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Planning at the urban fringe: an examination of the factors influencing nonconforming development patterns in southern Florida

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Abstract. Although the components of plan quality are well defined, little empirical research has been conducted to understand the degree to which policies are being implemented after plan adoption and the factors contributing to the variation in plan implementation. The authors test the efficacy of land-use planning and plan implementation in Florida by measuring the degree to which wetland development over a ten-year period conforms to the original design of adopted comprehensive plans. First, they spatially identify concentrated areas of wetland alteration permits and compare these locations with the adopted future land-use maps for county and city jurisdictions in the southern portion of the state. Second, they examine the major factors influencing nonconforming development patterns across the study area. Results indicate a well-defined spatial pattern of nonconforming wetland development and isolate specific socioeconomic, demographic, and geographic variables impacting these deviations from the original spatial intent of local plans.

1 Introduction

Although a large amount of research has been conducted on the measurement and prediction of plan quality, there has been little systematic empirical work to determine the quality of plan implementation subsequent to approval. Additional research is needed to understand the degree to which policies are being implemented after plan adoption and the factors contributing to the variation in plan implementation. Lack of data, methods, and empirical enquiry makes it difficult to respond to critics who consider plans to be 'dead on arrival' or 'paper shells' that are never put into action (Bryson, 1991; Burby, 2003; Calkins, 1979; Clawson, 1971; Talen, 1996a). This shortcoming is particularly relevant in the case of legally binding, spatially oriented local plans. How do planners and policymakers know if the pattern of development shaping their communities adheres to the original intent of the land-use plan? How can they measure the effectiveness of adopted plans in guiding growth, protecting the natural environment, and creating livable communities?

In this paper we seek to test the efficacy of land-use planning and plan implementation in Florida by measuring the degree to which wetland development over a ten-year period conforms to the original design of adopted comprehensive plans. Through a statewide comprehensive planning mandate, local jurisdictions identify areas designated for growth to guide future development, reduce negative environmental, social, and economic impacts, and provide adequate public services to community residents. Comprehensive plans and associated future land-use maps are thus the regulatory and prescriptive growth-management policy instruments used by local jurisdictions. Despite the importance of local plan adoption as a legally binding growth-management tool in Florida, the success of their implementation has never been thoroughly examined or explained. We address this issue by identifying concentrated areas of wetland alteration permits and compare these locations with the adopted future land-use maps for county and city jurisdictions in the southern portion of the state. Once we have measured the degree of implementation or plan conformity we then examine the major factors influencing nonconforming development patterns across the study area. Through statistical analyses we seek to answer the following research questions: (1) to what degree does development as signified by spatial clusters of wetland alteration permits conform to the original spatial design of the plan and (2) what are the major physical, socioeconomic, and market-based factors influencing the degree of development conformity in southern Florida?

We build directly on previous research in which we mapped and spatially described the pattern of nonconforming development as signified by clusters of wetland alteration permits (Brody and Highfield, 2005). In that earlier study we found nonconforming areas of development to be spatial indicators of urban and suburban sprawl. For example, nonconforming clusters occur at the fringes of coastal urban areas containing large populations where development pressures are most intense (figure 1). The nonconforming patches are almost always located adjacent to conforming areas of development.

The next step in a thorough examination of the degree to which plans are implemented subsequent to adoption, and the focus of this analysis, is to explain the factors driving

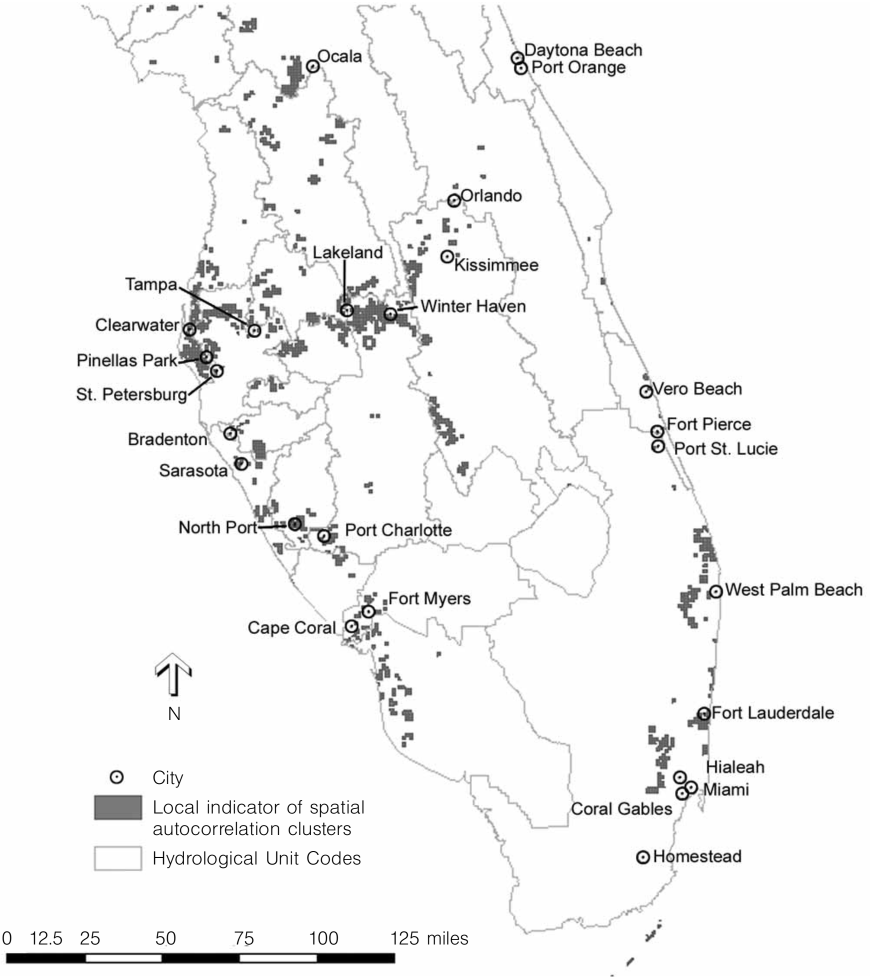

Figure 1. Statewide map of spatial clusters of wetland permits with major cities and counties.

nonconforming development patterns. This research approach should help identify why development may or may not adhere to the original spatial design of the plan and provide guidance to planners on how to mitigate nonconforming development (or sprawl) in the future. In section 2 we examine the debate on measuring plan implementation and the issue of conformity, and in section 3 we highlight nonconforming development as an indicator of sprawling growth patterns and use this literature base to develop a conceptual model explaining the variation in plan conformity across the study area. In section 4 we describe the sample selection, measurement of variables, and data analysis procedures. In section 5 we provide a statistical overview of the degree of nonconformity by watershed unit and then report the results of spatial regression analyses explaining the most influential factors driving nonconformity. In section 6 we discuss how the results can provide direction for planners and policymakers to reduce instances of spatially nonconforming development and increase the quality of plan implementation in general. Some conclusions are provided in section 7.

