CONSERVATION IN A FULL WORLD: EXPLORING THE RELATIONSHIPS AMONG LAND USE POLICY, HUMAN COMMUNITIES, AND ECOLOGICAL INTEGRITY IN THE NORTHERN FOREST

By

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ABSTRACT

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The question of how to use land use policy to meet conservation goals has never been more salient. Conservationists have tried a variety of policy tools to slow the loss of biodiversity, but the effectiveness and unintended consequences of these tools have rarely been tested. In a time when wildlife and humans increasingly share the landscape, it is important to understand which policies are successful at conserving biodiversity, and what effects those policies have on adjacent human communities. This research is aimed at understanding the effects of regional land use policy on human and ecological communities. In this dissertation, I investigate the outcomes of two large-scale policy approaches in rural mixed-use regions in the United States.

I assessed differences in biodiversity and human wellbeing associated with each of these large-scale policy approaches, including accounting for the effects of more traditional land use tools such as public land and zoning. I compared biodiversity and wellbeing outcomes first at the regional scale, in order to understand the effects of large-scale policy, and then at the township scale to quantify the effects of forest cover, development, public land, and zoning. I further examined the factors that make a conservation policy successful, and evaluated the possible outcomes for biodiversity under each large-scale policy approach for future scenarios of economic and political change.

Important findings from this research include 1) Restrictive regional land use policy was not associated with increased biodiversity in the regions I analyzed; 2) Restrictive regional and use policy was associated with somewhat increased metrics of human wellbeing; 3) The effects of public land and zoning on both biodiversity and human wellbeing were highly dependent on the regional context, and;

4) More restrictive regional land use policy is associated with decreased biodiversity loss in most future scenarios. These finding suggest that more restrictive regional land use policy does not harm human communities, but is likely to lessen or prevent biodiversity loss in comparison with regions that do not have this kind of restrictive policy. Top-down, restrictive land use policy thus represents the possibility of a win-win situation for rural regions: it appears to promote human wellbeing through a variety of mechanisms while also making a region's wildlife community more resilient to economic and political change.

For my grandmothers and my nieces

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Prologue

"There are no new places to go anymore. The land is full. We have to stay where we are, take care of what we have. There isn't going to be anything else." –Edward Abbey

In the 21st century United States, the world is full and getting fuller. Human fingerprints are everywhere, from construction to climate change, and demand for land is not slowing down. In this environment, conservation of biodiversity represents a unique challenge. Biodiversity is owned by no one and everyone, and is difficult to value in an economic sense (Chee 2004, Hein et al. 2006, Thompson and Starzomski 2007). Biodiversity conservation necessitates the conservation of land, and in a full world, land is nearly always in demand for some other use. Therefore, use of land for conservation purposes typically represents a trade-off between conservation and other uses (McShane et al. 2011). This trade-off gives rise to the frequently-repeated claim that prioritizing conservation of biodiversity places nature over people (Porter et al. 2009, Casperson 2012, Miller 2012). Land is not only valued for the wood or agricultural products it produces, but also for the tax revenue it creates or the jobs it supports. Reserving land for conservation means forgoing those benefits, with possible negative effects on the surrounding communities.

Because in a full world, there *are* surrounding communities. Nature and people are not as separate as many scholars used to think. Large tracts of land that can be reserved for conservation with no thought as to human inhabitants or neighbors are vanishingly rare; instead, significant conservation needs to be accomplished on lightly-settled landscapes, where towns and open space are interspersed, and where lands are at risk of conversion (Baldwin et al. 2009). If conservationists can pick apart the factors that make conservation on these landscapes successful, and if we can understand those factors' impacts on human communities, we might be able to find a way to balance all uses on these rural, multiple-use landscapes.

Despite the controversies that sometimes arise over land use, much of United States society seems to agree that conservation of some type is a worthy goal (Anderson 2017). Conservation is usually accomplished through the policy process, in which societal values can be expressed through non-market means (Song and M'Gonigle 2001, Purdy 2015). But how much conservation, and at what cost? These questions are the source of controversy. Restrictive land use policy is one answer. However, balancing conservation with human uses requires that policy not be overly restrictive. So how much is enough? And which policies are the right ones to accomplish conservation without overly burdening human stakeholders?

Two regions in the Northern Forest of the United States provide us with a natural experiment to answer these questions. In one region, New York's Adirondack Park, society has decided on one of the most restrictive sets of land use policies in the United States (Porter et al. 2009). In the other, Michigan's Upper Peninsula, a patchwork of management approaches have evolved over time (Dempsey 2001). The two regions have many ecological, economic, and demographic similarities. By comparing outcomes between regions, we can start to understand the effects that land use policy has had on people and wildlife. If land use policy truly represents a trade-off between people and nature, we would expect that the region with more restrictive land use regulations would be higher in biodiversity and lower in human wellbeing as compared to the region with fewer restrictions.

