Landscape and Urban Planning 139 (2015) 94–103

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

Research Paper

Are state growth management programs viable tools for biodiversity conservation? A case study examining Florida local governments

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HIGHLIGHTS

- Florida county government biodiversity conservation plans are highly variable.
- Plan quality is related to local education and wealth socioeconomic variables.
- State growth management programs may not be viable tools for conservation planning.

ARTICLE INFO

Article history:
Received 2 September 2014
Received in revised form 5 February 2015
Accepted 10 February 2015

Keywords:
Local land-use planning
Conservation planning
Comprehensive plans
State growth management programs
Landscape ecology

ABSTRACT

We examined the quality of Florida's state growth management program and associated county comprehensive plans as an overall biological conservation strategy. A plan evaluation coding protocol using a conceptual framework derived from the science of conservation planning was applied to local comprehensive plan Conservation Elements to determine the extent to which county-level conservation planning met the well-accepted conceptual framework. We found a high degree of variability in the quality of conservation planning for biodiversity, which was related to political geography. The quality of plans in coastal counties was significantly higher than that of inland counties. Significant regional differences were also evident, with conservation planning quality in South Florida counties significantly higher than in Panhandle counties. Geographic differences in the quality of local conservation planning are attributable to socioeconomic differences, education of the public, and availability of resources for planners. A model selection and averaging approach based on information theory was employed to develop a predictive model of conservation planning quality of Florida local governments. The results of this study call into the question the efficacy of state growth management programs as land-use regulatory tools to stem current rapid losses in biological diversity.

1. Introduction

Biological diversity is declining worldwide (Clavel, Julliard, & Devictor, 2011). The main proximate driver of global biodiversity loss is land transformation (Vitousek, Mooney, Lubchenco, & Melillo, 1997). In the United States, most land transformation is driven by urban development (Noss et al., 2009). By 2045, cities are projected to expand by 79%, or 45 million acres in the United States, an area larger than the state of Florida (Ramalho & Hobbs, 2012). This rapid land development will result in increased habitat loss and fragmentation, furthering declines in natural systems. Accordingly, there is a pressing need to ensure that land-use policies designed, at least in part, to conserve biodiversity are as effective as possible (Beatley, 2000).

In the United States land development is primarily regulated at the local level (Bengston, Fletcher, & Nelson, 2004). City councils, county commissioners, and local planning departments influence how land is used through land-use regulations, zoning ordinances, and comprehensive plans. Given pressures to meet local economic and resource demands and accommodate property rights, the impacts of local land-use decisions on plant and animal populations and on larger ecological systems are often not considered (Burby & May, 1998). A hodge–podge of varying land usages materializes across the larger landscape when land development ensues absent coordination among neighboring local governments or across regions (Brody, 2003b). Natural systems and populations are degraded when land is divided into competing residential,

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http://dx.doi.org/10.1016/j.landurbplan.2015.02.003
0169-2046/

urban, industrial, agricultural, and natural resource uses, bisected by highways, roads, levees, and canals (Odell, Theobald, & Knights, 2003; Saunders, Hobbs, & Margules, 1991). Collectively, local land-use decisions can result in significant adverse impacts on native species and communities (Brody, 2003b).

One strategy to facilitate coordination of planning at broad scales, mitigate biodiversity loss, and contain land development is state growth management laws. Roughly a quarter of U.S. states have enacted growth management legislation, which enables states to exercise control over land-use decisions of local governments and protect natural resources (Anthony, 2004; Bengston et al., 2004). Under these programs, the state develops a comprehensive plan for future growth and development and also requires local governments to develop comprehensive land-use plans and regulations to manage land development and contain sprawl (Bengston et al., 2004). Regional and local plans must be consistent with the state vision for land development as well as with plans of other regions and local jurisdictions and are subject to state approval (Miller et al., 2009). Central to the state growth management concept is the premise that coordinating the activities of local governments and regions will ensure that land is developed in a consistent, rational way that will balance economic growth and natural resource protection (Carruthers, 2002). Because growth management laws have the potential to affect land-use decisions at ecologically relevant scales, they can be important components of the toolbox to stem the loss of biodiversity (Beatley, 2000).

Nevertheless, among the thirteen states that have enacted growth management programs, legislative frameworks vary from strong to relatively little state oversight over local comprehensive plans (Anthony, 2004; Boarnet, McLaughlin, & Carruthers, 2011); Carruthers, 2002). Moreover, with respect to environmental protection, local comprehensive plans within some of these states have been found highly variable in their content, quality, and implementation (Berke & Manta Conroy, 2000; Brody, 2003b; Brody, Highfield, & Carrasco, 2004; Brody & Highfield, 2005; Tang, 2009). Research investigating the sources of variability in local comprehensive plans shows that the content of local comprehensive plans and the degree of their implementation is a product of local sociopolitical-economic variables and urbanization pressure (Tang, Bright, & Brody, 2009), the wealth and education level of the public (Brody, Carrasco, & Highfield, 2006), the education level of planners, and the existence of state mandates requiring specific plan content (Sandstrom, Angelstam, & Khakee, 2006).

Because local land-use decisions collectively have a critical impact on larger natural systems (Beatley, 2000), understanding the extent to which biodiversity conservation is considered in local comprehensive plans, and the degree of variability among local comprehensive plans, is important to conservation efforts. Successful long-term preservation of biodiversity requires long-range land-use planning that encompasses science-based planning methodologies applied at the regional or landscape level (Knight & Landres, 2002; Noss & Harris, 1986). Coordination is necessary between conservation and land-development planning at large scales so that land uses are designed to balance human needs and ecological functioning (Beatley, 2000; Sanderson, Redford, Vedder, Coppolillo, & Ward, 2002). As the majority of the nation's biodiversity is contained on privately-owned lands, it is imperative to find ways to minimize the cumulative adverse impacts of local land-use decisions (Doremus, 2003).

One way to evaluate plans is a goals-achievement approach, where the provisions of a plan are evaluated to determine how well they achieve pre-determined goals (Brody, 2003a,c; Brody, Carrasco, & Highfield, 2003; Brody et al., 2004; Tang et al., 2009; Tang, Brody, Quinn, Chang, & Wei, 2010). In this approach, a conceptual model of a high quality plan is first developed (Brody, 2003b; Tang et al., 2009). Indicators are developed for each plan component, which are words, pieces of information, strategies, or policies that comprise the component in theory. A coding protocol is then developed to score the extent to which the indicators are included in the plan. Plan provisions are then evaluated against that conceptual model to determine how well the plan meets the theoretical criteria. These studies assume that the greater the number of indicators found in the plan, the higher the quality of the plan (Brody, 2003b).