2 Plan implementation and the issue of conformity

As noted by Talen (1996a; 1996b; 1997), there is a relative lack of quantitative research on implementation processes in the planning domain, particularly for plans that serve as blueprints or guides for the future physical development of urban areas. In these cases, there is little understanding of the relationship between the processes of planning, the adopted plan, and plan implementation or performance (Alterman and Hill, 1978). As a result, the field of planning seems to this day to be mired in what Calkins (1979) referred to as the 'new plan syndrome', in which plans and policies are adopted without any attempt to measure the progress toward achieving stated goals and objectives. Furthermore, no effort is made to determine why a previously adopted plan is unable to meet its goals even if they are partially or totally met.

Aside from methodological difficulties in measuring plan performance, the lack of empirical analysis on implementation is fueled by the debate over the meaning of planning success and the assessment of plan conformity. Conformity measures the degree to which decisions, outcomes, or impacts adhere to the objectives, instructions, or intent expressed in a policy or plan (Alexander and Faludi, 1989). Alexander and Faludi (1989) rejected this means–ends approach to measuring plan effectiveness because, owing to the complexities of the decisionmaking process, deviation from the original design of a plan is a normal consequence of policy implementation. Additionally, policy statements are meant to undergo modification in response to uncertain political and socioeconomic conditions. Under these arguments, the mere consultation of a plan may be viewed as an indicator of implementation success. Mastop and Faludi (1997) reinforced this stance when discussing the merits of evaluating strategic plans. They asserted that the established policy or plan should never be followed blindly but rather needs to be constantly reenacted and readjusted. Instead, the key to plan performance is the way in which a strategic plan holds its own during the deliberations following plan adoption.

At the other end of the plan implementation spectrum is the belief that plan intent and policy outcomes should follow a strict linear association (Wildavsky, 1973). Any departure from the goals and objectives of the adopted plan would, under this line of thinking, be considered a failure. Owing to the uncertainties involved in the planning process, and the social and political complexities of plan implementation, a direct cause and effect relationship may be an unrealistic expectation for most plans. In his later work Faludi (2000) distinguished between strategic plans and project plans. Whereas strategic plans are open and flexible, a project plan is a 'blueprint' for the intended end-state of physical development. Once adopted, these plans are meant to be unambiguous guides to action where outcomes must conform to the specifications detailed in the plan. Faludi (2000) further elaborated that the evaluation of a project plan must follow the logic of ends and means and conformance of outcomes to intentions.

Realistic expectations as to the degree to which plans should be followed can most likely be found not at the extremes but somewhere towards the middle of the implementation spectrum. That being said, failure to hold planners and planning participants to account for their adopted policies would be to undermine or delegitimize the field of planning. Talen (1996a, page 254) asserted that the dismissal of linear association between the adopted plan and its outcome on the basis of uncertainty "can be seen as evaluation avoidance".

Although the difficulties involved in evaluating plan implementation have restricted the focus of most empirical planning studies to measuring plan quality (among others, see Berke and French, 1994; Brody, 2003a; 2003b; Burby and May, 1998; Burby et al, 1997) there have been a few past attempts specifically to measure the degree of plan implementation. This body of research helps provide a conceptual and methodological foundation on which our study firmly rests. For example, in Israel Alterman and Hill (1978) conducted perhaps the most comprehensive study on plan implementation by measuring the degree to which plans conformed to their original design. By using building permits as an indicator of plan implementation, they found that the level of accordance with the master plan in their study area was approximately 66% of the land area planned. Calkins (1979) presented a 'planning monitor' to measure the extent to which plan goals and objectives are met, to explain the differences between the plan and actual state of the environment, and to understand the reasons for any observed differences between the plan and the outcome. By using algebraic expressions, Calkins showed how to evaluate not only the overall plan but also whether the desired spatial distribution had been achieved. This was the first attempt not only to measure if policy implementation conforms to the adopted plan but also to identify where any discordance may occur. Such an approach is particularly relevant when one is evaluating plans that guide the physical development of a community.

Talen (1996b) built on Calkins's work by employing geographic information systems (GIS) and spatial statistical analysis to compare the distribution of public facilities called for in a plan in Pueblo, Colorado with the actual distribution that occurred after plan implementation. By mapping relationships between access to facilities as denoted in the plan and actual access years later she revealed areas of the city that did not match the policymakers' original intent. Most recently, Burby (2003) examined sixty local jurisdictions in Florida and Washington to explain the relationship between stakeholder participation in the planning process and implementation of policies on natural hazards. By studying the ratio of proposed hazard mitigation actions that were subsequently implemented to proposed actions that were not implemented, Burby found that greater involvement of stakeholders in the planning process significantly improved implementation success.

3 Major factors contributing to nonconforming development

The scarcity of research on the degree of local plan implementation makes it difficult to specify an explanatory model. Alterman and Hill (1978) and Burby (2003) both modeled implementation success by using contextual variables such as population and population growth but provided little additional guidance for the focus of this study. We can, however, draw from the growing literature on spatial development patterns and the influences of sprawl to help construct a statistical model for nonconforming development. As mentioned in section 1, our previous analysis showed that nonconforming development in Florida is an indicator of outwardly sprawling development patterns. The highest degree of nonconformity occurs outside of urban areas experiencing intense population growth. As growth spirals outward from existing urban centers, development infringes upon rural or protected areas or takes place in locations not intended in the jurisdiction's land-use plan (Brody and Highfield, 2005). As it appears that the same factors driving outwardly expanding growth patterns also contribute to the formation of nonconforming development clusters we can gain insight from this literature to specify the model for our study.

For example, Pendall (1999) acknowledges that land value is one of the most significant drivers of development and that sprawl occurs where land values are lower. Administering a survey in twenty-five metropolitan areas over 180 counties, Pendall found that high housing prices led to more compact development. Given that high housing values both reflect and perpetuate high land values, higher densities result with increased land values. Brueckner (2000) also cites the importance of land value in the urban expansion of cities. He states that "land conversion is guided by the economist's 'invisible hand' which directs resources to their highest and best use" (page 162). Therefore, agricultural land will be preserved only if its productive value is worth more than the developer is willing to bid. Economists identify three underlying forces that interact with land values to create spatial urban expansion or sprawl (Brueckner, 2000). First, population growth results in the outward expansion of urban areas. Second, rising incomes allow residents to purchase greater living space. These residents locate where housing options are less expensive, such as in suburban and exurban areas generally located at the periphery of metropolitan areas. Third, decreasing commuting costs produced by investments in transportation infrastructure also fuels outward expansion of development.

Socioeconomic and demographic characteristics are also considered important contributors to sprawling patterns of growth. For example, Carruthers and Ulfarsson (2002) show that population density influences the spatial extent of developed land. As the numbers of people and jobs per acre increase, the more compact the development from a regional perspective. Increasing wealth further exacerbates urban expansion by allowing residents to purchase larger houses and properties (Alonso, 1964; Brueckner, 2000; Carruthers and Ulfarsson, 2002; Heimlich and Anderson, 2001). With a high demand for low-density, single-family housing developments, residents seek to locate where housing options are inexpensive, such as in the suburbs along the urban fringe. Daniels (1999, page 4) concurs, stating that the "rising affluence of many Americans really drives the development of the fringe, because as income increases, the choices of what to spend money on expands as well." Carruthers and Ulfarsson (2002) evaluated 283 metropolitan counties in the USA at three points in time to examine the relationship between government fragmentation and several measurable outcomes of urban development, including per capita income. They showed that income works to lower densities, spread out development, increase the amount of urbanized land, and increase property values. In contrast, Carruthers (2003) evaluated 822 metropolitan counties in the continental USA between 1992 and 1996. Results from this analysis indicated that per capita income is only occasionally significant for determining the amount of growth at the urban fringe.

