance measures are, and which group would conduct the monitoring of those measures. It would link several relevant and appropriately detailed models: a lake model, a watershed model, and a management model in ways that would clarify the connections between scientific and technical issues and KCOL management challenges.**

- **One of the more striking omissions in the KCOL LTMP report is the absence of a thorough discussion of possible management options for the lakes and for their water control catchments. Explicitly identify the kinds of changes that decision makers can potentially make to manage the lakes.**

- **The management plan should fully describe how adaptive management will be implemented and how management strategies will be altered when new information is obtained from monitoring. We outline the steps completed to date in the LTMP and the steps still needing work for adaptive management to occur.**

- **Although some links between and among the conceptual ecological model, the APMs and AIMs, the data collection and monitoring plan, and the system assessment are described, more work is needed to integrate them and to connect them to both adaptive management and a successful management plan.**

- **We recommend that the KCOL LTMP identify key uncertainties and utilize natural experiments to reduce uncertainties whenever opportunities present themselves. We provide examples that would be appropriate at the KCOL.**

- **In many natural resource contexts, scientists and managers must depend on best professional judgment. Serious management mistakes can be made when dogma[4] passes for best professional judgment. Great care should be exercised in use of best professional judgment and, if it has to be used, this**

[4] A **point of view or tenet put forth as authoritative without adequate grounds; Merriam-Webster's Collegiate Dictionary, 11th Edition.**

should be explicitly stated and justified. Monitoring, natural experiments, and pilot management projects should be used to reduce reliance on best professional judgment.

Recommendations on APM Choice and Content

- **The selection of attributes should be an iterative process that takes into account information needs of managers and stakeholders after specific health goals for each lake or lake group have been established.**

- **Substantial energy should be dedicated to the transition from the current array of very general attributes to more precisely defined and rigorously evaluated attributes known (empirically) to respond to changes in the drivers and the stresses imposed on the system by human actions and natural events.**

- **Although the selected set of performance measures and indicators covers many important issues, some important issues are not included, and the measures presented need to be described and defined in greater detail.**

- **We recommend organizing the APMs conceptually and defining APM priorities. In addition, we recommend some APM consolidation to reduce duplication of field efforts and to coordinate and integrate monitoring programs. For example, by consolidating the many APMs directed at measuring vegetative habitat requirements for vertebrates groups (and for the vegetation on its own merit), a more cost-effective and scientifically rigorous monitoring program will strengthen the scientific foundations of the indicators and improve information to managers. A specific example is shown for consolidating the APM for littoral macrophyte abundance and composition because we conclude that the many littoral macrophyte APMs are redundant and in some cases contradictory (e.g., plant requirements for wading birds versus reptiles).**

- **The report presents little information on the statistical precision of each proposed APM as well as costs and difficulty in measuring them. Develop this kind of information to help inform the developing plan. Without this context, it is difficult for the Panel to comment on the utility of specific APMs or to decide which should be measured for effective management.**

- **For the *Hydrilla* APM (2-06), we recommend that thresholds of maximum allowable *Hydrilla* coverage should be set for each lake. This important issue should be addressed more directly in the LTMP.**

- **Considerable work has been completed during the past two decades to define how indicators are selected and used. We urge the District and its partners to study those efforts as they strive to identify the most appropriate ecological**

indicators. We describe examples from the Biological Assessment of Wetlands Working Group (BAWWG) and other sources, often with explicit reference to Florida systems.

A General Recommendation

- **We encourage managers and members of the public to read our review and the rationales for our recommendations. Please do not just rely on the bulleted recommendations found in this Executive Summary.**

Our goal with this review was to assist the development of a rigorous, comprehensive management plan. Plan development inevitably requires several iterations that depend on cycles of learning by all participants. Interactions between the end users (decision makers) and information generators will serve to refine the management plan, including the always important monitoring and assessment program. We believe that implementing our recommendations will enhance the LTMP, and will thus serve the needs of all institutions and individuals with an interest in the KCOL system.

Section 1. Panel Charge and Report Overview

The South Florida Water Management District formed a three-person committee to serve as an outside panel to review the first draft of a management plan (*Draft Kissimmee Chain of Lakes Long-Term Management Plan*; KCOL LTMP) for the Kissimmee Chain of Lakes region. The Panel (Mike Allen, Jim Karr, and Arnold van der Valk) reviewed the document and participated in a one-day discussion of the report on July 20, 2007, in Kissimmee, Florida. Between July 20 and August 10, the panel worked to produce a draft report for submission to the District. This final report is submitted to the District includes revisions developed by the Panel in response to questions raised by the District and our own perceptions of ambiguities in the draft report.

The panel commends the authors of the KCOL LTMP on a strong start to developing a long-term management plan. The development of a long-term management plan is a difficult process. Multiple management agencies (stakeholders), diverse user groups, and complex management issues (e.g., rapidly expanding human populations and associated development, continuing alterations in lake hydrology, and the challenges posed by non-native taxa such as *Hydrilla*) make the task difficult.

The KCOL LTMP report makes significant gains in several key areas: First, the report initiated the process of agencies working together to solve management issues from a broader perspective than any one agency’s charge (e.g., fish and wildlife, water quality). Thus, the LTMP is already moving toward its stated goal of ecosystem management. Second, the report identified many attributes to be monitored that will provide information useful for making management decisions. Third, the report did a solid job of summarizing the past work and existing data in the KCOL that were used to develop attribute targets.

At the time of this review, the full management plan had not been completed because Chapter 7, Agency Action Plans, was not yet available for review. Although this omission precluded a review of the management plan, it allowed the panel to suggest points that should be considered in the process of developing an effective management plan. We encourage managers and members of the public to read our review and the rationales for our recommendations; they should not just rely on the bulleted recommendations found in our Executive Summary. One major goal of our report is to provide insight and advice that will aid in the development of the LTMP. We believe that advice will result in improved and more effective management at the KCOL.

Our report contains six sections. Section 2 responds to the specific questions provided to the Panel by the District. Our responses to each question are brief in this section but they are fleshed out in the following three sections. Section 3 describes the general shortcomings of the report, especially the absence of a integrative framework for defining goals and making management decisions, the lack of an adequate definition of ecosystem health, an inadequate mechanism for developing and evaluating a monitoring plan, and failure to anticipate the need for ways to reduce uncertainty in future management decisions. Section 4 addresses the general process of selecting suitable ecosystem measures (indicators) to monitor and the need to clearly frame the analytical process that takes monitoring data and converts it to useful management guidance. Section 4 also suggests approaches for reducing redundancy among the measures and making them more useful to managers. Finally, Section 4 provides the individual panelist's detailed comments on the individual APMs and AIMs. Section 5 provides definitions of key terms (integrity, health, condition, and sustainable) that are used in the LTMP so that stakeholders and other users of the LTMP will have a common understanding of their meaning. A clear grasp of these terms, especially how they are to be used in the KCOL LTMP, is essential for setting management goals, for selecting ecosystem and watershed measures to track the parts and processes of ecosystems in routine monitoring, and for establishing targets for these attributes that can be used to judge the effectiveness of the management program designed to ensure the health of each of the KCOL lakes. Section 6 provides full citations for each document that we cite in the text of our report.

The next iteration of the KCOL LTMP, especially its monitoring program, will be significantly improved if the comments and suggestions made in Sections 3, 4, and 5 are addressed and acted on by the stakeholders.

Section 2. Answers to Questions for Peer Review Panel

The District provided four sets of questions as a focus for the Panel's review of the KCOL LTMP Report. Here we provide specific responses to each of the 10 questions included in those four sets. The rationales for our answers to these questions, more detailed discussion of the issues raised in these questions, and, as appropriate, proposed solutions can be found in Sections 3, 4, and 5 of this report.

1a. Have this document's purpose, goals and objectives been conveyed clearly in Chapter 1?

Purposes, goals, and objectives are not as clear and as connected as they should be. Many critical terms are not adequately defined. "Health" is used often as both a concept and a goal. The concept is explored in Chapter 1 (e.g., Figure 1-3) but not in a way that clearly shows how it will be employed in the KCOL LTMP. For example, the suggestion is made that the management goals will vary among the lakes within the system, but no effort is made to illustrate or describe how health will be defined for any of the lakes. Elsewhere the report states that health will be "determined collectively by the partner agencies." By then it will be too late to use it appropriately in development of this Management Plan.

The report should be very clear about whether the lakes are currently considered to be "healthy." Users of the LTMP will need to know whether the objectives of the management plan are to (1) maintain the status quo, or (2) improve the lake attributes in the future. In short, it should be clear whether the goal of the LTMP is to change the lakes to a condition that is different from that found today.

Another word that is not adequately defined is "stakeholder." In some contexts it seems to refer to the agencies involved in natural resource issues in the region and in other contexts it seems to suggest that citizens of the region are stakeholders as well. A survey of the second group is available but there is no indication in the report how or when the results of that survey will be used.

1b. Do Chapters 1–6 achieve them?

Chapters 1–6 demonstrate progress but they do not yet ensure achievement of the goals and objectives. We are not able to evaluate whether the LTMP will achieve these objectives because (1) the document does not specify what management actions will be taken if the APM targets are not met, (2) management targets are either not specified or are vaguely articulated, (3) key uncertainties about the system and what is needed to help management are not discussed; and (4) the APMs have few measures of precision or information about the difficulty in measuring them. Thus, we were unable to discern how well or even if the goals and objectives can be met by the LTMP at the time of this review.

1c. Are the purpose, goals and objectives of this document tied clearly to the overall purpose and goals of KCOL management as explained in Chapter 1?

The general goals of the KCOL LTMP plan are outlined, but no management plan is presented that describes how these goals will be attained. In large part, this is due to absence of Chapter 7, which presumably will describe the proposed management plan. Without knowing (1) who will be making management decisions, (2) what kind of information these decision makers will require, and (3) what aspects of the KCOL can be altered to ensure that these goals are met, it is difficult to judge the relevance of the proposed attributes, targets, and measures. This document describes the data that information generators would like to collect, but it does not address the needs of the information end users who will ultimately be making management decisions. Neither does it address how the two will be linked.

The introductory chapters do not address current monitoring plans and how data currently being collected are or will be used (existing monitoring plans are listed but not really evaluated in Chapter 5). Likewise, these chapters do not describe why current monitoring efforts are inadequate and what additional crucial data are needed to improve the management of the lakes. Existing management options are not described. In order to carry out lake management, one must identify what can be changed and how to bring about the desired changes. Some types of lake management are obvious (e.g., *Hydrilla* management), while others are not (e.g., reduction of organic sediment buildup or reduction of nutrient inputs).

2a. Have the right ecosystem attributes been identified in Chapter 3?

Many appropriate ecosystem attributes are identified in Chapter 3 but more detail is needed before they can be effectively applied. The selection of attributes, an iterative process, should take into account information needs of managers and stakeholders as it strives to attain the specific health goals previously defined for each lake or lake group.

One key challenge that must be faced is the translation of the proposed and very general attributes to more precisely defined and rigorously evaluated attributes likely to respond to changes in the drivers and the stresses imposed on the system by human actions and natural events. The reality is that virtually all changes in the ecosystem could improve some lake attributes and reduce others. Chapter 3 would be the appropriate place to specify uncertainties and information needs, and Chapter 7 (not yet present) would be the place to show how management, attribute selection, and monitoring and assessment design would reduce those uncertainties, maximize information gain, and minimize sampling effort.

2b. Do these attributes address the key natural resource concerns identified in the Scope and Goals document?

The attributes selected address to varying levels some but not all of the key natural resource concerns identified in the Scope and Goals document.

The attributes selected reflect primarily the interests of the agencies that make up the stakeholder group. They may not, however, adequately reflect the interests and concerns of the people who live in the area. This is unfortunate because their interests and concerns and those of local government entities must be understood in order to establish meaningful criteria for lake health. Some of the proposed attributes will probably be of little interest to local residents (e.g., benthic macroinvertebrate and palustrine wetlands), but are indirectly related to attributes of interest to the public (e.g., birds and fish). Thus, the importance of each attribute should be communicated in creative ways to local residents. Some attributes should be relevant to protecting downstream interests. The final suite of attributes should be comprehensive enough to track the interests of all relevant stakeholders. Because local resident concerns are not fully described and are not well reflected in the proposed list of performance measures, not all the relevant ecosystem attributes have probably been identified. Not all the measures identified are likely to provide clear, rigorous, and easily interpreted knowledge of lake or landscape condition. Identifying which attributes are reliable as indicators and which are not remains as a major task of the KCOL LTMP program.

The selection of attributes is always a challenge because of the need to both provide robust and easily interpreted information and provide information that will help all stakeholders understand why specific management changes are important to their stated goals.

3a. Have we selected an appropriate set of performance measures and indicator measures to achieve our purpose?

The selected set of performance measures and indicators covers many important issues, but the suite of measures is not adequately integrated. Moreover, some important issues are not included, and the measures presented need to be described and defined in greater detail.

The five goals defined in the document titled “Goals for the Kissimmee Chain of Lakes Long-Term Management Plan” contain no less than 23 specific objectives. Considerable overlap occurs among these objectives. Many are addressed with the proposed measures, at least in a general sense, but others are not even mentioned (e.g., monitoring mercury in fish tissue, establishing specific public uses, and enforcement guidelines and regulations). Concordance among goals, objectives, and proposed measures should be strengthened.

The LTMP includes many APMs that should be useful for detecting ecological change. The question is how realistic is it to measure all these APMs with reasonable precision and frequency? General guidance for APMs and AIMs and detailed comments on each are provided in Chapter 4.

3b. Does the document appropriately link the APMs, AIMs, Data Collection and Monitoring Plan, and System Assessment to the Conceptual Ecological Model?

Although some links between and among the conceptual ecological model, the APMs and AIMs, the data collection and monitoring plan, and the system assessment are described, more work is needed to integrate them and to connect them to both adaptive management and a successful management plan (see Section 3).

The proposed performance measures are grouped into the five attribute categories identified in the conceptual model, but the absence of direct links or references to the conceptual model in Chapter 4 suggests that it was not used routinely in the development of performance measures. Many other equally or more relevant performance measures could have been proposed, including ones based on local resident interests and concerns.

We recommend removing the Conceptual Ecological Model (CEM) from Chapter 3 because it is not used as a guide in the later sections of the LTMP. Instead, the report should include a schematic of the proposed management process as it is envisioned in Chapter 7 (Agency Action Plans). This schematic would identify how management decisions would be made, what the highest priority performance measures are, and which group would conduct the monitoring of those measures. Because such a figure would clarify how the LTMP is proposed to work, it would be a more useful tool than the CEM.

The list of proposed performance measures has not been ranked in any way. Some of them are ecosystem drivers while many others are ecosystem responses. Too many performance measures are proposed for inclusion in the program. Some are unlikely to be useful in management decision making while others duplicate information included in other measures. In the aggregate they constitute a plan that is unnecessarily expensive and not well focused on needs. The list should be shortened by combining ones that deal with the same lake feature or similar groups of organisms and by dropping ones of little direct relevance for gauging lake health.

Another component of the APM selection process should be the careful evaluation of how each performance measure will contribute to decision making about those goals. The APM's and their targets are interrelated, but the LTMP does not make it clear how management for one APM will influence management decisions based on other APM's.

4a. Do Chapters 1–6 constitute a complete and scientifically defensible product?

