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Spatial Decision Support Systems for Landscape Ecological Evaluations in the Southwest Florida Feasibility Study

The objective of the Southwest Florida Feasibility Study (SWFFS) is to develop a comprehensive and ecologically sound regional plan for water resources in southwestern Florida. Boundaries of the study are shown in figure 1. The SWFFS study area covers about 4,300 square miles, and lies west of the Everglades and most Comprehensive Everglades Restoration Plan (CERP) activities. The study was recommended by CERP and the Comprehensive Review Study for inclusion in the Central and Southern Florida (C&SF) Project because of: (1) water-supply and ecological issues with water releases from Lake Okeechobee to the Caloosahatchee River, and because (2) inland hydrologic alterations have substantial existing and potential effects on rich natural resources and biodiversity within the study area. This study will address the health of upland and aquatic ecosystems and will consider a variety of parameters including water flow, water quality, water supply, maintenance of existing flood protection, wildlife, biological diversity, and natural habitat. The SWFFS is being conducted by the U.S. Army Corps of Engineers and the South Florida Water Management District. The USGS, in cooperation with the University of Florida, is providing technical assistance for evaluation of hydrologic impacts to natural systems.

Landscape level decision-making is a process that involves multiple objectives, large data sets, and many unknowns and uncertainties. To support this process, evaluation tools are needed to make informed long-term regional resource decisions and recognize research needs. These tools can help authorities involved in ecological restoration by identifying decision variables, developing problem solving heuristics, and evaluating the consequences of alternative policy actions. Spatial decision support systems (SDSS) for natural resource management are computer-based tools that tightly integrate decision theory models with ecological models and Geographic Information System (GIS) analyses and mapping. The information provided by SDSS gives decision makers increased ability to follow outcomes of interacting variables, improves the reproducibility of decisions, and documents the reason why (with conflicting alternatives) a particular choice was made (Rauscher 1999).

The framework for decision support of landscape habitat evaluations has four components (fig. 2). The first two components, primarily intended for use by the scientist, assist in assessing which criteria best define performance measures for ecological evaluation and which values those criteria will have with a particular scenario. The first component is an analysis of the proposed scenarios and their respective effects on the physical environment. These analyses are supported by inputs from models that simulate each scenario such as hydrologic models, urban growth models, and water-quality models. Tools provided in the second component evaluate effects on wildlife habitat and ecological communities caused by changes in the physical

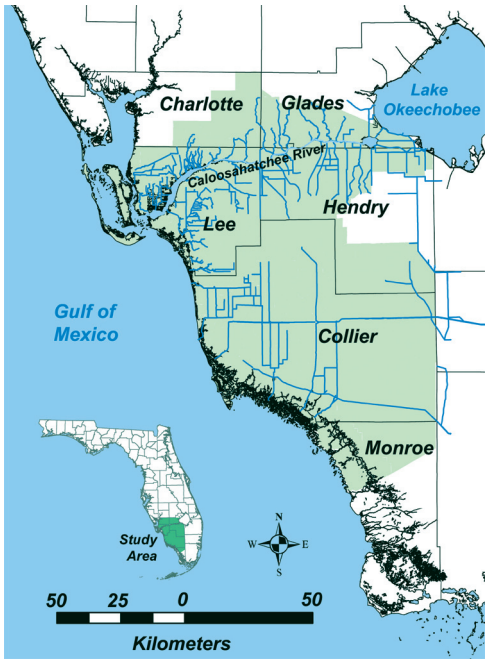

Figure 1. The Southwest Florida Feasibility Study area (shaded in green) showing major canals.