In addition to population density and rising incomes, race has been identified as another socioeconomic indicator of urban and suburban sprawl. Racial strife in the centers of cities such as Los Angeles and Detroit led to an out-migration of middle-class and upper-class white people to the urban fringe (Daniels, 1999). This relocation of residents soon became known as 'white flight'. Pendall (1999) analyzed this 'white-flight' hypothesis and found that low-density zoning led to a decrease in construction of attached and rental housing. This in turn caused rents to rise, leading to a decrease in the population of Hispanic and Black people in less compact development areas. Carruthers and Ulfarsson (2002) support the 'white-flight' hypothesis, showing that it is marginally associated with greater overall densities, more spread out metropolitan areas, and lower property values. Carruthers (2003) provided similar conclusions that race has a substantial effect on the spatial pattern of urban development.

Further, several researchers have considered age as a factor in determining the spatial pattern of development. Specifically, Zhang (2001) found that the proportion of younger residents is significantly related to new housing development. Although other studies have shown that age is an insignificant predictor, the direction of the coefficients are consistent with the expectation that younger families promote sprawl and nonconforming development patterns by seeking out affordable housing options at the urban fringe (Carruthers, 2003).

In addition to socioeconomic factors, decreases in commuting costs as a result of infrastructure investment are another underlying force in the sprawling expansion of cities (Brueckner, 2000). Alonso (1964) cites improvements in transportation infrastructure as one of the primary reasons for a city expanding outwards. Daniels (1999) supports this idea, noting that the construction of new roads will lead to greater access to the fringe. Heimlich and Anderson (2001) state that infrastructure drives the growth of cities by providing the essential framework for development. Once new development takes place, residents then demand improvements in infrastructure, which further ignites development along the urban fringe. Widespread access provided by improvements in transportation infrastructure allows developers to utilize cheap land located outside the city center (Gillham, 2002). Carruthers and Ulfarsson (2002) and Carruthers (2002) also found that per capita spending on road and sewerage systems influence the spatial extent of development. In contrast, survey findings by Pendall in a 1999 study of twenty-five metropolitan areas over 180 counties showed that investments in infrastructure, particularly heavy spending on highways, did not lead to less compact development. In a study published in 2003, Carruthers found that infrastructure investments had mixed effects on growth at the urban fringe. Roadway investments appeared to have no impact on growth in suburban counties, whereas per capita spending on sewerage products occasionally led to greater growth at the urban fringe.

Last, land-use planning and growth management policies have been theorized as determinants of the spatial pattern of development (Bengston et al, 2004). Local policies, such as clustering of development, conservation easements, transfer of development rights, and urban growth boundaries have been suggested as strategies to reduce sprawl and promote a more compact form of development (Mattson, 2002; Pendall, 1999). These policies are likely to help guide growth in an ecologically sustainable manner and assist local communities in attaining the intended spatial design and land-use intensities designated in their plans. The absence of such policies may allow for more sprawling development patterns involving an increasing loss of wetlands and leading to a greater degree of nonconformity. However, the results of empirical studies are mixed. Shen (1996) found that growth management controls actually promoted sprawling development in outlying parts of Solano County, CA. In contrast, Knaap (1985) showed that the use of urban growth boundaries in Oregon contributed to increased density in urban areas and facilitated conforming development patterns. In most cases, all researchers note that a single growth-management policy is not enough to mitigate outwardly expanding development but must be installed as part of a broader program.

4 Research methods

4.1 The Florida planning mandate

Evaluation of local comprehensive plans in Florida provides an ideal opportunity to study plan implementation because they are legally binding, spatially oriented, local growth-management frameworks. Pursuant to the 1985 Local Government Comprehensive Planning and Land Development Act (Florida Growth Management Act, 1985), Florida requires that each local community prepare a comprehensive plan. Under this state mandate, comprehensive plans must adhere to the goals of the State Plan, follow a consistent format (in terms of production, element types, and review and updating processes), and, most importantly, provide a blueprint for future city and county growth patterns. Florida Administrative Code Rule 9J-5, adopted by the Department of Community Affairs in 1986, requires that specific elements and goals be included in local plans and prescribes methods local governments must use in preparing and submitting plans. Additionally, each jurisdiction is required to update its plan by drafting an evaluation and appraisal report every seven years. The plans evaluated in this study were prepared in response to this directive.

At the heart of this coercive and highly detailed state-planning mandate lies the requirement for each local jurisdiction to adopt a future land-use map. This 'regulatory and prescriptive' map designates the types of land uses permitted in specific areas within each local jurisdiction. The requirement is meant to ensure that growth and development proceeds with adequate public infrastructure, does not adversely impact critical natural habitats (for example, wetlands), and does not promote the harmful effects of urban and suburban sprawl.

Each adopted plan under the state mandate is thus a legally binding policy instrument offering spatial guidance for future development patterns. The plan is not simply a broad, strategic policy statement but is a set of explicit directives adopted through a participatory planning process where future outcomes are expected to conform to the original design of the plan. Although this so-called 'blueprint' approach to planning has been heavily criticized in the past, it offers an ideal opportunity to test the degree to which development outcomes adhere to the adopted plan and indicate precisely where significant deviations may occur.

4.2 Sample selection

All available state and federal permits issued (under part IV of chapter 373 of Florida Statutes and Section 404 of the Clean Water Act) to alter a wetland in Florida between 1993 and 2002 were selected for analysis and evaluated according to watershed units. No nationwide or regional Section 404 permits or programmatic state permits were included in the dataset or subsequent analysis. We used watersheds to select and summarize permit data because they are functional ecological units within which wetlands are located. When examining the effectiveness of plan implementation based on wetland alteration, we believe it is appropriate to focus on areas within ecological boundaries as opposed to those defined by humans, such as local jurisdictions (Williams et al, 1997). We therefore examined approximately 36 350 issued wetlands permits within twenty adjacent watersheds as defined by the fourth-order Hydrological Unit Code (http://water@usgs.gov/GIS/huc.html) of the US Geological Service (USGS) (see figure 2, over).

To determine the degree to which wetland development permits conform to the original design of comprehensive plans, we selected a statewide digitized coverage of future land use for all city and county jurisdictions in Florida. This dataset was created in 1992 by the Southwest Florida Regional Planning Council, which compiled each of the state's eleven regional planning councils' future land-use maps, gathered from