A host of principles from conservation science have been developed for use in conservation planning (Theobald et al., 2000). Those prescriptions include, for example, criteria that prioritize species for conservation action (Lewandowski, Noss, & Parsons, 2010), guidelines to select species to represent large classes of biodiversity and which can be monitored as bellwethers of the integrity of the larger system (Noss, O-Connell, & Murphy, 1997), methods to establish quantitative conservation targets for populations and habitats through the use of empirical data and population models (Armstrong, 2005), guidelines to prioritize and plan for ecological and evolutionary processes through process models and simulations (Klein et al., 2009; Pressey, Cabeza, Watts, Cowling, & Wilson, 2007), considerations about the effective size and design for protected areas, and how to prioritize potential sites for acquisition through the use of decision-support tools (Beier, Majka, & Spencer, 2008). We evaluated the quality and variation of local government comprehensive land-use plans in Florida using a goal-achievement approach, to consider the degree to which the existing comprehensive planning framework can facilitate effective biodiversity conservation. We hypothesized that quality of land-use planning for biodiversity conservation would vary geographically in response to economic, social, and geographic attributes.

2. Methods

We selected the state of Florida and its county governments as a case study because Florida has had one of the stronger state growth-management frameworks in place since the 1980s (Dawson, 1996; Dorworth, 2011). Driven by population growth pressures, in 1984 and 1985 the state of Florida enacted growth management laws requiring state agencies, regions, and local governments to develop comprehensive land-use plans to balance economic growth with the protection of natural resources (Carriker, 2006). Local government comprehensive plans are required to include a Conservation Element, which must establish a vision and policies for conserving local natural resources and biodiversity, and which must be consistent with state natural resource and biodiversity protection goals. Local governments must also develop specific ordinances, zoning regulations, and development orders to protect natural systems by minimizing the effects of urbanization (Carriker, 2006).

Florida's 67 counties provide a large sample size for hypothesis testing. Moreover, because of the importance of regional and landscape-level planning for biodiversity conservation and because of the emphasis on regional planning in Florida's growth management program, four regions were delineated for analysis, based both on general ecological patterns and on regions created by Enterprise Florida, Inc., a public–private entity that promotes statewide economic development (Beatley, 2000; Bengston et al., 2004). The regions were (1) Panhandle, (2) North, (3) Central, and (4) South (Fig. 1).

Our conceptual model of a high-quality plan for biodiversity conservation included five plan components: (1) Biodiversity Status Assessment, (2) Goal Setting, (3) Coordination, (4) Reserve Selection and Design, and (5) Management. For each of these components we created a list of indicators, which included the methods, tools, potential activities, pieces of information, or criteria

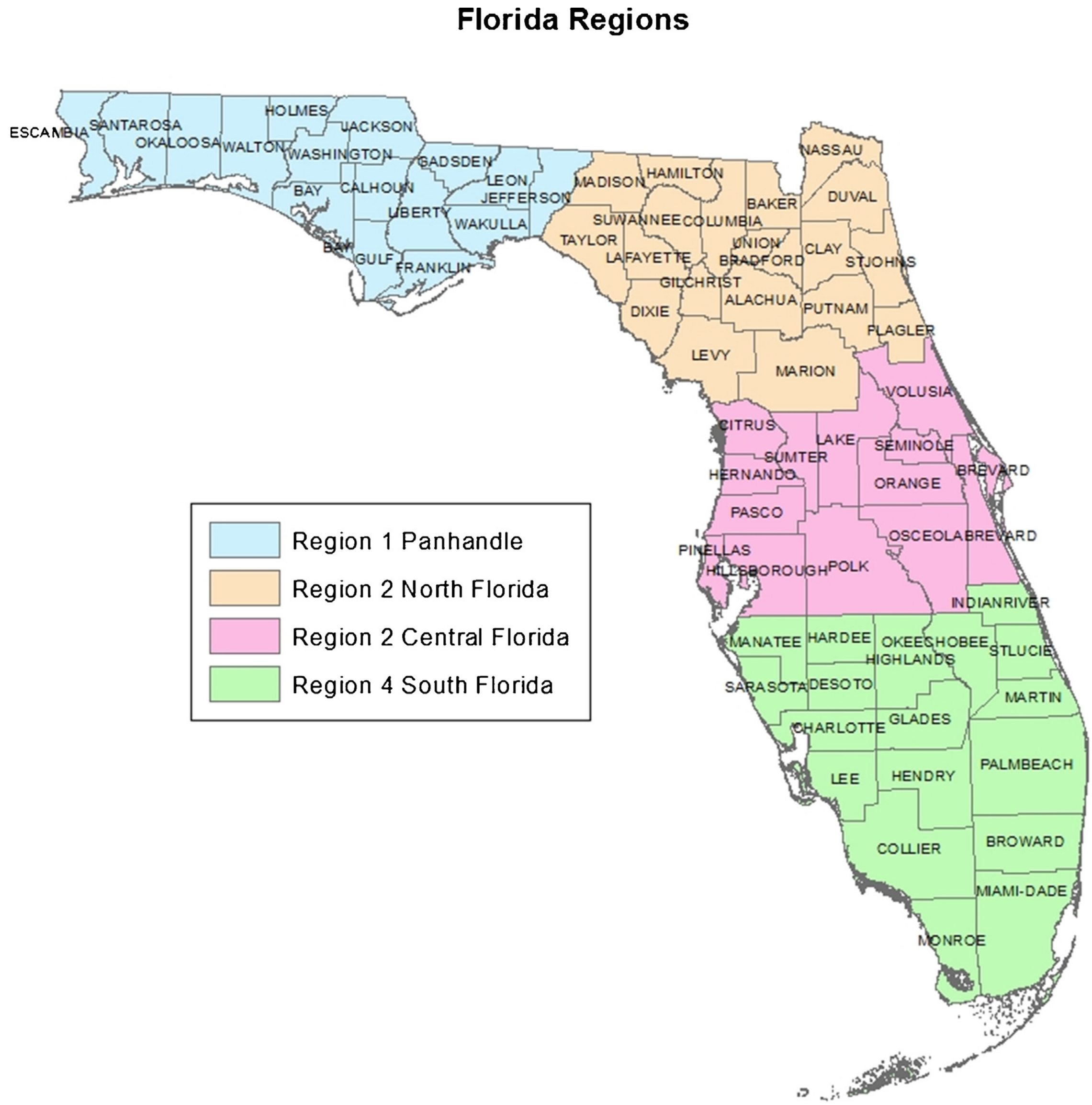

Fig. 1. Florida regions.

important in that step of conservation planning that could be applied to Florida county governments (Table 1). The list of indicators was then used to evaluate the Conservation Elements of each of the 67 Florida counties' comprehensive plans.

