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Examining the Effects of Biodiversity on the Ability of Local Plans to Manage Ecological Systems

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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 paper 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 high biodiversity does 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 paper discusses implications for policy and suggests recommendations to improve proactive planning practices associated with managing ecological systems over the long term.*

Introduction

A traditional species-by-species approach to regulation and management has been unable to prevent the decline of critical natural resources across the USA (Noss & Scott, 1997; Yaffee & Wondolleck, 1997). Increasing development and consumption of natural systems have resulted in adverse impacts to water quality, loss of habitat, and the overall reduction of biological diversity (Noss & Cooperrider, 1994; Szaro *et al.*, 1998). Logging of old growth forests, conversion of land to agriculture, introduction of exotic species and suburban sprawl are the major contributors to the degradation of ecological systems. Above all, the fragmentation of habitat from human activities across American landscapes is considered to be the leading cause of species decline and the loss of ecosystem integrity (Peck, 1998).

In response to the increasing decline of critical natural resources across the USA, 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 (Szaro *et al.*, 1998). In this approach, entire ecological systems (e.g. watersheds, ecological communities, etc.), and the ecological struc-

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tures, functions, and processes within them, become the focus for management efforts, rather than a single species or jurisdiction (Grumbine, 1994; Christensen *et al.*, 1996). At least 18 federal agencies have committed to the principles of ecosystem management and are exploring ways to incorporate this concept into their present day activities (Haeuber, 1998). The most recent comprehensive survey identified over 600 ecosystem management projects ranging from the Greater Yellowstone Ecosystem (GYE) and the Everglades Ecosystem to the Chesapeake Bay and the Gulf of Maine (GOM) (Yaffee *et al.*, 1996).

The protection of biological diversity is most often the overarching goal of ecosystem management (Grumbine, 1990, 1994; Noss & Scott, 1997; Slocombe, 1998; McCormick, 1999). 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 (Vogt *et al.*, 1997). Defined as "the full range of variety and variability within and among living organisms, and the ecological complexities in which they occur" (Peck, 1998; p. 189), biodiversity is often conceptualized as species richness (the overlap of focal species). It is the intersection of key species that supports the overall function and processes of ecological systems (Noss & Cooperrider, 1994). 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. Furthermore, ecosystem management may not be realized solely by structural or engineering approaches to management, but by the co-ordination of local plans and policies across larger landscapes (Kirklin, 1995; Beatley, 2000). 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 (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, some of the most powerful tools 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 (Duerksen *et al.*, 1997).

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 paper 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. By examining the effects of biodiversity on plan quality, this paper will test and confirm a land-use management paradox where communities adopt environmental plan components only after much of the critical natural resources they intend to protect are lost to human development.

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. Finally, based on the results, this study provides a set of 'proactive planning levers' to improve the ability of local jurisdictions to protect the components of ecological systems in Florida and in other states before they are severely degraded by human activities.

The Effects of Biodiversity and Human Disturbance on Plan Quality

The protection of biological diversity is often considered a major goal of ecosystem management (Grumbine, 1990, 1994; Noss & Scott, 1997; Slocombe, 1998). 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 (Vogt *et al.*, 1997). 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 (Noss & Cooperrider, 1994). 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 (Peck, 1998). 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 (Noss & Scott, 1997; Peck, 1998). 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 (Kirklin, 1995).

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 (e.g. loss of seagrass in the Chesapeake Bay, water quality declines in the Everglades, loss of the Spotted Owl in the Northwest, etc.), human threats to biodiversity or disturbance to habitat may also positively impact plan quality (Wondolleck & Yaffee, 2000). 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 & French (1981) discovered a similar policy response they termed a 'land use management paradox'. In their study, communities tended to enact strong hazard management programmes only after the damage to or development of the flood zone had taken place. Hazard mitigation strategies were installed as reactionary strategies rather than proactive measures to avert loss of critical natural resources and, in this case, human life. The paradox emerges because communities protected their flood plains once development had already taken place, causing these policies to be far less useful in accomplishing planning goals. Although this study used different variables, measurements, and analyses, the same type of paradox applies to the amount of biodiversity or critical habitat within a jurisdiction and corresponding efforts at ecosystem planning. In these cases, communities may implement goals, policies and strategies to protect ecosystem integrity only when there is little left to protect. Rapid human growth and development resulting in disturbance under this hypothesis will drive ecosystem plan quality.

