Does biodiversity matter? Implementing the principles of ecosystem management in Florida

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Abstract

The protection of biological diversity (hereafter biodiversity) is considered one of the fundamental goals for the sustainable management of ecological systems. This article examines how existing levels of biodiversity influence ecosystem capabilities at the local level. Specifically, it tests the effects of biodiversity and the degree of threat to biodiversity on the quality of local comprehensive plans in Florida as measured by the ability to manage ecosystems. Regression analysis indicates that areas of high biodiversity do not stimulate planners to adopt higher-quality plans. Instead, human disturbance or threats to existing levels of biodiversity are the most significant factors in driving ecosystem plan quality. Based on the results, the article discusses implications for policy and plan making.

1 Introduction

In response to the increasing decline of critical natural resources and overall biodiversity across the United States, public decision makers are abandoning the traditional species-by-species approach to regulation and instead are embracing ecosystem approaches to management. Ecosystem management represents a departure from traditional management approaches by addressing the interaction between biotic and abiotic components within a land or seascape, while at the same time incorporating human concerns [1]. In this approach, entire ecological systems and the ecological structures, functions, and processes within them,

become the focus for management efforts, rather than a single species or jurisdiction [2] [3].

The protection of biological diversity is most often the overarching goal of ecosystem management [2] [4] [5]. Because species diversity is perceived as a fundamental component to maintaining viable ecosystems over the long term, the identification and protection of biodiversity lies at the core of planning for ecosystem integrity [6]. Defined as "the full range of variety and variability within and among living organisms, and the ecological complexities in which they occur" [7], biodiversity is often conceptualized as species richness. It is the intersection of key species that supports the overall function and processes of ecological systems [8]. For this reason, planners have targeted biodiversity and its various components in their attempts to manage ecosystems.

It is increasingly being recognized that the protection of biodiversity and the sustainable management of ecosystems will require planners to target policies at the local level with local land use decisions [9] [10]. The factors causing ecosystem decline, such as rapid urban development and habitat fragmentation occur at the local level and are generated by local land use decisions [5]. 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 [11] [12]. As a result, some of the most important decisions that threaten or protect biodiversity are in the hands of county commissioners, city councils, zoning boards, and local planning staff. Thoughtful policies and actions at the local level may protect biodiversity and critical habitats of regional significance more effectively and less expensively than the best-intentioned state or federal protection schemes [13].

While much research has been geared towards instituting the broad principles of managing natural systems, comparatively little work has been done to assess ecosystem management capabilities at the local level and understand why plans vary in the attention they give to this management approach. This article seeks to fill gaps in the research on ecosystem planning by examining the relationship between levels of existing biodiversity in Florida and the ability of local comprehensive plans to implement the principles of ecosystem management. It seeks to form a better understanding of how local jurisdictions respond to declining levels of critical natural resources by: 1) developing a measure of ecosystem plan quality based on the main components of or best practices for a sound ecosystem management plan at the local level; and 2) explaining how the quality of these plans is influenced by the amount of biodiversity and the degree of threat placed on the existing natural resource base within local jurisdictions.

The following section examines the importance of biodiversity to ecosystem planners and the expected relationship between existing levels of critical natural resources and the quality of local plans. Sample selection, variable measurement, and data analysis procedures are then described. Results based on multiple regression analysis indicate the degree to which biodiversity and threats or human disturbance to biodiversity contribute to the quality of local plans associated with ecosystem management.

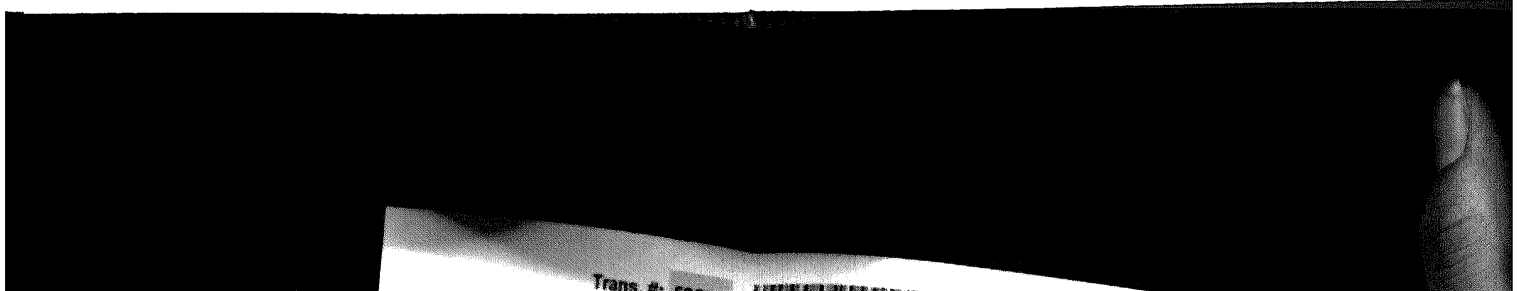
2 The effects of biodiversity and human disturbance on plan quality