We obtained Conservation Elements from county web sites and reviewed each Conservation Element for the presence of each indicator. The extent to which each indicator was incorporated into the Conservation Element was scored based on the plan evaluation coding protocol employed by Brody et al. (2004). Under this protocol, we scored indicators on a 0–2 scale: 0 = the indicator is not mentioned, 1 = the indicator is mentioned but not discussed thoroughly or 2 = the indicator is fully considered. To receive a score of 1, the indicator was mentioned less than four times. To receive a score of 2, the indicator was mentioned more than four times. Where an indicator was mentioned exactly four times, we re-reviewed the context in which the indicator was discussed in the document and then determined based on context whether the indicator should be scored 1 (mentioned but not discussed thoroughly) or 2 (fully considered). All indicators were weighted equally within each plan component. The indicator scores for each plan component were summed, then divided by the total possible score for each plan component and multiplied by 10, to standardize the scores so that the total possible score for each component was 10. Next, plan Component Scores were added to derive the Total Plan Sore for each county, where the maximum possible planning quality score was 50 (5 components × total possible score of 10 for each component). Component Plan Scores and Total Plan Scores were calculated using the following equations:

$$PCj = 10 \times \left[\left(\sum_{i=1}^{mj} Ii \right) / 2mj \right] \tag{1.1}$$

$$PQ = \sum_{j=1}^{5} PCj \tag{1.2}$$

where PCj is the quality of the jth plan component (Component Plan Score), (ranging from 0 to 10), mj is the number of indicators within the jth plan component, and Ii is the ith indicator's score (ranging from 0 to 2). PQ is the quality of the total conservation planning activity of the county (Total Plan Score), resulting from the summation of plan component scores.

Total Plan Scores were used as a measure of conservation planning quality following methods established in the planning literature for evaluating planning documents (Berke & Manta Conroy, 2000; Brody et al., 2004; Tang, 2009; Tang et al., 2009, 2010).

Table 1
Conservation planning components and indicators.

Component	Indicators
Biodiversity Status Assessment	Utilize surveys
	Utilize Florida Fish and Wildlife Conservation Commission (FFWCC) data
	Utilize Florida Natural Areas Inventory (FNAI) data
	Employ spatially-explicit population models
	Employ population viability analysis
	Utilize gap analysis
	Utilize sensitivity analysis
	Utilize remote sensing data and/or vegetation analysis
	Employ Geographic Information System (GIS) data
	Utilize climate change predictive models
	Utilize sea level rise models
Goal-Setting	Represent all ecosystem or community types
	Conserve listed and imperiled species (endangered, threatened, species of special concern)
	Ensure long-term persistence
	Maintain viable populations of species
	Sustain ecological processes or function
	Sustain evolutionary processes
	Protect sensitive species, communities, or habitats
	Protect rare species
	Protect endemic or unique species or communities
	Identify and utilize focal species
	Create networks adaptable to changing environment
	Identify and quantify targets
	Select surrogates
	Protect critical areas
	Use a fine filter, coarse filter approach
	Consider multiple levels of biodiversity and species' life history requirements
	Consider different spatial scales
	Consider different temporal scales
	Prevent dynamic threats
	Increase ecosystem resilience
	Increase the acreage of protected areas and reserves
	Increase linkages
	Conserve and/or increase genetic diversity
	Assist colonizations in response to sea level rise
	Minimize threat of development and urbanization
Coordination	Engage in interjurisdictional coordination
	Engage in regional coordination
	Coordinate with private landowners
	Coordinate with planning and zoning and land use regulations
	Coordinate considering ecological instead of political boundaries
	Engage in landscape-scale coordination
Reserve Selection and Design	Utilize reserve selection algorithms
	Utilize decision support software
	Minimize fragmentation
	Consider protecting reserve of large size
	Create continuous areas of protected land
	Protect hydrology
	Protect natural disturbance regimes
	Protect edge habitats
	Protect core areas
	Create buffer areas
	Increase connectivity between protected areas
	Protect habitat that has no roads or has minimal roads
	Protect ecosystem, community and habitat heterogeneity
	Create corridors
Management	Maintain targets for individual protected areas, communities or species
	Impose human use restrictions
	Manage for evolutionary processes
	Manage for dynamic threats
	Manage for ecological processes
	Consider patch dynamics
	Consider metapopulation dynamics
	Protect dispersal, nesting and breeding
	Protect migration species and habitats used for migration
	Protect and facilitate gene flow
	Restore degraded habitats and systems
	Restrict hunting, poaching, and fishing
	Employ management techniques to mimic natural disturbances
	Manage for habitat and/or species heterogeneity
	Manage for climate change
	Manage for sea level rise
	Prevent and/or control erosion
	Translocate biota when necessary
	Increase genetic diversity
	Assisted colonizations and dispersal
	Control invasive exotics
	Conserve peripheral and disjointed populations
	Give special attention to species confined to a small portion of their range
	Employ an ecosystem management approach
	Employ adaptive management, evaluate indicators, set and evaluate performance measures to evaluate plan effectiveness
	Monitor populations, habitats, systems, and human activities
	Use natural areas for scientific research or as controls for ecosystem management

Although this methodology measures only plan provisions and cannot determine if and to what extent plans are implemented, the methodology still provides valuable information about the extent of planning for biodiversity conservation as well as the extent to which conservation science tools, methods, and criteria are being utilized, and how well science is integrated with policy. Total Plan Scores were analyzed using descriptive statistics to quantify the variability in conservation planning quality among Florida counties (SPSS version 21.0, IBM Corp. 2012). Total Plan Scores were also analyzed for spatial autocorrelation in ArcGIS 10.0, using a spatial weights matrix based on an inverse distance conceptualization of relationships (a distance-decay model). Each county's calculations considered a minimum of ten neighbors and no distance band (Lee & Wong, 2001).