These instances have become known as 'train wrecks' throughout the environmental policy community (Haeuber, 1998). '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.

Ruth (1990) captures this environmental planning problem in a description of two philosophies or approaches of natural resource managers: (1) damage control, and (2) anticipation/prevention. Damage control-driven planning and management reacts to negative criticism and clearly demonstrated problems. Ruth (1990) terms this outdated approach a dinosaur because it reacts to problems rather than anticipating and preventing them. In contrast, management propelled by anticipation/prevention proactively resolves environmental conflicts before they become intractable.

Including human disturbance in a conceptual model 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. Although human disturbance on natural ecosystems may alone stimulate the adoption of higher scoring plans, if that disturbance is also associated with the loss of high biodiversity, the motivation to enact environmental plans may be even greater. A perceived environmental problem or threat, such as habitat loss most often initiates the adoption of environmental

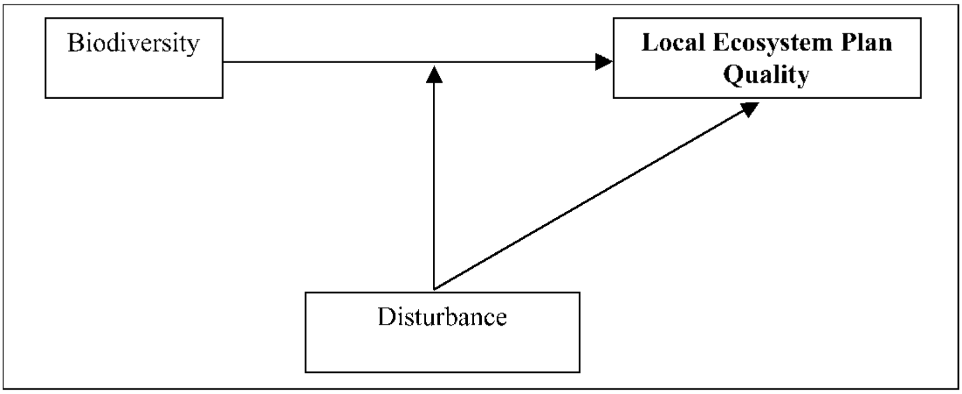

Figure 1. Disturbance as an impure moderator.

plans (Lein, 2003). Increasing attention to and awareness of the problem can help open a 'policy window' of opportunity to generate plans to mitigate continued decline of ecosystem components (Kingdon, 1984; Haeuber, 1998). For this reason, the impact of biodiversity on plan quality may be dependent on the level of disturbance. 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. As illustrated in Figure 1, disturbance, in this instance, is conceptualized as an impure moderator between biodiversity and the dependent variable ecosystem plan quality.

Research in natural hazards mitigation further illustrates the relationship between the perception of threat and policy change. Focusing events help generate public interest in a particular problem and trigger the policy-making process (Birkland, 1997). Increased attention based on the perceived seriousness of the problem is thus an essential precondition for action (Turner *et al.*, 1986; Lindell & Perry, 1999). For example, Lindell & Prater (2000) found that the level of personal intrusiveness of a seismic event (based on the frequency a respondent thought and talked about an earthquake) is a significant predictor of seismic hazard adjustment. They observed that when the perception of threat is heightened, it is more likely to be addressed by taking action.

Based on the results of previous studies, several contextual factors were included in the conceptual model to further identify the importance of environmental variables to plan quality. Population (Berke *et al.*, 1998), wealth (Berke *et al.*, 1996), planning capacity (Burby & May, 1998), and agency commitment (Berke *et al.*, 1996) have all been shown to have positive effects on measures of plan quality. Jurisdictions with larger populations usually have more complex environmental problems that result in a need for strong planning. Wealthier populations usually have more financial resources to devote to planning staffs and plan development. The higher the planning agency capacity for a given jurisdiction, the more technical expertise and personnel devoted to producing the plan. Finally, agency commitment to critical habitat protection should positively influence plan quality by emphasizing the importance of habitat protection and devoting time during the planning process to discuss pertinent environmental issues.