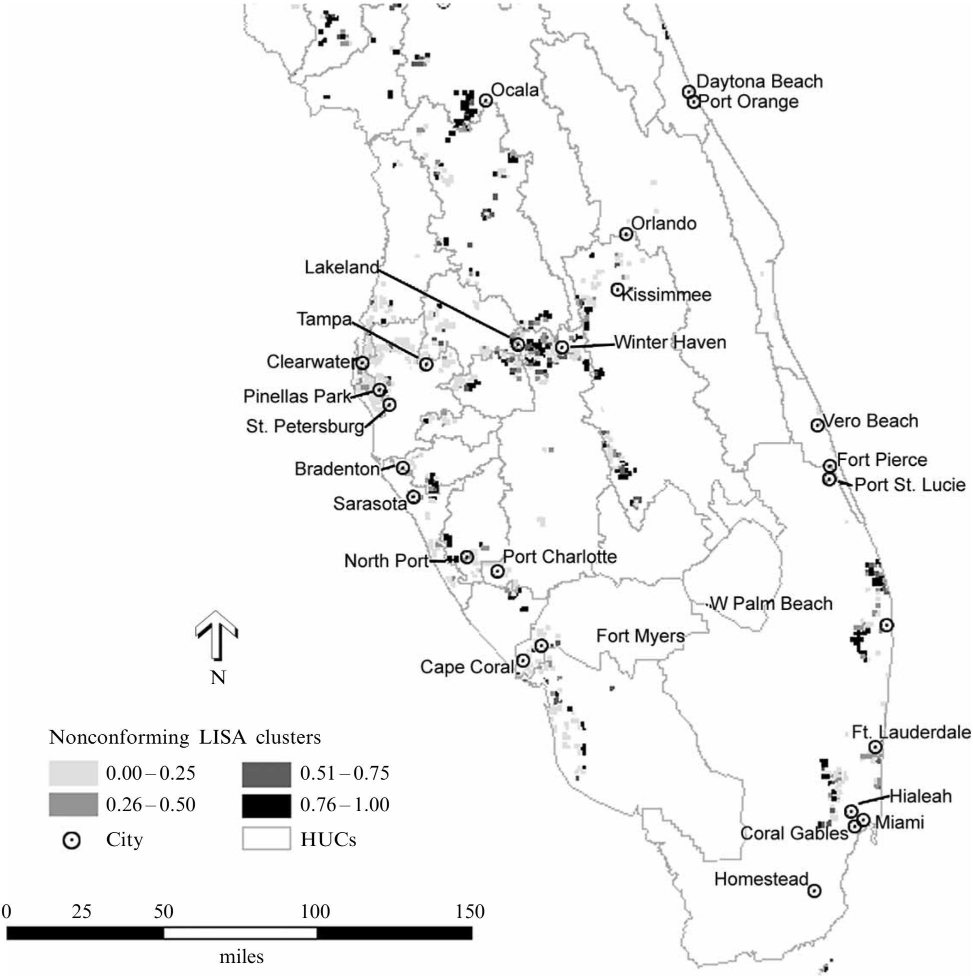

Figure 2. Map of Hydrological Unit Codes (HUCs) as defined by the US Geological Service (USGS; see permit paper 1). Note: LISA, local indicator of spatial autocorrelation.

458 local governments. Because land-use categories can vary by local jurisdiction, they were placed into one of the following ten classes to derive a standardized map for the entire state: agriculture, single-family, estate, multifamily, commercial and office, industrial, mining, military, preserve, and water bodies. This future land-use coverage provided a basis for evaluating the degree of conformity of wetland development permits between 1993 and 2003.

Wetland permit data were collected from the Florida Department of Environmental Protection (DEP; http://www.dep.state.fl.us/water/wetlands/techgis/index.htm) and individual water management districts that collect this type of data. The DEP data, which contained the bulk of the permits, were organized by township-range units (that is, the number of wetland permits in each township-range division). Therefore, any additional permit data were also summarized into these units. The State of Florida is divided into 54 285 township-range units, with an average size of 2.6 km^2. Watersheds were delineated and mapped by the USGS and downloaded in digitized format from the DEP website (http://www.dep.state.fl.us/gis/datadit.asp). Digitized future land-use data as described above were also obtained from the DEP website. Local comprehensive plans current as of 2003 were collected from each selected jurisdiction in southern Florida. When available, the plan was downloaded in its entirety from the Internet.

4.3 Concept measurement

4.3.1 *Dependent variable: nonconformity*

The dependent variable, degree of plan conformity, was measured on the basis of several spatial analytical steps conducted in a GIS framework. First, we used the original township range to total the number of permits over the study period. This procedure enabled us to calculate an intensity variable with which to conduct spatial statistical analyses across multiple watersheds. Second, we used a measure of spatial autocorrelation to identify and map significant hotspots or clusters of permits granted across the study area. These clusters represent adjacent townships containing a large number of permits (high values surrounded by high values) and indicate where intense levels of development occurred in each watershed. In total, there were 1585 wetland development clusters (all clusters less missing values for land prices and clusters located outside of the sample area for environmental policies) identified in the study area. To locate these hotspots of high-density wetland development, we calculated a local indicator of spatial autocorrelation (LISA) (Anselin, 1995). The LISA statistic was further represented as a cluster map identifying units that fall into four distinct categories: high values surrounded by high values (HH), high values surrounded by low values (HL), low values surrounded by high values (LH), and low values surrounded by low values (LL). The LISA cluster map includes only statistically significant observations ($p < 0.05$, following 999 iterations of a randomization procedure). We used the significant HH clusters to identify and map clusters of wetland development within the study area. LISAs detect significant spatial clustering around individual locations and pinpoint areas that contribute most to an overall pattern of spatial dependence. We used a local Moran's I statistic, given by

$$I_i = \frac{(Z_i - \bar{Z})}{S_z^2} \sum_{j=1}^{N} [W_{ij}(Z_j - \bar{Z})] , \qquad (1)$$

where $\bar{Z}$ is the mean intensity over all observations, Z_i is the intensity of observation i, Z_j is the intensity for all other observations, j (where $j \neq i$), S_z^2 is the variance over all observations, and W_{ij} is a distance weight for the interaction between observations i and j.

Third, we reclassified the future land-use data layer into two values: conforming and nonconforming. As mentioned above, conformity is when high-density development occurs in areas previously designated for such events. We conservatively measured conforming areas as clustered permits granted in areas designated for growth. These include single-family, multifamily, commercial and office, industrial, mining, and military land uses. Nonconformity takes place when dense development is located in areas not intended by the spatial design of the originally adopted plan. Nonconforming areas were measured by combining land-use designations meant for low-density or no development. These include agriculture, estate, and preserve land-use designations. Fourth, the spatial clustered permits data layer was overlaid on top of the reclassified data layer of future land use to determine the degree to which clusters were conforming or nonconforming. The percentage of area for each cluster containing nonconforming values was calculated to derive a measure for conformity on a scale of 0 to 1, where 0 is completely conforming and 1 is completely nonconforming.

Although we expect comprehensive plans and their future land-use maps to be updated and modified over the study period, spatial changes are almost always minor, and a complete reversal of land-use intent (for example, from preserve to industrial) is even more of a rarity. Furthermore, as we combine multiple land uses into two broad categories, minor alterations in land-use designation during plan updates were not detected. Finally, the broad spatial focus of our analyses makes possible small changes in a local plan insignificant. Thus, the research design permits some degree of flexibility between future land-use designation and expected development outcomes without confounding the results.

4.3.2 *Independent variables*

To model nonconformity, we measured and analyzed the following three suites of independent variables based on our literature review: geographic variables, sociodemographic variables, and policy and market variables.