We tested the hypothesis that local comprehensive land-use plans exhibit a high degree of variability in their provisions for biodiversity conservation. Because of sociopolitical-demographic and geographic differences across the state (Cohen, 2012), we hypothesized that geographic differences exist in the quality of conservation planning between Florida coastal and inland counties and between Florida counties grouped into regions. Roughly half of Florida's counties border an ocean and are heavily populated, while the other counties are land-locked and rural, supporting agriculture, ranching, and silviculture. Florida is also politically divided into the heavily populated Democratic major cities in Central and South Florida versus less populated and strongly Republican Panhandle in North Florida. Comparisons were performed using the nonparametric independent samples *t*-test and Kruskall–Wallis test. A map of conservation planning quality was produced in ArcGIS 10.0 (Fig. 2).

To understand how socioeconomic factors influence conservation planning by Florida county governments, we developed a list of variables that have been found to influence conservation and environmental protection planning in other studies, e.g. education of planners (Stokes, Hanson, Oaks, Straub, & Ponio, 2010); resources available to planners (Sandstrom et al., 2006); state mandates (Bengston et al., 2004; Sandstrom et al., 2006); wealth (Kline, 2006); urbanization pressure (Kartez & Casto, 2008); stakeholder involvement (Theobald et al., 2000); education and environmental values of the public (O'Connell, 2008); and political affiliation (Press, 2003). These factors fell into four general categories: (1) demographics, (2) resource availability, (3) collaboration on

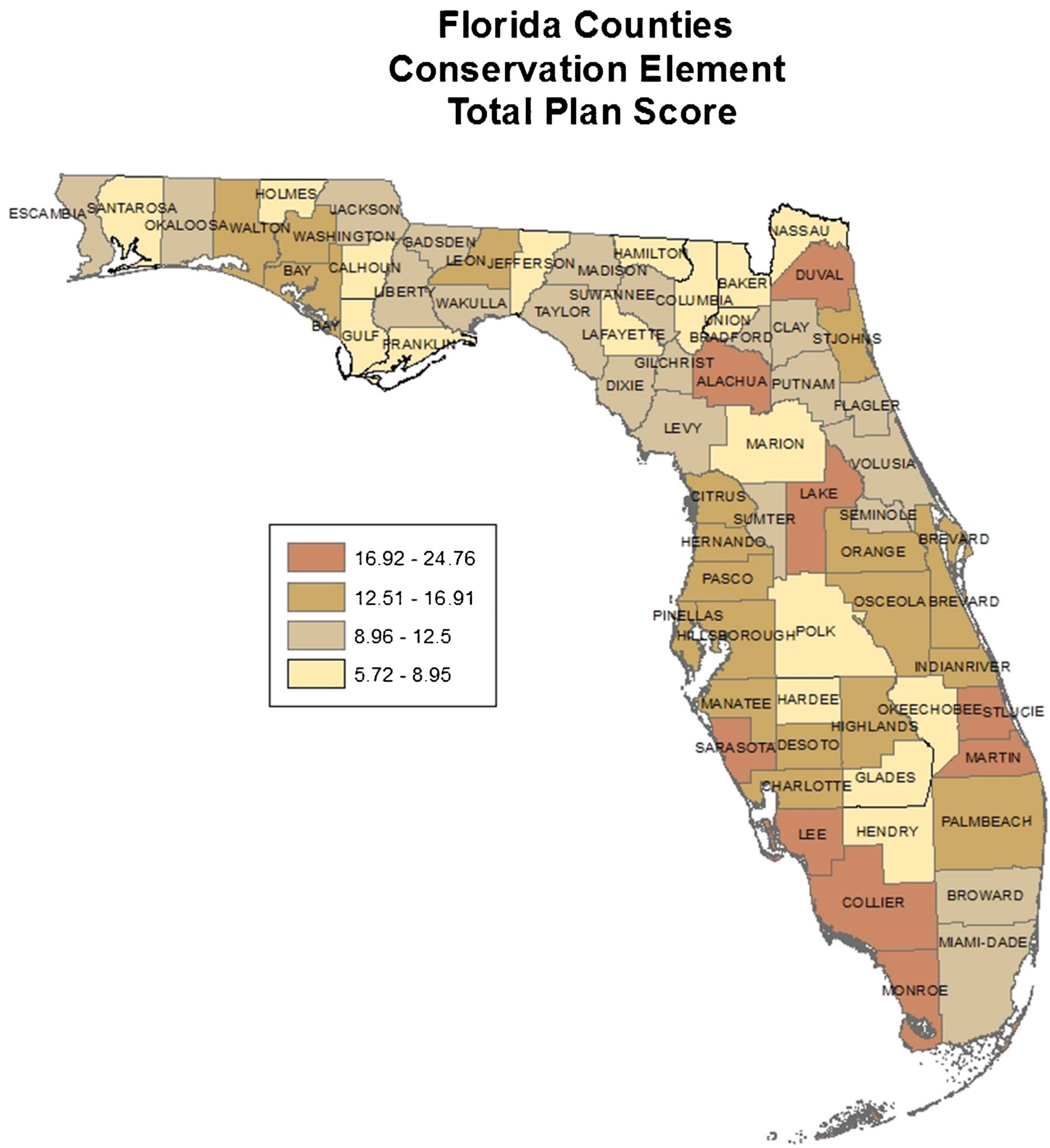

Fig. 2. Total Plan Scores for 67 counties in Florida showing four different levels of conservation planning quality out of a possible 50 points based on natural data breaks.

biodiversity issues, and (4) recognition of legislative mandates. We then researched U.S. Census and state data sources for current data on Florida's counties for each of these variables. Variables from each of these categories for which county data were available were selected as indicators. Categories, the variables selected as indicators for each category, their measurement, and the data sources for those indicators are listed in Table 2. Data for each variable were collected for each of Florida's 67 counties.