Research Methods and Data Analysis

Since Florida hosts both strong ecosystem management and local growth management programmes, the state provides an ideal institutional and biogeographical setting in which to conduct the study. Specifically, the growing emphasis on ecosystem management and planning makes Florida a well-suited location for the following reasons. First, Florida contains some of the most biologically diverse and valuable 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). Second, Florida has a well-established framework for ecosystem management to ensure a level of consistency in the way the concept is understood and carried out. Local communities across the state which seek to protect broader ecosystems thus have a model for their specific programmes. In 1993, Florida's Department of Environmental Protection (DEP) recognized that traditional approaches to management could not adequately protect biodiversity and thus decided to reorient the state's environmental programmes around an ecosystem approach to management (now termed regional watershed management). Under this approach, DEP moved away from media-based management, which addresses water and land separately, and directed efforts toward an integrated understanding of problems and solutions based on natural boundaries rather than those defined by humans. Third, Florida 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 new local comprehensive plans to be written and required that they be consistent with goals of the state plan.

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 (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. Required elements, among others, include land use, coastal management (where applicable), conservation, and intergovernmental coordination. In each element, the rule lists the types of data, issues, goals, and objectives that must be addressed using a 'checklist' format (May *et al.*, 1996). For example, in the conservation element, objectives must conserve wildlife habitat while policies must pursue cooperation with adjacent local governments to protect vegetative communities (9J-5.013). These plans act as strong gauges of how well local jurisdictions will manage ecosystems over the long term because they need to look beyond jurisdictional boundaries, drive collaborative efforts with other jurisdictions or organizations, and contain policies that seek to protect critical habitats comprising broader ecosystems. 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.

Sample Selection

The sample of jurisdictions studied was selected initially for use in an investigation of the quality of the hazards elements of comprehensive plans (see Burby *et al*., 1997) and is used again here to examine the quality of plans with regard to ecosystem management capabilities. The 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 throughout the state and was subjected to the following sampling strategy. First, the sample of local jurisdictions was limited to jurisdictions with a population of 2500 or more to make certain the sample was not skewed towards small communities (Berke & French, 1994). Second, large cities such as Miami were excluded from the sample because it is believed that these jurisdictions have very different contextual factors that may skew the sample (Berke *et al*., 1996). Third, the sample was limited to coastal jurisdictions to maintain a degree of consistency and comparability in terms of the types of ecosystems assessed. From the sampling frame, a random sample of 30 jurisdictions was drawn and evaluated against a protocol determining plan quality for ecosystem management.

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. Plan quality has been conceptualized for other issues, such as natural hazards (Berke *et al*., 1998; Godschalk *et al*., 1998; Godschalk *et al*., 1999), but never for ecosystem management capabilities. This study builds on and extends previous conceptions of plan quality which identify factual basis, goals and policies as the core components by adding two additional plan components: inter-organizational coordination and capabilities and implementation. The first additional component more accurately captures the aspects of collaboration and conflict management inherent in ecosystem approaches to management. The implementation component captures, among other issues, the concepts of monitoring, enforcement and adaptive management. The addition of these components to original conceptions enables the definition of plan quality to capture the principles of ecosystem management more effectively (for a more detailed explanation on measuring ecosystem plan quality, see Brody, 2003a).

Ecosystem plan quality was thus 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 such as a 40% reduction in nutrient runoff to reduce impacts on an estuarine system. (3) Inter-organizational coordination and capabilities capture the ability of a local jurisdiction to collaborate with neighboring jurisdictions and organizations to manage what are often transboundary natural resources.[1] This plan quality component addresses joint fact-finding, information sharing, intergovernmental agreements, and integration with other plans in the region (e.g. higher order ecosystem plan, National Estuary Program, etc.). (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 programmes, 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 designation of responsibility, a timeline for actions, regular plan updates, and monitoring of resource conditions and policy effectiveness.