4.3.2.1 *Geographic variables*

Four separate geographic variables were selected to help explain nonconformity in south Florida: distance to protected areas, distance to major roads, distance to 1990 Census places, and distance to the coast (for more details, see tables 1 and 2, over). The 'distance to protected area' variable was created by using the Florida Natural Areas Inventory (http://www.fnai.org/). This spatial inventory of protected areas includes federal, state, local, and private lands that are managed for conservation purposes. The second geographic variable, 'distance to major road', was created by using a subset of statewide roads coverage as obtained from the Florida Geographic Data Library (FGDL, http://www.fgdl.org). We selected four main classifications to derive a spatial coverage of major roads that included major collectors, minor arterials, principal arterials, and interstates. Distance to 1990 Census places was determined by using the TIGER product (http://tiger.census.gov/) of the US Census Bureau (USCB). The USCB definition of 'place' consists of three separate entities: designated places, consolidated cities, and incorporated cities. The place coverage offers a more complete picture of developed areas, highlighting areas that might go unnoticed if one were to use city boundaries alone. The fourth geographic variable, 'distance to coast', was calculated by measuring the distance from a township-range centroid to the nearest coastline.

4.3.2.2 *Sociodemographic variables*

Four sociodemographic variables were also calculated and analyzed in the regression model (table 1). These variables include: median household income, proportion of minorities, proportion of population over 50 years old, and population density. Owing to the small size of the township-range, the determination of exact populations for each unit was not feasible. Instead, we used the 1990 USCB TIGER block group summary level to transfer population estimates spatially from each block group to the township-range unit of analysis. In cases where a township-range crossed two or more block groups, we used the average. Median household income, proportion of minorities (proportion of nonwhite and non-Hispanic people), and proportion of population over 50 years old were taken directly from census records. Population density was calculated by dividing the population estimate by the area of block group within a GIS framework prior to joining it to a township-range unit.

4.3.2.3 *Policy and market variables*

The environmental policy index was measured by evaluating the comprehensive plan for each jurisdiction occupied by a significant wetland permit cluster. We evaluated each local plan for the presence of four policies that are considered effective planning tools for concentrating growth and protecting critical habitats such as wetlands (Beatley, 2000; Brody et al, in press; Duerksen et al, 1997). Environmental policies include: capital improvements programming to protect critical habitat and ecological processes, density bonuses in exchange for habitat protection, transfer development rights away from critical habitats, and clustering away from habitat and/or wildlife corridors.

Table 1. Concept measurement.

Variable	Description	Source	Mean	Standard deviation
Nonconformity	The degree of nonconforming land uses, from 0.00 – 1.00[a]	LISA wetland clusters and future land use	0.211	0.321
Geographic variables				
Distance to protected area	Distance from centroid of each township-range to the nearest protected area (m)	Florida Natural Areas Inventory	3 464	2 754.16
Distance to major road	Distance from centroid of each township-range to the nearest major road (m)	Subset of roads from FGDL functional road classification coverage	482	536.51
Distance to 1990 Census places	Distance from centroid of each township-range to the nearest MSA (m)	USCB, 1990 TIGER coverage	919	1 735.4
Distance to coast	Distance from centroid of each township-range to the coastline (m)	DEP Florida counties coverage	23 945	26 752.56
Sociodemographic variables				
Median household income	Average median household income of each township-range ($)	USCB	31 136.46	13 721.84
Proportion of minorities	Average proportion of minority population in each township-range	USCB	0.15	0.199
Proportion of population over 50 years old	Average proportion of persons over 50 years of age in each township-range	USCB	0.37	0.192
Population density	The average population density of each township range (persons per km^2)	USCB, 1990 TIGER coverage	527.25	636.94
Policy and market variables				
Environmental policy index	Environmental policy index from local and county comprehensive plans[b]	Coded county and local comprehensive plans	5.24	2.03
Land values	Total land value of each township-range ($)	FGDL	24 300 000	34 300 000

[a] 0.00, totally conforming; 1.00, totally nonconforming.
[b] See equation (2) in text, section 4.3.2.3.
Note: LISA, local indicator of spatial autocorrelation; FGDL, Florida Geographic Data Library; MSA, metropolitan statistical area; USCB, US Census Bureau.

Table 2. Correlation matrix.

	NC	d^{pa}	d^{mroad}	d^{1990}	d^{coast}	MHI
Nonconformity, NC	1.000	−0.025	0.355**	0.314**	0.278**	0.023
Distance to protected area, d^{pa}	−0.025	1.000	−0.002	0.104**	0.190**	0.000
Distance to major road, d^{mroad}	0.355**	−0.002	1.000	0.353**	0.070**	0.111**
Distance to 1990 Census places, d^{1990}	0.314**	0.104**	0.353**	1.000	0.135**	0.012
Distance to coast, d^{coast}	0.278**	0.190**	0.070**	0.135**	1.000	−0.218**
Median household income, MHI	0.023	0.000	0.111**	0.012	−0.218**	1.000
Proportion of minorities, P^{min}	−0.059*	0.013	−0.052*	−0.110**	0.065**	−0.189**
Proportion of population over 50 years old, $P^{>50}$	0.006	−0.094**	−0.013	0.048	−0.023	−0.018
Population density, D^{pop}	0.009	−0.028	0.052*	0.060*	−0.024	0.131**
Environmental policy index, EPI	−0.066**	−0.063*	0.045	0.122**	−0.240**	−0.019
Land values, LV	−0.373**	−0.101**	−0.335**	−0.365**	−0.417**	0.162**

$n = 1585$

** $p < 0.01$, * $p < 0.05$.

An environmental policy (or plan quality indicator) was coded if it was intended to protect ecologically significant habitat and restrain sprawling development that would adversely impact additional wetlands. 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. Two trained coders working independently of each other evaluated the sample of plans. An 'intercoder 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%. The literature suggests that an intercoder reliability score in the range of 80% is generally considered acceptable (Miles and Huberman, 1994). Under the assumption that not one but a set of policies working together in a plan facilitates conforming development, we calculated an environmental policy index (as done by Berke et al, 1998; Brody, 2003a; Brody et al, 2003) based on the three steps. 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,

$$Q_j = \frac{10}{2m_j}\sum_{i=1}^{m_j} I_i\,, \qquad (2)$$

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

The land values from 1992 county tax records, previously summarized by township-range, were downloaded from the FGDL for the study area (see table 1). A total land value for each township-range was derived by summing across all land uses identified within the original coverage.(1)

(1) The township-range units by which land values are summarized are nearly uniform in area across the state of Florida; approximately 2.6 km^2 in area.

Table 2 (continued).

	P^{min}	$P^{>50}$	D^{pop}	EPI	LV
Nonconformity, NC	−0.059*	0.006	0.009	−0.066**	−0.373**
Distance to protected area, d^{pa}	0.013	−0.094**	−0.028	−0.063*	−0.101**
Distance to major road, d^{mroad}	−0.052*	−0.013	0.052*	0.045	−0.335**
Distance to 1990 Census places, d^{1990}	−0.110**	0.048	0.060*	0.122**	−0.365**
Distance to coast, d^{coast}	0.065**	−0.023	−0.024	−0.240**	−0.417**
Median household income, MHI	−0.189**	−0.018	0.131**	−0.019	0.162**
Proportion of minorities, P^{min}	1.000	−0.347**	−0.026	0.035	−0.026
Proportion of population over 50 years old, $P^{>50}$	−0.347**	1.000	0.053*	−0.002	0.105**
Population density, D^{pop}	−0.026	0.053*	1.000	−0.107**	−0.031
Environmental policy index, EPI	0.035	−0.002	−0.107**	1.000	0.078**
Land values, LV	−0.026	0.105**	−0.031	0.078**	1.000

4.4 Data analysis

The data were analyzed in two phases. First, we examined the degree to which these wetland permit clusters conform to the original designs of local comprehensive plans. Conformity was statistically and graphically described both among and within watershed units. Second, we examined the major factors influencing nonconforming development by using spatial regression analysis.