Data that were not available from U.S. Census or state data sources were acquired through a survey questionnaire sent to the planning departments of all 67 Florida counties in October 2012. The survey questionnaire was divided into four categories: (1) general position on the value of conservation of nature (values), (2) resource availability, (3) collaboration, and (4) mandates. To prepare survey data to be incorporated with other independent variables in multiple regression analysis, missing values for item non-response due to "don't know," "not applicable" and blank responses were imputed into five multiple imputation datasets in SPSS. The questions presented for each survey category are shown in Table 3. Results from the five imputation datasets were averaged for each survey category (values, resource availability, collaboration, and mandates) resulting in a total score containing imputed values for each category (total values, total resource availability, total collaboration, total mandates). Next, the survey total category scores and socioeconomic variables acquired from U.S. Census and Florida state records were analyzed for descriptive statistics and for significant differences between coastal and inland counties and between regions after verifying assumptions of the tests and addressing multicollinearity eliminating some variables to avoid correlations >0.75. Survey results are in Appendix A.

We next developed a theoretical model of the factors influencing Florida county government conservation planning quality, where the four categories of socioeconomic factors identified above were independent variables and county government

Table 2
Variables selected as potentially influencing Florida county conservation planning. Variable definitions are described in the Supplement.

Variable	Measurement	Scale	Data source
Demographics			
Wealth	Median household income 2011	Continuous	2011 American Community Survey (U.S. Census Bureau)
	Total county revenues	Continuous	FL EDR
Education	Percentage of persons age 25 or older with a bachelors degree or higher 2010	Continuous	FL EDR
Population density	Persons per square mile 2012	Continuous	FL EDR
Political affiliation	Percent registered voters Republican Percent registered voters Democrat	Continuous	FL DE
Value of nature	Total value of nature conservation	Continuous	Survey
Urbanization	Percent change number of housing units 2000–2011	Continuous	FL EDR
	Percent population growth 1980–2012	Continuous	FL EDR
Resource availability			
Conservation lands	Percent of county land area as conservation lands in 2011	Continuous	FNAI
	Percent of county conservation lands owned or managed by county in 2011	Continuous	FNAI
	Percent of county land area is state and/or federally owned or managed conservation lands in 2011	Continuous	FNAI
Total resource availability	Total county conservation planning resources	Continuous	Survey
Collaboration on biodiversity issues			
With all groups	Total collaboration	ContinuousSurvey	
Existence of mandates			
Recognition of conservation mandate	Total county recognition of state mandates for conservation planning	Continuous	Survey

Table 3
Survey questions the responses to which were summed for each category to produce a total category score for each county.

Values category questions
1. How would you rank “Preserve native species and habitats” in terms of its importance in land-use planning in your county?
2. How would you best characterize land-use planning for conservation of nature (native species and habitats), as a part of land-use planning overall in your county?
3. How important is it for planners in your county to have education and training in conservation planning (land-use planning methods to ensure the representation and long-term preservation of plants, wildlife, and their habitats) to perform their job?
4. How would you best describe the conservation values of the public in your county?
5. When land-use planning decisions designed to avoid loss of native species and habitats are made in your county, how would you best characterize those decisions?
6. Where proactive land-use plans for the conservation of nature (native species and habitats) have been developed in your county, how often have those plans been implemented?

Resource Availability category questions
1. What is the size of the planning staff in your county, including planners and support staff?
2. Does your county provide training, funding, or other active opportunities for planners to learn about conservation planning (land-use planning methods to ensure the representation and long-term preservation of plants, wildlife, and their habitats)?
3. To the best of your knowledge, how well are most planners in your county trained in conservation planning (land-use planning methods to ensure the representation and long-term preservation of plants, wildlife, and their habitats)?
4. Are there currently one or more people employed by the county who are conservation specialists or biologists with specific knowledge of conservation science, and who are employed to utilize this knowledge in conservation planning?
5. Does your county have a department, agency, or program responsible for acquiring conservation lands?
6. Does your county have a department or agency responsible for managing conservation lands?
7. Which of the following best characterizes the nature of funding for conservation lands purchases in your county since the 1980s?
8. Which of the following best characterizes the nature of funding for conservation lands management in your county since the 1980s?
9. How aware are planners of the availability of the following types of biological information, and how often are they used by planners and/or others assisting planners in developing land-use plans?
10. How aware are planners of the availability of the following sources of biological information, and how often are these information sources consulted by planners in developing land-use plans?
11. How aware are planners of the availability of the following resources for incorporating biological information into land-use plans, and how often are they used

Collaboration category questions
1. To the best of your knowledge, how often do the parties listed below collaborate on developing land-use plans to conserve native species and habitats?

Mandates category questions
1.To the best of your knowledge, do federal and/or state laws currently require local governments to develop land-use plans to conserve and protect native species and habitats within the local government’s jurisdiction?
2. To the best of your knowledge, do federal and/or state laws currently require local governments to work together to plan for development in such a way that will conserve and protect native species and habitats within the two or more local governments’ jurisdictions?

conservation planning quality (Total Plan Score) was the dependent variable. Ordinary least squares multiple regression analysis was used to determine which independent variables were statistically significant. Diagnostic tests were then run to assess model fit (Field, 2000). We employed model selection based on maximum likelihood and information theory to develop a predictive model of Florida county conservation planning quality. Eight alternative models were evaluated using Akaike’s information criterion

Table 4
Candidate models for Log Total Plan Score. Model selection was based on second-order Akaike's Information Criterion differences (ΔAICc) among models.

Model	Model description	Number of parameters in model K	$AICc_i$	Δ_iAICc	w_iAICc
1	Pct bachelors degree + log total county revenue + total resources: $d_3 + d_2 + r_4$	3	14.57	0	0.3731
2	Pct bachelors degree + total resources: $d_3 + r_4$	2	15.3350	0.765	0.2545
3	Pct bachelors degree + total resources + log pct conservation lands county-owned + total collaboration: $d_3 + r_1 + r_2 + c_1$	4	15.3355	0.766	0.2544
4	Pct bachelor's degree + log total county revenues + total resources + log pct conservation lands county-owned + total collaboration: $d_3 + d_2 + r_4 + r_2 + c_1$	5	16.88	2.31	0.1175
5	All resource availability variables: $r_1 + r_2 + r_3 + r_4$	4	25.70	11.13	0.0022
6	All demographic variables: $d_1 + d_2 + d_3 + d_4 + d_5 + d_6 + d_7 + d_8 + d_9$	9	31.40	16.83	0.0001
7	All parameters: $d_1 + d_2 + d_3 + d_4 + d_5 + d_6 + d_7 + d_8 + d_9 + r_1 + r_2 + r_3 + r_4 + c_1$	14	38.71	24.14	0.0000
8	All collaboration variables: c_1	1	46.11	24.14	0.0000

Table 5
Composite model estimates, standard errors, and 95% confidence interval.