The goal of this research was to understand the ways in which land use policy affects human and non-human communities on multi-use landscapes. I tested the effects of different land use policies on bird community diversity and on several aspects of human wellbeing in two regions, and extrapolated from current patterns of biodiversity and wellbeing into future patterns. At the regional level, I evaluated whether a region-wide approach to policy resulted in different outcomes for human and non-human communities than a more piecemeal approach. At the township level, I tested whether the effects of public land and zoning varied based on the regional approach. The results of my research are presented in three chapters.

In the first chapter, I investigate the relationships among land use policy and biodiversity using bird community diversity as a reference. More restrictive land use policy is often thought to result in higher biodiversity, but this claim has rarely been tested on the combinations of policies often present on mixed-use landscapes. Land use policy is often made at multiple scales that may cover similar locations, so to understand the full effects of policy it is necessary to evaluate biodiversity as it relates to each specific policy context. My objectives in this chapter were to (1) test whether a region-wide, top-down approach to land-use policy results in higher biodiversity as compared to the more typical laissez-faire approach, and (2) evaluate the effects of public land and zoning on biodiversity under each approach to regional level policy.

In the second chapter, I investigate the relationships among land use policy and several aspects of human wellbeing. More restrictive land use policy is often claimed to be detrimental to human communities, but this claim has also rarely been tested, especially across multiple dimensions of wellbeing. Understanding whether land use policy in reality produces a trade-off between human and ecological wellbeing requires evaluation of wellbeing on landscapes where human and non-human uses are meant to coexist. My objectives for this chapter were to (1) evaluate whether human communities are significantly worse-off in a region with more stringent land-use regulations and (2) test if the presence of public land and zoning laws have a detrimental effect on human wellbeing under each approach to regional level policy.

In the third chapter, I review the aspects of effective land use policy, both in terms of biodiversity conservation and community acceptance and compliance. The hallmarks of effective land use policies are often similar across space and time. I also use a qualitative technique, scenario planning, to evaluate the resilience to change of ecosystems under the two regional policy paradigms investigated in the first two chapters. The objectives of this chapter were to 1) Identify common characteristics of effective land use policies and 2) analyze likely effects of land use policies under future social and ecological change.

These chapters provide a step forward in understanding how to best make land use policy that effectively conserves biodiversity into the future, while not harming the human communities that also occupy the land. The research presented here addresses perennial questions about the trade-offs between conservation and human interests. By untangling the effects of different kinds of policy, we can better fit our approach to management on landscapes so that human communities and conservation can continue to coexist.

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Chapter 1: Land use policy and biodiversity in two Northern Forest regions

INTRODUCTION

In recent decades, conservation planners in the United States have gone big. Recognizing that individual parks and reserves are insufficient to conserve biological diversity and ecological processes, conservation planning has more often happened at the level of the region, the watershed, or the state (Groves et al. 2002, Baldwin et al. 2018, Cheok et al. 2019). Organizations dedicated to ecosystem conservation across traditional political boundaries have proliferated, and approximately 13 of the U.S. states have state-level growth-management plans in place (Pannozzo et al. 2015). States that have comprehensive land use regulations have been shown to be more effective at conserving open space than states without them (Nelson 1999, Carruthers 2002, Boyle and Mohamed 2007).

At the same time, conservation organizations are pushing for an expansion of protected lands worldwide (Convention on Biological Diversity 2011). Protected lands are widely understood to contribute to conserving biodiversity, open space, and other ecosystem services, and are usually owned by the public, making it easier for governments to regulate what activities can happen there. Both regional-level land use planning and protected areas represent efforts on the part of governments to ensure that some land stays undeveloped. However, both land protection and regional conservation planning have been controversial in the United States, where land use policy is traditionally made on the local level (Godschalk 2004, Golding 2012, Miller 2012). While proponents of conservation-focused land use policy point to the need to conserve common property resources, skeptics worry about government overreach and infringement on private property rights. Even zoning, a traditional tool with which local governments regulate land use, can look like overreach to opponents of regulation (Hurley and Walker 2004, Golding 2012).