As mentioned above, the protection of biological diversity is often considered a major goal of ecosystem management [5]. Protecting critical habitats, ecosystem integrity, and the landscape mosaic begins with identifying and protecting areas of high biodiversity. Species diversity is considered a fundamental component in maintaining viable ecosystem processes, structure, and function over the long term [6]. Furthermore, the presence of biodiversity is a strong indicator of ecosystem health, making the concept a logical integrator of ecology and sustainable levels of management [8]. Finally, compared to other measures of ecosystem integrity biodiversity (or species richness) is easily defined, measured, and interpreted by resource planners.

Given the importance of biodiversity in supporting viable ecosystems and the increasing emphasis on protecting biodiversity and associated critical habitats in environmental plans, planners, and stakeholders involved in drafting plans, should be stimulated by the amount of biodiversity contained within a specific jurisdiction [7]. As proactive policy statements, the environmental elements of comprehensive plans identify existing critical natural resources, recognize their value, and seek to protect these resources for future generations. Thus, as a major factor influencing conservation and management efforts, it is postulated that the amount of biodiversity in a jurisdiction will have a positive impact on the quality of management plans and strategies [5] [7]. Higher levels of biodiversity may increase local ecosystem plan quality because there will be a greater perceived need to protect valuable natural resources before they are irreversibly damaged. Since the purpose of comprehensive plans is to act as long-range policy instruments, conservation elements should take a precautionary stance when it comes to sustainable resource management. Jurisdictions with high biodiversity should be interested in safeguarding critical ecological components with directed goals and policies for future generations [9].

However, with lower levels of biodiversity, planners and planning participants may feel an urgency to protect natural resources, which will in turn increase ecosystem plan quality. Levels of biodiversity then, are intricately connected to levels of disturbance within a landscape. Since ecosystem management efforts are often reactions to some level of environmental crises, human threats to biodiversity or disturbance to habitat may also positively impact plan quality [14]. Human disturbance to habitat occurs in many forms, but is mostly driven by increased impervious surfaces associated with urban development, loss of native vegetation from forestry and agriculture, the introduction of exotic or invasive species into a native ecosystem, and water pollution caused by urban run-off. Under this notion, the higher the perceived (or actual) degree of threat, the stronger the expected level of plan quality.

Reactionary approaches to environmental planning are not entirely new phenomena. Over twenty years ago, Burby and French [15] discovered a similar policy response they termed a "land use management paradox." In their study,



communities tended to enact strong hazard management programs only after the damage to or development of the flood zone had taken place. These instances have become known as "train wrecks" throughout the environmental policy community [16]. "Train wrecks" occur when there are clashes between urban development and biodiversity, which spur major environmental initiatives such as the protection of the spotted owl in the Northwest or the attempted restoration of the Everglades in south Florida. While these "wrecks" could have been avoided with sound planning, they were seen as necessary to bring about environmental efforts in the first place.

Including human disturbance in a conceptual model, and controlling for planning process variables and contextual factors through regression analysis is not enough to isolate the effect of disturbance in relation to other environmental factors on local ecosystem plan quality. As discussed above, a conceptual model must consider that disturbance and biodiversity are intricately linked concepts and measures. Increasing levels of disturbance will invariably result in decreasing levels of biodiversity. In fact, the impact of biodiversity on plan quality may depend entirely on the level of disturbance. Taking into consideration the environmental paradox, disturbed-biodiversity may have the largest impact on ecosystem plan quality and therefore must be included in a model explaining ecosystem plan quality as the interaction between biodiversity and disturbance. Disturbance, in this instance, is conceptualized as an impure moderator between biodiversity and the dependent variable ecosystem plan quality.