			95% CI	
Parameter	Estimate	SE	Upper	Lower
Intercept	1.499	0.6838	2.1328	0.7651
Total resources	0.003	0.0007	0.0037	0.0022
Percent bachelor's degree	0.015	0.0101	0.0251	0.0048
Log total county revenue	0.054	0.0604	0.1144	−0.0064
Total collaboration	−0.007	0.0078	0.0008	−0.0148
Log percent conservation land county-owned	0.027	0.0351	0.0621	−0.0081

corrected for small sample size (AICc) (Wagenmakers & Farrell, 2004). We compared eight candidate models based on the variation in AICc of each model (ΔAICc) relative to the lowest AICc model. Models with ΔAICc < 10 were selected as the most plausible (Burnham & Anderson, 2004) (Table 4). We computed normalized relative likelihoods, or Akaike weights, for each model to evaluate the weight of evidence in favor of each model (Wagenmakers & Farrell, 2004). A confidence set of three models was selected, (which included the model with the highest AICc weight and two models that had Akaike weights within 10% of the highest weight model), and compared using model evidence ratios (Burnham & Anderson, 2004). We then calculated importance weights for individual parameters in the confidence set of models using Akaike weights to estimate the relative importance of each covariate.

We used AIC model-averaging to weight the parameter estimates and variances and combine them in a composite model. Finally, model-averaged standard errors and confidence intervals were calculated and reported with the composite model parameters and coefficients (Table 5) (Burnham & Anderson, 2004). SPSS version 21.0 and JMP version 10.0 (SAS Institute) were used for statistical analysis.

3. Results

Total Plan Score had a mean of 12.30 (SD = 4.29) out of a possible score of 50, ranging from a low of 5.72 (Holmes County) to a high of 24.76 (Alachua County). We divided counties into four groups representing quality of conservation planning based on natural breaks in the Total Plan Score data: Very High quality (scores 16.92–24.76, $n = 9$), high quality (scores 12.51–16.91, $n = 19$), medium quality (scores 8.96–12.50, $n = 21$), and low quality (scores 5.72–8.95, $n = 18$) (Fig. 2). The majority of Very High quality scores (77.7%) and High quality scores (68.4%) occurred in coastal counties. The majority of low quality scores occurred in inland counties (72.2%). The overall spatial relationship of all of the counties for Total Plan Score was statistically clustered and globally spatially autocorrelated (Moran's $I = 0.045$, $p = 0.010$).

Differences in Total Plan Score between coastal (mean = 13.58, SD = 4.06) and inland counties (mean = 2.33, SD 0.33) were significant ($t(-16.35) = 34.50$, $p < 0.001$, logarithmically transformed data). The results of the Kruskall–Wallis test indicated significant differences also in Total Plan Score median ranks among regions ($H = 12.37$, 2 df, $p < 0.001$). Pairwise comparisons of regional Total Plan Score data were computed via Mann–Whitney U tests with a Bonferroni correction (0.05/6 possible comparisons = 0.008) to maintain the overall probability of a Type I error at 0.05. Significant differences in Total Plan Score were detected between the Panhandle region and South Florida ($U = 61$; $p = 0.004$).

Inland and coastal counties differed significantly for nearly all demographics category variables. Coastal counties had significantly higher median household incomes (inland median: $41,288.00, coastal median: $ 48,225.00, $U = 230.00$, $p = 0.001$) and total county revenues (in $thousands) (inland median: $58,052.50, coastal median: $341,055.00, $U = 243.00$, $p = 0.002$). Coastal counties also had significantly higher educated populations than inland counties (in percent bachelor's degree or higher) (inland median: 12.4%, coastal median: 25%, $U = 206.00$, $p < 0.001$) and population densities (in persons per square mile) (inland median: 58.95, coastal median: 277.30; $U = 261.00$, $p = 0.004$). Coastal counties also had significantly higher total value scores than inland counties ($t(45) = -2.129$, $p = 0.039$).

Significant differences in several demographics variables were also found for Florida regions, including differences in total county revenues ($H = 22.233$, 3 df, $p < 0.001$), percent bachelor's degree ($H = 7.810$, 3 df, $p = 0.050$), persons per square mile ($H = 19.645$, 3 df, $p < 0.001$), percent population growth 1980–2012 ($H = 10.226$, 3 df, $p = 0.017$), and total values ($F(3,30) = 3.74$, $p = 0.016$). The Panhandle region had significantly lower total county revenues than Central Florida ($U = 14.00$, $p < 0.001$) and South Florida ($U = 37.00$, $p = 0.001$), and North Florida also had lower total county revenues than Central Florida ($U = 27.00$, $p < 0.001$) and South Florida ($U = 67.00$, $p = 0.007$). Regional differences in percent bachelor's degree were not significant at the $p = 0.008$ threshold level. Panhandle and North Florida had significantly fewer persons per square mile than Central Florida (Panhandle: $U = 16.00$, $p < 0.001$; Central Florida: $U = 21.00$, $p < 0.001$). The Panhandle also had significantly lower percent population growth than Central Florida from 1980 to 2012 ($U = 33.00$, $p = 0.004$) and significantly lower scores for total values than South Florida (Tukey HSD; $p = 0.031$).

Coastal counties had significantly higher total resources scores than inland counties ($t(30) = -3.02$, $p = 0.005$). Significant regional differences also occurred in total resources scores between the Panhandle and South Florida ($F(3,28) = 3.35$, $p = 0.033$; Tukey HSD

$p = 0.021$). The Panhandle had a significantly lower percentage of conservation land that is county-owned (median = 0.06%) than Central Florida (median = 6.8%) ($U = 30.00$; $p = 0.002$).