Chapters 1–6 do not constitute a complete and defensible product at this time. They provide a useful foundation for the next round of attribute selections needed for a management plan at the KCOL. As already noted, the report does not adequately describe how the management will be adaptive, what will be manipulated, or what should be measured as part of the monitoring program. We believe that management of the lakes can be improved based on the principles presented in this draft LTMP, but it is currently a work in progress and not ready for implementation.

We see the measures proposed here as primarily derived from existing monitoring plans and perceived shortcomings in these plans. The next iteration of the attribute selection process should have two important goals: (1) Select carefully from the present list of attributes those that are most relevant for making management decisions, and (2) Define additional attributes that will focus on important dimensions of lake health not yet captured in the list of attributes presented in the report.

4b. Do they present an approach for assessing and monitoring ecosystem health that provides a sound scientific and technical basis for adaptive management?

The approach for assessing and monitoring ecosystem health outlined in the report is an important first step in what will be a continuing effort to provide a sound scientific and technical basis for adaptive management and management plan development.

Because no management model is presented and lake health is not adequately defined, the ultimate relevance of the proposed performance measures is not easy to assess.

4c. Can lake ecosystem health be monitored, improved, enhanced, and/or sustained using this methodology as a means to inform adaptive management?

The ideas developed in preparation of this draft report can with additional work advance monitoring and thus should in the future improve, enhance, and/or sustain lake ecosystem health. This Report suggests how to improve the APMs and the AIMs, and the data collection and monitoring programs. One crucial aspect of that improvement will be definition of when improve vs. enhance vs. sustain will be the core goal for a lake or lake group.

The report does not adequately describe how monitoring information has been or will be used to improve the management of the lakes nor does it comprehensively describe the role of adaptive management in the overall program. If adaptive management is properly incorporated into the management plan, adaptive management will make it feasible to adjust KCOL management and possibly its goals over time.

Section 3. Management and Monitoring Plan Shortcomings

General Comments

Efforts to develop management and monitoring plans that involve a variety of private and public stakeholders are inherently difficult and typically require several iterations. The draft KCOL LTMP Report is an important and essential step in the development of a management plan for the Kissimmee Chain of Lakes. As is typical of ambitious and wide-ranging management plans, however, additional work is needed to clarify management goals and to adjust proposed lake attributes and monitoring plans to these goals. An extensive and insightful literature on environmental management (Grumbine 1994, Christensen et al. 1996) and monitoring (Griffith 1997, Jorgensen et al. 2005, O'Neill et al. 1997, Vos et al. 2000, Carignan and Villard 2002) is already available. In addition to these general discussions, a number of agencies, institutions, and scientists have explored many of the dimensions of monitoring, assessment, and management of diverse water bodies (Simon 1999, 2003, Larsen et al. 2001, Radar et al. 2001, Karr 2006), including those in Florida (Schulz et al. 1998, Doherty et al. 2000, Cohen et al,. 2004, Brown and Vivas 2005, Fore 2005, Reiss and Brown 2007). Unfortunately, this extensive literature seems to have been mostly ignored in the development of the Kissimmee Chain of Lakes Long-Term Management Plan (KCOL LTMP). Consequently, the proposed plan falls short of what it could and should be.

Our individually prepared, detailed comments on the report (see Section 4, pages 39–57 of this report) provide many specific comments and suggestions. Here we provide expansive comments on six general shortcomings of the draft KCOL LTMP report that need to be addressed:

(1) Inadequate development of the management plan
(2) Ambiguous definition of lake health
(3) Inadequate evaluation of the proposed monitoring plan
(4) No consideration of management options
(5) Inadequate discussion of management uncertainties and how to reduce them
(6) Failure to define how an adaptive management plan will be implemented

The Management Plan

One important decision that was made by the stakeholders (here defined as a team of agency representatives) was that this would be an ecosystem management plan. It would not be a plan designed to improve specific species (e.g., Snail Kites) or group of species (e.g., fish). This attempt to develop an integrated and coordinated management plan for the KCOL is a significant advance in management planning for these lakes.

As Grumbine (1994) pointed out, ecosystem management plans typically have a number of common goals:

(1) Protect native species
(2) Maintain native ecosystems and their natural variation
(3) Preserve ecological and evolutionary processes
(4) Define strategies to cope with short-term and long-term environmental change
(5) Define strategies to accommodate human activities to minimize the adverse effects of those activities on native ecosystems.

The KCOL LTMP goal to "improve, enhance, and/or sustain lake ecosystem health." is so ambiguous that it cannot be attained unless and until more specific, operational goals are formulated. Development is clearly one of the major challenges to the management of the lakes today and in the future. For example, more specific goals that address development could be formulated: (1) to accommodate current and future development in ways that minimize adverse impacts on the lakes; and (2) to preserve and protect the key natural resources (native species and ecosystems) that are valued by both residents and visitors to the KCOL region.

According to the KCOL LTMP report, this new management plan has two important characteristics: (1) a "scientific and technical basis for assessing current and future environmental conditions relative to agreed upon targets" and (2) "collaborative strategies for identifying the need for management intervention or modification to achieve targets" (Chapter 1, page 3). The KCOL LTMP report falls short of being a comprehensive management plan. The report deals almost exclusively with describing what lake attributes will be monitored and the proposed targets for these attributes. Little or no insight is provided on how the data collected will be analyzed and synthesized to provide decision makers with the information that they need to make management decisions. Neither is there discussion of the kinds of management changes that could be made in response to this information. Consequently, in spite of its title, the report can only be evaluated as a monitoring plan, not as a management plan.

Monitoring programs must be designed as part of a system (Figure 1) that includes management goals (targets); monitoring plans and activities; data storage, analysis, and synthesis; reports for information end users; and management decision making. As noted, the KCOL LTMP report deals primarily with setting targets and with developing suitable monitoring plans for collecting data. It does not put these two facets of the management plan into an overall system for managing the KCOL. Neither does it provide a firm foundation of support for the targets selected for the measures described in the report.

Data *per se* is not information. Decision makers need information. Information is produced as a result of collecting and processing (analyzing) data in such a way that the recipients of this information can draw conclusions from it. Timmerman et al. (2000) provide a useful overview (Figure 2) of how best to design monitoring programs to produce the information needed by managers and policy makers.

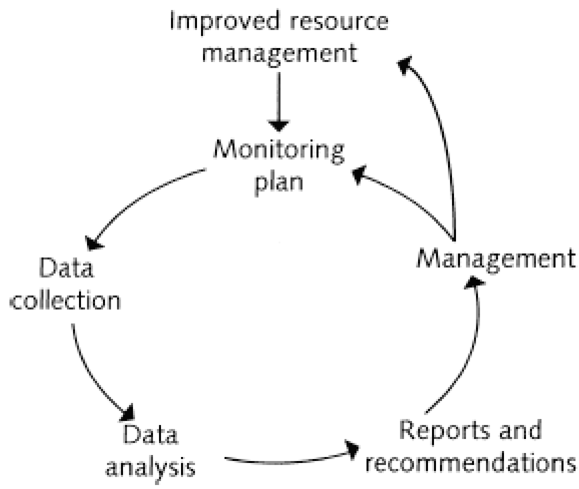

Figure 1. Essential features of resource management plans (MacDonald 1994).

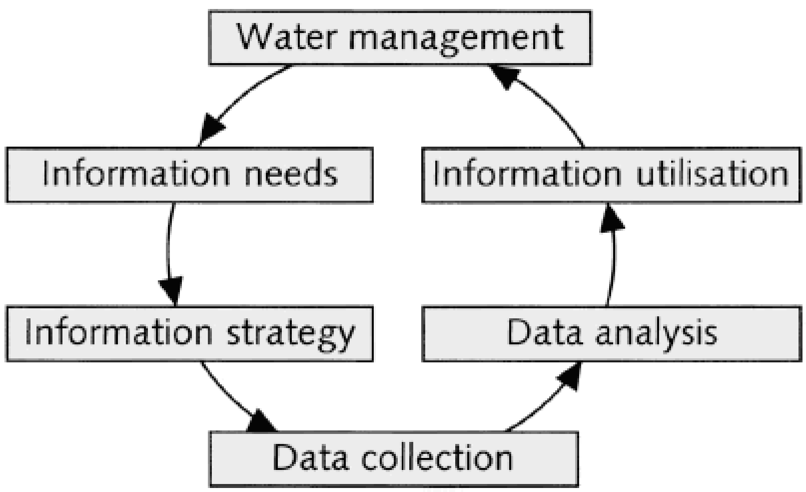

Figure 2. The information cycle framework for developing management plans (Timmerman et al. 2000).

Formulating the specific objectives of a management plan is the most important and difficult part of the process of developing a plan (Timmerman et al. 2000). As is illustrated in this report, it is easy to identify a host of data types that could be collected, and the means to collect them. However, determining what information is needed to make management decisions and the specific monitoring objectives required to provide this information requires considerable thought and consultation among information producers and end users (decision makers) who will have to act on the information generated. The proposed monitoring plan does not adequately discuss what information decision makers will need. The data needs of various stakeholders (mostly state agencies) were taken into account, but not the information needs of all the decision makers, especially local decision makers, who will ultimately have to make decisions about how the watersheds around the various groups of KCOL lakes—as well as the lakes themselves—are developed and managed.

From the perspective of the information cycle model of Timmerman et al. (2000), the KCOL LTMP inadequately addresses the information needs of decision makers and consequently it does not contain an information strategy (e.g., an integrated monitoring plan) optimized to meet their information needs. The KCOL LTMP report also has little to say about how data collected will be analyzed and synthesized or how and by whom the resulting information will be used (i.e., who are the end users of the information that will be generated). Presumably Chapter 7 will deal with these issues. Without Chapter 7, we cannot judge the ultimate utility or efficacy of the proposed attributes, measures, and monitoring plans. However, it is still possible to assess them based on general criteria that are used to judge monitoring plans (Vos et al. 2000, Carignan and Villard 2002).

Lake Health

In the report, "lake ecosystem health" is the framework proposed for developing a monitoring program that is relevant to decision makers. For this framework to be useful, **lake ecosystem health needs to be clearly and operationally defined; without clear definitions, managers will not be able to define what lake or landscape attributes should be monitored**.

Health when applied to ecosystems is a controversial term (Carignan and Villard 2002). Unfortunately, the exact meaning of ecosystem health in the context of the KCOL is side stepped in the report. The report notes that it will be "determined collectively by the partner agencies." By not first answering the hard questions (What is meant by ecosystem health? What information will be needed to determine if a lake is healthy or not?), designing a suitable management plan is unfeasible.

The report acknowledges that health is a societal value judgment as pointed out by Lackey (2001) and cites Karr and Chu (1999) to justify why different criteria can be used to define the health of each lake. However, these authors propose a different approach to defining health than is used by the authors of this report. (See Section 5 of this report for an expanded treatment of health and related topics.)

Because it is a societal value judgment, the characteristics of a healthy lake should be in part those of the local people. Nevertheless, because what happens in these lakes has profound effect on water resources downstream, a much larger societal context needs to be considered. Consequently, a variety of state agencies that have mandated responsibilities for managing some aspects of the lakes in the KCOL and downstream ecosystems are also important stakeholders. According to this report, establishing criteria for lake health is the prerogative solely of state agencies that have some legal mandate to work on the lakes. In other words, health was being defined by the information generators and they seem to have paid little attention to the wants of local residents and the information needs of local decision makers. **The group of stakeholders that will ultimately define lake health should be expanded to include local citizen's groups and government entities in the KCOL region**.

More than the health of the lakes *per se* needs to be considered in a suitable management plan for the KCOL. Lake health is inseparable from the health or condition of the water control catchments in which the lakes are located. Existing and future changes in land use have and will have a major impact on a given lake's health. This is another reason why local citizen's groups and government entities must be major stakeholders in the development of the KCOL LTMP.

The failure of the current group of stakeholders adequately to define health, or even to discuss in the report what is meant by health in other aquatic systems, means that the proposed attributes to be measured can not be evaluated and ranked based on their relevance for assessing lake health. The report should clearly define whether a lake or lake group is currently considered healthy. For unhealthy lakes, the changes required to attain a healthy state should be specifically stated.

The Monitoring Plan

The introductory chapters do not evaluate current monitoring programs. What are the shortcomings of the current monitoring programs? What are their strengths? How have their results been used to inform past management decisions? What additional information do KCOL decision makers need? Who are those decision makers? How do they make decisions? In other words, no description of the current monitoring plan's strengths and weaknesses are provided. Likewise, no theoretical or conceptual framework to design and evaluate the proposed monitoring plan is provided.

Chapter 3 presents a conceptual ecological model that was developed for the Kissimmee Chain of Lakes. This model was developed independent of and by a different group than the proposed monitoring plan. Trying to fit the stakeholder's proposed attributes in the monitoring plan into the attribute categories in the conceptual plan creates confusion and makes it more difficult to optimize the design of the monitoring plan. **The conceptual model in its current form should be deleted from the KCOL LTMP report. Replacing the current conceptual model with an appropriately detailed lake model linked to a watershed model would make explicit and thus improve the connections between the scientific and technical issues and KCOL management challenges.**

Many frameworks have been suggested for the evaluation of monitoring plans. Figure 3 outlines one such general framework proposed by Vos et al. (2000). Although many steps in the design of a monitoring program outlined in Figure 3 were considered by the stakeholders, some crucial ones seem to have been overlooked or not adequately discussed, such as the actual use of monitoring results in decision making and for adaptive management. We are not suggesting that the approach outlined in Figure 3 is the only or even the best way to design and evaluate monitoring programs. **We recommend,**

however, that a suitable framework for evaluating monitoring programs be adopted that takes into account the whole information cycle as outlined in Figure 2.

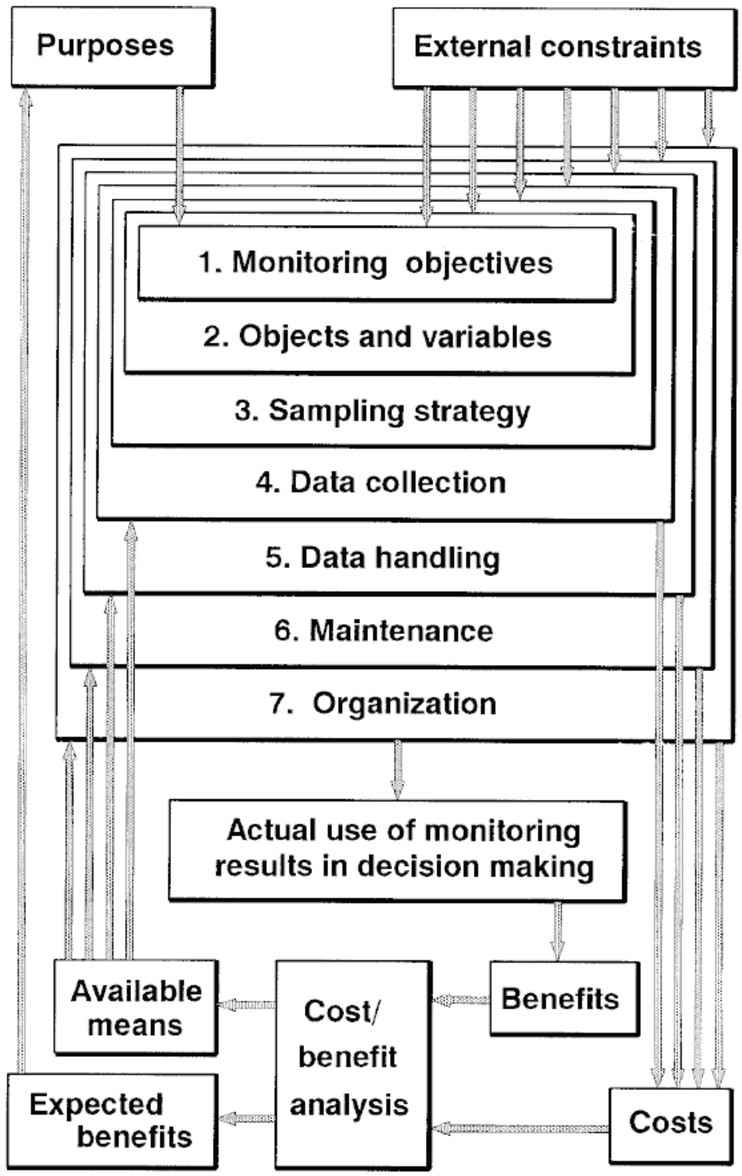

Figure 3. A general framework for the design and evaluation of monitoring programs (Vos et al. 2000).

