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Measuring the collective planning capabilities of local jurisdictions to manage ecological systems in southern Florida

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Abstract

Although ecosystem approaches to management often look beyond specific jurisdictions and focus on broad spatial scales, the contribution local level plans and policies make in managing ecological systems must be strongly considered along with state and federal initiatives. Increasingly, environmental planners and policy makers are acknowledging the importance of local land use decisions implementing ecosystem management. However, little research has been conducted to understand how local jurisdictions can together solve ecosystem-based problems. This article evaluates the collective planning capabilities of local jurisdictions to manage transboundary watersheds based on an evaluation of comprehensive plans in Florida. In addition to describing the spatial pattern of collective watershed planning scores, this paper identifies the major factors contributing to the strength or weakness of local jurisdictions to manage ecological systems. Results indicate that strong ecosystem management capabilities exist for watersheds with the following characteristics: high levels of human disturbance; large, wealthy, and educated populations; and a high degree of planning capacity to address complex environmental issues. Based on the findings, policy implications are discussed and suggestions are made as to how local jurisdictions can more effectively contribute to the management of large ecological systems.

Keywords: Ecosystem management; Watershed planning; GIS; Collaboration; Land use policies

1. Introduction

Increasingly, environmental planners are focusing management efforts on entire ecological systems and their components as opposed to areas defined by jurisdictional or political boundaries (Grumbine, 1994; Christensen et al., 1996; Szaro et al., 1998; Wondolleck and Yaffee, 2000). At the same time, local natural resource and land use planners recognize that while ecosystem approaches to management require looking beyond specific jurisdictions and focusing on broad spatial scales, they will in part be implemented at the local level through local land use decisions (Kirklin, 1995; Beatley, 2000; Michaels, 2001). Many of the factors causing ecosystem decline such as rapid urban development, urban run-off, and habitat fragmentation occur at the local level and are generated by local land use decisions (Noss and Scott, 1997). The vast majority of these decisions affecting large ecosystems will be made at a smaller scale where they make the largest impact on the natural environment (Endter-Wada et al., 1998; McGinnis et al., 1999). As a result, many of the decisions that could threaten or protect natural habitats providing

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the ecological infrastructure for larger ecosystems are in the hands of county commissioners, city councils, town boards, local planning staff, and the participating public. Thoughtful policies and actions at the local level can often protect critical habitats of regional significance more effectively and less expensively than the best intentioned state or federal protection schemes (Duerksen et al., 1997). The importance of local ecosystem-based planning is further highlighted by the declining role of the federal government in the protection of habitat and associated ecological systems over the past 10 years, and a future political climate that suggests giving more control to local jurisdictions for making resource use decisions. Given this political direction, the contribution local level plans and policies make in managing entire ecological systems such as transboundary watersheds, must be strongly considered along with state and regional initiatives. The coordination of local plans and policies across larger landscapes becomes even more important at the local level when a single ecological unit is fragmented by several jurisdictions.

While a large amount of research suggests collaborative ecosystem management is a desirable approach to protect the integrity of critical natural resources in the United States (US), comparatively little work has been done to show how local jurisdictions are playing a role in the management of large-scale natural systems. This article evaluates the collective potential of local jurisdictions to manage transboundary ecological systems (as defined by watershed units). Specifically, it uses Geographic Information Systems (GIS) to map, measure, and analyze the existing mosaic of management based on policies in local comprehensive plans across 22 adjacent watersheds in southern Florida. In addition to describing the spatial pattern of watershed plan scores based on local level plans and policies, we seek to explain the major factors contributing to the strength or weakness of local jurisdictions to manage transboundary ecological systems. An analysis of plan quality measures based on aggregating multiple local indicators of ecosystem management builds on a previous study which focuses on the spatial distribution of individual policies and strategies.

The following section examines the importance of inter-jurisdictional collaboration and necessity for considering the collective capabilities of local jurisdictions in managing ecological systems in Florida. Next, we explain how the principles of ecosystem management can be incorporated into local land use planning frameworks and then conceptualize a measure for local ecosystem plan quality by adding ecological considerations to existing notions of what constitutes a high quality plan. Following this section, sample selection, variable measurement, and data analysis procedures are described. Results are presented in two phases. First, total ecosystem plan quality and its components are mapped and analyzed for watersheds in southern Florida. Second, correlation analysis is conducted to identify the major socioeconomic, demographic, and environmental factors contributing to these scores. Finally, based on the results, policy implications are discussed and suggestions are made as to how and where natural resource management can be strengthened by future local planning initiatives.

2. The importance of inter-jurisdictional collaboration for managing large watersheds

The management of ecological systems such as watersheds, increasingly depends on collaboration across political, administrative, and ownership boundaries (Blumenthal and Jannink, 2000; Selin and Carr, 2000; Benthrup, 2001). Because these approaches adhere to ecological systems rather than human defined boundaries, inter-organizational collaboration across jurisdictions, agencies, and land ownership is often necessary to achieve effective management of transboundary resources. Management decisions must be made collectively because, in most cases, no single entity has jurisdiction over all aspects of an ecosystem. The need to integrate the values and knowledge of a broad array of jurisdictions and organizations translates into a need to focus on collaborative planning efforts among resource owners, managers, and users (Cortner and Moote, 1999; Wondolleck and Yaffee, 2000).

Early support for collaboration to address multiparty, large spatial problems is found in the organizational design literature. For example, Emery and Trist (1965) argued that problem domains (ill-defined problems that depend on multiple perspectives for their solution) could be stabilized by inter-sectoral collaboration. These so called “meta-problems” which transcend boundaries of single organizations or jurisdictions must be addressed cooperatively. Others have also noted that multiple stakeholders in different sectors, having different viewpoints, interests, and values, must cooperate to solve problems whose parameters are transboundary or not clearly defined (Clark, 1989; Brown, 1991). Environmental planning researchers have also argued for cross-jurisdictional collaboration to manage ecological units effectively. Innes (1996) examined the role of consensus building through case studies of environmental problems involving multiple issues that cut across jurisdictional boundaries. She found that collaboration resulted in stronger outcomes or plans that were beneficial to the resource or to the natural system as a whole. More recently, Kennedy et al. (2000) found in their analysis of 100 cases involving watershed management in the US that collaboration by stakeholders was a key feature in improving resource management.