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' listing each plan component and its indicators is provided in Appendix A. This protocol evaluates and measures 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. In the factual basis component of the protocol, several items have more than one indicator. For example, habitats can either be mapped, catalogued or both. In these cases 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 cataloguing was given an overall issue score of 1). This procedure assured that items remained on a 0–2 scale and favoured plans that support their descriptions with clear maps. 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 (as done by Berke *et al.*, 1996 and Berke *et al.*, 1998). 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.

Measuring Biodiversity and Disturbance

Satellite images of land cover generated by the Florida Fish and Wildlife Conservation Commission (FFWCC) were used 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. 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. 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 (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 local jurisdiction creating a disturbance variable on a scale of 0–1. Disturbed-biodiversity was measured as the interaction of biodiversity and disturbance (biodiversity and disturbance multiplied). The means of biodiversity and disturbance were subtracted before the interaction was performed. This commonly performed statistical procedure reduces the threat of multicollinearity in the model (Aiken *et al*., 1991).

Measuring Contextual Control Variables

Contextual control variables were included in the model to effectively isolate the effects of environmental factors. Agency commitment to natural habitat protection and planning capacity were determined through a survey of planning directors in each sampled jurisdiction in the summer of 1999 as part of a National Science Foundation (NSF) research project. Population and Wealth were measured through US Census data. Commitment to habitat protection was measured on a 0–2 scale based on 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. Planning agency capacity is usually defined as the amount of professional planning expertise involved in developing a plan. This variable was measured based on the number of staff devoted to writing the plan and evaluated on an interval scale. Population for each jurisdiction was measured based on the natural log of 1997 census estimates which was the median year the plans were adopted (natural logs were used to reduce skewness in the data, which is common for population and wealth). Similarly, the natural log of the median home value based on census estimates measured the wealth of a community.

Analysis

The analysis of the data was based on two phases of OLS regression. First, the impacts of environmental variables alone on plan quality were examined. Second, contextual control variables were added to estimate the influence of biodiversity and human disturbance in a more fully specified model. Several statistical tests for reliability were conducted to ensure the OLS estimators were Best Linear Unbiased Estimates (BLUE). Tests for model specification, multicollinearity, and heteroskedasticity revealed no violation of regression assumptions. In addition, a series of diagnostics was performed to test for influential data points or outliers in the data set. Given the small sample size, influential data points may have a significant impact on the interpretation of ecosystem plan quality. Various types of plots, as well as robust regression, uncovered no influential data points affecting the results.

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% of the variance

Table 1. The impact of environmental variables on plan quality*

Variable	Coefficient	Standardized coefficient	Standard Error	T-value	Significance
Area of jurisdiction with biodiversity	− 10.73	− 0.17	12.25	− 0.876	0.389
Area of jurisdiction with disturbance	14.24	0.39	4.14	3.441	0.002
Disturbed-biodiversity	128.40	0.90	26.25	4.891	0.000
Constant	9.24		3.02	3.063	0.005
n	30				
F-ratio (3,26):	28.01				
Significance:	0.0000				
Adjusted R-squared:	0.7364				

Note: * 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.

on the dependent variable (Table 1). The proportion of area with high biodiversity within a jurisdiction has no significant statistical bearing on plan quality (in fact the coefficient is negative). However, the area of biodiversity that is associated with disturbance generates markedly higher quality plans. Disturbance by itself is also a significant factor ($p < 0.05$) 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.

The statistical findings explaining ecosystem plan quality in Table 1 is exemplified by the case of Pinellas County. With only 280 square miles, Pinellas is the second smallest county in Florida. Its small land area and comparatively large population make it the most densely populated county in the state with 3228 persons per square mile. As a result, less than 10% of the County is considered vacant and available for urban development. Rapid growth and development from the 1950s to the 1980s led to a reactionary interest in environmental planning (Brody, 2001). At present, Pinellas is approximately 92% urbanized. As the County approaches a completely built-out stage, its government and community are focused on protecting remaining pockets of open space and wildlife habitat. As a consequence, the Pinellas County 1998 comprehensive plan is extremely strong in terms of protecting the integrity and function of