Prior to statistical modeling, the conformity measure was tested for global spatial autocorrelation. Because township clusters analyzed in this study are not always adjacent it was necessary to define an appropriate lag distance in order to specify a distance-based contiguity weights matrix. Although the determination of lag distances can often be subjective, we relied on a common practice that examines the spatial pattern of a major variable influencing the variation on the dependent variable. The literature on development described in section 3 highlights land value as the most important factor influencing development patterns, providing us with a rationale to observe the spatial pattern of this variable to specify the spatial lag. The mapping of land values in urban areas, where the majority of the wetland clusters are located, revealed a clear break in land-value intensity approximately 10 miles from a city center. From this analysis, we concluded a 10-mile lag distance defines 'neighbors' as all nonconforming township-range units within 10 miles of each other based on centroid-to-centroid Euclidian distance.

Two separate multivariate regression models were calculated and diagnosed in order to quantify and correct for spatial dependence in the data.[2] First, an ordinary least squares (OLS) regression model was run. A global Moran's I test of the OLS residuals yielded a result of 0.1743 (expected $I = -0.0006$, $p < 0.001$). The presence of significant spatial autocorrelation in the OLS residuals violates the assumption of independent observations. Additional spatial diagnostics of the OLS model (robust Lagrange multipliers) indicated that a spatial error model was the appropriate spatial autoregressive model for the data. However, the inclusion of a spatial lag or spatial error term into an

[2] We thank an anonymous reviewer for additional clarification of these issues.

OLS regression equation can be inconsistent and is considered inappropriate (Anselin, 1988; Ord, 1975). Instead, the 10-mile lag distance described above was used to run a second regression model consisting of a maximum likelihood estimation with a spatial error term. The global Moran's I test on the spatial error residuals resulted in a insignificant Moran's I value of 0.0019 (expected $I = -0.0006$, $p < 0.3130$) and a final regression model that was free of spatial autocorrelation.

5 Results

5.1 Overall levels of nonconformity

In figure 3 we illustrate the spatial pattern of plan conformity (as measured by wetland development permit clusters) based on quartiles. Nonconforming clusters occur primarily at the fringes of coastal urban areas where development pressures tend to be most severe, which is consistent with our previous analysis (Brody and Highfield, 2005). Nonconforming patches are most often located adjacent to areas of conforming development. These areas include the western outskirts of Miami, Boca Raton, and West Palm Beach on the southeast coast and areas to the east of Bradenton and Sarasota on the west coast of the state. Areas to the north of Lake Okeechobee in the central park of the state do not have large protected areas, such as the Everglades National Park and Big Cyprus Preserve, to restrain growth and therefore contain significant clusters of wetland permits. Large patches of nonconformance are located around urban growth areas associated with Disney World just south of Ocala and the Kissimmee River. In general,

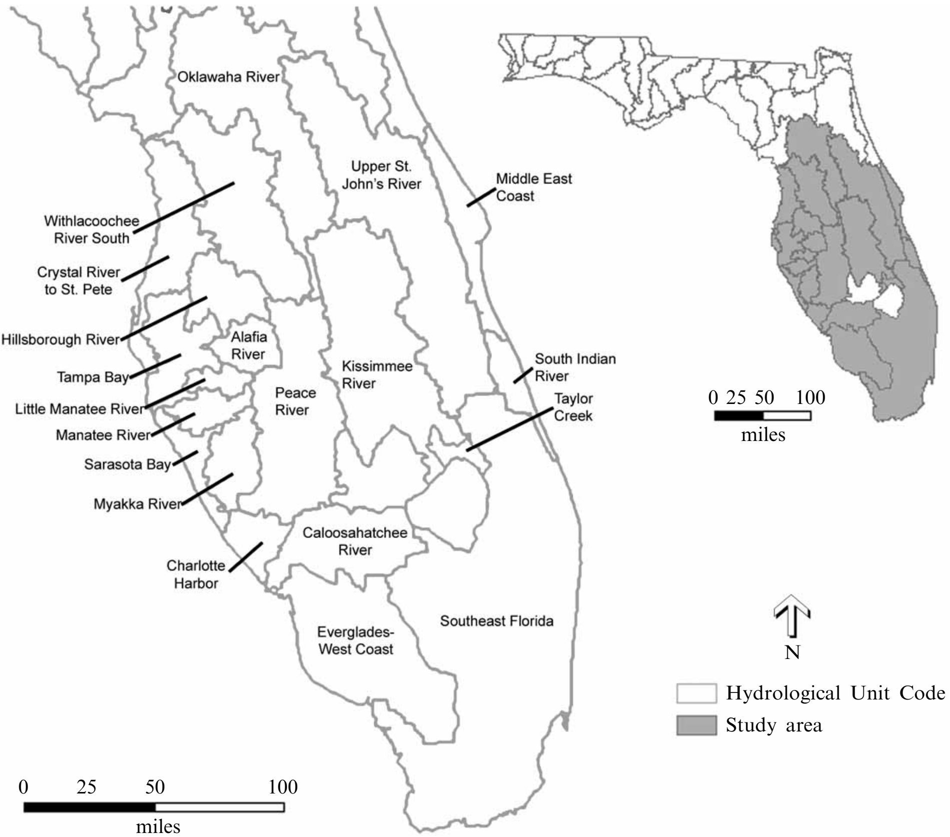

Figure 3. Study-area nonconforming development clusters with major cities and counties.

Table 3. Plan conformity scores (CS) by watershed.

Watershed	Area[a]	Av. CS	CS < 0.25		0.26 < CS < 0.50		0.50 < CS < 0.75		0.75 < CS < 1.00	
			area[a]	prop.[b]	area[a]	prop.[b]	area[a]	prop.[b]	area[a]	prop.[b]
St Johns River, Upper	21.09	0.032	21.09	1.000	0.00	0.000	0.00	0.000	0.00	0.000
Taylor Creek	3.79	0.039	3.79	1.000	0.00	0.000	0.00	0.000	0.00	0.000
Sarasota Bay	236.99	0.047	221.47	0.935	10.68	0.045	2.24	0.009	2.60	0.011
East Coast, Middle	15.58	0.070	13.87	0.890	1.71	0.110	0.00	0.000	0.00	0.000
Caloosahatchee River	138.70	0.093	128.65	0.928	0.00	0.000	6.04	0.044	4.02	0.029
Tampa Bay	333.45	0.094	307.52	0.922	18.16	0.054	2.68	0.008	5.09	0.015
Crystal River to St. Petersburg	429.86	0.102	374.77	0.872	41.41	0.096	3.53	0.008	10.16	0.024
Indian River, South	15.28	0.103	12.75	0.835	2.53	0.165	0.00	0.000	0.00	0.000
Hillsborough River	246.88	0.112	209.66	0.849	15.46	0.063	14.92	0.060	6.83	0.028
Everglades, West Coast	339.44	0.124	287.70	0.848	12.99	0.038	17.66	0.052	21.09	0.062
Little Manatee River	56.71	0.142	43.60	0.769	10.47	0.185	0.00	0.000	2.65	0.047
Manatee River	144.58	0.223	103.32	0.715	8.21	0.057	5.36	0.037	27.69	0.192
Peace River	531.90	0.236	354.93	0.667	57.87	0.109	47.28	0.089	71.81	0.135
Southeast Florida	634.78	0.265	384.57	0.606	89.35	0.141	51.70	0.081	109.10	0.172
Kissimmee River	390.38	0.298	235.95	0.604	44.01	0.113	44.55	0.114	65.87	0.169
Alafia River	174.94	0.303	105.17	0.601	19.89	0.114	23.64	0.135	26.24	0.150
Withlacoochee River, South	306.77	0.340	170.63	0.556	36.27	0.118	34.83	0.114	65.05	0.212
Myakka River	104.97	0.371	62.32	0.594	13.00	0.124	0.00	0.000	29.65	0.282
Charlotte Harbor	38.65	0.452	15.75	0.408	4.27	0.110	2.63	0.068	16.00	0.414
Oklawaha River	152.36	0.724	18.46	0.121	17.11	0.112	33.87	0.222	82.91	0.544
Average	215.86	0.210	153.80	0.740	20.17	0.090	14.55	0.050	27.34	0.120
Total	4317.10		3075.97		403.39		290.93		546.76	