In Florida, it is largely recognized at the state level that ecosystem approaches to management and corresponding regional watershed management are important aspects of ecologically sustainable development. Ecological systems, particularly regional watersheds, extend across multiple jurisdictions making sustainable management of the entire natural system more complicated (Kirklin, 1995). Because ecosystems often do not adhere to what has become a "crazy quilt" of land ownership and governance, environmental management goals are not being reached and natural systems such as the Everglades continue to decline (Light et al., 1995; Daniels et al., 1996). While this natural system is intricately connected over broad spatial and temporal scales, the land use decision-making framework is limited to local jurisdictions and some limited input from regional planning councils. Uncoordinated local land use decisions have cumulative negative impacts on the system as a whole. In other words, the Everglades and its sub-ecological systems are suffering a "death" from thousands of locally imperceptible, individual development decisions. Collaboration across jurisdictional lines and among multiple organizations thus becomes imperative if approaches to ecosystem management are to be attained (Daniels and Walker, 1996; Randolph and Bauer, 1999). Although the rationale for collaboration in natural resource management is well defined, the planning outcomes of collective efforts are not well understood at the ecosystem level. Examining the collective capabilities of local jurisdictions within large ecosystems from a statistical and spatial perspective is an initial step in improving the ability of local plans and planning processes to manage transboundary natural systems.

3. Conceptualizing local ecosystem plan quality

To evaluate the ability of local jurisdictions to protect the components and processes of ecosystems, it is first necessary to understanding how the principles of collaborative ecosystem management can be integrated into local plans and policies. This study develops a conceptual definition of local ecosystem plan quality by building on and extending previous conceptions of plan quality which identify factual basis, goals, and policies as core components (Kaiser et al., 1995). Adding two additional plan components of *inter-jurisdictional coordination and capabilities and implementation* enables the definition of plan quality to capture the principles of ecosystem management more effectively. Plan quality is thus conceptualized (and measured) through the following five components: *factual basis*, *goals and objectives*, *inter-jurisdictional coordination and capabilities*, *policies*, *tools and strategies*, and *implementation*. Together these five plan components constitute the ability of a local plan and planning effort in general to manage and protect the integrity of ecological systems. Based on these elements of sound plan making, we show how they play out when applied to ecosystem management. Each plan component is discussed below in more detail.

3.1. Factual basis

The factual basis of an ecosystem-oriented plan is an inventory of existing natural resources, the status of their conditions, the human impacts to these resources, and the existing environmental management framework. It takes both a written and visual form and serves as the factual and descriptive basis upon which policy decisions are made within the plan. Items within the factual basis plan component are grouped into three categories. First, the resource inventory category includes indicators such as maps of ecosystems and habitat boundaries, descriptions of ecological functions, and classifications of wildlife and vegetation. To protect the ecological infrastructure of a landscape, planners also must identify critical habitat, areas of high biodiversity and, most importantly, corridors that facilitate the movements and migration of key species. Second, the human ownership category characterizes the existing management of critical habitats and areas of high biodiversity. To identify new lands for protection, a planner must begin by identifying the existing network of management. Human impacts, the third category of the factual basis plan component, identifies resource problems stemming from human development. Indicators in this category include human population growth, the development of wetlands, water pollution, and habitat fragmentation.

3.2. Goals and objectives

The goals and objectives plan component guides the implementation of ecosystem management. It contains both general statements of long-term goals regarding clarity and consistency as well as specific measurable objectives, such as a 30% reduction in nutrient run-off to reduce negative impacts on an estuarine system. Goals should be clearly specified and objectives should be measurable to provide benchmarks of success. Spatially specific and prescriptive goals generated through effective planning provide more detail than vague commitments to ecosystem protection. They draw upon ecosystem science by seeking to maintain large intact communities of native species, connections among significant habitats, and inter-generational sustainability of natural systems. Furthermore, well-defined goals protect the functionality of the ecosystem as well as its unique landscapes and rare species.

3.3. Inter-jurisdictional coordination and capabilities

The *inter-jurisdictional coordination and capabilities* plan component captures the ability of a local jurisdiction to collaborate with neighboring jurisdictions and organizations to manage what are often transboundary natural resources. This is a key component in defining local ecosystem plan quality because it measures the degree to which a local community is able to recognize the transboundary nature of natural systems in Florida and coordinate with other parties both within and outside of its jurisdictional lines. All county and city comprehensive plans in Florida are required to include an inter-governmental coordination plan (Rule 9J-5), but there is wide variation among plans with regard to protecting natural systems. This plan quality component addresses the critical factors necessary to foster collaboration: coordination with public and private entities, joint fact finding, information sharing, inter-governmental agreements, conflict management processes, and integration of other regional environmental plans in the watershed. In addition, joint database production, cooperative agreements, and the commitment of financial resources indicate that power and information are being shared among individuals and organizations.

3.4. Policies, tools, and strategies

The fourth plan component *policies*, *tools and strategies* represents the heart of a plan because it actualizes community goals and objectives by defining actions to protect critical habitats and related natural systems. This plan component draws heavily on the environmental and land use planning literatures to identify tools that effectively protect ecological systems and their components (Duerksen et al., 1997). Indicators in this plan component fall into four broad categories: regulatory, incentive, land acquisition, and other. Regulatory tools include traditional land use policies such as land use or density restrictions, control or removal of exotic species, buffer requirements, and the maintenance of wildlife corridors. Incentive-based tools deal with strategies that encourage landowners to protect critical ecological components as opposed to forcing them to do so. Incentives include clustering, density bonuses, the transfer of development rights (TDRs), preferential tax treatments, and mitigation banking.

Land acquisition programs are another important category because they indicate the ability of jurisdictions to fund the purchase of critical habitats and sensitive lands. Florida is considered a leader in acquisitions efforts across the country (Beatley, 2000). Under its Preservation 2000 Initiative, the State generated US$ 300 million per year for 10 years to fund the acquisition of sensitive lands. However, leadership at the state level has not necessarily translated into local initiatives to acquire areas containing critical habitat. Finally, the other policies category addresses items that do not easily fall into land use or environmental tools, but are important in implementing the principles of ecosystem management. These indicators include the designation of special taxing districts, control of public investment, and educational efforts on the importance of protecting watershed functions and processes.

3.5. Implementation mechanisms

The *implementation* plan component conceptualizes a commitment to implementing the final plan in the future (but does not indicate how well the plan is actually implemented once it is adopted). An important attribute of a high quality plan is that it articulates mechanisms and procedures to implement the plan once it is adopted. Implementation depends not only on the ability of a community to implement its plan in a timely fashion, but also to designate responsibility for actions, enforce adopted standards, and sanction those who fail to comply. This plan component also focuses on monitoring both ecological conditions and program effectiveness. Through these indicators a community can adapt to changing conditions by setting updated standards to obtain stated goals and objectives most effectively (for a more comprehensive discussion of conceptualizing ecosystem plan quality, see Brody, 2003b,c).