Obviously, selecting what to measure is the most important decision made in designing a monitoring plan. Ward et al. (1986), who reviewed monitoring plans, concluded that most monitoring programs were, as they put it in the title of their paper, “data-rich but information-poor”. In other words, little of the data collected can actually be used to improve the management of the system being monitored. Much of the data typically collected is redundant because it is autocorrelated. Consequently, identifying and eliminating attributes that are highly correlated should be an important part of designing any monitoring plan. No attention to eliminating highly correlated attributes seems to have been made in evaluating the proposed attributes in Chapter 4. Eliminating redundant attributes does not mean that multiple measures of a given attribute should not be monitored, assuming that they yield different or confirming information, or that different descriptive statistics should not be calculated in order to extract the maximum information content from a data set.

Classifying the attributes to be measured into meaningful categories can help in identifying autocorrelation. In the KCOL LTMP, the attributes selected for monitoring are classified based on the attribute categories in the conceptual model (Chapter 3), but there is no explanation of how the specific attributes were selected or how they will be used to measure the condition of a lake and thus judge its health status. The categories in the conceptual model unfortunately are not very relevant for designing a monitoring plan. One possible way, but certainly not the only way (see Carignan and Villard 2002), to select suitable attributes would be to do a force analysis of the ecosystem of interest (Whitfield and Clark 2001). Force analysis is used to identify the putative relationship between the environmental forces that drive ecosystems (such as inputs of matter and energy, weather patterns, and unusual biological events) and ecological responses to them. Those forces most likely to yield information about the current and future condition of the ecosystem should be monitored as well as those ecosystem components most responsive or sensitive to these changes. Force analyses can also identify the critical periods when some force will have its maximum impact on the system. This approach, however, has its limitations. For many ecosystems the nature of the drivers (forces) that shape these ecosystems are only poorly understood and how various components of an ecosystem will respond to changes in a driver are often uncertain.

For example, a more relevant classification of the proposed attributes could be done along these lines:

(1) Water control catchment attributes
(2) Hydrological attributes (water quantity)
(3) Water quality attributes
(4) Plant or vegetation attributes
(5) Animal attributes

This classification scheme also captures the five levels at which management is commonly done. Although management is possible at all five levels, it will be most consequential at the first three levels because it would directly affect ecosystem drivers or human uses of the lakes rather than specific biological components of the ecosystem.

Management Options

One of the more striking omissions in the KCOL LTMP report is the absence of a thorough discussion of possible management options for the lakes and for their water control catchments. Although there is some discussion of past management (e.g., chemical control of *Hydrilla),* no general discussion of other available options is provided. Lake health is a function of many factors, including hydrology, water quality, fish populations, boat traffic, shoreline development, invasive species, and others. For the lakes in the KCOL, what can be done to alter lake hydrology, nutrient inputs, fish populations, boat traffic, shoreline development, and native and exotic aquatic plants and animals? What state agency or local government entity can alter any of them? What information about them is required to trigger a change in management by some decision maker?

The overall goal of the LTMP is to preserve the health of the lakes, but it is not clear from this report how this can be done. The major advance in this report is to propose a more integrated and coordinated monitoring program for the KCOL. As noted, however, the report fails to specify who will use the information generated by this monitoring program. Currently, no group or entity is empowered to make management decisions for the KCOL. The preservation of the health of the KCOL will not result automatically from a new and improved monitoring program. It may also require the establishment of a new entity that can act on the information that this monitoring generates. Similar efforts to preserve the health of other regions of the country like Chesapeake Bay and Puget Sound have required the establishment of some kind of new regional entity that has a legal mandate to make management decisions and has access to the funds needed to implement them. This is a key omission from the report at this stage: how will integrated management decisions be made among these agencies? See Section 5 for more examples of regional-scale efforts to protect and manage natural resources.

Management Uncertainties

Decision makers responsible for implementing management plans will always have to cope with some level of uncertainty. As Vos et al. (2000) point out, in the presence of significant uncertainty, the precautionary principle should apply whenever a management action might cause severe or irreversible harm to an ecosystem. The precautionary principle states that, in the absence of a scientific consensus, management actions that could cause severe or irreparable damage should be avoided as a precautionary measure. In these situations, the burden of proof falls on those who would advocate taking the management action. In most cases, the burden of proof would fall on the state agency wanting to take unilateral action to deal with an issue or organisms for which they have a legal mandate.

We note that the precautionary principle can be an impediment to reducing uncertainty by causing inaction. If the response of an ecosystem (its parts or processes) to a management action is expected to be temporary (i.e., reversible), then probing for knowledge by manipulating the system can reduce uncertainty and improve management in the future. Management actions should seek to reduce uncertainty where possible (Walters 1986). Reducing uncertainty to an acceptable level may require doing pilot studies to examine how a lake will respond to some proposed treatment or funding a research study to examine some aspects of a lake or landscape’s ecological dynamics. Opportunities to use the monitoring program to reduce uncertainty should be fully exploited.

Scientists who design monitoring programs that are part of a management plan assume a causal relationship between the observational data collected and the state or condition of the ecosystem (Vos et al. 2000). Accurate diagnosis of lake condition is crucial if a monitoring and assessment program is to be worthwhile. Management actions should be underpinned by actual causal relationship between management actions and desired endpoints (health criteria). Can causal relationships be inferred from the kinds of observational data to be collected as part of the monitoring program? Causality in ecology can be established using three criteria (Vos et al. 2000):

(1) "consistency: at any place and at any time, there should be a strong association between level of putative stressor and level of symptom;
(2) responsiveness and temporality: at any place and at any time, exposure to the putative stressor should produce the symptoms;
(3) exclusion of alternative explanations: there should be no consistency and/or responsiveness with alternative hypothetical stressors."

Although it is not usually possible to do controlled experiments as part of a management plan in order to confirm causality, different areas, in this case lakes, can be managed in different ways to determine the consequences of some change in environmental conditions on various ecosystem attributes. Although this observational approach seldom establishes causality, it can demonstrate associations and can eliminate some alternative hypotheses. Monitoring the response of different groups of organisms at different trophic levels can help to confirm causality (Vos et al. 2000). If an expected change at one trophic level is confirmed by expected changes at higher trophic levels, this provides some level of confirmation that there is a causal link. Thus our understanding of the system being managed can be increased by carefully planning management strategies or taking advantages of "natural experiments" to aid in establishing or confirming causal links.

For the KCOL, some major uncertainties could be explored with management actions in several contexts:

(1) Significance of Water Level Fluctuations. If stabilized water levels are a stressor, then a range of water level regimes could be implemented across lakes, and the KCOL LTMP could seek to identify how the APMs vary under each regime (e.g., stable vs. maximum allowable fluctuation). For example, monitoring programs could be designed to measure the rate of tussock formation in lower and upper lakes to clarify how inter-annual range in water levels influences this metric.

(2) Characteristics of the Optimal Littoral Zone. The littoral zone APMs and AIMs assume that the optimal aquatic plant mosaic is known for each animal group (i.e., fish, wading birds, reptiles). However, considerable uncertainty exists about how changes in the littoral zone would influence these groups at the species level and collectively. The LTMP could seek to create differences in the littoral zones among lakes, such as by maximizing tussock habitat for reptiles in some lakes to allow monitoring of how fish and

wading bird communities respond to this potentially “suboptimal” habitat for these groups. The recent drawdown and muck removal at Lake Tohopekaliga provides natural experiments along these lines. Lake Tohopekaliga has relatively few tussocks while Hatchineha, Cypress, and East Lake Toho still have areas with dense tussocks.

(3) Development and Water Quality. Impacts of human development on KCOL water quality will likely vary across the basin. Choosing sites to monitor the trophic state index (TSI) and nutrient load rates (or virtually any other factors associated with human influence) should incorporate a design that maximizes the contrast in human development, so that the most pristine and most impacted portions of the basin are monitored. Emphasis on measurement along a known gradient of human influence has been a central component of monitoring and assessment programs for more than two decades (Karr and Chu 1999, Davies and Jackson 2006, Fore et al. 2007, Reiss and Brown 2007). Information on the impacts of future land development would then be maximized by including the most and least impacted sections of the basin at the start of the LTMP process.

Utilizing these and other natural experiments or planned management manipulations could reduce uncertainties and allow better management in the future. **We recommend that the KCOL LTMP utilize opportunities provided by pilot studies, natural experiments, and local management manipulations to reduce uncertainties when possible.** The key to taking advantage of these natural experiments will be to monitor areas with different levels of a stressor.

Adaptive Management

The proposed implementation of adaptive management in the KCOL LTMP is incompletely described (Chapter 4, pages 1–8). It is not clear how the “adjustment of a management strategy” will be implemented based on information from the monitoring program. **The management plan should fully describe how adaptive management will be implemented and how management strategies will be altered when new information is obtained from monitoring.** What will be done if targets are not met? What is the process for changing the management regime?

If the KCOL LTMP is to include adaptive management, it should propose hypotheses, identify uncertainties, and implement different management strategies to test system responses to stressors. As already noted, if stabilized water levels are a stressor, then a range of water level regimes could be implemented across lakes, and the monitoring program could identify how relevant APMs vary under each hydrological regime. The KCOL LTMP does not propose anything of this sort; it simply identifies target preferred ranges in the APMs without explicitly stating what strategies will be altered to test responses. The report should be more detailed about the management plan (i.e., what can and will be done), and, if truly adaptive, it needs to state hypotheses and outline a design that will inform management how the system responds to various stressors.

Walters (1986) identified five key components of adaptive management plans, and all of them should be incorporated into of the KCOL LTMP:

(1) Define what one wants to learn from the system, including its key elements and relationships
(2) Bound the system
(3) Document current understanding of the system
(4) Identify uncertainties
(5) Design policies to probe for better understanding

Overall, the KCOL LTMP report identifies lake attributes, but it does not specify what the LTMP needs to learn about this system to improve its management. The LTMP report does an inadequate job bounding the system. The lake basins *per se* are not the logical outer bounds, and their water control catchment boundaries should be used. The report provides a good overview of the status or condition of the lakes based on previous work. Key uncertainties, however, about how this system works are not addressed, nor are strategies proposed that will provide a better understanding of it.

Section 4. Definition and Selection of Indicators: APMs and AIMs

As the KCOL LTMP document notes (Chapter 1, page 12), the plan "is built around performance measures that provide environmental targets for management." Performance measures are to "serve as indicators" of the condition of lakes.

Thus, the report wisely recognizes the key role of measures (or indicators) in the success of the KCOL management program. Unfortunately, little or no foundation is established for indicator selection. For example, there is no description of the important characteristics of ecological or other indicators. Do those characteristics change as a function of the kind of indicators or the specific use to be made for an indicator? What advances have come from the technical and scientific community in recent decades to guide development, selection, and use of indicators? What useful information could be derived from recent indicator development initiatives to guide indicator selection for the KCOL program? The answers to all of these questions must be grounded in the exploration of three key questions: The first two questions—Who will be using the information captured by the selected indicators to make decisions? How will that information be used?—are a central focus of Section 3 of this report. The focus of Section 4 (measures and indicators) centers on an equally important third question: What are we trying to indicate? We begin this section with a quote from an in press paper (Karr 2008a).

Characteristics of Ecological Indicators

> "Like competent medical practitioners, ecosystem managers can deduce ecosystem condition through standardized evaluation procedures if they use appropriately selected indicators. A variety of individuals and organizations over the past 30 years have been identifying the most important characteristics of ecological indicators. Their explorations inevitably center on the fundamental question, What are we trying to indicate?
>
> Ecological indicators should be measurable, integrative, ecologically relevant, socially relevant, interpretable, cost-effective, anticipatory, collected at appropriate geographic scales, collected at appropriate temporal scales, and able to detect trends; they should provide data that are quantitative, statistically rigorous, reliable, and comparable; and they must be useful as diagnostic tools. Appropriate indicators should stand upon empirical and conceptual ecological foundations, which should in turn arise from and describe the many dimensions of real ecological systems. Combining information from individual, population, assemblage, and landscape levels enriches our ability to understand the many dimensions of ecological systems, just as economic indexes based on multiple economic indicators (the consumer price index, for example) can help us understand the behavior of economic systems. Furthermore, good indicators should be sensitive to a broad range of known stressors

> and, ideally, be likely to sense unknown or as yet unidentified stressors. Finally, the activity required to collect data for an ecological indicator should be unobtrusive, to minimize any alteration of or harm to the system itself or its threatened or endangered species." (Karr 2008a)

As is implicit from this description, the selection of indicators must be more than an effort to catalog existing monitoring programs in a variety of agencies.

Five major classes of indicators came into use through the twentieth century (Karr 2008a).

- *Administrative indicators:* fishing and boat operation regulations; number of pollutant discharge or development permits issued, enforcement actions, planning exercises, and pollution-control grants
- *Technological indicators:* application of technologies to reduce effluents or limit the effects of other human activities (implementation of best management practices such as low impact development, stormwater detention or other flow management, conservation tillage)
- *Stressor indicators:* amount of boat traffic, altered hydrology, measurements of effluent reduced through a particular technology, or land use practice
- *Exposure indicators:* measures of physical habitat, altered nutrient dynamics, rates of sedimentation, or concentration of pollutants in water;
- *Response indicators:* measures of biological condition, such as taxa richness; population demographics; thermodynamics, including plant productivity and emergy (contraction of embodied energy, equivalent to the amount of energy consumed to produce something, for example, the total amount of fossil fuel–derived fertilizers, mechanized and human labor, and sunlight needed to grow corn); multimetric indexes that integrate multiple biological attributes

Exposure and response indicators arose as environmental managers and regulators came to recognize that the first three groups of indicators neither assessed real ecological condition nor ensured that legally mandated goals (e.g., protecting ecological integrity) were attained. Only exposure and response indicators directly measure ecological endpoints and might thus appropriately be called ecological indicators.

Ecological indicators are chosen to report on the state, or condition, of ecosystems. In contrast to the more familiar environmental indicators, ecological indicators are not intended to report on the quantities of pollutants or other stressors affecting ecosystems or on what government or other programs are doing (e.g., issuing permits).