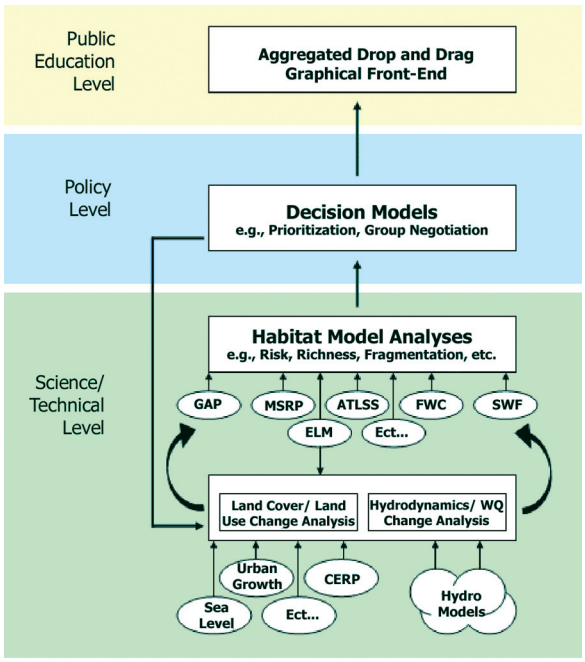

Figure 2. A hierarchical and modular approach to development of a Spatial Decision Support System. Abbreviations represent current habitat models in southern and southwestern Florida.

environment. These tools evaluate habitat suitability and risk evaluations based on inputs from habitat models.

The third and fourth components are intended for use, respectively, by policy makers and the public. Decision models (the third component) rank and aid decisions among criteria and alternative scenarios. Evaluations of alternatives at this level may lead to modified or new scenarios, which would then be returned to scientists for evaluation using the support tools in the first two components. A graphical, public education version of the decision process (the final component) can increase public understanding of conservation actions, create a sense of involvement and "ownership" in decisions, and alert policy makers and resource managers to social judgments of alternative plans. A web-based interface is one option for public and policy maker participation. The Internet has the advantages of removing geographic restrictions to participation, easy access to discussion materials, anonymous input and nonconfrontational feedback opportunities (Kingston and others, 2000).

Ecological Issues in Southwestern Florida

The Caloosahatchee and Big Cypress watersheds that make up the SWFFS include mangrove- and seagrass-dominated coastal estuaries. The benthic-based primary productivity of these protected nursery grounds supports fish and microinvertebrate communities that, in turn, feed many commercial and recreational marine species. Together with these coastal communities, inland short hydroperiod freshwater marshes, wet prairies, and wetland forests are habitat for up to 20 Federally listed species and 43 species of migratory nongame birds of management concern (U.S. Department of the Interior, 2004). Southwestern Florida is also one of the most important regions that support wide-ranging species such as the Florida panther, Florida black bear, and wood stork (Cox and others 1994). Because southwestern Florida is one of the most rapidly developing areas across the Nation, concern has arisen among the public and decision makers about urban and agricultural growth in proximity to extensive public land holdings and privately owned natural areas with the ecological attributes just described.

Southwestern Florida Ecological Evaluations

The following discussion provides examples of the types of tools and procedures being developed for southwestern Florida evaluations. The SWFFS is an ongoing project, and tools may change substantially over the course of the study.

Ecological evaluations examine the effects of hydrologic change in two geographic regions. In coastal areas, instream changes in water-delivery schedules along the Caloosahatchee River are evaluated for their effect on the Caloosahatchee River estuary. In inland areas, changes in overland hydrologic characteristics are evaluated for their effect on forested and emergent wetlands.

Criteria for assessing ecological effects to southwestern Florida are being developed at three principal scales. The criteria address changes in: (1) potential habitat distributions and quality for individual species, (2) community composition and hydrologic characteristics, and (3) landscape connectivity.

Species Evaluations

Coastal species evaluation tools include species habitat suitability models for sea trout, American oyster, blue crab, three species of sea grasses (Halodule, Thalassia, Syringodium), and a submerged freshwater grass (Vallisneria). Inland species evaluation models are now being created or adapted from existing models for indicator species of inland wetland health including:

- Long-legged wading birds (for example, blue heron, roseate spoonbill, wood stork)
- Short-legged wading birds (for example, white ibis, snowy egrets, small herons)
- Wide-ranging mammals (bobcat, the Florida black bear, and Florida panther)
- Amphibians (change in proportions of frog species)
- Aquatic fauna (insects, forage fishes, and crayfish)