To evaluate the ability of local plans to integrate the principles of collaborative ecosystem management, we constructed a plan coding protocol based on the five components of plan quality. A total of 127 indicators within the plan components serve to operationalize and measure the degree to which local comprehensive plans in Florida are managing natural systems traversing multiple jurisdictions. Table 1 provides a complete listing of ecosystem management indicators by component and category.

Past research not only helps us to conceptualize a definition of ecosystem plan quality, but also informs a model to explain the major factors influencing ecosystem plan quality scores. Existing environmental conditions and human impacts are thought to stimulate planners to install environmental policies in local plans. For example, Brody (2003b,c) found that levels of biodiversity within a jurisdiction are not related to the quality of plans, but instead the degree of human disturbance (e.g. pavement, agriculture, exotic species, etc.) significantly increases the quality of a jurisdiction's plan to management ecological systems.

Previous studies have also tested the impacts of socioeconomic and demographic variables on plan quality scores. Berke et al. (1996) examined the positive influence of wealth on plan quality associated with natural hazards. Jurisdictions with wealthier population usually have more financial resources to devote to planning staffs and plan development. Residents with high incomes also are often more educated and have more time and interest in participating in the planning process, particularly when it comes to environmental issues. Brody (2003a) found that higher population levels increased the quality of local plans to manage ecological systems. Berke et al. (1998) found that population growth (as a proxy for growth pressure) increased the quality of environmental plan. In general, jurisdictions with larger populations usually have more complex environmental problems that result in a need for strong planning. Growth pressures are associated with higher levels of disturbance to habitat, resulting in a greater perceived need to protect remaining areas of biodiversity. Furthermore, high population areas tend to have more financial resources and expertise to devote to plan development. Finally, Burby and May (1998) examined the significance of planning capacity as a contextual control variable in a study on plan quality associated with natural hazards. Planning capacity refers to the number of planners that contributed to the development of the comprehensive plan. The higher the planning capacity for a given jurisdiction, the more technical expertise and personnel devoted to producing the plan.

4. Research methods, concept measurement, and data analysis

4.1. Unit of analysis

Florida was selected to study ecosystem management capabilities at the local level partly because the state requires each local community to prepare a legally binding comprehensive plan. City and county comprehensive plans in Florida stem from the 1985 *Local Government Comprehensive Planning and Land Development Act*, which mandated that new local comprehensive plans be written for each local

Table 1
Plan coding protocol

Factual basis		
(A) Resource inventory		
Ecosystem boundaries/edges	Ecological zones/habitat types	Ecological functions
Species ranges	Habitat corridors	Distributions of vertebrate species
Areas with high biodiversity/species richness	Vegetation classified	Wildlife classified
Vegetation cover mapped	Threatened and endangered species	Invasive/exotic species
Indicator/keystone species	Soils classified	Wetlands mapped
Climate described	Other water resources	Surface hydrology
Marine resources	Graphic representation of transboundary resources	Other prominent landscapes
(B) Ownership patterns		
Conservation lands mapped	Management status identified for conservation lands	Network of conservation lands mapped
Distribution of species within network of conservation lands		
(C) Human impacts		
Population growth	Road density	Fragmentation of habitat
Wetlands development	Nutrient loading	Water pollution
Loss of fisheries/marine habitat	Alteration of waterways	Other factors/impacts
Value of biodiversity identified	Existing environmental regulations described	Carrying capacity measured
Incorporation of gap analysis data	Loss of key species	Loss of native vegetation
Boating impacts		
Goals and objectives		
Protect integrity of ecosystem	Protect natural processes/functions	Protect high biodiversity
Maintain intact patches of native species	Establish priorities for native species/habitat protection	Protect rare/unique landscape elements
Protect rare/endangered species	Maintain connection among wildlife habitats	Represent native species within protected areas
Maintain inter-generational sustainability of ecosystems	Balance human use with maintaining viable wildlife populations	Restore ecosystems/critical habitat
Other goals to protect ecosystems	Goals are clearly specified	Presence of measurable objectives
Inter-organization coordination and capabilities for ecosystem management		
Other organizations/stakeholders identified	Coordination with other organizations/jurisdictions specified	Coordination with adjacent counties
Coordination with state-level organizations	Coordination with federal level	Coordination within jurisdiction specified
Inter-governmental bodies specified	Joint database production	Information sharing
Coordination with private sector	Coordination with water management districts	Participation in ecosystem-based initiatives (i.e. NEP, EMAs)
Links between science and policy specified	Position of jurisdiction within bioregion specified	Inter-governmental agreements
Conflict management processes	Commitment of financial resources	Integration with other plans/policies in the region
Other forms of coordination		
Policies, tools, and strategies		
(A) Regulatory tools		
Resource use restrictions	Density restrictions	Restrictions on native vegetation removal
Removal of exotic/invasive species	Buffer requirements	Fencing controls
Public or vehicular access restrictions	Phasing of development	Controls on construction

Table 1 (*Continued*)

Conservation zones/overlay districts	Performance zoning	Subdivision standards
Protected areas/sanctuaries	Urban growth boundaries to exclude habitat	Targeted growth away from habitat
Capital improvements programming	Site plan review	Habitat restoration actions
Actions to protect resources in other jurisdictions	Establishment of a network of system of protected areas	Create wildlife corridors
Protect threatened or endangered species	Structural or design solutions to protect habitat	Other regulatory tools
(B) Incentive-based tools		
Density bonuses	Clustering away from habitats	Transfer of development rights
Preferential tax treatments	Mitigation banking	Specific mitigation measures to protect habitat
Impact fees to protect habitat	Other incentive-based tools	
(C) Land acquisition programs		
Fee simple purchase	Conservation easements	Other land acquisition techniques
(D) Other policies, tools, and strategies		
Designation of special taxing districts for acquisition funding	Control of public investments and projects	Public education programs
Studies or ecological surveys		
Implementation mechanisms		
Designation of responsibility	Provision of technical assistance	Identification of costs or funding
Provision of sanctions	Clear timetable for implementation	Regular plan updates and assessments
Enforcement specified	Monitoring for plan effectiveness and response to new information	Monitoring of Ecological health and human impacts

jurisdiction and required that they be consistent with goals of the State plan.