3 Research methods and data analysis

Since Florida hosts both strong ecosystem management and local growth management programs, the state provides an ideal institutional and biogeographical setting in which to conduct the study. This study principally relies on local city and county comprehensive plans as the unit of analysis. These plans serve as the basis for measuring ecosystem protection. While there are many different types of resource management plans in Florida, comprehensive plans follow a consistent format, are an institutionalized policy instrument, and most importantly provide a basis for city and county land use and resource management decisions. In this sense, comprehensive plans are an important tool for accomplishing many of the goals of ecosystem management at the local level since they mark the starting point for specific ordinances, land development codes, and environmental policies.

3.1 Sample selection

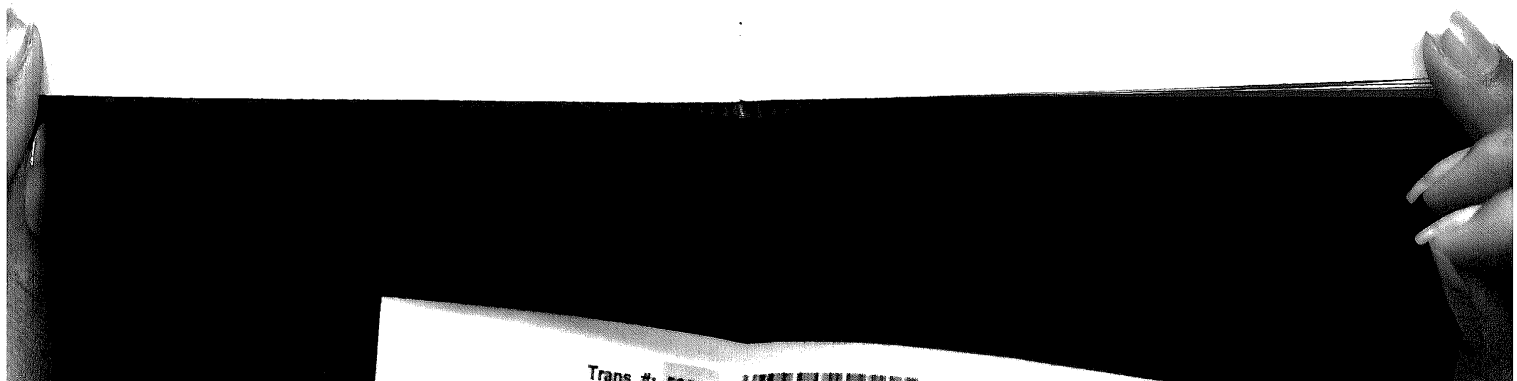
The sample population was based on local jurisdictions in Florida that have completed recent updates to their comprehensive plans. A sampling frame was obtained through a list of local jurisdictions (>2,500 people) throughout the state and a random sample of 30 jurisdictions was drawn and evaluated against a protocol determining plan quality for ecosystem management.

3.2 Measuring ecosystem plan quality

Ecosystem plan quality was defined and measured by adding ecosystem considerations to existing conceptions of what constitutes a high quality plan. Ecosystem plan quality was conceptualized through the following five components: 1) Factual basis refers to an understanding and inventory of existing resource issues, environmental policies, and stakeholders' interests within the ecosystem. It takes both a written and visual form and serves as the resource inventory and problem identification instrument upon which policy decisions within the plan are made. 2) Goals and objectives guide the implementation of ecosystem management. They contain both general statements of long-term goals regarding clarity and consistency as well as specific measurable objectives. 3) Inter-organizational coordination and capabilities captures the ability of a local jurisdiction to collaborate with neighboring jurisdictions and organizations to manage what are often transboundary natural resources. This component addresses joint fact-finding, information sharing, intergovernmental agreements, and integration with other plans in the region. 4) Policies, tools and strategies represent the heart of a plan because they set forth actions to protect critical habitats and related natural systems. Policies include both regulatory tools such as buffer requirements, as well as incentive tools, land acquisition programs, and educational efforts. 5) Finally, for comprehensive plans to be effective, implementation must be clearly defined and specified for all affected parties. This plan component includes accountability, a timeline for actions, regular plan updates, and monitoring of resource conditions (for a more detailed explanation on measuring ecosystem plan quality, see [17].

Together these five plan components constitute the ability of a local plan to manage and protect the integrity of ecological systems. Indicators (items) within each plan component further "unpack" the conceptions of plan quality. A "plan coding protocol" containing 107 indicators was used to evaluate and measure plan quality for the random sample of local comprehensive plans in Florida. 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. Together, these indicators capture the principles of effective ecosystem management and translate them into elements that can be identified, measured, and compared across each plan.