Table 2. The impact of environmental variables on plan quality[a] when controlling for contextual factors

Variable	Coefficient	Standardized coefficient	Standard Error	T-value	Significance
Area of jurisdiction with biodiversity	4.74	0.077	11.33	0.419	0.68
Area of jurisdiction with disturbance	13.05	0.386	4.66	2.801	0.013
Disturbed biodiversity	139.95	0.469	47.60	2.94	0.010
Population[b]	4.79	0.382	1.77	2.70	0.013
Wealth[c]	10.26384	0.207	4.916447	2.088	0.049
Capacity[d]	0.0070555	0.0031755	0.2659991	0.027	0.979
Commitment[e]	2.089107	0.1664867	1.430596	1.460	0.164
Constant	9.24		3.02	3.063	0.005
n	30				
F-ratio (7,22):	17.03				
Significance:	0.0000				
Adjusted R-squared:	0.7947				

Notes:
[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 US Census population estimates for 1997.
[c] wealth is the natural log of US 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.

ecological systems both within and adjacent to its borders. Its total plan quality score is the highest in the study sample. The commitment to the protection of biodiversity and ecosystem management has emerged in the Pinellas County plan after most of the urban and suburban development had already taken place. While strong goals and policies are set in place, there is relatively little remaining to protect and manage in the way of critical natural resources.

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 0.05 level, while undisturbed biodiversity continues to have a non-effect on the plan quality measure. These results support the initial findings that when biodiversity is under threat or disturbance from human activities such as rapid urban development, communities are more likely to produce plans that implement the principles of ecosystem management. The more severe the level of disturbance is to natural systems, the higher the quality of the adopted plan.

While disturbance-related variables remain statistically significant, there is a noticeable increase in the *p*-values 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. Growth pressures are associated with higher levels of disturbance to habitat, resulting in a greater perceived need to protect remaining areas of 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 factor 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.

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.

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 confirms the 'land use management paradox' by finding that planners and planning participants are reacting to the loss of biodiversity at

Table 3. Interaction of biodiversity and disturbance

	Disturbance level	
Biodiversity level	Coefficient[a]	*p*-value[b]
Minimum	9.63	0.030
Mean	17.44	0.10
Maximum	46.64	0.038

Notes:
[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.

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 not feasible.

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 (i.e. assessing the plan quality measure) that may help communities incorporate ecosystem considerations into plans and planning processes before substantial degradation of biodiversity takes place.

First, monitoring activities can be an essential proactive planning lever for ecosystem management. Monitoring ecological process, critical habitats and the impacts to these resources from human activities is an essential part of anticipating the decline of ecosystems and setting preventative policies. Managers must be able to react to constantly changing ecological systems, sudden shifts in interests and objectives and a continuous barrage of new and often ambiguous information. A strong local monitoring programme can provide an informational lever for identifying adverse impacts to biodiversity before they become irreversible. With a greater understanding of existing critical resources, planners and planning participants may be more likely to incorporate ecosystem management policies at the outset of adverse human impacts. For example, jurisdictions can initiate a community based water-monitoring programme for coastal estuaries. Changes in nutrient levels can be reported to the local planning or environmental agency and actions can be taken before major declines in water quality pose a threat to fisheries or recreational areas.

A second proactive planning practice involves the use of Geographic Information Systems (GIS). GIS not only helps planners understand precisely where critical habitats exist, but the degree to which they are in need of protection. As an analytical tool, GIS helps project the future and enables planners to make proactive choices about the management of existing natural resources. Like monitoring programmes, a GIS database can identify potential environmental problems and trigger planning actions to protect critical natural resources. There are hundreds of GIS data layers available throughout Florida ranging from watershed boundaries to vegetation cover. However, only a few jurisdictions in the sample take advantage of the large amounts of existing data and the analytical power of this technology to make ecologically sustainable planning choices. For example, only 7% of the sample in the study incorporated GIS data layers in their plans.