While there are many different types of resource management plans in Florida (e.g. Water Management District plans, Ecosystem Management Area plans, National Estuary Program (NEP) plan, etc.), comprehensive plans follow a consistent format (in terms of production, element types, and review/updating processes), are an institutionalized policy instrument, and most importantly provide a basis for city and county land use and resource management decisions. Rule 9J-5, adopted by the Department of Community Affairs (DCA) in 1986, requires that specific elements be included in local plans and prescribes methods local governments must use in preparing and submitting plans. These plans must look beyond jurisdictional boundaries, drive collaborative efforts with other jurisdictions or organizations, and contain policies that seek to protect critical habitats comprising broader ecosystems. Thus the DCA can effectively gauge how well local jurisdictions will manage ecological units, such as watersheds, over the long term.

A second rationale for selecting Florida as a study site is that it contains some of the most biologically diverse and valued ecosystems in the country. The state is widely recognized as one of North America's most important reservoirs of biological diversity (Cox et al., 1994). In addition to the Everglades ecosystem, Florida contains some of the last remaining plant species, panther populations, and coastal habitats in the eastern United States. These ecosystems and associated biodiversity are in a state of decline due to increasing population growth and human development. The growth of Florida's resident and tourist populations, as well as its agricultural industry has contributed to a dramatic loss of forest and wetland communities. This degradation and fragmentation of critical habitat has created an immediate need for understanding how to effectively implement ecosystem policy. In other words, the precarious balance between rapid urban growth and the conservation of critical natural resources in Florida make it an ideal living laboratory within which to study the impacts of local land use decisions on protecting ecological systems.

4.2. Sample selection

Watersheds have been identified as an ideal planning unit for ecosystem managers when considering the protection of ecological processes and critical natural habitats (Williams et al., 1997) and served as the unit of analysis for the study. We selected 23 adjacent watersheds for analysis in the southern portion of Florida defined by the United States Geological Service's (USGS) fourth order Hydrological Unit Code (HUC). In areas south of Lake Okeechobee, we took direction from Florida's Department of Environmental Protection (DEP) which redefined watershed boundaries due to human alteration and fragmentation of traditional water flows. The sample of watersheds stretches from the west coast near Tampa Bay to the heavily developed southeast coast of the state, representing a wide variety of biophysical regions and institutional/political settings (Fig. 1).

Local jurisdictions were then selected containing land area within one of the 22 watersheds. Thirty adjacent counties intersecting the watershed boundaries, plus the 15 largest cities in land area were selected for analysis (Fig. 2). Since the goal is to achieve the greatest level of spatial coverage, cities were selected based on area rather than by population. Watersheds in our sample contain an average of 5.13 jurisdictions.

The most recent comprehensive plans for these counties and cities were evaluated against the ecosystem plan quality protocol containing indicators to determine their collective ability to manage watersheds or, more generally, ecological systems. Two trained coders working independently of each other evaluated the sample of plans. An "inter-coder reliability score" was computed equal to the number of coder agreements for indicators divided by the total number of indicators. We calculated a score of 97%.

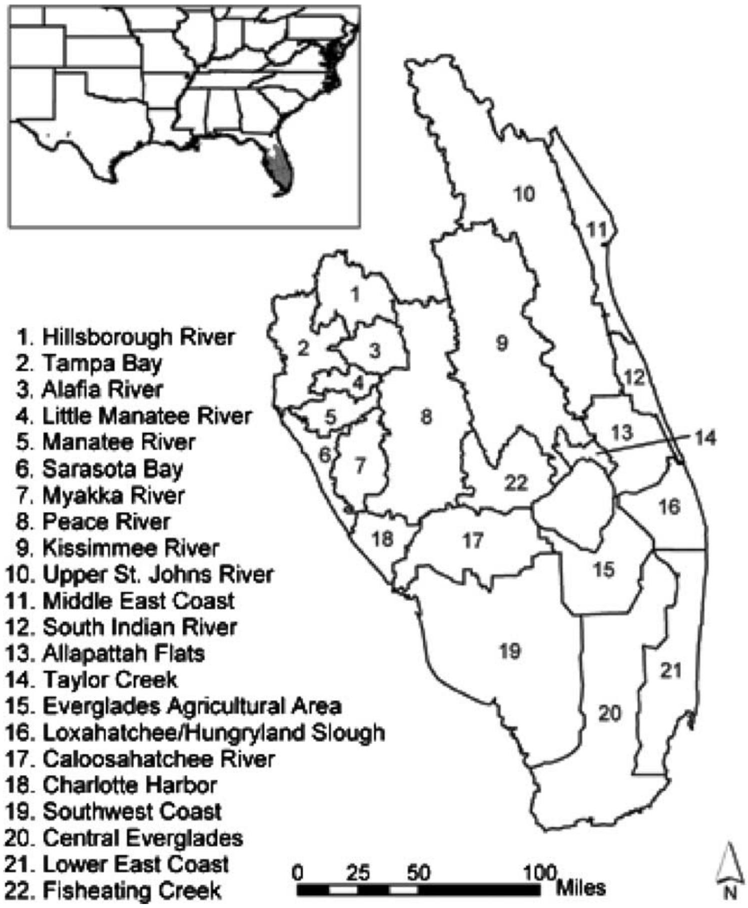

Fig. 1. Selected watersheds.

Fig. 2. Selected local jurisdictions.

The literature suggests that an inter-coder reliability score in the range of 80% is generally considered acceptable (Miles and Huberman, 1994).

4.3. Variable measurement

The dependent variable ecosystem plan quality was measured by evaluating the comprehensive plan for each jurisdiction located within a selected watershed against the 127 ecosystem management indicators (see Table 1 for a complete listing of indicators comprising the coding protocol). Each indicator was measured on a 0–2 ordinal scale, where 0 is not identified or mentioned, 1 is suggested or identified but not detailed, and 2 is fully detailed or mandatory in the plan. In the factual basis component of the protocol, several items have more than one indicator. For example, critical natural habitats can either be mapped, catalogued, or both. In these instances, an item index was created by taking the total score and dividing it by the number of sub-indicators (i.e. an item that received a 1 for mapping and 1 for cataloging was given an overall issue score of 1). This procedure assured that items remained on a 0–2 scale and favored plans that supported their descriptions with clear maps.

Measures of overall plan quality were calculated by creating indices for each plan component and overall plan quality (as done by Berke et al., 1996, 1998). There were three steps in the construction of the index for each plan component. First, the scores for each of the indicators (I_i) were summed within each of the plan components. Second, the sum of the scores was divided by the total possible score for each plan component ($2m_j$). Third, this fractional score was multiplied by 10, placing the plan component on a 0–10 scale. That is,

$$\mathrm{PC}j = \frac{10}{2mj}\sum_{i=1}^{mj} I_i, \tag{1}$$

where PC_j is the plan quality for the jth component, and m_j is the number of indicators within the jth component.