[a] In square kilometers.
[b] Proportion of total area in the given watershed.
Note: Av. CS, average conformity score for the given watershed.

based on the observed patterns of nonconforming wetland development, it appears urban areas in southern Florida (surrounding the Everglades ecosystem) have experienced unintended growth towards interior portions of the state, causing wetlands to be filled in for development. As development pressure increased, urban and tourism-oriented areas pushed outward and were, in this instance, constrained only by large nationally protected areas.

In table 3 we show in more detail the degrees of nonconforming wetland development according to watershed. We calculated the total clustered area and average conformance score for each quartile on the conformance scale ranging from 0 (completely conforming) to 1 (completely nonconforming). The average level of conformity for the entire study area is 0.21, suggesting that the majority of wetland development in southern Florida is relatively in conformance with the spatial intent of local plans. This finding is supported by results for the first quartile (where the conformance score is equal to or less than 0.25), which contains the most area, approximately 3076 km^2, or 74% of all clustered area. However, the fourth quartile, where development conformance is the lowest, contains approximately 547 km^2, which is nearly as much as the second and third quartiles combined. In fact, 12% of all clustered wetland development permits are more than 75% nonconforming based on the future land-use maps of their associated comprehensive plans.

5.2 Explaining nonconforming development patterns

Results from spatial regression analysis (table 4) indicate a spatial lag of 16 km has a highly significant impact on the dependent variable, plan conformity ($p < 0.000$). That is, nonconforming development clusters are spatially dependent within 10 miles of each other and that analysis of a model that does not incorporate a spatial lag (that is, OLS regression) may result in biased parameter estimates and misinterpretation of relationships between x and y variables. Land values are also significantly correlated with the degree of planning conformity ($p < 0.000$), where high values are located in areas of conforming development, primarily in urban areas. In contrast, low land values are associated with nonconforming development where residential and commercial projects have pushed into outlying rural and conservation areas.

Table 4. Spatial error regression model.

Varible	Coefficient	Standard error	z value	Probability
Distance to protected area	-1.55×10^{-5}	2.98×10^{-6}	−5.194	0.000
Distance to major road	0.000	1.33×10^{-5}	9.339	0.000
Distance to 1990 Census places	1.88×10^{-5}	4.68×10^{-6}	4.033	0.000
Distance to coast	4.15×10^{-6}	9.63×10^{-7}	4.303	0.000
Median household income	1.66×10^{-6}	5.64×10^{-7}	2.551	0.003
Proportion of minority population	−0.033	0.037	−0.885	0.376
Proportion of population over 50 years old	−0.069	0.040	−1.731	0.083
Population density	−0.001	0.0003	−3.393	0.000
Environmental policy index	0.005	0.006	0.861	0.389
Land values	-2.56×10^{-5}	3.36×10^{-6}	−7.615	0.000
λ	0.778	0.032	24.266	0.000
Constant	0.197	0.061	3.198	0.001
R^2 statistic = 0.388				
Log likelihood = −84.498025				
n = 1585				
Degrees of freedom = 1573				

Proximity variables are also important factors driving the degree of nonconforming development, complementing the findings for land values. Distance from the nearest major road is the strongest predictor, where development in proximity to highways and other primary arterials significantly increases conformity to the spatial design of local plans. In contrast, development farther away from roadways increases the likelihood that wetland development will be nonconforming. Distance from major protected areas also significantly impacts the degree of plan conformity based on the location of wetland alteration permits. Intense development activity occurring further away from protected areas such as Big Cyprus and the Everglades tends to be more conforming. This result supports our previous findings that protected areas act as a buffer for sprawling or nonconforming growth in Florida and can help confine growth to the urban core (Brody and Highfield, 2005). Further, proximity to settled populations where public services such as sewers and water are most likely to be available has significant implications for local plan conformity. Development close to or within a settled area is more conforming. In contrast, wetland development clusters located on the periphery of commercial and residential centers where public infrastructure is less likely is an indicator that development patterns have deviated from the original intent of the adopted plan.

Socioeconomic and demographic variables in the model have less of an impact on plan conformity compared with market-based and geographic factors. Wealthy residents, as measured by median home values, are associated with significantly greater degrees of nonconformity ($p < 0.01$). This result reflects a common pattern of development in Florida, where large homes are built in planned subdivisions (often gated) away from urban centers. These planned developments attract relatively wealthy second homeowners and seasonal tourists from out of state. Those attracted to resort-oriented residential communities originally designated for rural land uses are most likely to be young in age. Although the effect is fairly weak, the percentage of the population over 50 years of age is associated with greater degrees of plan conformity ($p < 0.05$). In addition, high population density is associated with increased plan conformity, although we would expect a more statistically significant effect considering that the greatest concentration of people should be located in the urban core, rather than in outlying suburban and exurban communities.

Finally, it is important to note from a planning perspective that environmental policies have a negative, but nonsignificant, effect on the degree of plan conformity. In other words, even when policies meant to reduce sprawl and increase spatial conformity are adopted in local comprehensive plans, they do not appear to increase significantly the likelihood that development will adhere to the original spatial design of the plan itself.

6 Discussion

The results of our study suggest that the majority of wetland development clusters in southern Florida conform reasonably to the original spatial design of local land-use plans. These findings are in contrast to existing literature emphasizing the general lack of plan implementation and may reflect the strong state mandate for local comprehensive planning. At the same time, a significant portion of these clusters is over 75% nonconforming, particularly where development is accelerating into the outskirts of urban cores. This sprawling pattern of growth, where residential development occurs in areas previously designated for agricultural use or conservation, necessitates a planning focus on the fringe of urban areas. To mitigate high degrees of nonconformity (>75%), which can lead to adverse environmental, social, and economic impacts, planners and other public decisionmakers must orient growth-management policies and programs towards the ever-fading transition zone between urban and rural areas. This domain is where planners must hold the line in the face of development pressures that can encroach on critical natural resources and agriculture operations. A focus on the urban fringe may include, among other alternatives, local planning strategies such as greater restrictions on wetland development, a sharper distinction between urban and rural areas through the designation of urban growth boundaries incentives that promote clustered development and higher densities in the urban core, careful placement of public facilities and capital investment, and programs that encourage infill development or redevelopment in central urban areas.