An overall measure of ecosystem plan quality was derived by creating indices for each plan component and overall plan quality. Indices were constructed for each plan component based on three steps. First, the actual scores for each indicator were summed within a plan component. Second, the sum of the actual scores was divided by the total possible score for each plan component. Third, this fractional score was multiplied by 10, placing the plan component on a 0-10 scale. A total plan quality score was obtained by adding the scores of each component. Thus, the maximum score for each plan is 50.



3.3 Measuring biodiversity and disturbance

I used satellite images of land cover generated by the Florida Fish and Wildlife Conservation Commission (FFWCC) to predict species overlap and identify "hot spots" of biodiversity. Areas of biodiversity based on the overlap of 44 focal species were selected for final analysis, since they consider the broadest biological factors over both public and private lands [18]. 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. The amount of biodiversity was measured by calculating the area of all values (1-3) and dividing that value by the total acreage of a jurisdiction so that the variable could be interpreted on a scale of 0-1. 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 included grassland and agriculture, shrub and brush, barren and urban, and exotic species. Disturbed-biodiversity was measured as the interaction of biodiversity and disturbance.

4 Results

Together, the impact of environmental variables tested in the model can be considered significant factors driving ecosystem plan quality. Biodiversity, disturbance, and disturbed-biodiversity by themselves explain 74 percent of the variance on the dependent variable (Table 1).

Table 1. The Impact of Environmental Variables on Plan Quality [a]

Variable	Coeffici ent	Standardized Coefficient	Standard Error	T-value	Significance
Area of Jurisdiction with Biodiversity	-10.73	-.17	12.25	-.876	.389
Area of Jurisdiction with Disturbance	14.24	.39	4.14	3.441	.002
Disturbed-Biodiversity	128.40	.90	26.25	4.891	.000
Constant	9.24		3.02	3.063	.005
N:	30				
F-Ratio (3,26):	28.01				
Significance:	.0000				
Adjusted R-squared:	.7364				

[a] plan quality is the total plan coding score divided by the total possible score and multiplied by 10 to create a scale from 0-50.

The proportion of area with high biodiversity within a jurisdiction has no significant statistical bearing on plan quality. However, the area of biodiversity that is associated with disturbance generates markedly higher quality plans. Disturbance by itself is also a significant factor ($p<.05$) in raising the quality of plans in the sample. These results support the hypothesis that increasing levels of disturbance or threats to biodiversity will result in higher quality local comprehensive plans. In other words, an increased proportion of human disturbance, such as pavement, agricultural practices, and the presence of invasive species within a jurisdiction, is the major environmental factor driving ecosystem plan quality. 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.

The results suggest that planners and planning participants developing comprehensive plans are reacting to the degradation of critical natural resources and are driven by the incidence of environmental "train wrecks" to generate high quality ecosystem-based plans. On the other hand, with high levels of undisturbed biodiversity, there seems to be less of a perceived need to protect critical natural resources within the context of comprehensive planning. Without the warning signals of habitat fragmentation and loss of keystone species, planners seem to lack motivation to initiate early protection measures.

Contextual control factors were added to the statistical model to further isolate the effects of environmental variables on ecosystem plan quality by controlling for alternative explanations (Table 2). In addition to population, income, and planning agency capacity (i.e. the number of staff devoted to drafting the comprehensive plan), the level of agency commitment to the protection of critical natural resources was also included in analysis. Those jurisdictions which emphasize the importance of habitat protection and devote time during the planning process to discuss pertinent environmental issues, should be more likely to draft a plan that implements the concepts of ecosystem management.

Jurisdictions associated with anthropogenic disturbance of biodiversity remain the most powerful predictors of local ecosystem plan quality in the fully specified model. Both human disturbance and disturbed-biodiversity are statistically significant at the .05 level, while undisturbed biodiversity continues to have a non-effect on the plan quality measure. However, there is a noticeable increase in the p-values of disturbance-related variables compared to the initial analysis of environmental variables. This decrease in significance may be associated with the inclusion of population in the model, which has a significantly positive impact on ecosystem plan quality. Population can often be associated with increased urban development and decline of critical habitats or overall biodiversity. The addition of population thus causes some redundancies in measurement (as evidenced by a high zero-order correlation between population and human disturbance) that may account for the decrease in significance of some environmental variables.