Coastal counties had significantly higher total collaboration scores than inland counties (inland mean = 37.30, SD = 10.80; coastal mean = 43.48, SD = 8.52; $t(52) = -2.34$, $p = 0.023$). No significant differences existed among regions in total collaboration score data, however ($F(3,50) = 0.15$, $p = 0.927$). Total mandates score data were not significantly different between inland and coastal counties (inland median: 4, coastal median: 4; $U = 325.5$, $p = 0.787$) or between regions ($H = 0.75$, 3 df, $p = 0.862$).

The most informative regression model ($R^2 = 0.455$, $F = 24.240$, $p < 0.001$) included total resources and percent bachelor's degree:

$$\log \text{total plan score} = 1.644 + 0.003\,(\text{total resources}_i) + 0.018\,(\text{percent bachelors degree}_i)$$

Total resources and percent bachelor's degree contribute significantly to the outcome (total resources: $t = 3.837$, $p = 0.000$; percent bachelor's degree: $t = 4.358$; $p = 0.000$), though percent bachelor's degree (*standardized* $\beta = 0.444$) is somewhat more important of the two (total resources *standardized* $\beta = 0.391$). Both predictor variables had variance inflation factors under 1.2, and the tolerance statistic for both predictors was 0.906 or less (Field, 2000).

Models 1–3 had Akaike differences (Δ_iAICc) < 2, indicating substantial support for those models (Table 4). With an AICc difference (Δ_iAICc) of 2.31, there was somewhat less support for Model 4. All other models had Δ_iAICc above 10, indicating they were not plausible explanations for the outcome variable (Burnham & Anderson, 2004). Furthermore, considering Akaike weights, the probability of Model l was 37%, while the probabilities of Models 2 and 3 were each 25%. The evidence in favor of the other models was much weaker.

Examination of evidence ratios revealed the strongest support for Models 1–3. The evidence ratio for Model 1 compared to Model 2 was 0.37/0.25 = 1.48. Because the Akaike weights were nearly identical for Models 2 and 3, Model 1 was also approximately 1.48 times stronger than Model 3. The evidence ratio for Model 1 versus Model 4 was 0.37/0.12 = 3.08. Models 1, 2 and 3 were retained as the confidence set of models (Burnham & Anderson, 2004).

Importance weights indicated that total resources and percent bachelor's degree were the most plausible explanations for the response variable. Both of these were (0.882/0.3731 = 2.36) 2.36 times more likely explanations for the outcome than the log-transformed total county revenue predictor, and (0.882/0.2544 = 3.47) 3.47 times more plausible than total collaboration and log-transformed percent conservation lands county-owned. However, the parameter estimates differed in the three confidence set models. To determine the reliability of the parameter estimates for each confidence set model, we examined the standard errors of the parameter estimates. None of the parameter estimates had standard errors that were large (greater than 2× the parameter estimate) (Burnham & Anderson, 2004).

We calculated model-averaged parameter estimates for the three confidence set models to obtain a composite model. The composite model for log-transformed Total Plan Score has the following parameters:

$$\begin{aligned}\log \text{total plan score} = {} & 1.499 + 0.003\,(\text{total resources}_i) \\ & + 0.015\,(\text{percent bachelors degree}_i) \\ & + 0.054\,(\text{log total county revenues}_i) \\ & - 0.007\,(\text{total collaboration}_i) \\ & + 0.027\,(\text{log percent conservation} \\ & \text{land county} - \text{owned}_i) + \text{error}\end{aligned}$$

We calculated the model selection variance (MSV). Model selection variances were then used to calculate unconditional standard errors for the model-averaged parameters in the composite model. The unconditional standard errors (SE) are reported with 95% confidence intervals for each model-averaged parameter below (Table 5) (Burnham & Anderson, 2004).

4. Discussion

Our results indicate that local socioeconomic factors strongly correlate with the content of local comprehensive plans, resulting in variability in local plan quality. Our study was novel in evaluating such variability in the context of a conceptual model of planning developed from conservation science. Conservation planning quality was highly variable among Florida counties. Conservation science principles for biodiversity preservation are strongly incorporated into local government conservation planning in counties in Very-High and High-quality Total Plan Score tiers and only weakly incorporated into conservation planning quality in Middle-and Low-quality Total Plan Score tiers. High-quality tier scores occurred primarily in wealthy, heavily-populated coastal counties on both sides of the peninsula. Low-quality tier scores occurred in largely rural, low-density counties in inland peninsular Florida, North Florida, and throughout the Florida Panhandle. Plan Scores were significantly higher for coastal counties than inland counties, and South Florida had significantly higher scores than the Panhandle.

The socioeconomic variables statistically correlated with the quality of the Conservation Elements were education level of the public, availability of resources for planners, and total county revenues. Education and the availability of resources for planners were the strongest predictors of conservation planning quality. These predictors have tight confidence intervals, indicating that the model reflects accurate relationships between these predictors and the outcome variable. However, the total resources parameter was more informative than percent bachelor's degree.

High education level has been associated with high-quality environmental protection and land-use planning in other studies (Kline, 2006; Stokes et al., 2010). Highly-educated populations are more knowledgeable about environmental issues than less well-educated populations and have a corresponding high likelihood of supporting actions that protect biodiversity and the environment (Robelia & Murphy, 2012). In this study education levels were significantly higher for coastal counties than for inland counties, as were total (conservation) values scores. Central and South Florida had significantly higher education levels than North Florida counties, and South Florida had a significantly higher total values score than the Panhandle.

Availability of resources for planners has also been identified as a key factor correlated with the quality of local land-use plans for biodiversity conservation (Miller et al., 2009; Stokes et al., 2010). The availability of resources for planners is, in part, a function of financial resources, as wealthy jurisdictions have the ability to support large and well-equipped planning departments (Brody et al., 2004). In this study, coastal counties had significantly higher overall total county revenues (in thousands = $341,055) than inland counties (in thousands = $58,052), and significantly higher total resources scores (coastal mean = 148.06) than inland counties (inland mean = 104.21). Greater financial resources translate into funding for conservation lands acquisition and management, informational materials, continuing education for conservation planning, staff expertise, and planning staff size. Similarly, Central and South Florida have significantly higher total county revenues (Central Florida in thousands = $635,200; South Florida in $thousands = $359,313) than the Panhandle (in thousands = $40,305) and North Florida (in thousands = $56,578); South Florida has a significantly higher total resources score than the Panhandle (Panhandle mean = 117.7; South Florida mean = 150).