Spatial regression analysis indicates there are several factors impacting the degree of nonconforming wetland development, each with distinct planning implications. First, nonconforming wetland development clusters are significantly spatially correlated up to 10 miles apart (tests for spatial autocorrelation were not performed for greater distances). This result suggests that, on average, a dense area of wetland development does not stand alone in space but occurs in relative proximity to other development clusters. Additionally, the formation of one cluster will encourage others to emerge in the same general area. An understanding of this pattern of development visually and quantitatively is important for planners interested in mitigating sprawl and unintended outbreaks of nonconforming development. For example, the allowance of a large-scale development project in a previously designated rural area can become a catalyst for future development nearby, even when limited public facilities are available and local growth-management policies have been adopted. The making of project-level decisions without regard to the broader spatial ramifications may, over time, promote unintended patterns of development.

Second, the value of land strongly contributes to the degree of plan conformity. Residential developers are often eager to purchase comparatively inexpensive property outside of urban areas originally containing wetlands or agricultural operations. Just as higher profit margins attract developers, more affordable housing prices in locations away from the congestion of cities appeal to prospective homebuyers, particularly seasonal residents. This phenomenon is driven by what Mattson (2002) calls rising 'trigger levels'. The trigger level is defined as the point within the development process when a combination of declining agricultural prices, rising public service costs, and increased local property tax assessments cause an owner of urban – rural fringe property to sell his or her land. By selling, the landowner perpetuates the occurrence of sprawl and unintended development outside of the urban areas.

Given that the presence of inexpensive land appears to be one of the strongest predictors of nonconforming development, planners and other public officials must be conscious of the way they assess and tax real property. Currently, land is taxed based on its highest and best use, which tends to elevate trigger levels. Preferential tax treatments, however, can assess property based on actual current uses rather than its potential. In areas where pressure to develop in outlying areas not intended by the original plan create higher property values and tax burdens, current use assessments can provide tax relief to landholders who chose to continue to pursue agricultural, forestry, or conservation land uses (Duerksen et al, 1997). Another financial incentive approach to maintaining development conformity is the use of tax credits. In this instance, federal tax deductions are offered to a landowner who donates a portion of his or her property to a land trust as open space or an open space easement. This provision simultaneously rewards the landowner for reducing the potential development of his or her land and provides a potential buffer for sprawling development outward from the urban core.

Third, proximity to likely public services, potential recreational areas, and major transportation corridors significantly affects the degree of plan conformity. These geographic variables support the visual results described above: that nonconforming wetland development occurs on the fringe of urban centers and far from essential public infrastructure. This trend can be interpreted in different ways. On the one hand, development adhering to the spatial design of the local plan is close to major roadways, water treatment facilities, and away from ecologically sensitive protected areas. As the majority of clustered areas leans toward conformity (<25%), there is evidence that planners are effectively placing public infrastructure in designated growth areas and preventing development from encroaching on critical natural resources. On the other hand, the most nonconforming development clusters occur primarily outside of urban centers, suggesting that even the most well-intentioned spatial planning designs cannot guarantee conformity or prevent the adverse impacts of sprawling growth patterns.

Fourth, wealthy homeowners appear to be driving nonconforming development through preferences for newly constructed resort communities located outside of congested downtown areas. This trend facilitates the development of large single-family homes often situated on golf courses where wetlands once predominated. Although southern Florida will continue to be an attractive resort and retirement destination, planners should encourage developers to build communities that adhere to ‘smart growth’ or ‘new urbanist’ principles and that are situated closer to urban centers. Such options include planning policies, such as urban growth boundaries, clustering of development, and mixed-use zoning, among others. Additionally, financial incentives, including special tax districts, transfer of development rights programs, and density bonuses, can help persuade developers to locate their projects within existing urban or commercial areas. Projects such as Seaside in the Panhandle region and Myzner Place on the southeast coast provide lifestyle alternatives that reverse the trend of nonconformity discussed above, but these are relative anomalies compared with most large-scale developments across the state.

Finally, planning policies such as those mentioned above that promote a well-defined urban core and reduce sprawling growth patterns are clearly not enough by themselves to ensure conforming development. This finding is evidenced by the fact that the environmental policy index analyzed in the spatial regression model was not statistically significant. In addition to strong plans and policies, implementation mechanisms need to be adopted, such as accountability, enforcement, sanctions for failure to comply, and perhaps most importantly participation of key stakeholders in the planning process. As demonstrated by numerous studies (such as Brody, 2003a; Brody et al, 2003; Burby, 2003), public participation increases ownership over and accountability for the contents of a plan, often leading to stronger levels of implementation.

7 Conclusions

By mapping and measuring the degree of plan conformance, we have gained a stronger understanding of the regional spatial pattern of development in Florida. The value of our approach is twofold. First, GIS analysis provides a spatial compass for keeping a plan on track and ensuring effective implementation over the long term. This method can help planners recognize where there is nonconformity or a significant deviation from original plan design that may adversely impact wetland systems. It serves as a statistical and graphical tool with which to gauge the direction of plan implementation, to adjust course to updated information, or to chart a new heading before negative outcomes become irreversible. Second, explanatory spatial analysis provides a better understanding of the major factors contributing to nonconforming development and sprawling growth into rural areas. Identification of why development occurs in unintended areas can help planners reduce such an occurrence in the future. Our results provide insights into which programs and policies may be most effective in improving plan implementation and in mitigating sprawling development patterns. Most importantly, the techniques and findings of this study could facilitate an adaptive approach to regional growth and environmental management where communities can make microadjustments more informally and more often than the usual official seven-year plan update cycle in Florida. An adaptive approach to long-term planning can more effectively reduce undesirable outcomes such as sprawl or prevent development patterns from taking major detours from the originally intended path.

Although this study provides important information on the degree of plan implementation and why development does not conform to the original spatial design of the local land-use plan, the results should be considered only an initial step towards understanding the links between plans and plan implementation. Further research is needed on several fronts. First, we have outlined just one method for increasing the degree of plan implementation, which by itself is not sufficient. Other implementation evaluation techniques must be developed, and plan implementation should be evaluated with use of multiple methods of analysis, both quantitative and qualitative. Second, we have examined only one state. Future research should analyze plan implementation in multiple states with varying degrees of local planning mandates. Comparative analyses would provide an increased understanding of the effectiveness of spatial planning and plan conformity in general. Third, we have evaluated plan conformity on a broad spatial scale and have not detected local variations in urban form. With such a high degree of aggregation, important local details may be lost. Further study at a finer scale and for specific wetland development clusters (for both high and low conformity) would generate additional insights into the impacts of development deviating from the original design of a plan. Case-study analysis for specific watersheds where various stakeholders are interviewed would certainly provide insights into the contextual nuances influencing the spatial pattern of development. Finally, more research is needed on the factors driving plan conformity and the degree of plan implementation. The statistical model presented in this paper is only preliminary. Additional variables should be added to the model, including the location of specific public facilities such as sewerage lines and wastewater treatment plants (analysis and/or variable creation of public facilities is currently not possible at this scale). Also, a broader range of local and regional land-use policies should be considered in order more effectively to isolate the effects of growth-management tools on plan implementation and sprawling growth patterns.

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