A final step involved calculating a total plan quality score (TPQ_j) by summing the scores of each component (PC_j). Thus, the maximum score for each jurisdiction's plan is 50. That is,

$$\mathrm{TPQ}_j = \sum_{j=1}^{5} \mathrm{PC}_j \tag{2}$$

To measure and map plan quality scores based only on a jurisdiction's area within a watershed, we measured the percentage of spatial coverage for each plan quality component within each watershed in two stages. First, we computed the proportion (P_{ij}) of the areas in the ith watershed that was occupied by the jth jurisdiction. Second, we used this proportion to weight that jurisdiction's contribution to the watershed score on that plan component (PC_j) and the total plan quality score (TPQ_i). That is,

$$\mathrm{PC}_{ik} = \sum_j P_{ij}\,\mathrm{PC}_j, \tag{3}$$

and

$$\mathrm{TPQ}_i = \sum_j \mathrm{PC}_{ik} \tag{4}$$

We measured environmental variables using satellite images of land cover generated by the Florida Fish and Wildlife Conservation Commission (FFWCC) which predict species overlap and identify "hot spots" of biodiversity. Areas of biodiversity based on the overlap of 44 focal species (identified by the Florida Fish and Wildlife Conservation Commission) were selected for final analysis. These focal species serve as umbrella or indicator species of overall biodiversity in Florida (Cox et al., 1994). Each pixel in the raster-based data layer was assigned a value on a scale of 1–3 depending on the number of species overlap. We calculated the amount of biodiversity by calculating the area of all values (1–3) and dividing that value by the total area of a watershed. The amount of disturbance was calculated in a similar manner based on the same land cover image developed by the FFWCC. Areas interpreted as disturbed land cover (grassland and agriculture, shrub and brush, barren and urban, and exotic species) were summed in a rasterized coverage and then divided by the area of a watershed, creating a disturbance variable on a scale of 0–1.

We measured socioeconomic and demographic independent variables with data obtained from the 2000 US Census. Population, population growth between 1990 and 2000, wealth (median home value), education (percentage of the population with a high school degree), and land use were recorded for each jurisdiction occupying a selected watershed. Land use was measured based on five different types of uses which include commercial, industrial, agricultural, multi-family residential, and single-family residential. We then weighted the values of each variable by the proportion (P_{ij}) of area in a watershed that was occupied by that jurisdiction. Finally, we calculated ecosystem level variables by summing all weighted values within each watershed.

Contextual variables include the number of jurisdictions within each watershed, the area of each watershed (as calculated by the GIS program), and planning agency capacity. Information on planning capacity was obtained by contacting each planning department in the sample and measured based on the number of staff devoted to writing the comprehensive plan.

4.4. Data analysis

The data were analyzed in two stages. First, we calculated and mapped total ecosystem plan quality and each plan component score for selected watersheds. Second, we calculated Pearson's product moment correlation coefficients (correlations of zero-order) to test the relationship between several independent variables and ecosystem plan quality scores. Independent variables were categorized follows: environmental, socioeconomic and demographic, and contextual variables. Correlation analysis is a first step toward explaining the major factors driving collective ecosystem-planning capabilities. Due to the small sample size and lack of statistical power, we considered a correlation significant when $P < 0.1$. The small sample size also caused us to limit our analysis to correlations, which does not control for other factors. The results of stage two should therefore be interpreted with caution and considered preliminary until more data can be gathered and more extensive quantitative analysis can be conducted.

5. Results

5.1. Total ecosystem plan quality and plan component scores

Results from the first phase of analysis provide a statistical and graphic assessment of the degree to which local jurisdictions are collectively managing watersheds in southern Florida based on an assessment of their local comprehensive plans. As reported in Table 2, the mean score for total ecosystem plan quality is 18.43, which on a scale of 0–50, indicates a relatively weak potential effort to manage ecological systems at the local level. Mean scores for all plan components (scale of 0–10) register fairly low despite a federal initiative to restore and manage the Everglades system, a strong state program on ecosystem and regional watershed management, and a prescriptive local comprehensive planning mandate which entails protecting critical habitats and ecological functions.

Factual Basis is the lowest scoring plan component, demonstrating a general lack of local knowledge regarding existing natural resources, human impacts to these resources, and their management status within a given watershed. This finding is consequential since goals, objectives, and policies rely on a thorough understanding and inventory of the natural resource to be managed by the plan. The highest scoring watersheds are for the most part associated with high profile bays located in the western portion of the state (see Fig. 1). Allahpattah Flats is a notable exception where the jurisdictions within this watershed collectively make the effort to catalogue and analyze their natural resource base. Various ecological surveys and studies of human impacts to water quality have been conducted in

Table 2
Plan quality scores by watershed

Watershed	Factual base	Goals and objectives	Coordination capabilities	Policy	Implementation	Total plan quality
Alafia River	3.02	3.66	3.11	2.93	1.18	15.11
Allahpattah Flats	4.01	5.93	4.95	5.12	3.41	24.31
Caloosahatchee River	2.77	2.39	3.95	4.23	2.21	17.10
Central Everglades	1.46	4.08	4.94	4.17	4.30	20.04
Charlotte Harbor	3.15	2.70	3.90	3.87	1.56	16.37
Middle East Coast	0.80	2.58	3.66	3.42	3.40	14.02
Everglades Agricultural Area	1.91	5.56	7.08	6.97	6.57	29.30
Fisheating Creek	3.42	2.60	3.17	4.13	2.05	15.93
Hillsborough River	3.11	3.85	3.67	4.51	0.80	17.00
South Indian River	3.79	2.93	4.00	4.02	3.86	18.80
Kissimmee River	2.78	2.43	4.19	3.27	2.29	15.48
Little Manatee River	3.43	4.85	3.74	4.49	1.96	20.12
Lower East Coast	1.10	4.68	5.70	4.75	4.55	21.81
Loxahatchee/Hungryland Slough	2.72	6.96	7.45	7.42	8.02	33.55
Manatee River	0.57	5.03	6.26	5.65	4.70	23.17
Myakka River	3.16	3.77	4.49	5.05	2.03	19.50
Peace River	1.08	2.69	3.41	2.83	1.91	12.46
Sarasota Bay	4.03	2.62	3.43	3.94	0.83	15.94
Southwest Coast	1.58	2.58	4.37	4.15	2.44	16.57
Upper St. Johns River	2.36	3.97	5.02	4.76	4.17	20.87
Tampa Bay	3.83	4.20	3.88	4.16	3.16	21.00
Taylor Creek	1.17	2.64	4.08	2.27	3.24	13.60
Average Score	2.41	3.61	4.29	4.19	3.00	18.43

Tampa and Sarasota Bay partly because of their designation as estuaries of national importance under EPA's National Estuary Program. Increasing interest in understanding these natural systems and the availability of resources to conduct studies most likely contributes to the high scoring factual basis of the local plans associated with these two watersheds. In contrast, watersheds with the lowest scoring factual basis tend to be inland (Little Manatee River) or coastal (East Coast Middle) areas that receive less attention for their ecological importance and are not considered high priorities for ecological study.