Wealth, as measured by the medium home value within a jurisdiction, is also a significant variable in explaining ecosystem plan quality. Jurisdictions with wealthier populations usually have more financial resources to devote to planning staffs and plan development, leading to the adoption of higher quality plans. Furthermore, residents with high incomes are also often more educated and have more time and interest in participating in the planning process, particularly when it comes to environmental issues. These two factors may explain the significant positive effect of wealth on ecosystem plan quality.

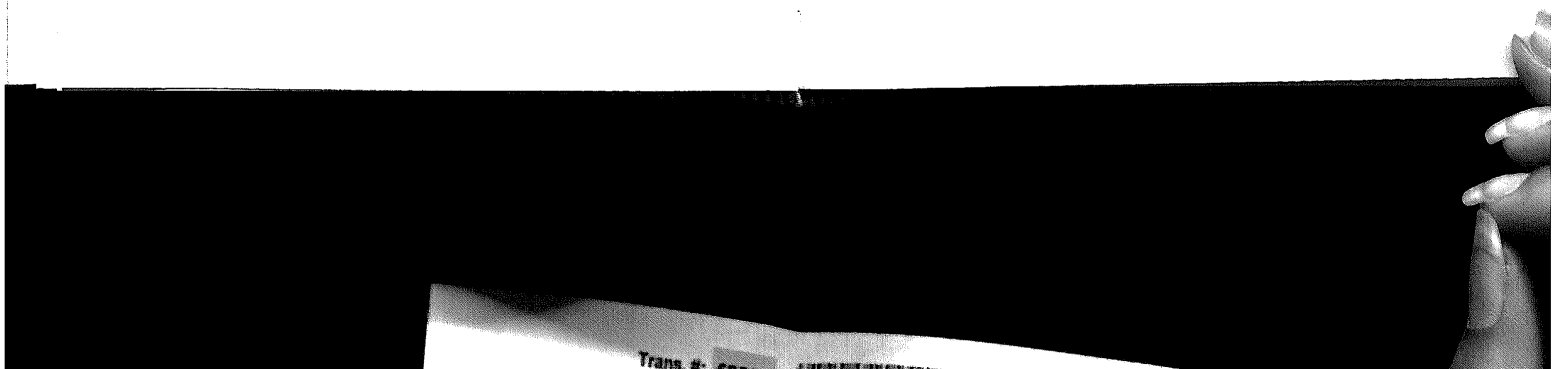


Table 2. The Impact of Environmental Variables on Plan Quality [a] When Controlling for Contextual Factors

Variable	Coeffic ient	Standardized Coefficient	Standard Error	T-value	Significance
Area of Jurisdiction with Biodiversity	4.74	.077	11.33	.419	.68
Area of Jurisdiction with Disturbance	13.05	.386	4.66	2.801	.013
Disturbed-Biodiversity	139.95	.469	47.60	2.94	.010
Population [b]	4.79	.382	1.77	2.70	.013
Wealth [c]	10.263 84	.207	4.916447	2.088	0.049
Capacity [d]	.00705 55	.0031755	.2659991	0.027	0.979
Commitment [e]	2.0891 07	.1664867	1.430596	1.460	0.164
Constant	9.24		3.02	3.063	.005
N:	30				
F-Ratio (7,22):	17.03				
Significance:	.0000				
AdjustedR-squared:	.7947				

[a] plan quality is the total plan coding score divided by the total possible score and multiplied by 10 to create a scale from 0-50.
[b] population is the natural log of U.S. Census population estimates for 1997.
[c] wealth is the natural log of U.S. Census estimates of median home value.
[d] capacity is the number of planners involved in developing the plan.
[e] commitment is the degree of effort spent on the issue by the local government combined with the degree to which the government emphasized the issue during the planning process.

Table 3. Interaction of Biodiversity and Disturbance

	Disturbance Level	
Biodiversity Level	Coefficient [a]	P-value [b]
Minimum	9.63	.030
Mean	17.44	.10
Maximum	46.64	.038