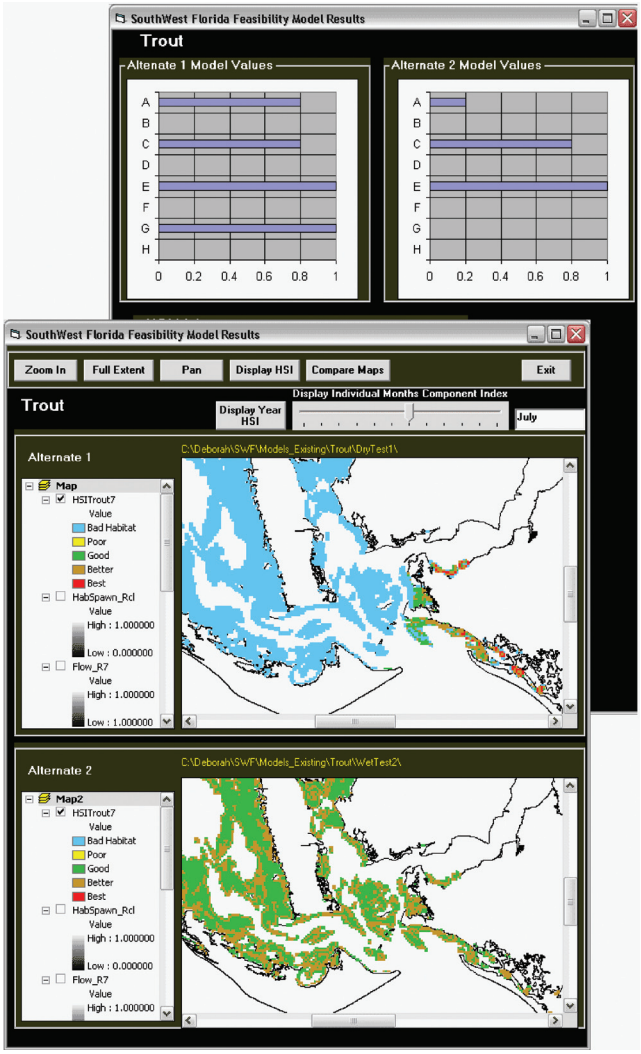

Figure 3. The Southwest Florida Feasibility Model interface showing spotted sea trout habitat suitability.

Figure 3 shows output from a species habitat model for spotted sea trout in San Carlo Bay and Pine Island Sound at the mouth of the Caloosahatchee River. Maps of potential habitat for sea trout are shown for two alternative water-release schedules along the Caloosahatchee River. Habitat quality is grouped into five classes, from "best" to "unsuitable," based on five modeled components: bathymetry, type of seagrass/substrate, flow, salinity, and water temperature. Bar charts shown above the maps allow natural-resource managers and policymakers to see the contribution of each component to the overall habitat score. For example, the bar chart for alternative 2 shows that, for the location selected, the suitability of salinity for sea trout is low ("A" on the chart), but flow conditions ("E" on the chart) are optimal. Suitability scores for the individual components are considerably better under the first alternative, as shown on the left bar chart.

Community Evaluations

Community evaluations involve the use of hydrologic models to evaluate hydrologic characteristics within indicator regions in the study area. Indicator regions are representative areas of a single community such as hydric pine flatwoods or cypress prairie. Predevelopment hydrologic characteristics modeled at an indicator region are compared to the same characteristics in alternative hydrologic scenarios using a similarity measure. Alternatives that more closely preserve predevelopment hydrology of a community are ranked as better for maintaining natural conditions at the site.

Community evaluations also include measures of listed-species diversity, overall biological diversity, community fragmentation, and the influence of other landscape features such as proximity to conservation lands or development. A model interface allows managers to spatially assess and map these community measures.

Landscape Evaluations

Landscape connectivity is a measure of how landscape elements, such as habitat patches, edges and contiguity, affect organism movement and usage of landscape resources (Tischendorf and Fahrig, 2000). Land-cover preferences and dispersal characteristics of three wide-ranging mammals (bobcats, Florida black bear, and Florida panther) are used to create least-cost path analyses to weigh the effects of alternative hydrologic and land-use scenarios against a predevelopment scenario. Least-cost path analysis finds travel paths between two locations that have the most suitable characteristics (for example, best land cover) for target species. Figure 4 shows the least-cost path for the Florida panther moving between the Corkscrew Swamp and protected lands north of the Caloosahatchee River along the western coast. Land surrounding the Corkscrew Swamp Sanctuary and adjacent to areas of rapid development along the coast up to Fort Myers has a high value as movement habitat for the panther.