Scores for the *goals and objectives and policies, tools and strategies* plan components follow a similar trend. Both plan components score highest for watersheds to the west and directly south of Lake Okeechobee. Allahpattah Flats, Loxahatchee/Hungryland Slough, and the Everglades Agricultural Area are among the highest scoring watersheds. These ecological units, surrounding the Everglades region, contain some of the fastest growing and most planning-oriented local jurisdictions in Florida. The plans of communities located within high scoring watersheds include both broad goals and specific measurable objectives for managing watershed systems. Associated policies tend to be mandatory and include not only traditional regulatory measures, but also incentive-based and other non-regulatory tools. Surprisingly, Sarasota Bay, which is among the top scoring watersheds for its *factual basis*, is not as strong when it comes to goals, objectives, and policies associated with ecosystem approaches to management. Plans with strong factual basis often build upon this foundation with well-crafted environmental strategies.

The *inter-jurisdictional coordination and capabilities* plan component is, overall, the highest scoring of the five plan components (4.3 on a scale of 0–10). This result suggests that jurisdictions recognize the transboundary nature of ecosystems and are committed to collaborating with other jurisdictions to manage these natural resources over the long term. Because this study evaluates watersheds crossing multiple jurisdictions, collaboration is an essential component for effective management of large-scale ecological systems. Loxahatchee/Hungryland Slough and the Everglades Agricultural Area watersheds directly north of the remaining Everglades system each receive a score of greater than 7.0 indicating a high degree of information sharing, joint database production, and other collaborative efforts among jurisdictions, organizations, and major landowners. The Lower East Coast and Manatee River watersheds (in the western portion of the state) also score high in terms of collaborative capabilities.

Again, watersheds to the west and southeast of Lake Okeechobee have the highest scores for the *Implementation* plan component. These areas contain some of the highest population figures and population growth rates for the state, as well as some of the most complex environmental problems. As a result, the public pressure to draft a strong environmental plan and also ensure that it is implemented may contribute to high implementation scores in these areas.

The total plan quality score computed from the area-weighted sum of all plan components allowed us to evaluate the overall management capabilities of multiple jurisdictions for each watershed in the southern part of the state. This phase of analysis serves as a global assessment of the relative strength of ecosystem management capabilities from a spatially "bottom-up" perspective. Watersheds with above average total ecosystem plan quality scores generally occur in two clusters (Fig. 3). The first concentration of high scores are located to the east and south of Lake Okeechobee, extending to the lower east coast of the state encompassing the urban corridor from West Palm Beach to Miami. The Loxahatchee/Hungryland Slough and the Everglades Agricultural Area watersheds are the highest scoring in the sample, indicating that these are prime areas to facilitate collaborative ecosystem management initiatives. High scores for these watersheds can be attributed to the strength of the Palm Beach County plan which is one of the highest scoring jurisdictions among selected comprehensive plans.

The second concentration of above average watershed scores occurs to the west of the study area in the greater Tampa Bay region. Tampa Bay, Manatee River, and Little Manatee Rivers watersheds all receive strong total plan quality scores. From a hydrological perspective these watersheds are associated with the Tampa Bay Estuary which, as mentioned above, is a natural system of national significance. In contrast, inland watersheds in the northern portion of the study area with lower levels of perceived biodiversity and lesser-known natural value receive some of the lowest total plan quality scores (for a more

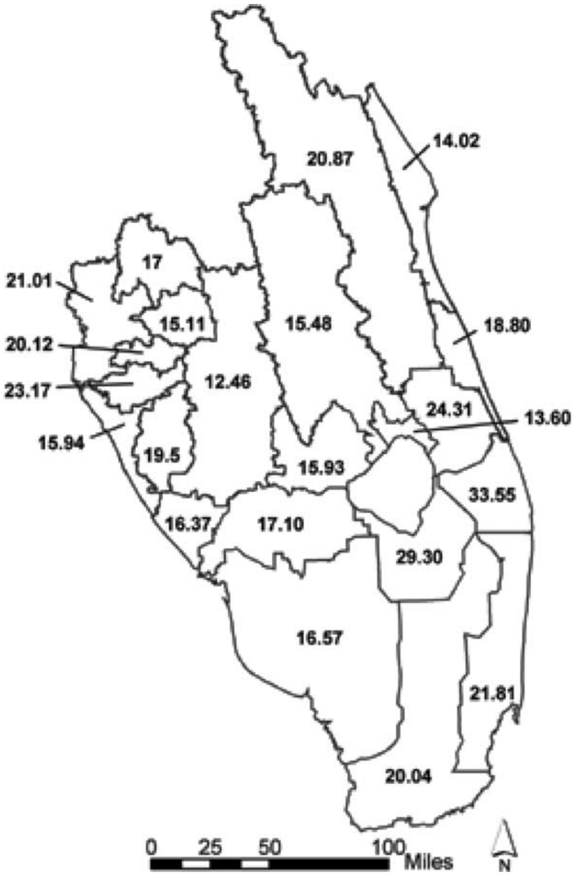

Fig. 3. Total plan quality scores by watershed.

detailed discussion of the presence or absence of specific indicators within plan components, see Brody (2003b,c) and Brody et al. (in press).

5.2. Explaining ecosystem plan quality scores

Correlation analysis provides an initial step in understanding the major factors contributing to the ability of local jurisdictions to collectively manage ecological systems. Table 3 reports correlations between the various measures of plan quality and several environmental, socioeconomic, demographic, and other contextual variables.