Two recent initiatives have engaged hundreds of individuals in defining the condition of ecosystems: a Heinz Foundation project, which produced *The State of the Nation's Ecosystems (2002),* and the global Millennium Ecosystem Assessment (MEA 2005a, b). Both projects have been extraordinarily successful, providing unprecedented advances in the development and use of ecological indicators and garnering substantial interest from governmental and nongovernmental institutions.

The Heinz Foundation's goals were to define indicators characterizing ecosystems—on the scale of small watersheds to the planet as a whole and at any scale in between—and to support policy debate and decision making at the national scale. The report identifies four classes of information—system dimensions (geographic extent), chemical and physical condition, status of biological components, and goods and services that human society receives from the ecosystems being measured. The configuration of measures envisioned in the KCOL report includes some but not all of these dimensions. **We recommend a careful review of this conception (and other analogous conceptions) to ensure that relevant variables from all four dimensions are considered as core measures to guide KCOL managers.**

Biological Assessment of Wetlands Working Group (BAWWG)

More than a decade ago, U. S. Environmental Protection Agency initiated an effort to develop a practical approach to assess the conditions of wetlands nationwide. The effort, called the Biological Assessment of Wetlands Working Group [BAWWG], included representatives from a number of state and federal agencies, universities, and NGOs. Although this national effort has been less active in recent years, local and regional programs throughout the U.S. continue today. A wide array of program information, publications, and guidance documents can be found at: http://www.epa.gov/owow/wetlands/bawwg/ (checked August 2, 2007).

Florida Department of Environmental Protection was one participating agency in BAWWG and much work has been done in Florida since then. One report (Doherty et al. 2001, Biological Criteria for Inland Freshwater Wetlands in Florida) available under the publications tab at the BAWWG website is a comprehensive compilation of information on how specific stressors in Florida's inland freshwater wetlands affect various species assemblages. It was specifically designed to assist Florida agencies in developing biological assessment programs and to help identify appropriate assemblages, methods, and metrics for future studies. Here we mention three components of that document to illustrate its relevance to many of the issues involved in the KCOL project.

First, Doherty et al. (2001) identified a number of key characteristics of wetland indicators:

- Some species with narrow and specific environmental tolerances
- Cosmopolitan distribution
- Numerical abundance
- Low genetic or environmental variability… narrow demands
- Limited mobility
- Known life history (seasonal and daily)
- Reliable response to stressor(s)
- Predictable response to stressor(s)
- Quick response to stressor(s)

- Standardized methods of collection
- Taxonomic soundness
- Easy recognition by non-specialists
- Large body size (esp. for macroinvertebrates)
- Established measures, metrics, indices
- Established databases
- Suitable for use in laboratory studies (to determine causality)
- Cost effective sampling
- Public perceives organisms and assemblages as important

Any number of such lists of indicator characteristics could be compiled from the many efforts of the past two decades. Our point here is not to advocate the use of one or another list [this one, the Heinz Center Report, or the description taken from Karr (2008a) above], but to suggest that unless and until one carefully considers such lists, and makes a concerted effort to develop a list that is appropriate to the KCOL decision making process, any effort to define performance measures will be weaker than it can and should be. **We recommend a systematic effort to identify the characteristics of indicators that will be necessary within the KCOL project.**

The second component of the Doherty et al. study that is especially relevant to the next round of KCOL LTMP planning involves a more comprehensive view of stressors that drive change in lake systems. The conceptual ecological model described in Chapter 3, page 3 of the KCOL LTMP document under review here identifies five "drivers" (water management, shoreline development, aquatic plant management, introduction of exotic plants, intensified land use) and five associated stressors (altered hydrology, drainage of wetlands, fire suppression, dense exotic plants, altered nutrients). This incomplete framework includes among the drivers one item that is a subset of another (shoreline development is arguably a subset of intensified land use) and it leaves out other factors (introduction of exotic animals). It leaves out numerous stressors to Florida lakes as illustrated by Table 2.2 from Doherty et al. They provide a more comprehensive conception of the stressors (while at the same time leaving out some important issues such as alien taxa) that affect Florida waters. Their conception, it seems to this panel, provides relevant guidance for the selection of indicators and current and future management needs. **We recommend a systematic and more inclusive effort to identify the drivers of change and associated stressors in the KCOL lakes.**

Third, the selection of measures for use in KCOL LTMP reflects a narrow conception of such measures. Abundance or biomass measures dominate the APMs and AIMs. For most proposed measures, in fact, the measures to be derived from various sampling programs are described in only the vaguest terms. One example is the suggestion that taxa richness or diversity will be a measure for littoral plant communities but this subject is not explored in sufficient detail to demonstrate what will actually be measured and how.

Table 2.2. Stressors in inland freshwater wetlands addressed in this report. (Modified from Doherty et al. 2000).

ENRICHMENT, EUTROPHICATION, and REDUCED DISSOLVED OXYGEN. Increases in concentration or availability of nitrogen and phosphorus. Typically associated with fertilizer application, cattle, ineffective wastewater treatment, fossil fuel combustion, urban runoff, and other sources. DO reduction refers to increases in carbon, to a point where increased biological oxygen demand (BOD) reduces dissolved oxygen in the water column and sediments and can increase toxic gases (e.g., hydrogen sulfide, ammonia).

CONTAMINANT TOXICITY. Increases in concentration, availability, and/or toxicity of metals and synthetic organic substances. Typically associated with agriculture (pesticide applications), aquatic weed control, mining, urban runoff, landfills, hazardous waste sites, fossil fuel combustion, wastewater treatment systems, and other sources.

ACIDIFICATION. Increases in acidity (decreases in pH). Typically associated with mining and fossil fuel combustion.

SALINIZATION. Increases in dissolved salts, particularly chloride, and related parameters such as conductivity and alkalinity. Typically associated with road salt used for winter ice control, irrigation return waters, seawater intrusion (e.g., due to land loss or aquifer exploitation), and domestic / industrial wastes. [This one probably does not apply to KCOL.]

SEDIMENTATION and BURIAL. Increases in deposited sediments, resulting in partial or complete burial of organisms and alteration of substrate. Typically associated with agriculture, disturbance of stream flow regimes, lake level stabilization via flood control efforts, urban runoff, ineffective wastewater treatment, dredge and fill activities, and erosion from mining and construction sites.

TURBIDITY and SHADING. Reductions in solar penetration of waters as a result of blockage by suspended sediments and/or overstory vegetation or other physical obstructions. Typically associated with agriculture, disturbance of stream flow regimes, urban runoff, ineffective wastewater treatment, and erosion from mining and construction sites, as well as from natural succession, placement of bridges and other structures, and re-suspension by organisms and wind.

VEGETATION REMOVAL. Defoliation or reduction of vegetation through physical removal, with concomitant increases in solar radiation. Typically associated with aquatic weed control, agricultural and silvicultural activities, channelization, bank stabilization, urban development, defoliation from airborne contaminants, grazing / herbivory, disease, and fire.

THERMAL ALTERATION. Long-term changes (especially increases) in temperature of water or sediment. Typically associated with power plants, other industry, and climate change. Secondary impacts of thermal alteration would include changes in rainfall patterns, river flows, and lake water levels.

DEHYDRATION and INUNDATION. 1) Reductions in water levels and/or increased frequency, duration, or extent of desiccation of sediments. Typically associated with ditching, channelization of nearby streams, colonization by highly transpirative plant species, outlet widening, subsurface drainage, climate change, and ground / surface water withdrawals for agriculture, industry, or residential use. 2) Increases in water levels and/or increase in the frequency, duration, or extent of saturation of sediments. Typically associated with impoundment (e.g., for cultivation, flood control, water supply, or waterfowl management) or changes in watershed land-use that result in more direct and rapid runoff entering wetlands and lakes.

HABITAT FRAGMENTATION, DISTURBANCE, and MISCELLANEOUS. Increases in the distance between, and reduction in sizes and connectivity of suitable habitat and increases in noise, predation from pets, disturbance from visitation, and invasion by noxious species capable of out-competing species that normally characterize wetlands and lakes.

Recent work illustrates the value of exploring a richer array of signal about the condition of ecological systems. A recent Florida DEP report (Fore et al. 2007), for example examines use of benthic macroinvertebrates in the assessment of river condition. The focus on eight major dimensions of invertebrate biology in the evaluation and selection of metrics to be used as indicators of biological condition: taxonomic richness, voltinism, feeding group, habitat, community structure, sensitivity and tolerance, and "BioRecon metrics." By exploring this broader array of "views" of biology, they provide an insightful model for metric selection.

Similar approaches have been used to define measures appropriate for other taxonomic groups. Doherty et al. again provide a Florida-based examples for plant assemblages. Instead of just counting species, one can, for example, classify species according to a variety of factors (e.g., human influence), an approach that is illustrated in Table 4.1 here taken from Doherty et al. (2001).

Table 4.1. Wetland plant species that typically increase and decrease with disturbance (adapted from Rochow (1994) and SWFWMD).

DECREASERS:	INCREASERS:
Eriocaulon spp.	*Eupatorium*
Sphagnum spp.	*Andropogon*
Pondeteria cordata	*Amphicarpum*
Nymphaea	*Euthamia minor*
Nymphoides aquatica	*Rubus* spp.
Utricularia inflata, purpurea	*Erianthus*
Hypericum fasciculatum	*Axonopus*
Sagittaria spp.	*Lycopus*
Bacopa caroliniana	*Pinus* spp.
Polygala nana, lutea, rugeli, cymosa	*Paederia*
Xyris fimbriata	*Paspalum notatum*
Rhynchospora tracyii, corniculata, inundata	*Blechnum*
Eleocharis (except *baldwinii*)	*Woodwardia*
Drosera	*Smilax* spp. + *glauca*
Juncus repens	

Other tables in the Doherty report describe sensitivity to specific nutrients and other stressors for a variety of major taxa (e.g., algae, vascular plants, fish). These tabulations illustrate that much work has been done not only generally but specifically in Florida to identify biological and ecological signal useful in monitoring and assessment programs beyond simple abundance, biomass, or diversity (taxa richness). One advantage of such diverse approaches to assessment is that the variety of measures that can be developed from a simple data set adds substantially to scientists and managers ability to diagnose the causes of degradation.

Two other studies, not directly related to the BAWWG program, illustrate the kind of approach that we feel the KCOL LTMP program should follow. One study from Florida (Fore 2005) should be very useful to the KCOL LTMP team as guidance on how to define indicators of both the cumulative effects of human actions and the biological condition of KCOL lakes. Fore provides a comprehensive and rigorous approach to assessment of Florida lakes using plant assemblages. She found that the different types of plants found in Florida lakes were strongly associated with lake condition and the level of human disturbance observed around the lake perimeter. Ten metrics (indicators or measures) were highly correlated with independent measures of human disturbance and four of those metrics were selected for inclusion in a statistically and biologically rigorous Lake Vegetation Index (LVI). She used a sample of 95 lakes to develop and test metrics and followed that with a validation study of 63 other lakes to determine if the LVI, as defined by the study of the first 95 lakes, was highly correlated with measures of disturbance related to water chemistry, habitat condition, and land use intensity in the second set of lakes. They were. We urge the LTMP team to review this report carefully for the insights it can provide on important components of a rigorous lake monitoring and assessment program. Fore summarizes her results as follows: "The primary goal of this study was to test the feasibility of using plants as biological indicators. Results reported here confirm that simple measures of the plant assemblage can provide a reliable and meaningful biological assessment of lake condition."

Although the Fore study explicitly focuses on plants, the lessons are very appropriate for those defining indicators for other taxonomic groups as well. One example from another taxonomic group (fish) comes from work on coastal wetlands in the Laurentian Great Lakes (Seilheimer and Chow-Fraser 2006, Seilheimer et al.2007). Seilheimer and colleagues combined knowledge of human disturbance (land use alteration in wetland watersheds), a water quality index (WQI), and knowledge of the fish assemblages in coastal wetlands to develop a Wetland Fish Index (WFI). They showed the usefulness of the WFI for detecting intra-wetland (among sites within a single wetland) and inter-wetland (distinguish heavily impacted wetlands from less-impacted wetlands) variation when only fish data were available to assess the condition of sites. Here again by following a relative simple but rigorous process they developed a fish-based assessment measure that was very sensitive and that provided useful and rigorous guidance to managers.

Another outgrowth of the early BAWWG discussions was a three level approach to wetland assessment (Fennessy et al. 2004).[5] The three levels are:

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[5] The U.S. Environmental Protection Agency also produced a two-page fact sheet summarizing this framework: EPA. 2002. Wetland Monitoring and Assessment: A Technical Framework, Office of Water, USEPA, Washington, DC. EPA 843-F-02-002(h).

Level 1: Landscape-scale assessment, largely examining the nature and type of human activity in the study landscape

Level 2: Rapid field methods, simple, quick assessment methods are employed that involve limited field work.

Level 3: Intensive site assessments, quantitative chemical, physical, and biological information is collected to provide actual measurements of the condition at sampled sites.

Reiss and Brown (2007) employed this hierarchy of assessment methods in wetlands in Florida, demonstrating the range of inferences that can be made through careful study of both the condition of places (level 2 and 3) and the drivers (level 1) likely to be responsible for those conditions.

Success in the KCOL LTMP requires this kind of thinking, analysis, and planning in ways that integrate planning for data collection, the data collection itself, and the decision making and management programs essential to protection of the healthy lakes sought by the diverse stakeholders in the region.

Comments on APMs and AIMs

The three members of the panel independently reviewed the KCOL LTMP document under review. We organize this synthesis of those comments at three levels: General Comments, Synthesis comments across the measures, and Comments on specific measures.

General Comments on Presentation and Organization

Fourteen lake attributes were identified in the conceptual model presented in Chapter 3. From these, 17 APMs and 16 assessment indicator measures (AIMs) were developed. Table 4-1 presents a summary of the attributes and their proposed measures (metrics) and Table 4-2 relates these proposed attributes to overall project goals (hydrologic management, habitat preservation and enhancement, aquatic plant management, water quality improvement, and recreation and public use). The specific measures (metrics) outlined for each attribute in Table 4-1 are not explained or justified. Who selected these measures? What other measures were considered? Are these attributes the best indicators of lake health? Which of these measures if it is not met would require a change in a lake's management? What management actions would be taken when an APM does not meet the target values?

The general layout of APMs and AIMs is also outlined. Why are targets for a metric not presented first in APM descriptions and then the Geographic Scope? Is the target not the most important feature of an APM?

The 33 APMs and AIMs proposed are not ranked with respect to their relevance as attributes of lake health. Figure 1-3 (Chapter 1, page 10) indicates that lake health is determined by a lake condition along a biological or environmental gradient. There is no indication of the health threshold values needed for the various measures proposed or what will be done if some of the measures are not met for a given lake or lake assemblage. Some of these attributes like surface water and trophic state are clearly the result of human activity and its interactions with natural events; both collectively determine the condition or health of a lake. Setting suitable targets for these attributes is essential for ensuring the health of any lake or lake group. Other attributes like the density of native and nonnative apple snails are relevant for only one species, the snail kite. Such attributes are a very restricted and thus very limited and uncertain measure of lake health. This is true for many proposed attributes dealing with birds and threatened species (e.g., wading bird nesting effort, wading bird abundance, and number of bald eagle nests). While these measures are of interest to some stakeholders (and therefore fall under the definition of health developed in Section 4) , they must be employed carefully because of the narrowness of their perspective and because many of them may be significantly influenced by factors external to a specific lake or even to the KCOL region (e.g., in the case of migrant birds).