A third potential proactive planning lever is the use of incentive-based policies and programmes. The plans examined in the study generally do not emphasize incentive-based tools or policies. Instead, jurisdictions concentrate primarily on a narrow set of regulatory actions, such as land use restrictions or conservation zoning. However, the use of incentive-based policies, such as density bonuses, transfer of development rights and preferential tax treatments (included in the plan coding protocol in Appendix A) can effectively achieve the goals of ecosystem management at the local level. Most importantly, they encourage rather than force parties to protect critical habitats and areas of high biodiversity. For example, allowing increased densities for residential developments in exchange for the protection of critical wetland habitat enables developers to meet their objectives while instilling motivation to protect important ecological components. Efforts to protect ecosystems become more proactive when landholders act because they want to, not because they have to. In this way, incentive-based strategies encourage community members to think about and act on the principles of ecosystem management before they must be coerced with a regulatory 'stick'. However, incentive-based policies should not replace regulatory alternatives in every community. In some locales the protection of biodiversity might require curtailment of development options and reliance on strict regulatory actions.

Finally, environmental education programmes are one of the most effective ways to change behaviour and generate proactive ecosystem management practices. Local outreach programmes can build public awareness on the importance of protecting the value of critical natural resources and maintaining ecological integrity. Educational strategies include informational workshops, information dissemination (printed and electronic), presentations and community programmes such as monitoring or waste clean-up. Learning through involvement fosters a sense of place and facilitates early action to protect the natural environment upon which communities depend before deterioration takes place. Only half of the sample includes public environmental education programmes in its set of policies, indicating that the link between planning and education is being underemphasized in Florida.

While this study provides a greater understanding of how 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 stakeholder groups and other socioeconomic factors (Brody, 2003b). 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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Note

1. The term 'transboundary' is defined for this study as a management approach that focuses beyond a single human boundary, such as a local jurisdiction or some line of human ownership.

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Appendix A. Ecosystem Plan Coding Protocol

Table 4.

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 & 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		
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 intergenerational 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 & Capabilities for Ecosystem Management		
Other organizations/stakeholders identified	Coordination with other organizations/jurisdictions specified	Coordination within jurisdiction specified
Intergovernmental bodies specified	Joint database production	Coordination with private sector
Information sharing	Links between science and policy specified	Position of jurisdiction within bioregion specified
Intergovernmental agreements	Conflict management processes	Commitment of financial resources
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
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	Other regulatory tools	
B. Incentive-based Tools:		
Density bonuses	Clustering away from habitats	Transfer of development rights
Preferential tax treatments	Mitigation banking	Other incentive-based tools
C. Land Acquisition Programs:		
Fee simple purchase	Conservation easements	Other land acquisition techniques
D. Control of Public Investments and Projects	*G. Public Education Programs*	
E. Designation of Special Taxing Districts for Acquisition Funding		

F. Monitoring of Ecological Health and Human Impacts		
Implementation		
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	

Appendix B. Concept Measurement

Table 5.

Name	Type	Measurement	Scale	Source	Mean	Std. Dev.
Plan quality	Dependent	Sum of five plan components: factual basis + goals and objectives + inter-organizational coordination + policies + implementation	Interval; 0–50	Sample of Plans	20.62	7.76
Area of jurisdiction that contains biodiversity	Independent	Area of regional biodiversity in square meters divided by the area of the jurisdiction	Interval	GIS calculation from FWCC data layer	0.112	0.124
Area of jurisdiction that is disturbed	Independent	Area of disturbance in square meters divided by the area of the jurisdiction	Interval	GIS calculation from FWCC data layer	0.599	0.212
Disturbed-biodiversity	Independent	Interaction of biodiversity and disturbance	Interval	GIS calculation from FWCC data layer	0.032	0.0544
Planning agency capacity	Independent	Number of planners devoted to drafting the plan	Continuous	Survey	2.833	3.13
Commitment	Independent	Effort devoted to protecting critical natural areas + emphasis on protecting critical habitat	Ordinal; 0–2, where 0 is no commitment and 2 is high commitment	Survey	0.533	0.571

Population	Independent	Natural log of the population estimate for a jurisdiction for 1997	Interval	1990 US Census	4.513	0.620
Wealth	Independent	Natural log of the median home value	Interval	1990 US Census	4.931	0.157