County conservation planning quality has a spatial component. Total Plan Scores were non-independent of one another, indicating that political geography is influencing the variability in conservation planning quality. Mean regional Total Plan Scores increased progressively from the north to the south of the state (Panhandle Region 1 mean = 10.12; North Florida Region 2 mean = 11.17; Central Florida Region 3 mean = 13.89; South Florida Regions 4 mean = 14.33), and significant differences were found between Regions 1 and 4, which are the furthest apart.

A well-recognized tenet of policy theory, known as policy transfer or diffusion, is that actors in neighboring jurisdictions often borrow policies from one another (King & Mori, 2007). Neighboring jurisdictions have been found to have more similar public policies than jurisdictions that are more distant because governments with social, political, and economic similarities often develop "like-mindedness" (Cho & Nicley, 2008). Like-minded counties may have a greater propensity to adopt the policy provisions of neighboring counties (diffusion) because of their shared context, whereas counties with disparate socio-demographic conditions may adopt very different policies (negative diffusion) (Berry & Berry, 2007). The differences between the Panhandle and South Florida in conservation planning quality therefore may be a result of policy diffusion processes influencing the selection and adoption of information, methodologies, and activities set forth in the Conservation Element.

Based on these results, we call into question the efficacy of Florida's state growth management program as a land-use planning tool for biodiversity conservation. Local socioeconomic-political variables currently appear to be the main drivers of conservation-related planning in Florida, rather than landscape ecology, conservation science, or broad state goals related to conservation. The main premise underlying state growth management programs is that states can effectively limit the autonomy of local governments through state mandated coordination and consistency in land-use planning and policy (Carruthers, 2002). However, it is also well-recognized that state growth management programs lacking adequate incentives, strong consistency, and enforcement mechanisms are largely ineffective in containing land development and reducing sprawl, and may even increase low-density development patterns (Boarnet et al., 2011). For biodiversity conservation, strong consistency and enforcement is even more critical because of the spatial mismatch between the local scale of land-use planning and the landscape and regional scale of most natural processes relevant to biodiversity. Moreover, because biodiversity preservation is often a low priority for local governments, in many cases biodiversity data and conservation goals are only marginally incorporated into local land-use plans to meet minimum state requirements (Miller et al., 2009; Stokes et al., 2010), or as a reactionary measure only after biodiversity has been seriously degraded (Berke, 2007; Brody, 2003a). To be effective for biodiversity conservation, then, state growth management laws must ensure a high degree of consistency in the goals, methodologies, and strategies employed for biodiversity conservation across jurisdictions to produce the desired landscape and regional scale outcomes on which biodiversity preservation depends (Berke, 2007; Carruthers, 2002; Moilanen & Arponen, 2011).

5. Conclusions

The variability in local land-use planning for biodiversity preservation reflected in this study for Florida is concerning. Of the public policies available for protecting biological diversity and natural systems, land-use regulation is the only policy that can be applied across broad landscapes, regions, and natural ecological systems to systematize land usage (Bengston et al., 2004). Conceivably, if state growth management approaches are not strong enough to induce uniformity and consistency in how local jurisdictions approach land-usage, these policy instruments may not be successful in reducing sprawl and stemming the rapid declines in biodiversity across the United States. Given that only 25% of U.S. states have enacted growth management laws, and those state growth management programs that exist vary in the strength of their mandates and enforcement mechanisms, it is unlikely that broad-scale biodiversity conservation can be successfully achieved by state growth management laws. It has been suggested that a federal role in land-use regulation may be necessary to better strengthen and coordinate local, state, and national biodiversity conservation efforts or provide greater funding to increase planning capacity (Bengston et al., 2004). Other strategies that have been proposed to address unbridled land development are better training for planners in landscape ecology, increased, regular funding for landscape ecology research and application in biodiversity conservation, increased ecological literacy of the public, education about the human benefits of biological diversity, better coordination among different levels of government and different agencies, increased use of conservation science in decision-making, and recognition and action on the part of policy-makers to address the fundamental causes of land transformation, which are population growth and excessive consumption (Klein et al., 2009; Noss et al., 2009; Stokes et al., 2010).

We did not analyze the extent to which the goals and strategies set forth in local government Conservation Elements are actually implemented or the quality of that implementation. Possibly, in some counties, conservation actions are not implemented to the extent they are set forth in local comprehensive plans. Conversely, it is also possible that some counties engage in biodiversity conservation measures that exceed comprehensive plan requirements, especially if they are collaborating with other entities, for example, private landowners and nongovernmental organizations. Studies are needed to evaluate plan implementation to understand the extent to which plans for biodiversity conservation are translating into conservation actions that will ensure long-term biodiversity persistence. Nonetheless, this study provides insights about the degree to which counties are envisioning biodiversity conservation and incorporating conservation science principles into local comprehensive plans. Moreover, given the legally-enforceable nature of county comprehensive plans, there is a high likelihood that once provisions are set forth in plans, local governments will take steps to create the necessary land-use regulations to enact those provisions (Brody, 2003b; Brody et al., 2004).

Finally, additional variables may influence conservation planning quality that were not examined in this study, including the influence of various stakeholders involved in the planning process, the degree of influence of special interest groups on local land-use policy, local government structure, and perhaps other demographic variables such as religion. Nevertheless, the strong results we found for the influence of socioeconomics on the quality of local government land-use plans have important implications for improvements in policy and law to better protect nature in the face of human population and economic growth.

Florida's current growth management laws may be inadequate for protecting native species and natural communities. As Florida's growth management laws have been recognized as some of the stronger laws among the thirteen states that have adopted such legislation, the results here raise concerns about the efficacy of other state growth management programs for protecting biodiversity. To further evaluate the effectiveness of current growth management laws in Florida and elsewhere, research is needed to determine how variability in local conservation planning impacts native species and communities. Studies using data on species' populations are needed to determine if variability in local conservation planning affects different types of species in different ways. Ecological studies taking life history characteristics into account, and considering dispersal, migrations, patch dynamics, and ecological and evolutionary processes are needed to understand how variability in conservation planning among county governments will affect biodiversity persistence.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.landurbplan.2015.02.003.

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