For reasons that are not clear to us, some commonly measured attributes of lakes are not included in Table 4-1 or mentioned in the report (e.g., measures of light penetration are not discussed or described). One commonly measured attribute of lake water quality not described in the report is Secchi Disk depth. Turbidity, a measure allied with Sechi Disk depth, is another water quality measure not considered as an attribute. The list of attributes in Table 4-1 does not resemble one that you would expect from looking at limnological sampling manuals like Wetzel and Likens (1991).

Synthesis Comments

We turn now to a short list of substantive issues that transcend the details of any specific APM and AIM.

<u>1. Reduce redundancy</u>

One obvious way to reduce redundancy in the APMs involves littoral zone vegetation attributes. Many vegetation APMs appear throughout the report but the level of detail among them varies considerably. We suggest that a single plant APM for littoral zone assemblages is more appropriate and useful. That APM should perhaps be composed of several different dimensions of the plant assemblages that could be summarized using one or more multimetric indexes. This APM would describe the targets for macrophyte assemblages (abundances, species complexes, and so on) because those plant assemblages are important in their own right and because they also provide information about the likely fish, wildlife, and other animal assemblages associated with this vegetation. Setting macrophyte targets for plants themselves, then fish, then reptiles, as is currently proposed, is redundant.

We do not intend to minimize the extent to which some species may depend on certain narrowly defined habitat contexts (e.g., bald eagle nest sites or shorebird foraging). However, we do feel that it should be possible for a group of program participants to develop a synthetic approach to vegetation measurement that will reduce the costs of that sampling and provide the core data needed by all groups. Moreover, that approach might even permit conceptual advances about the relationships among habitat requirements for diverse groups because the practitioners are working together in ways that have not been true in the past. This is an important objective if the LTMP is to be successful in shifting to a broader ecosystem approach to conservation, restoration, and management of natural resources. This integrative approach could also be a key to avoiding management that might have selection for habitat conditions for one group that causes a decline for another group. Thus, our example with macrophytes demonstrates a way to reduce redundancy and prevent the measures from being contradictory.

2. The Littoral Zone

The current document often places emphasis on the littoral zone without recognizing that this term encompasses a rich array of vegetation types from periodically flooded wetlands with emergent plants to areas of floating and even submersed aquatic plants. This variety of vegetation types creates heterogeneous physical and chemical conditions that are not fully recognized in the KCOL LTMP report. How to cope with this heterogeneity in efforts to measures the condition of the "littoral zone" is not adequately addressed.

In addition, littoral zone APMs should be developed with an understanding of how variation in the littoral zone is driven by normal interannual fluctuations in water level and by other factors (e.g., changes in water yields from the watershed, animal grazing, plant pathogens, increasing trophic state, and so on) that may be responsible for littoral zone degradation or losses. If lake littoral zones are currently considered to be in a generally desirable state (an issue that we submit deserves careful review and evaluation), then the total littoral zone area could be mapped under a few different water level conditions to obtain suitable target ranges.

Making these distinctions in littoral zone plant assemblages should also carry over into consideration of vertebrates where the following general patterns of littoral zone use by vertebrates might be considered:

Wading birds: emergent and floating
Waterfowl: floating and submersed
Fish: emergent, floating, and submersed
Amphibian and Reptiles: dense emergent, with peat and organic substrate

A new target for littoral zone vegetation could be framed as follows:

APM Number X-X. Littoral Zone Area and Plant Species Composition

Target Components:

1. Minimum total acreage of the littoral zone vegetation of each lake, perhaps including some sub-classes of littoral zones vegetation types.

2. Species composition of the vegetation, including emergent, floating, and submersed plant components. Percent cover of each type of plant (e.g., emergent, submergent; monocot dicot), or even plant species, could also easily be estimated. The target of this APM would be the acceptable range in total area of the littoral zone in a lake and the desired mix of species types. The species composition targets would include coverage of various plant metrics that are considered healthy and mutually beneficial to plant, animal, and invertebrate communities. Using a study of 158 Florida lakes, Fore (2005) illustrates one way to organize and frame the assessment of lake condition using plants, including approaches to data collection, analysis, and synthesis. (See page 32 for discussion of this paper.)

A carefully formulated APM design along these lines could replace APMs 2.03, 2.04, 2.05, 3.04, 4.04, and 4.06. APMs 2.01 and 2.02 need better definitions as it is not clear how these groups are tied to lake health and the other attribute categories (e.g., wading birds, reptiles, etc.).

<u>3. The *Hydrilla* Issue</u>

Hydrilla is an important component of the littoral zone of some of the lakes in the KCOL. *Hydrilla* can have positive (i.e., at low to intermediate cover) or negative (i.e.,at high cover) effects on a lake's aquatic biota, on recreation, and even on navigation and flood control. Research to date has not identified any harm from low levels of *Hydrilla* on biota, recreation, navigation, or flood control. The KCOL LTMP should set thresholds for maximum allowable *Hydrilla* coverage, and manage *Hydrilla* to not exceed these levels for each lake.

<u>4. Measurement accuracy and power</u>

Many ecological attributes can track ecological change, but careful consideration needs to be given in formulating and selecting attributes to be sure that scientists and managers understand: 1) the precision and power associated with each measure, 2) the frequency with which it is important to measure, and 3) the amount of effort that would be required to obtain robust estimates of the measure. For example, measures of fish community composition are probably not necessary every year, but could be collected at three-year intervals to monitor trends. The LTMP should include estimates of precision and the relative cost of each APM, so that decisions of what to monitor are more informed than is currently reflected in the document. Without this information, it is difficult for the panel to evaluate the relative value of the various APMs or AIMs.

5. Dependence on habitat measures

Habitat is far and away the most common measure proposed. The underpinning of these measures is the assumption that we know and can specify with sufficient precision what habitat features are crucial to the presence of species or assemblages dependent on any specific environment type. Yet there is little or no evidence that empirical documentation is currently available (or will be developed) before management decisions are made on the basis of presumed habitat requirements. The use of such serious but perhaps inadequately documented assumptions about habitat-organism connections should be avoided.

One important lesson of the past two decades is that tracking sets of species as opposed to just single species can provide substantial amounts of important information about the condition of places. These measures are also especially valuable in diagnosis of the causes of degradation when systems are assessed as degraded. For diverse reasons (different trophic levels behave differently, taxa differ in their responses to the presence of human activity and so on), it is very important to measure both plant and animal groups in the same place. At the limit, this logic would have us measuring everything, everyplace, and all the time. That is obviously not practical. The challenge in a program such as the KCOL LTMP is deciding what and when to measure. We must carefully define when we have collected enough data to make robust inferences about the condition of a place while we avoid collecting more data than needed. Another important issue is not to collect more data in a year than can actually be analyzed; unanalyzed collections on the shelves and in the files is an effective indicator of wasted resources (Karr and Chu 1999).

6. Dependence on best professional judgment.

In many natural resource contexts, scientists and managers must depend on best professional judgment. But decisions based on best professional judgment can result in serious management mistakes when dogma passes for best professional judgment. Great care should be exercised in use of best professional judgment in selecting attributes and setting attribute targets, and, when it has to be used, this should be explicitly acknowledged. Reducing uncertainty whenever feasible is the best way to minimize the erroneous use of best professional judgment. Some of the attributes described in the KCOL LTMP report and the targets proposed for them are based largely on best professional judgment. The old adage “trust but verify” is relevant. The role of attribute targets based on best professional judgment in management decision making should be limited, and they should never take precedence over those attributes based on data.

7. Lakes and Lake Groupings

The 19 lakes in the KCOL are placed into different management units based primarily on the water control structure(s) used to manage their hydrology. These management units also reflect major differences in land use (primarily development) around the various lake units. The lake management units described in Chapter 1, however, are not the same as the four lake groupings presented in Chapter 2. For an effective management program to emerge, clear explanations should be provided to describe how and why the lakes are grouped. Those groupings should be used consistently throughout the report.

At least three factors are relevant to that classification system.

1. Water control structure context just mentioned
2. Other human activity in and near the lake
3. Lake ecological context: lake size, basin shape, depth configuration, and so on

The impression left by Chapters 1 and 2 is that either lake management units or lake groupings will be used in the APMs to set targets for each lake assemblage. But descriptions of the measures or indicator do not provide lake specific criteria for the measures; neither are they discussed elsewhere in the report. In other words, a disconnect is obvious between the first two introductory chapters which stress the need to recognize different lake assemblages in order to develop suitable APMs and the actual APMs which make no direct use of these lake assemblages.

The discussions of the various potential indicator organisms are inconsistent in their depth. For things like alligators and largemouth bass the discussion is richer than it is for other things like fish assemblage and reptiles and amphibians. Although work in the past in some of these issues and taxa in the KCOL may be lacking, it is not lacking in a broader context. Reviewing the relevant literature beyond the region is essential to capture the best ideas from scholars throughout the world about the most appropriate indicators and the problems that might be encountered in sampling them.

Although the stakeholders claim to have adopted an ecosystem management approach, many APMs and AIMs focus on habitat value or condition rather than lake health. Developing targets and monitoring plans using habitat frameworks have a long history of leading society astray because they were based on overly simplistic models of what is good habitat. For example, fish biologists in the Pacific Northwest removed woody debris to enhance fish passage for some species. We now know that the effects of this removal decreased river habitat quality for the target species and for many others as well. Water quality specialists made the same kind of mistake when they assumed that clean water would protect physical, chemical, and biological integrity. Effective protection of any and all components of regional natural systems should not be grounded in narrow surrogates of their broader ecological or biological condition. This is not an argument against thinking in terms of habitat requirements. It is an argument against using that kind of thinking as a comprehensive and adequate surrogate that will ensure protection of the health of the KCOL lakes. Ground-truthing of hydrological models is essential and widely accepted. Likewise, the ground-truthing of habitat requirement models is also essential. And the only way to do that ground-truthing is to incorporate diverse biological endpoints into the APM and AIM structure.

Summary of Panel Comments on Individual APMs or AIMs[6]

This section pulls together in one place the individual comments of the panelists for each APM or AIM. In some cases the suggested revisions to the APMs are described above based on consensus of the panel. However, the individual comments below provide more detail and guidance to the specific APMs or AIMs. The origin of each comment is defined by as follows: ADVD–Arnold van der Valk, Karr–James R. Karr; Allen–Michael S. Allen.

Measure 1-01. Duration and Timing of High and Low Lake Stages

AVDV

This is one of the most important attributes of lake health. The rationale for it is well explained and more than adequate historical data provided. Although it has very detailed targets (Table 4.1.5), these targets are evidently based mostly on best professional judgment.

Although values for expected extreme high, extreme low, normal high, etc. water levels are given for the various lakes in Table 4.1.4, this water quantity attribute and those that follow do not have a metrics based directly on expected maximum and minimum water levels in the different lakes. Why not have targets based on extreme high and low water levels directly? Such an APM could replace AIM 1.0-2.

Karr

As we found in the KBMOS report, a large number of measures are defined here. Are they all really needed or could the number be pruned a bit?

Page 5, last paragraph. Why will future assessments not use a fixed period of record? This deserves a brief explanation.

Page 6, table 4.1.1, footnote 3. By defining these things as the current vegetation, how close is that likely to be to the situation before water control? Doesn't that assume that whatever the current condition of the lake that will be the goal for the future? Does the values definition process suggest that the lakes should be managed in ways to maintain their current condition? If not, why is the current condition the benchmark?

Page 7, middle of text paragraph. The choice of words "fish and wildlife for spawning and foraging" seems an odd and narrow juxtaposition. Only spawning is important to fish and foraging is the only important thing to wildlife? Please clarify.

[6] Some typos and other errors have been corrected in this version of our comments that are otherwise a copy of comments submitted to the District on or about July 13, 2007.

Page 14, paragraph 2 of Target. If no experimental data support the relationship, are there other things that lend support to their use? What is the best that can be said to connect the targets and health?

AIM 1.02 (4.3 on material sent): Lake Littoral Zone Inundation

AVDV
This attribute is really a sub-attribute of APM 1.01.

Karr
Please be more specific about the selection of the depth zones based on input from the study team. What was their thinking? Why did they select those boundaries? Without that, it is difficult to evaluate the wisdom of those selections.

Rationale. Why not attempt to connect the depths here to plants as well as a few bird species? These issues seem to be equally important for understanding the distribution of the plants and vegetation zones.

APM 1.03 (4.4 in material sent): Lake Stage Recession

AVDV
The rationale for this APM is well described. The targets (Tables 4.4.4 and 4.4.5) are very detailed but have too many significant digits to be realistic (e.g., 30 vs. 31 %). This APM is inseparable from APM 1.01 and could be combined with it.

APM 1.04 (4.5 in material sent): Seasonality and Variability of Lake Stages

AVDV
The target percentages seem improbably precise in Tables 4.5.2.

Karr
Page 29, last sentence. Why is productivity highlighted? Is there some reason to focus on productivity here? It seems to me that many other bad things are likely to happen as well across a broad range of taxa and biological contexts. The graphic of intra-annual stage variation showing a shift about 1970 is pretty striking.

AIM 2.01: Palustrine Wetlands

AVDV
This AIM is only peripherally relevant to the assessment of the health of a specific lake or group of lakes. No convincing rationale is provided for it.

Karr
The focus here is stated as tracking changes in area. How about the relevance of changes in distribution (patch size and so on) and quality or condition as well?

APM 2.02. Remnant Littoral Wetland Area

ADVD
The relevance of this APM to lake health is not mentioned in the rationale for it. That remnant littoral wetlands are animal habitat is undoubtedly true, but what does this have to do with lake health. In any case, this attribute is just a subset of littoral zone area (APM 2.03) attribute.

Karr
Net decrease is a slippery concept. So many of the aspects of wetland quality relate to the interdigitation and proximity of the different wetland zones, largely defined by water depth patterns but important to a broad range of organisms from birds to fish, to herps and others. How will that be dealt with? Also, what will be the baseline for that net change evaluation? Will that need to be defined for each of the lakes and how will that be done, especially to couple it with the value-based health definition for each of the lakes?

APM 2.03. Littoral Zone Area

AVDV
What exactly is meant by littoral zone (or littoral wetland) is not defined. Does this refer only to emergent vegetation beds? Does it include submerged vascular aquatic beds?

Littoral zone area can fluctuate with changes in water level, especially inter-annual changes. This APM needs to consider more carefully how expected variation in littoral zone area due to normal interannual fluctuations in water level can be distinguished from losses of littoral area due to other factors (e.g., changes in water yields from their watersheds, animal grazing, plant pathogens, and so forth).

Karr
Repeat the question here about no net loss as stated above for 2-02.

AIM 2.04. Littoral Vegetation Community Structure

AVDV
As noted in this incompletely described AIM, many possible vegetation metrics. A pilot study seems to be underway and careful attention needs to be paid to how to relate vegetation metrics to lake health. Previous attempts to do this for other lakes have not always been successful.