Decision Models

Ecological models provide essential output for evaluating landscape habitat changes, but do not provide it in a form that: (1) permits collective evaluations of the habitat

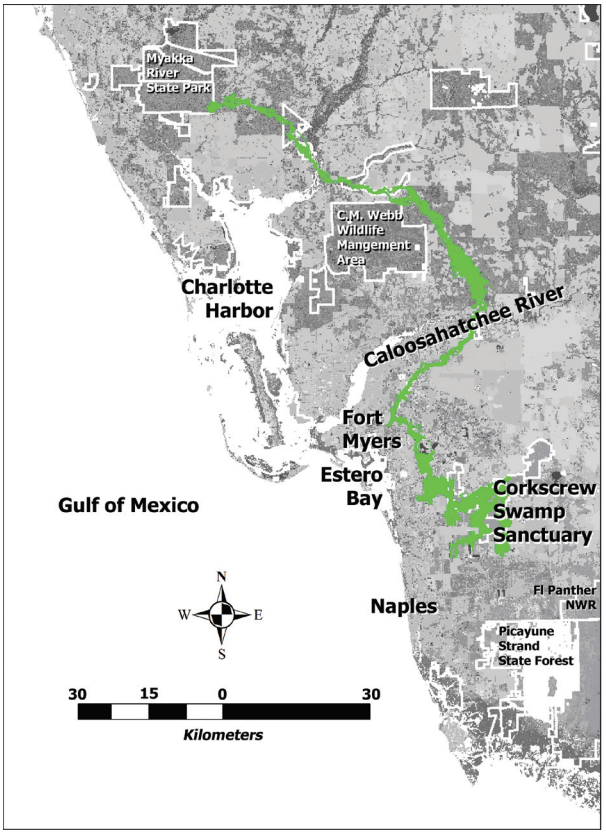

Figure 4. A least-cost path for Florida Panther movement (shown in green) between Corkscrew Swamp and Myakka River State Park.

changes, or (2) allows decisions to be made from multiple evaluations. Decision analysis provides tools for systematically formulating and evaluating multiple criteria and explaining why (under several conflicting preferences) a particular decision was made (Lahdelma and others, 2000).

Figure 5 presents a procedural relation between scientific/technical evaluations and policy making in an adaptive management framework. Conceptual models are an effective initial tool

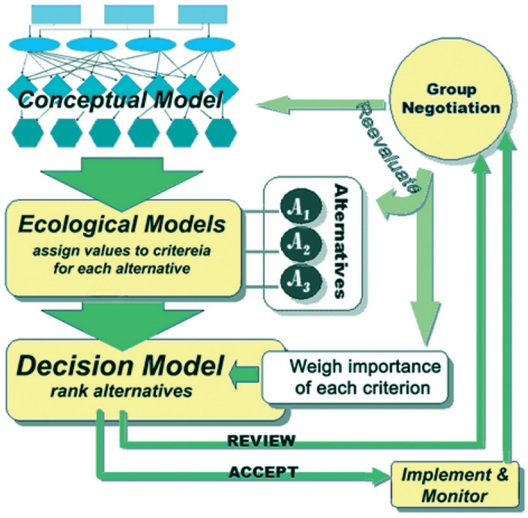

Figure 5. The decision support process.

for group identification of sources of stressors and linkages to attributes in the environment. Criteria, or performance measures, are selected as measurable values of identified attributes and are used to evaluate success of implemented plans. For example, if an attribute of the natural environment is oyster community structure and function, then criteria for that attribute may be oyster growth, disease, mortality, and recruitment. Scientists place expected values on these criteria under alternative scenarios of environmental change. This task is usually accomplished with ecological modeling. Decision makers then determine the importance of each of these criteria and use this information to evaluate different alternatives. Decision models aid in weighing and evaluating alternatives and may also help decision makers pinpoint conflicts between objectives and conceptualize new alternatives that minimize these conflicts (Ozernoy, 1984). Once an alternative is selected and implemented, expected environmental change is compared to actual conditions through monitoring and directed experimentation, which may lead again to reevaluations of criteria and implemented plans.

Multicriteria decision analysis calls for agencies to define issues, propose alternative solutions, and develop measurable criteria for evaluating the performance of each alternative. Decision tools and graphical methods help provide a critical and careful examination of the process. In southern and southwestern Florida, the need for evaluation approaches that help to structure the decision process is increasingly felt by natural resource personnel as indicated by results from a preliminary decision support survey (Pearlstine and others, 2003).

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