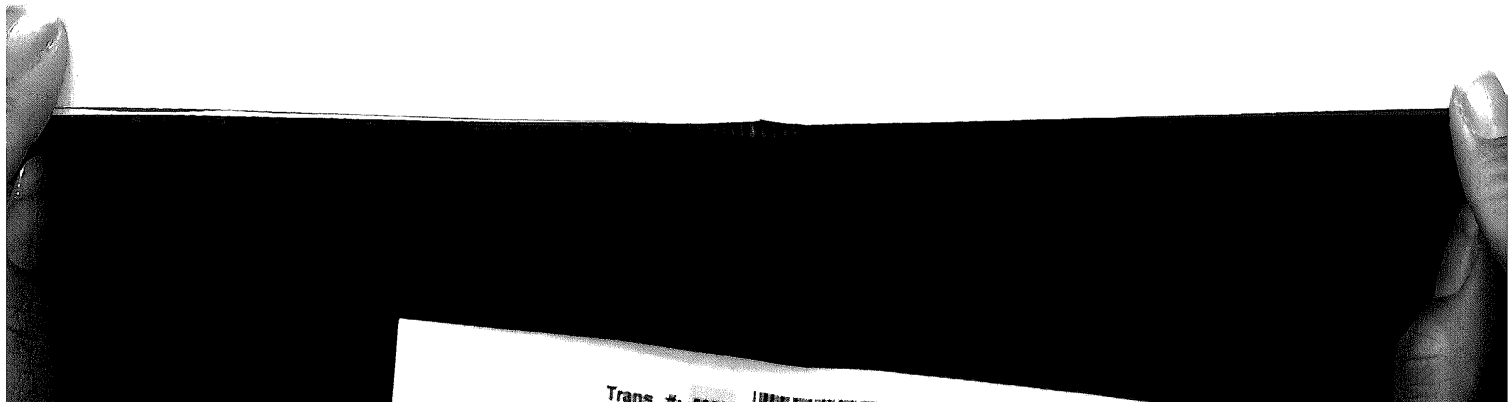
[a] the covariance between the parameter estimates of disturbance and plan quality when biodiversity is set at a specific value.
[b] level of significance of disturbance on plan quality when biodiversity is set to a specific value.

Perhaps the most salient result is the significance of the interaction of biodiversity and human disturbance where disturbance to biodiversity drives ecosystem plan quality significantly higher. This interaction was investigated in more detail by observing the impact of disturbance on ecosystem plan quality when biodiversity was set at different levels. Significance levels for disturbance were calculated for plan quality when biodiversity was set at its minimum, mean, and maximum (Table 3). In terms of significance levels, disturbance has the greatest effect on the dependent variable when biodiversity is at its extremes. Human disturbance may be most noticeable to planners and planning participants when the amount of biodiversity is either very low or very high. Even more insightful, however, is the dramatic increase in the coefficient of disturbance as levels of biodiversity increase. When biodiversity is at its maximum value, the effect of disturbance on ecosystem plan quality is extremely strong. This finding further supports the proposition that the combination of high biodiversity and disturbance is the most powerful predictor of ecosystem plan quality.

5 Conclusions and planning implications

The most significant finding of the study shows that the degree of disturbance or threat to biodiversity is the strongest predictor of ecosystem plan quality. Even though comprehensive planning is intended to be a proactive policy-making process where communities lay out their long-term vision of the future, the quality of the plans increases only after there is a clear and present adverse impact to biodiversity. 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 finds that planners and planning participants are reacting to the loss of biodiversity at the point where there is little left to protect. The threshold for planning response in Florida appears to be so high that the integration of ecosystem management abilities at the local level is essentially counter-productive. A "damage-control" approach to natural resource management must rely on restoration activities. This style of environmental planning is costly, inefficient, and in many instances practically infeasible.

Because local jurisdictions can greatly impact ecological systems and their components through land use decisions, increasing the ability of land use plans to manage entire natural systems rather than a fragment is critical to attaining state and federal environmental goals. The central issue for local ecosystem planning thus is determining how to motivate communities to protect critical ecosystem components *before* they are lost to human growth and development. Motivating action involves increasing the sensitivity of the planning response threshold so that those involved in drafting a plan are stimulated to protect ecosystem components early in the process of natural resource decline. While further study is needed to understand how to lower the environmental planning response threshold, there are several recommendations stemming from the results of this study that may help communities incorporate ecosystem considerations into plans and planning processes before substantial degradation of biodiversity takes place. Proactive planning levers include monitoring activities, use of Geographic Information Systems (GIS), incentive-based policies, and environmental education programs.



While this study provides a greater understanding of what drives planners to implement the principles of ecosystem management at the local level, it is only a starting point for exploring the topic. Further research is needed to determine what factors drive the quality of local plans, such as the participation of specific stakeholders groups and other socioeconomic factors [19]. The quality of local plans should also be related to the ecosystem itself, which is often the ultimate target for management efforts. Understanding how several adjacent local jurisdictions together can protect the integrity of the ecosystem within which they are located may be the only way to accurately measure the degree to which an ecosystem is being managed over the long term.

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