Karr
In my experience measuring biological condition in a variety of environments and using everything from bugs and fish to plants, one needs to carefully define the metrics to be employed. If one is not sure of the best approach to measurement a series of alternatives should be carefully described and then carefully evaluated for their individual merit. Minor changes such as expressing something as species richness vs. relative abundance

of individuals in those species (relative to the total fauna) can yield very different results. Here and in other proposed measures I suggest that clarity of definition of what is to be measured is essential. In this one, how is plant species diversity to be expressed? The rest of the measures here depend on lots of work being accomplished before the connections between the plant assemblage metrics suggested are validated for use in defining conditions required by the broad range of vertebrates explicitly mentioned here.

I suggest that here again one needs to make explicit and robust the connections between photo-interpretation, actual plant assemblages present and their condition, and the vertebrates assumed to be supported by those habitat inferences from plant measures.

Finally, I wonder it might be useful to avoid mixing plant-focused measures and animal-focused measures, even when both deal with the plant assemblage. That is, this is not just a single measure but a rather large and complex set of measures to be lumped into a single measure. Should they be divided because of their conceptual differences or combined because they focus on plants?

APM 2.05. Organic Sediment in Littoral Wetlands

<u>AVDV</u>
How will depth of organic deposits be measured? Why should organic deposits decrease in depth? Is there any evidence that the build up of organic matter had resulted in the loss or reduction of the littoral zone in any lake? This APM needs work.

<u>Allen</u>
The target of net reduction in organic deposit depths is vague. Is this net reduction basin wide or per-lake? Not clear how this would be accomplished, but I assume it’s via the altered schedule from the KBMOS. If this is the proposed mechanism for the reduced organic material and no other actions are proposed here, then please say this!

AIM 2.06. *Hydrilla* Abundance and Management

<u>AVDV</u>
Why is *Hydrilla* monitoring not part of AIM 2.04 or APM 2.03? A reasonable scheme to sample the vegetation of the littoral zone could be devised to obtain the data needed for *Hydrilla* management by the FDEP. Having a separate *Hydrilla* monitoring program is an unnecessary and costly duplication of effort. Isolating *Hydrilla* sampling from other vegetation sampling will also increase the probability of desirable species being adversely affected by *Hydrilla* management practices.

<u>Karr</u>
The measure here seems to be biovolume estimated as the volume of lake water filled with *Hydrilla*. Shouldn’t this also be expressed as a percent of lake volume given the different basins sizes, shapes, and depths among the lakes? Should a portion of that volume beyond some depth be subtracted from the total volume?

Allen
The preceding discussion on *Hydrilla* issues is very thorough and is a good description of the issues. There is obviously a need to set threshold targets for maximum *Hydrilla* coverage at each lake. The KCOL LTMP seems the perfect place to do this, so my question is why not set targets and make this an APM? *Hydrilla* represents one of the most important metrics associated with aquatic habitat at the KCOL because it includes both positive (i.e., low to intermediate coverages) and detrimental (i.e., high coverages) impacts to aquatic biota and recreation and can influence navigation and flood control. I was surprised to see that the KCOL LTMP did not address this issue more directly with an APM in this case. The agencies involved here have worked on these lakes for decades and know the issues very well, so why not set some targets and manage for them? Alternately, why not set thresholds and test what happens when the thresholds are not met? If this is not done here, where and when will it be done?? The KCOL LTMP should step up to the plate on this issue. By failing to address this issue directly, the effectiveness of the LTMP will be compromised in my view.

APM 3.01. Number of Eagle Nests

AVDV
This attribute has nothing to do directly with lake health. As noted, it has a lot more to do with availability of suitable nesting sites.

Karr

For ease of viewing and evaluating, the sizes of the dots representing nests should be consistent across the maps.

This measure includes the use of a five-year average of active nests. What dangers arise as a result of such a long time scale? How big does the shift in number of nests have to be before one can infer something real is happening beyond normal short-term variation? If this is done at the accumulated total for all lakes as the text seems to suggest, how will rapid changes on a single lake or lake group be tracked? Should they be tracked?

One sentence suggests that if there are nests at a lake then the foraging habitat at that lake is of appropriate quality. It seems unlikely that any eagle restricts its range to a single lake. Do we know that eagles feed only in the lakes adjacent to their nests?

Is the goal inferences about habitat or the presence of viable populations of the focal species? Can one infer this relationship in either direction regardless of which type of data are collected?

Finally, as the closing sentence of the Rationale paragraph states, nesting habitat issues may limit populations even though high quality foraging conditions might be present. These complications require some careful analysis and documentation before the simple measure (total number of nests as a five year average) is accepted as the only measure relevant to eagles.

As we discussed in a recent conference call, the relevance of this and other measures turns on what is meant by the phrase lake health. The presence or absence of eagles in the region or at a specific lake is a function of many factors and it is certainly relevant to assessment of the condition of the landscape of a lake.

Allen
In my view this is a well justified APM regarding bald eagle nest with clear targets that make sense. Well done.

APM 3.02. Snail Kite Nesting Effort

AVDV
Snail kite nesting per se is not directly linked to lake health in the rationale as is pointed out in APM 4.10. Lake health and management do affect kite populations because of its potential effects on the kites' food, apple snails.

Karr
Does the use of rules such as only using lakes and years in which at least one nest was reported with a known outcome and for only known fate nests cause a bias in one direction or another? Is it appropriate to combine nest occurrence and success in a single measure? If only three lakes are selected for this measure, what is the consequence? Does this ignore more marginal nesting contexts and thus allow one to overlook the early lose of nesting at those lakes, delaying the recognition that things are going down hill?

Page 4, second paragraph. What is the evidence that measuring only at these lakes will provide sensitive trend-detection ability for this issue? Here again, we have the situation where references are cited about an ongoing monitoring program without adequate discussion and description of the merits of those monitoring efforts for this specific purpose.

Allen

The target for nest occurrence seems to attempt to maintain the status quo, but the text also suggests that conditions have worsened for snail kites at the system. Why not have a target that is better than the recent past? If the target is not met for number of nests and nest success, what actions would the KCOL LTMP take?

AIM 3.03. Wading Bird Nesting Effort

AVDV
Wading bird nesting effort is a function of increases in invertebrate and fish densities due to water level decline (recession) when these birds are breeding. Consequently, monitoring invertebrate and fish densities directly makes more sense than monitoring wading bird nesting effort.

Karr
Counts of rookeries seems not to be a very sensitive indicator, at least based on Figure 4-6 (Chapter 4, Page 36). This is yet another example of a measure that might not be construed as important, depending on how one defines lake health.

Allen
Figure 4-6 shows substantial variation in the number of wading bird rookeries at the KCOL, with numbers fluctuating over two fold from 1976 to 1999. Is there any information as to why these fluctuations occurred? Was the strong nesting year of 1988 a drought condition as per Frederick and Ogden (2001) for the Everglades? Teasing these relationships apart would seem to be useful, potentially allowing targets and making this an APM.

AIM 3.04. Wading Bird Foraging Habitat

AVDV
Because it is of definite relevance to wading bird populations, the nature of the littoral zone needs to be monitored. This has already been proposed in APM 2.03 and AIM 2.04. There is no need for a separate study of the same zone that is focused solely on wading birds. The next APM provides a better measure of the health of the lakes from a wading bird perspective.

Karr
What is meant by "relative quality of wading bird foraging habitat"? Specifically, how will the various measures proposed here, assuming that they are both valid and relevant measures for the specific context, be integrated and evaluated to determine patterns and trends or the presence or absence of health?

APM 3.05. Wading Bird Abundance

AVDV
Although wading bird abundance can be affected by factors other than lake condition at any time, wading bird surveys might provide a meaningful index of lake health. A reasonable rationale for this attribute and associated metrics are made.

Karr
Table here to 2 decimal places seems inappropriate. Given the variation in these kinds of counts, what are the acceptable boundaries before one can make clear inferences about status and trends? Brush (2006) is cited here but I can't find it in a lit cited section anywhere. I found this in a number of places so the final version should be carefully proofed to be sure that all cited material is actually in a lit cited section.

Are gallinules not included in the water bird group? They are not mentioned here but coots are.

Page 41, last paragraph. Note is made that counts may not reflect real changes in actual population size. Not clear how, if that is true, the data can be used for any substantive policy and management inferences.

APM 3.06. Waterfowl Habitat Characteristics

AVDV
This is yet another proposed measure of the characteristics of the littoral zone of the lakes. The data needed for assessing the lakes as waterfowl habitats should be collected from the proposed littoral zone sampling (APM 2.03 and AIM 2.04) or some expansion of it.

Karr
Acreage and winter acreage of habitat (a vegetation type??) are defined as the metrics. Is there to be some measure of quality involved in that and how is that done from aerial photointerpretation? On what basis is the inference made that current low populations are not indicative of the current habitat quality? This seems to reverse the approach used elsewhere to infer that if the habitat is present the birds will be or if the birds are present the habitat, at least for foraging, is present.

As already noted in these comments, major assumptions are made here re connections from interpretation of images to the vegetation types present, the habitat quality (for foraging or more), and presence of birds. Same point can be made for herps and other taxa mentioned in these habitat-based measures. Much of this seems to be tied to professional opinions. How can that be cross-checked and validated?

What is the basis for the depth classes adopted and the percent of emergent vs. open water environments? This seems a bit formulaic in view of what is presented here.

Allen
The targets for diving ducks are not specific. This APM suggests that any combination of the six plant species listed are equally suitable for diving duck habitat. Because these plants vary widely in their configuration and food quantity, I suspect that the optimal combination is not any combination of these. I recommend refining this target to be more specific about the types and vegetative plant cover. The target section on diving ducks says the "ability to measure this frequency may be infeasible." If it is infeasible to measure this, then why set a target?

AIM 3.07. Waterfowl Populations

See APM 3.05. Ideally, the two proposed bird surveys could be combined into one.

Karr
The effort to avoid using duck numbers because of the influence of environmental factors that influence their populations while they are in other portions of their range is inconsistent from other examples of measures given earlier. Some effort could be made

with the ducks (at least perhaps) if one examined the national duck surveys for population trends. There seems to be some inconsistency among the measures re how or why data can or can't be sued to understand some of the connections, or to decide which of the measures are defined as the proper substitute or surrogate of the true goal.

APM 4.01. Angler Total Catch of Largemouth Bass

Karr

According to the text in support of this APM, angling ranked third in a recent stakeholder survey among recreational uses. What were the first two and why are they not included in the measures if this is to be a values-based system of health evaluation? Here is a place where a 10-year running average is to be used. See questions already noted re these long time periods and the delay in inferences as well as the size of change necessary for robust inferences about status and trends.

Why was the grand mean selected as the target? Early years of data (Table 4-6) had very low counts and the highest counts came in the last few years? What about the meaning of these temporal trends? How big a difference is necessary before an inference can be made that the population size is changing through time?

Allen

The target for this APM should be clarified as to what it is trying to measure. Under "Description of Associated Metrics" it is not clear what the "trends through time" is referring to. If the objective of this APM is to monitor adult largemouth bass abundance, then angler total catch of largemouth bass alone is probably not the best metric and it should be combined with angler effort data. For example, increasing human population size in the region could result in increases in total angler catch while largemouth bass population abundance is stable or even declining. Likewise, declines in total angler catch may not suggest changes to the largemouth bass population if angler effort declines. High *Hydrilla* coverage could lower angler effort but not necessarily impact largemouth bass abundance. I realize that either scenario (lower angler effort or lower bass population abundance) is a concern, but the APM should be more explicit about what it is intended to measure. Total angler catch will generally index fishery quality, but I suggest that total angler effort needs to be coupled with this target to help separate changes in largemouth bass abundance from changes in angler effort.

This APM is certainly not set up for rapid assessment of a problem with the fisheries. As stated it requires a decline in the 10-year average. Conceivably the largemouth bass population could decline greatly, but no action would be taken for 3-5 years under this scenario because it would take years to move the 10-year average. I recommend shortening this time period to three or five years.

AIM 4.02. Recruitment Model for Largemouth Bass

AVDV

Undoubtedly a worthwhile project, but it is of little direct relevance to monitoring lake health. In fact, the proposed attribute data to be collected (APM 4.01 and 4.03), would have to be used to verify this model. This AIM has nothing to do with lake monitoring per se.

APM 4.03. Size and Age-0 Distributions of Largemouth Bass

AVDV

This is a reasonable APM that is linked to lake health. I am not sure how these data would be used to alter lake management.

Karr

My own experience with populations of YOY bass (smallmouth in streams in my case) suggest that the connections between YOY and future condition of the population is not as robust as we might like it to be. Figure and table clearly show much year-to-year variation in percentage of age-0 LMB. But what is the relationship between age-0 this year and age 1 next year. Is it robust?

From where does the inference of low levels of variability come in the confidence level statement. I don't see variation from less than 5 % to about 30% as low level variation.

Allen

This APM is not appropriately named. It doesn't set a target for fish size except to classify fish < 20 cm as age-0 fish. Note that in some years age-0 fish will be larger than this size (see Allen et al. 2003). Additionally, it does not measure the age distribution of largemouth bass, although I think it should (discussed below).

The percent of age-0 largemouth bass of the total bass population is not an informative APM, because it will vary with factors that are unrelated to age-0 largemouth bass abundance. There are at least three scenarios where percent age-0 largemouth bass would not be an informative metric for indexing bass recruitment:

1) Percent age-0 bass depends on the recruitment levels in the past. If two strong year classes are produced resulting in higher-than-average abundance of age-1 and 2 largemouth bass, then the percent age-0 fish will decline even if the abundance of age-0 fish is the same or even larger than in the past. Thus, percent age-0 is directly dependent on recruitment levels in from past years (i.e., fluctuations in abundance of adult lmb).

2) Percent age-0 fish can remain above 30% even for a population with very few fish and low abundance of adults. For instance, a bass population composed of 60% age-0 fish is not necessarily an abundant population or one that provides good catch rates to anglers or catches of large fish. This APM does not take into

account overall largemouth bass abundance, and the targets could be reached for periods of years while adult bass abundance declines greatly.

3) High numbers of age-0 fish do not necessarily cause high recruitment to the adult population, because survival of age-0 fish can vary substantially. Thus, documenting the recruitment of age-0 fish into the adult population is critical for monitoring largemouth bass fisheries, and percent age-0 lmb does not measure this.

I recommend collecting annual age structure information for the largemouth bass fisheries at the large lakes of the KCOL. Estimates of age structure every year would reveal whether age-0 fish are recruiting to the adult population and would allow estimation of total annual mortality via catch curves. Age structure estimates would provide a much better measure of the consistency and magnitude of recruitment fluctuations through time and could be combined into a recruitment variability index (see Quist 2007 for examples) if the true interest here is to measure how recruitment varies through time.

Alternately, an appropriate APM could be a target total annual mortality rate, such as "percent total annual mortality of adult fish not to exceed X% for three or more years". The target percentage could be obtained from a previous literature review of largemouth bass in Florida (Allen et al. 2002), so that perhaps the target total mortality rate would not exceed the 75th percentile of Florida lakes for three or more consecutive years.

Adult mortality would index fishing and natural mortalities combined, and if mortality was too high, further evaluation (e.g., estimation of exploitation) could be used to understand the reasons for the higher mortality. Inspection of annual age structures would also reveal whether age-0 fish are recruiting to the older ages as expected. As written, this APM will not effectively monitor largemouth bass recruitment through time, and I encourage the authors to consider replacing this APM with annual age structure estimates, target total annual mortality rates, verification of age-0 fish recruitment to the adult population (i.e., do high catches of age-0 fish cause abundant fish at older ages in the future).