In terms of the existing environmental conditions, the proportion of area with high biodiversity within a watershed has no significant statistical bearing on plan quality. This result runs contrary to the assumption that areas of high biological importance would stimulate planners, some of the most proactive policy agents, to draft plans that seek to protect the integrity of these critical natural resources. However, human disturbance is a significant factor ($P < 0.05$) in raising total ecosystem plan quality scores. An increasing proportion of human disturbance within a watershed, such as pavement, agricultural practices, and the presence of invasive species leads to stronger watershed planning capabilities. Only when biodiversity or critical habitat is under threat from anthropogenic stresses (e.g. urban development) does it appear to have a significant positive impact on plan quality. A notable exception is the *factual basis*. This plan component is not significantly correlated with measures of disturbance. Planners in highly urbanized local jurisdictions may not believe their natural resource base significant enough to inventory, analyze, and present in their plan.

Table 3
Zero-order correlations for total ecosystem plan quality

Variable name	Correlation coefficient	Significance
Environmental variables		
Biodiversity	−0.04	0.85
Human disturbance	0.40	0.05
Socioeconomic and demographic variables		
Population	0.44	0.03
Population change	0.39	0.06
Wealth	0.75	0.00
Education	0.72	0.00
Land use variables		
Agricultural	0.27	0.19
Commercial	0.06	0.76
Industry	0.30	0.16
Multiple family	0.16	0.44
Single family	0.05	0.82
Contextual variables		
Planning agency capacity	0.50	0.01
No. of jurisdictions in watershed	0.06	0.78
Area of watershed	−0.01	0.94

Socioeconomic and demographic factors are also associated with measures of ecosystem plan quality. Wealth, as measured by the median home value within a watershed, is the most significantly correlated variable with total plan quality in the study ($P < 0.001$). Jurisdictions with wealthier populations usually have more financial resources to devote to planning staffs and plan development which leads to the adoption of higher quality plans. Furthermore, residents with high incomes often have more time and interest in participating in the planning process, particularly in regard to environmental issues (Van Liere and Dunlap, 1981; Scott and Willits, 1994; Fransson and Garling, 1999).

Watersheds containing highly educated populations also help explain total ecosystem plan quality scores ($P < 0.01$) and its various components. Past studies have linked levels of education and the degree of environmental concern (Howell and Laska, 1992; Guagano and Markee, 1995; Raudsepp, 2001). The results of this study may provide additional insights by suggesting that an educated public can influence the planning process, and encourage the adoption of plans that are focused on protecting the integrity of ecological systems over the long term. Population levels ($P < 0.05$) and population change between 1990 and 2000 ($P < 0.1$) are positively correlated with total plan quality scores. These results are expected since high population levels are closely related to urban development and associated human disturbance. Growth pressures are associated with higher levels of disturbance to critical habitat, resulting in a greater perceived need to protect remaining areas of biodiversity.

Finally, the proportion of five different types of land use within a watershed is not significantly correlated with plan quality scores where $P < 0.1$. This result may be attributed to the small sample size and increased difficulty in finding statistically significant correlations due to lack of statistical power. It could also mean that the type of land use is not as important as the specific impact on a given parcel. However, the degree of association for these different land uses varies. Agriculture ($P = 0.19$) and industrial ($P = 0.16$) land uses have a much stronger correlation with ecosystem plan quality than multi and single family residential. These results are consistent with the findings above since industrial and agriculture uses are closely related to human disturbance on ecological systems. A test of means between high intensity land use (commercial, agricultural, industry, and multi-family residential) and low intensity land use (single-family residential, estate, and preserve) is statistically significant where $P < 0.05$.

The major finding for contextual control variables is greater planning agency capacity is significantly correlated with greater watershed planning capabilities as measured by plan quality ($P < 0.05$). High numbers of planning staff are associated with increased levels of financial resources, expertise, and commitment to drafting a high quality environmental plan. This result is also consistent with the above findings that large, wealthy populations living in urbanized areas contribute to strong watershed planning scores. The results may also indicate that small communities with understaffed planning departments are at a distinct disadvantage when it comes to protecting ecological systems from future development.

While the remainder of the contextual control variables are not significantly correlated with ecosystem plan quality scores, the results still provide insights on how to manage watersheds effectively at the local level. In this study, the number of jurisdictions in a watershed (ranging from 3 to 12) has no statistical bearing on the strength of plan quality scores. This result suggests that a relatively large number of jurisdictions within a single watershed may not compromise the ability of these jurisdictions to manage the entire ecological system collectively from the local level (although may help explain the overall low ecosystem plan quality scores). An increasing number of parties will inevitably demand more collaboration and political will to accomplish transboundary management; however in this study such hardships do not seem to adversely affect the degree to which the ecosystem is collectively managed. The size of the watershed also has no major statistical effect on ecosystem plan quality scores. One would expect larger ecological systems to be more difficult to manage at a local level (and in fact the correlation is negative), but we found no significant relationship between the areas of watersheds and plan quality measurements. It should be emphasized, however, that given the small sample size and lack of statistical controls, these results should be considered tentative. A larger study may yield different conclusions. Additional research and data are needed to fully understand the influence of these contextual control variables on watershed management capabilities.

6. Discussion and policy implications

While the results of this study are preliminary, they provide potentially valuable information about the degree to which local jurisdictions are collaboratively managing transboundary watersheds in southern

Florida, where management capabilities are the strongest, and which factors contribute most to high ecosystem plan quality scores. On average, locally driven watershed management is strongest in the Tampa Bay and Everglades regions where rapid urban development and population growth have adversely impacted areas of high biodiversity. These watersheds are home to wealthy, educated publics that posses the interest and resources to generate high quality environmental plans. Effective watershed management, then, appears to be driven not by the presence of critical natural resources (as might be expected), but by an increasing degree of human disturbance, such as pavement, agricultural practices, and the introduction of invasive species. Some level of threat or disturbance (this level has never been measured by researchers) to areas of high biodiversity can be seen as beneficial for stimulating planners and the public to adopt ecosystem management policies. These instances have become known as "train wrecks" (Haeubner, 1998), which occur when there are clashes between urban development and areas of high biodiversity. Such incidents can prompt major environmental initiatives, such as the protection of the spotted owl in the Northwest or the Chesapeake Bay Program in the US mid-Atlantic.

Some degree of adverse impact to critical natural resources can be productive in manifesting an environmental problem, thereby generating interest in ecological management and producing high quality plans. However, this study tentatively finds that planners and planning participants are reacting to the loss of biodiversity at the point where there is little left to protect (see Brody, 2003b,c). Without the warning signals of habitat fragmentation and loss of keystone species, planners seem to lack motivation to initiate early protection measures. For example, high scoring areas such as the Everglades Agricultural Area and the nearby urban corridor from Miami north to West Palm Beach contain only remnants of natural habitat. Similarly, the plan quality score for the Tampa Bay Watershed is driven primarily by a very strong Pinellas County plan. Pinellas also happens to be the most densely populated and built-out county in the state. Based on the limited results of this study, the threshold for planning response in Florida appears to be so high that the integration of watershed management abilities at the local level is essentially counter-productive. Such a "damage-control" approach to natural resource management is forced to rely on restoration rather than protection activities. This reactionary style of environmental planning is costly, inefficient and, in many instances, practically infeasible.