One final comment here, why were none of the other targeted sportfish listed here or described as either APMs or AIMs? Certainly these lakes provide high quality fisheries for black crappie and *Lepomis spp.*, which constitute a substantial amount of the total fishing effort at these lakes. The KCOL LTMP ignores these fisheries. Why?

APM 4.04. Area of Available and Suitable Littoral Zone Fish Habitat

<u>AVDV</u>
Yet another proposed attribute dealing with characteristics of the littoral zone. The data needed should be collected as part of littoral zone attribute monitoring (APM 2.02 and 2.03) and AIM 2.04).

Karr
I assume the blue tilapia is a non-indigenous species. If so, should it be mixed in this way or is this in line with that as a valued species by some segments of the human population? Not much information is provided here to illustrate how this measure will be developed, quantified, and used. Therefore it is hard to evaluate as a measure.

Allen
The target(s) for this APM was not clear to me. What are the acreages given here (5,530 for Toho and 8,540 for Lake Kissimmee)? Is this the total littoral zone area at each lake? Do these values constitute the total acreage of vegetation at the lakes today?

Given the title of this APM which seems appropriate to me, I think the primary target should be to maintain some minimum level of aquatic plant coverage (total acres) at the lakes regardless of the species. Large loss of macrophytes is probably the biggest threat to the fauna and fisheries of the lakes, and a target of total number of vegetated acres seems appropriate. A secondary target should be the species composition of those vegetated acres, and a third should be the coverage of those species within the vegetated zone. The target in this APM appeared to mix these values, and I wasn't sure which was which. Please separate the vegetation targets as a) total vegetated acres, and b) species composition of vegetation, and c) coverage of vegetation within the vegetated zone.

Once that is rectified, I note that the target range for coverage is very narrow (55-65%). If held to this standard, last drawdown and muck removal projects at Lakes Kissimmee and Toho would have resulted in lower values than this for periods of several years. The target range should probably be more like 30-65%, because most of the fish literature would indicates that anywhere in that range provides quality fish habitat. Managing an aquatic plant community within 55-65% would be difficult, and that narrow range is not required for quality fish habitat.

There is no time frame associated with this APM. Is the target level to be met every year? Every three years? Obviously the time scale here will depend on how often the agencies plan to measure the composition and abundance of aquatic macrophytes at the lakes. Finally, the contagion value of 20-45% for the secondary plant species is not clear. Is this 20-45% of the whole littoral zone, or 20-45% of the area occupied by the primary species? Please clarify.

AIM 4.05. Littoral Fish Assemblage Structure

ADVD
This is a classic measure of lake health. Surprisingly, it is only an AIM.

Karr
Of what value was the measure of species diversity calculated using the Shannon index? In my experience, it adds little that can't be inferred from species richness expressions. Early years of data are suspicious in that they are low. Why not delete them from the data set as likely or perhaps unreliable? Here again we see the 10-year averaging.

<u>Allen</u>
Should this be an APM? A target is proposed and there are historical data, so why not make this an APM?

Please clarify that this is the standard error and not the standard deviation. I was able to reproduce the standard error for Lake Kissimmee richness but not for Lake Toho (I got 0.8). Please check these and for diversity as well.

Also, the target values for this and APM 4-03 are not clear as to what the standard error means. Does this suggest that the target should not be lower and the long-term average minus one standard error? If so, please give the lower-end value for the target so it is clear. Why not make it two standard errors so that the target range cannot fall outside the lower confidence limit? The mean is very likely to fall outside of one standard error of the mean, especially with a low number of observations. Based on the historical data, it appears that fish richness fell below the target values for four of nine years at Lake Kissimmee, and 2 of ten years at Lake Toho. Is this reasonable?

Again, this AIM is not geared toward rapid assessment, because substantial reduction in richness and diversity could occur for years without the 10-year average falling below the target. Additionally, collecting these data annually would be a lot of work and I'm not sure it is necessary. Perhaps the assessment of fish richness, diversity, and biomass could be done at three year intervals, and the targets could be set as the last two measurements (one target would occur each six years, and those data (N=2 surveys) compared to the historical data prior to those six years).

AIM 4.06. Amphibian and Reptile Habitat

<u>AVDV</u>
See APM 4.04. This is not worthwhile as a separate AIM.

<u>Karr</u>
Extrapolation of habitat quality in alligators to make strong inferences about the habitat quality and thus population presence and size for all reptiles and amphibians seems questionable at best. his concern is reinforced by the language in this text ("will likely meet")

<u>Allen</u>
A solid target is identified here for all four of the big lakes, so why is this not an APM?

AIM 4.07. Amphibian Abundance

<u>AVDV</u>
The details are sketchy, but this APM appears to be a combination of habitat assessment with associated monitoring of selected amphibians. Habitat data should be collected as part of an integrated littoral zone vegetation study.

Karr
Several concerns here. Assumptions about what is true needs to be carefully evaluated. Focus on a small segment of the fauna, and especially those that are most abundant, seems to be an error. They are often the most tolerant, the least likely to provide clear early warning signal about local and regional degradation, and so on. This leaves out much of the fauna and thus perhaps much of the relevant signal about condition (proximity or not to healthy). Has anyone examined the BAWWG documents generated by the EPA working group in the last 15 years? What about using egg mass counts for amphibians?

AIM 4.08. Small Reptile Abundance

AVDV
See AIM 4.07.

Karr
Abundance is the title of this measure but it is also framed in the text as "selected reptiles assessed in the context of available habitat over time." How is this to be done? How will it be expressed? These issues need more attention before these measures can be carefully evaluated.

APM 4.09. Alligator Abundance and Size Distribution

AVDV
Alligators are the local charismatic megafauna, and their status needs to be monitored.

Karr
As noted before for other measures, not much is provided to give the reader an understanding of the foundation of information and PBJ that went into defining the numbers and bounds defined here.

APM 4.10 Density of Native and Nonnative Apple Snails

AVDV
The importance of apple snails to local Snail Kite populations justifies this esoteric measure of lake health.

Karr
Not clear from this text if the kites eat both the native and non-indigenous apple snail. That would seem to be important in defining how data were to be collected and interpreted.

How does the effort to restrict the range (near bottom of page 67) play out? Has it been done? Are the methods and protocols well defined?

Allen

Based on the track record for exotic species, the targets for nonnative apple snails are unlikely to be met over the next decade. Nonnative apple snails recently colonized the KCOL and this population would be expected to expand on the other lakes as they have at Lake Toho. Are the nonnative apple snail targets for this APM realistic? What measures are proposed to meet the targets and prevent the exotic snail to reach Lake Kissimmee? Is a target of zero nonnative snails realistic for Lake Kissimmee?

AIM 4.11. Benthic Macroinvertebrates

AVDV

This is another classic approach to monitoring the health of rivers and streams. The proposed AIM does not adequately address the spatial and temporal heterogeneity of benthic invertebrate communities in lakes. This heterogeneity can make it difficult to detect a changes in lake health.

Karr

Eventually one needs to show that the measures used, in this case for an invertebrate assessment, actually do systematically change as a function of magnitude of human influence. That is an empirical verification process. Several of the bulleted items here refer to "in the sediment." For many of the invertebrates sampled in wetlands they will not actually reside in the sediment but in the column of vegetation present in the water. Or do you really intend to focus only on sediment layer?

In most cases here the suggestion is made that the mean percent of taxa for some number of replicate samples will be used. In some cases % of taxa can be used but number of taxa can also be a more appropriate measure. For the latter, some use cumulative number of taxa across the replicates rather than the mean. The decision about what precise measure to use should be based on empirical evidence of dose-response behavior.

Table 14 indicates a number of metrics (e.g., % EDT) but does not specify whether that is percent of taxa or percent of individuals will be used, or if both will be tested. That should be clearly stated.

The rationale notes that the assumption is that change in the invertebrate assemblage are due to hydrology. That in my experience will be very difficult to demonstrate and distinguish from the other effects of human actions (such as changes in land use that are not only influencing hydrology).

Invertebrates as the focus of assessment programs has been a core group for several decades. But like use of any taxonomic group, diverse issues have to be considered before final judgment on focal groups is developed. Consideration should be given to cost, ease of sampling in field, extent of laboratory work needed, contribution to understanding of the condition of place, and so on. Be careful of simple statements that this group should not be sued in monitoring, assessment, and program evaluation.

Allen
Benthic macroinvertebrates are an important component of food webs and can be used to indicate ecological change. However, developing a monitoring program for benthic macroinvertebrates where no previous data exist is probably not the best use of resources. There are many variables that 1) are much easier to quantify (i.e., plant community composition and abundance, fish metrics, bird and alligator surveys); 2) have existing data; and 3) that will effectively measure ecological change with greater precision and reliability than benthic macroinvertebrate surveys. Quantifying the spatial and temporal trends in macroinvertebrate communities at the KCOL would be an enormous task, even for one lake! I don't believe this AIM is going to improve the KCOL LTMP significantly relative to the other APMs and AIMs already proposed. Suggest delete.

APM 5.01. Trophic State Index

AVDV
This is an essential attribute for determining and tracking lake ecosystem health.

Karr
Mention is made in the description of associated metrics section of a set of equations that will be used to calculate TSI. Perhaps those equations, at least in simple form, should be given here so that the reader understands the hypothesized relationships.

Confidence level says that data have been collected for 10 years. Why is that not enough to move to establishing standards? If it is not, should the kind of data being collected be altered to provide a quicker or more robust pathway to define standards? Why have none of the things described in the second paragraph been done already?

Number 4 on page 81. What is the criterion being used to define "similar biological assemblages"? At least one of the references on this page does not seem to be in a literature cited section. How was "provided meaningful results" judged in the last sentence of the page?

Finally, the first paragraph of item 4 describes exploratory analyses but I am not sure if the data were grouped by biology or grouped by color and pH and the biology assumed within that set of groups. Perhaps this should be clarified.

Page 82. How will one resolve the differences in N and P criteria derived from the different methods of calculation? In some cases the numbers are similar but in other cases not. The different methods are described and used but not much is said about their relative merits and demerits. That will need to be done eventually. Like so many other things in this document it is more a work in progress on what will be done than a real management plan.

Lots of numbers in Table 4-17 but not much guidance about the precision of those relationships. Is it overkill on quantitative data and their precision?

Allen

The introductory text provides a good summary of the water quality issues, but there are some contradictions. On page 4-75, it is noted that for the Kissimmee/Okeechobee Lowland lakes are naturally more productive and it is not realistic to move these lakes to a mesotrophic state. On page 4-76, the text says the main chain of lakes “remain in a eutrophic condition” and infers that anthropogenic impacts have caused the lakes to be eutrophic. The text should be clear about the goal here. Is moving these lakes to a eutrophic state even realistic? Is it desirable? Isn’t hypereutrophic the condition to be avoided for lakes in this Kissimmee/Okeechobee Lowland region? This point is important because it relates to all the target APMs and the AIMs below. This section is not clear about the current condition of the lakes and what, if any, improvements need to be made. Without that context up front, it is difficult to comment on whether the APMs or AIMs are appropriate.

Additionally, this section on nutrients ignores the influence of aquatic plants on chlorophyll levels. If the lakes contain abundant submersed plants (especially *Hydrilla*), it will alter reduce the in-water nutrient levels even though the trophic state of the lake may remain unchanged.

The text about the target for this APM is not informative, and the section “Pilot and Supporting Studies” does not help clarify the goals of this APM. How many of the KCOL lakes are considered impaired by FDEP? Are the TSI targets going to deviate substantially from the levels found in the lakes over the past decade? I was unable to critique this APM because it is not clear whether the lakes are currently considered to meet targets, be better than targets, or to be impaired with regard to water quality. This APM is not ready for review because it doesn’t outline a goal for the lakes.

AIM 5.02. Nutrient Loads

AVDV

The future health of the lakes will be determined to a large extent by annual nutrient loads. Estimating annual loads is one of the most important attributes that could be measured.

Karr

One challenge we face in simple mass-balance models is the problem of nonlinearity when linearity is assumed. How much will that be an issue here? Brown working with Florida DEP has developed some very creative ways to measure human influence in a watershed to provide a synthesis that yields a good human influence gradient. Have you explored the potential of employing his method? See Brown and Vivas (2005) and Reiss and Brown (2007) for more on this important Florida-based method.

AIM 5.03. Frequency and Duration of Algal Blooms

AVDV
Chlorophyll data are part of the trophic status index. Consequently, I am not sure why this additional metric is being proposed.

Karr
Some very interesting work has been done in the last decade on algal and diatom assemblages in streams (Fore 2002, Fore and Grafe 2002). It goes beyond the earlier work that emphasized production and chlorophyll a to explore comprehensive aspects of the nature of those assemblages and how they change under the influence of human actions. It might be useful to examine some of those studies for their utility in this effort. The text here doesn't do much to sort out how to be guided by the values based evaluation of health vs. what these measures tell us about the condition of the biology in a place. Also important to consider how that might vary among the lakes with different values-based goals and natural ecological context.

Allen
I agree that this AIM could serve as a good metric for documenting change in the lakes, but are the existing monitoring programs sufficient to document this AIM? Most blue green algae blooms come and go relatively quickly, so the actual frequency and duration of these events may not be measured with the current monitoring efforts. Perhaps the "Existing Data Source" section should say this.

AIM 5.04. Phosphorus Assimilation Capacity of Lake Sediments

AVDV
The internal loading of nutrients, especially P, in shallow water lakes is increasingly being recognized as a major contributor to their annual nutrient budgets. Thus estimating the internal loading of nutrients is of direct relevance to understanding the health of lake ecosystems.

Karr
Text in question 4 notes that Jones and James have reassessed some of the estimates but not much is said about what they concluded, and especially what that means to these systems.

Does the District really want to plan to use the absorption capacity up to the maximum? Isn't that a throwback to the "dilution is the solution to pollution philosophy?

APM 5.05. Class III Water Quality Parameters

<u>AVDV</u>
The proposed water quality measures are all of direct relevance for evaluating the health of lakes.

<u>Karr</u>
Basing decisions on water quality standards reflects some confidence in the adequacy of those standards to guide decisions no matter what the values-based goal might be for a water body.

Section 5. Pathways to Program Success: Defining Words, Thinking about Spatial Scale, and Learning from Others

Defining Key Concepts: Integrity, Condition, Health, and Sustainable

Words convey meaning but not always the same meaning to all people. The dictionary provides important guidance on the meaning of words but all too often a word may have more than one usage and thus different meanings. The situation worsens when scholarly disciplines use common words in idiosyncratic ways. Scholars and managers may even disagree on whether it is reasonable to use a certain word in historically unconventional contexts. For that reason, clear definitions for all words are crucial if science, management, and policymaking are to be effective.

Nowhere is this difficulty more obvious than in natural resource management, the primary context of the Kissimmee River restoration and associated activities, such as the developing Kissimmee Chain of Lakes Long Term Management Plan (KCOL LTMP). The KCOL LTMP uses “lake ecosystem health” as the framework for developing a monitoring program that is relevant to decision makers. Monitoring and management success depends on a clear operational definition of ecosystem health.[7] Without clear definitions, managers will not be able to communicate specific management goals or define what lake or landscape attributes should be monitored.