Local comprehensive planning is intended to serve as a proactive policy-making process where communities lay out their vision of development patterns and conservation initiatives well into the future. A central issue for local watershed planning thus becomes how to motivate communities to protect critical ecosystem components before they are severely impacted by human growth and development. Careful monitoring of regional development trends and potential associated negative impacts to critical natural resources is a starting point for stimulating the adoption of plans to protect ecosystem components early in the process of natural resource decline. Regional monitoring of both the human and natural environment can serve as an early warning system which invokes a proactive approach to management. Once potential "train wrecks" are identified, state-level organizations can put the financial and personnel related resources into place into place to accommodate watershed planning in the face of rapid growth and development. Fortifying local planning capacity in concert with environmental education programs can facilitate ecologically sustainable approaches to development before major environmental impacts occur. Although proactive approaches to local planning may require the commitment of time and resources at the outset, the long-term investment should be profitable considering the exorbitant costs of ecological restoration, removal of invasive species, and improvement of water quality.

As evidenced by the results of this study, waiting for the necessary planning capacity and public interest to materialize along with human disturbance associated with rapid growth and development may not be the most effective strategy to manage sustainably ecological systems in northwest Florida. Matching planning agency capacity with the level of expected regional growth could trigger ecosystem-planning initiatives before adverse environmental impacts take place.

7. Conclusion

While ecosystem planning focuses on large spatial scales, it must be accomplished in part at the local level with local planning decisions. This study measures and maps the collective capabilities of local jurisdictions to manage watersheds in an effort to understand where these capabilities are the strongest and which factors are most associated with high plan quality scores. We find that locally driven watershed management may be strongest in areas that are densely populated, highly disturbed by human development, contain wealthy, educated publics, and have large planning staffs.

Due to the small sample size, these findings should be considered preliminary until more data can be gathered and examined on the factors explaining the collective capabilities of local jurisdictions to management ecological systems. Additional research is also needed to thoroughly understand which variables stimulate communities to manage ecological systems and associated critical natural resources. Larger sample sizes will provide more statistical power and allow more confidence in interpreting results. A larger sample size will also allow for more advanced analytical techniques such as multiple regression analysis to explain watershed management capabilities. Finally, case study analysis of specific watersheds would complement statistical analyses and provide a more detailed contextual picture of how and why communities work together to protect ecological systems.

Appendix A. Plan quality scores by jurisdiction

	Factual basis	Goals and objectives	Inter-jurisdictional coordination	Policies, tools, and strategies	Implementation mechanisms	Total ecosystem plan quality
County governments						
Brevard	0.68	3.24	5.53	5.00	5.45	19.89
Broward	0.41	3.82	3.16	3.97	3.18	14.54
Charlotte	5.50	4.12	4.74	4.49	0.00	18.85
Collier	0.35	2.35	4.47	3.85	0.91	11.93
Dade	0.70	4.12	5.79	3.59	3.64	17.83
De Soto	0.23	1.76	2.11	3.46	2.27	9.84
Glades	2.36	1.76	3.16	3.21	1.82	12.31
Hardee	0.29	3.53	3.16	2.56	1.82	11.36
Hendry	2.60	2.06	4.21	3.72	2.73	15.31
Highlands	3.82	3.24	3.16	4.87	2.27	17.36
Hillsborough	4.75	4.71	2.37	3.85	0.45	16.12
Indian River	5.31	2.94	5.26	5.13	6.36	25.01
Lake	1.45	7.06	6.84	6.54	6.36	28.26
Lee	0.58	2.35	3.68	6.03	3.18	15.83
Manatee	0.47	5.29	6.58	5.90	5.00	23.24
Marion	0.29	4.71	3.95	5.64	4.09	18.68
Martin	3.66	8.24	6.58	7.05	10.00	35.53
Monroe	5.87	4.41	5.26	5.51	8.18	29.24
Okeechobee	0.29	1.18	2.11	1.28	0.00	4.85
Orange	3.31	2.94	5.26	3.59	0.91	16.02
Osceola	4.55	2.35	4.47	4.23	2.73	18.34
Palm Beach	1.72	6.18	7.63	7.56	7.27	30.37
Pasco	1.14	2.94	4.21	5.90	0.45	14.65
Pinellas	6.28	7.65	10.00	7.69	10.00	41.62
Polk	0.00	2.06	4.21	1.54	2.27	10.08
Putnam	1.03	2.06	2.63	3.33	0.45	9.51
Sarasota	4.96	2.35	2.89	4.23	0.00	14.44
Seminole	1.45	4.12	4.21	3.85	5.00	18.63
St. Lucie	4.21	5.29	3.68	4.36	0.00	17.54
Volusia	1.18	7.06	5.79	6.67	5.91	26.61

Appendix A. (*continued*)

	Factual basis	Goals and objectives	Inter-jurisdictional coordination	Policies, tools, and strategies	Implementation mechanisms	Total ecosystem plan quality
City governments						
Cape Coral	4.36	2.94	6.32	2.82	3.64	20.07
Clearwater	0.76	2.35	2.63	2.95	0.00	8.69
Coral Gables	1.90	2.35	3.68	1.28	1.82	11.04
Fort Lauderdale	2.19	4.41	5.79	3.21	8.18	23.78
Hialeah	1.71	0.59	3.42	1.03	0.00	6.74
Lakeland	2.23	2.35	3.95	2.18	1.82	12.53
Melborne	2.95	1.76	5.53	3.33	0.91	14.48
North Port	0.12	2.94	2.11	3.08	0.91	9.15
Orlando	2.21	2.06	5.26	3.85	0.91	14.29
Pembrooke Pines	1.61	2.65	2.11	1.92	1.82	10.10
Port St. Lucie	3.12	2.65	5.53	3.97	0.91	16.18
Sarasota	3.24	1.47	4.74	1.92	2.73	14.09
St. Petersburg	1.76	3.24	1.84	5.13	8.18	20.15
Tampa	4.53	3.53	5.79	3.59	1.36	18.81
West Palm Beach	3.97	3.53	4.74	2.82	0.45	15.51

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