Unfortunately, the meaning of health in the context of the KCOL is side stepped in the report with the disclaimer that it will be “determined collectively by the partner agencies.” This sidestepping traps the management team in an ambiguous limbo and makes it impossible for this review panel to judge whether the “approach for assessing and monitoring ecosystem health . . . provides a sound scientific and technical basis for adaptive management.” What is meant by health? Who will provide that definition? What information will be needed to determine if a lake is healthy or not? Are the lakes currently considered to be healthy? What is the foundation of that determination? Because the report does not answer these difficult yet crucial questions, designing a suitable monitoring plan is virtually impossible.

In our view, the concept of health is just one of a suite of words and concepts that is central to the success any LTMP. The KCOL LTMP is intended to be first a science-based monitoring and assessment program and, second, an effective management program that must be understood by all KCOL stakeholders. Those words—integrity, condition, health, and sustainable[8]—are important individually but their interrelationships

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[7] Lake and ecosystem definitions are not very problematic so we focus in this section on “health” and several related words.

[8] To further complicate the situation, all of these words are often coupled with one of a few adjectives that constrain or frame their meaning. Integrity, condition, and health for example, may be paired with biological, ecological, or ecosystem. For our purposes, here we will assume those three are more or less equivalent.

provide, if they are carefully defined and used, an essential foundation to program success.

One could, of course, avoid those words altogether, selecting substitutes to avoid the various baggage that they carry. But one would then need to define those new words and their interactions and interrelationships. Changing the words does not alter the problem, so let us march forward to, we hope, define and clarify a proposed usage for each of those words.

So two key questions emerge: “Can we clearly communicate what is meant when these four words are used within the KCOL LTMP program?” “Can these words be used in ways that are consistent across the several Kissimmee River Basin programs and projects?” To answer these questions, we quote from the KCOL LTMP report to illustrate the importance of these words and concepts in the Kissimmee River system. We then draw on our experience with these words in scientific, management, and policy contexts and offer our judgments about their definition and relevance to the developing KCOL management plan.

As described in Chapter 1 (pages 5 and 9) of the Draft KCOL LTMP document under review here, the KCOL LTMP in integrally related to the Kissimmee River Restoration Project (KRRP), Lake Okeechobee water levels, and the Kissimmee Basin Hydrologic Assessment, Modeling and Operations Study (KBMOS). An important distinction about project goals distinguishes between integrity and health in a general way as follows:

> “In contrast to the Kissimmee River Restoration Project, restoration of ecological integrity to the KCOL is not a possibility because the system cannot be restored to its condition prior to human settlement and basin development. . . . Recognizing this, the KCOL LTMP has been designed for a more viable, but no less worthy purpose, which is to improve, enhance and/or sustain lake ecosystem health” (Draft KCOL LTMP, Chapter 1, page 9)

Integrity

Integrity implies an unimpaired condition or the quality or state of being complete or undivided; it implies correspondence with some original condition. Biological or ecological integrity refers to the capacity to support and maintain a balanced integrated, adaptive biological system having the full range of parts (genes, species, assemblages) and processes (mutation, demography, biotic interactions, nutrient and energy dynamics, and metapopulation processes) expected in the natural environments of the region (Angermeier and Karr 1994, Frey 1975, Karr and Dudley 1981, Karr 1996). Inherent in this definition is that (1) living systems act over a variety of scales from individuals to landscapes; (2) a fully functioning living systems includes items we can count (the parts) plus the processes that generate and maintain them; and (3) living systems are embedded in dynamic evolutionary and biogeographic contexts that influence and are influenced by their physical, chemical, and biological environments (Karr 2008b). Because such places support a thriving living system, they retain the capacity to regenerate, reproduce, sustain, adapt, develop, and evolve; they retain the full legacy of wild nature, or, in Leopold's words, they still have "all the parts" (Leopold 1948). Complete and unimpaired living systems thus possess biological integrity: they support a biota that is the product of evolutionary and biogeographic processes with little or no influence from industrial society. A variety of initiatives from the U. S. Clean Water Act and the European Union's Water Framework Directive to Canada's National Parks Act, the United States' National Wildlife Refuge System Improvement Act, and the global Earth Charter provide legal, philosophical, and scientific foundations for defining and protecting biological or ecological integrity.

Defining integrity and incorporating it into philosophical, policy, scientific, and legal constructs is but the first step toward using the concept. For credibility in any of these arenas, practitioners need tools for translating the subjective concept into something objective; they needs tools to both quantify and describe. Scientists and managers need formal methods for sampling the biota and other components of ecological systems, evaluating the resulting data, and clearly describing the condition of the sampled areas. In short, scientists and managers need to define attributes (measures or indicators) that communicate the condition of places. For more on indicators, see Section 4 of this report.

Condition

Condition, the second of the four key words, now enters the conversation. Condition is measured as a divergence from biological integrity. As human influence increases in a watershed or other appropriately defined region or location, for example, the system and its physical, chemical, and biological dimensions change as a function of the magnitude of human influences. This is most easily conveyed in a graph that depicts the human influence gradient (*x*-axis) against the change in the biological system across that gradient (*y*-axis; Figure 4).[9] In effect, we have the analog of a toxicological dose-response curve. As human influence increases, biological condition declines from biological integrity along a gradient that goes from natural at one extreme to nothing left alive at the other extreme.

One will immediately recognize that the goal of restoring all places to biological integrity would be naïve. For example, streams in a major city would be nearly impossible to restore to their natural condition (biological integrity) just as corn fields in Iowa could not be returned to natural tall grass prairie in the face of human demand for food. For these kinds of places, one must define and formalize other goals. That is exactly what was done in the formation of the overarching "health" goal of the KCOL program.

[9] See also the related graphic in the KCOL LTMP report, Chapter 1, page 10, Fig. 1-3.

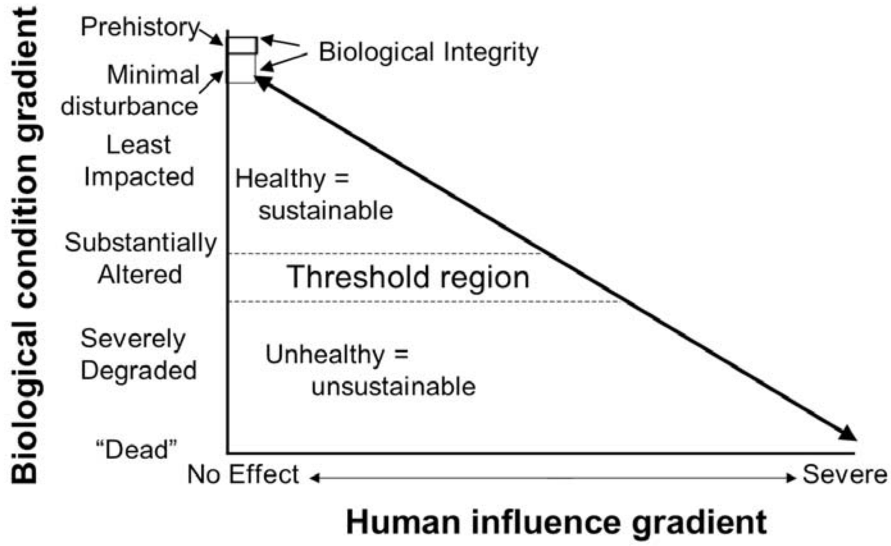

Figure 4. Relationship between biological condition and a hypothetical, synthetic, measure of human activity. Different human activities result in biological changes such as different dominant organisms or changing biological diversity along a descending slope of biological condition. (Modified from Karr 2004.)

KCOL program managers wisely recognized that "restoration of ecological integrity to the KCOL is not a possibility because the system cannot be restored to its condition prior to human settlement and basin development" (draft KCOL LTMP, Chapter 1, page 9). Instead the project team selected a "no less worthy purpose, which is to improve, enhance, and/or sustain lake ecosystem health." Health then emerges as another keyword.

Health

The concept of health embodies a human value judgment. That is, what we define as unhealthy might vary as a function of societal goals; not everyone, for example, might define a lake as healthy by the same criteria. Carp (*Cyprinus carpio*) anglers might regard a turbid lake that supports a large carp population as healthy, whereas swimmers and largemouth bass (*Micropterus salmoides*) anglers would no doubt consider that same lake unhealthy (Karr and Rossano 2001, Karr 2008a). Perception of health in a wetland might vary depending on whether one wanted to watch birds or hunt waterfowl vs. employ the capacity of a wetland to absorb pollutants despite the biological effects of those pollutants on nesting or feeding birds. Thus, one of the key problems with using the term "health" to describe goals for an ecosystem is the subjective nature of this term. Its use requires clear lake-specific definitions of goals if KCOL management programs are to be effective.

Limits to the term health, however, are not subjective. Consider a parcel of farmland. If agricultural practices damage the land (e.g., through soil erosion) so that farming can no longer take place on that parcel, or if these practices harm nearby lakes, streams, or other downstream places, then farming that parcel using those practices is not sustainable. Neither the place nor the practices can be considered healthy.

The goal then is to develop an approach that integrates scientific and social perspectives as society strives to protect the valued character of its lake ecosystems. The process requires exploration of four questions (modified from Karr and Rossano 2001):

1. What is the condition of the lake in biological terms?
2. Is that condition acceptable in scientific and cultural terms?
3. Is the lake self-sustaining, or does it require human intervention to maintain its current condition (to prevent further degradation)?
4. Do conditions at the lake affect condition and health in reaches downstream or downwind of the lake?

What results emerge if we apply these four questions to lakes within the KCOL region? To answer question 1, one must monitor (collect and interpret data) on attributes, commonly status and trend information, of the lake system to define its current condition. This is not a policy or management activity, except in the sense that goals about the lake must be specified with some precision before scientists can determine the relevant data to be collected to define condition (see Section 3 for more on that connection).

Question 2 is answered by a thoughtful integration of science and policy. If the density of floating macrophytes precludes water skiing, a primary goal for a certain lake, then the lake condition is not acceptable and thus the lake does not meet the social definition of healthy. If lake transparency is very low and an industry of glass bottom boats for tourists is a primary societal goal for the lake, again the lake is not healthy in the context of the stated goal. If the lake is considered an important sport and commercial fishery and it supports and sustains a very large population of largemouth bass and other harvested fish, it would be a healthy lake. Of course, the real situation is more complicated than these single goal contexts. Decisions become more complicated but the issues remain the same. One needs scientific information about lake condition in the dimensions relevant to society goals to judge if the lake meets the “acceptable condition” criterion of question 2.

Question 3 poses the question can these ecological conditions be sustained without or with only minimal intervention by humans? If so the answer to question 3 is yes, and the lake is judged healthy and sustainable. On the other hand, if normal lake processes cannot support the largemouth bass fishery, requiring massive human subsidies such as a major largemouth bass hatchery, the answer to question 3 may very well be no; the situation is not healthy and is likely only sustainable through direct and expensive manipulations that will be required forever. Note that the use of sustainable here, our fourth word, is not the ambiguous context so often implicit in conversations about sustainability. Rather it is a precisely defined “sustainable” associated with the explicit benefits that humans have decided are the priority goals for that exact lake. If human actions cause the largemouth bass to disappear, and a self-sustaining but less desirable population of nonnative walking catfish takes over the lake, many would conclude that the degradation is unacceptable and the lake is now unhealthy. Perhaps worse (Question 4), a successful walking catfish population might spread throughout the lakes and rivers in the region, with massive regional loss of other water resource values.

To recap, the four key words are integrity, condition, health, and sustainable.

Integrity: the characteristics of a natural, or undegraded environment. This condition serves as a benchmark, standard, or reference condition. It connotes being unimpaired , whole, undiminished or natural. The complex ecological systems that evolved at a site have already proved their ability to persist in and sometimes modify an area's physical, chemical, and biological environment. Their very presence means they are resilient to the normal variation in that environment; these ecological systems have integrity. Because evolution has tied ecosystems characterized by integrity to their home places, integrity becomes a valid benchmark against which to compare and evaluate places altered by human actions.

Condition: Scientists and managers develop measures (indicators) to document and understand the places they study. Commonly, these condition measurements are crafted to reflect a divergence from the natural or integrity benchmark. When society defines other goals for a location (e.g., growing corn, harvestable largemouth bass population) other appropriate indicators must be defined to track the condition of the desired system components (or their supporting processes). The most effective way to evaluate the condition of places is to employ a variety of indicators that reflect both the richness of natural systems and the special societal goals for those places. This context of condition measurement, rather than a catalog of ongoing monitoring programs, should be the guiding framework for the selection of measures in the KCOL system.

Health: Health is a social construct. Whether one refers to a human or to an ecological system, no precise boundary can be defined along the condition gradient as the threshold between healthy and unhealthy. That threshold inevitably involves social conventions and contexts. Once those conventions are defined, such as for a series of lakes, their condition can be measured and evaluated in the context of the defined conventions.

Sustainable: Healthy cannot simply be defined by societal desires. When extraction of the desired benefits involve harvests in excess of what the system can bear and still maintain itself, the judgment then must be that it is not healthy because the situation is not sustainable without strong intervention. This becomes the scientifically grounded governor, a device that regulates the speed of the human endeavor. That final step is integral to the success of a management program: determining whether the use defined by the specific goal is sustainable. Two criteria would help to set the thresholds for whether a loss is acceptable (Karr 1996). First, human activity should not alter the long-term ability of places to sustain the supply of goods and services those places provide. Second, human uses should not degrade off-site areas, a provision that requires a landscape-level perspective. Such criteria in decisions about environmental condition writ large—from land use to fish harvest quotas—would avoid the depletion of living or ecological systems.

Monitoring Lakes and Landscapes

One of the greatest strengths of the KCOL LTMP process is recognition that success in a project of this scale requires an effort to integrate the efforts of multiple regional (South Florida Water Management District), state (Florida Fish and Wildlife Conservation Commission, Department of Environmental Protection, and Department of Agriculture and Consumer Service), and national (U. S. Army Core of Engineers, Fish and Wildlife Service, and Environmental Protection Agency) agencies and their respective citizen constituencies. The continuing effort to advance the program goals should also strive to incorporate more local institutions (e.g., Osceola County Government). All of these and other organizations, including Non-Governmental Organizations (NGOs) and other components of civil society, can be instrumental in fostering a truly regional effort to accomplish the programs' important goals. Perhaps the most important reason to expand this conversation is the crucial role played by development, conservation, and other activities in the catchment or basin in which the Chain of Lakes are located. One cannot expect to "improve, enhance and/or sustain lake ecosystem health" unless the planning, regulatory, and incentive processes are integrated at the level of the catchment, basin, or watershed.

Learning from the Experience of Others

The past few decades have seen many initiatives to protect and restore regional ecosystems (the Laurentian Great Lakes, Chesapeake Bay, Colorado River, San Francisco Bay, Puget Sound, and the Elwa River among others). While these efforts have not always been as successful as those pushing for important regional goals had hoped, the most successful ones in our experience often establish some kind of regional authority to make management decisions. Chesapeake Bay and more recently the Puget Sound Partnership in Washington illustrate the value of this kind of regional consortium and authority. We recommend that the KCOL management team examine the lessons to be derived from these other conceptually similar efforts to protect regional natural resources.

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