This tension arises, in part, because the world is getting more crowded. The demand for land to satisfy human needs is growing (Hertel 2011, Lambin and Meyfroidt 2011), and there are few large pieces of uninhabited land that can be dedicated completely to conservation. Conservation of biodiversity represents a competing land use that must be balanced with other uses of land already occupied by humans, including privately-owned land. In the United States and other democracies, questions about how to conserve biodiversity and the right amount of land to dedicate to conservation are generally settled through the policy process (Steel et al. 2004, Singh et al. 2014). However, because almost all human uses of land affect biodiversity directly or indirectly, any policy governing how land can be used will likely affect biodiversity conservation. Understanding how land use policy affects biodiversity is an important component to building a conservation system that can function effectively on multi-use landscapes while addressing the competing needs and concerns of stakeholders. Without this understanding, conservationists risk advocating for ineffective policies, which could lead to the degradation of ecosystems and lessen the willingness of the public to accept future conservation actions.

It is therefore important to examine what kinds of regulations are necessary to conserve the integrity of ecosystems. Surprisingly, this question has not been thoroughly investigated in the context of large, mixed-use landscapes, even though these landscapes represent a relevant scale of the future of conservation (Miller and Hobbs 2002). In this research, we evaluate the roles of regional-level land use planning, public protected lands, and local-level zoning in determining ecosystem integrity in the Northern Forest region of the United States by comparing outcomes between two regions, the Adirondack Park of northern New York and the Upper Peninsula (UP) of Michigan.

These two regions share many aspects of ecology and environmental history, as well as human culture. The stringent, top-down approach to land use policy taken in the Adirondacks stands in contrast with the less unified set of regulations that characterizes the Upper Peninsula (and is more typical of the eastern United States.) By comparing biodiversity outcomes between these two regions, we test whether a region-wide approach to land use policy is more effective at conservation than a less coordinated system. We also examine the effects of public land on biodiversity within each region in order to understand both how public lands contribute to biodiversity on mixed-use landscapes and how differences in the larger regulatory environment may affect the contribution of public land to biodiversity conservation. Finally, we consider the role of zoning to see whether this highly localized approach to land use planning can help conserve biodiversity, either with or without a larger regional plan. The objectives of this research were to (1) test whether a region-wide, top-down approach to land-use policy results in higher biodiversity as compared to the more typical laissez-faire approach, and (2) evaluate the effects of public land and zoning on biodiversity under each approach to regional level policy.

METHODS

Study Areas

We chose two study areas exemplified by their different approaches to land-use planning and policy. The Adirondack Park is a rare example of a park in the United States that has historically encompassed both human and natural communities (Nash 2014). Established in 1885, the Park today is comprised of approximately equal parts private and state-owned land (Porter et al. 2009). The public land is protected in New York's constitution as Forever Wild, and all the land within the Park's boundary (including privately-owned land) is overseen by the Adirondack Park Agency (APA), a central planning agency established in 1987 by the state (State of New York 1987). The APA establishes regulations that apply to all private and public land within park boundaries, including several categories of allowed uses and maximum building densities. It also oversees building permits for both private and public land (Adirondack Park Agency 2019). While much of the state-owned land in the Park was acquired by default, in recent decades New York State has begun to strategically acquire land that has desirable natural features, or that would establish contiguity between parcels.

The Adirondack Park encompasses approximately 61 townships in an area of 19,700 km^2. It is located in the northern part of New York State, bordering Vermont and Lake Champlain to the east. Elevations range from 30 to 1600 m. Average annual summer temperatures in the Park range between 18 and 21 °C, with winter temperatures between −1 and 5 °C. Average snowfall is between 102 and 356 cm (Glennon and Porter 2005). Population centers in the Park are small, with the largest hamlets containing a year-round population of just over 5,000 people. Larger cities lie just outside of the Park's boundary. Population density is approximately 6.6 people per km^2.

In contrast to the centralized planning and oversight of the Adirondack Park, the Upper Peninsula is managed under a patchwork of state, local, and federal regulations, with historically little planning for land acquisition. Much of the state-owned land was acquired through forfeiture after logging companies failed to pay property taxes on the land once the timber had been harvested (Dempsey 2001). There are also two large national forests in the region. In total, about 68% of the Upper Peninsula is publicly owned. Individual townships set zoning regulations, although a few counties also have their own zoning systems to which unzoned townships are subject.

The UP is comprised of about 172 townships and cities in an area of 42,416 km^2. It is located in the far north of the state of Michigan, with borders on Lakes Superior, Michigan, and Huron, as well as a land border with Wisconsin. Elevations range from about 176 to 603 m. Average summer temperatures range between 16 and 19 degrees C, with average winter temperatures between -9 and -6 degrees C. Average snowfall is between 125 and 530 cm. Towns are scattered throughout the region, with the largest population centers (with populations of 10,000 to 20,000 people) concentrated on the shores of Lakes Michigan and Superior. Population density is about 7.34 people per km^2.

The population of both locations is seasonally variable, with many more summer residents and tourists than year-round residents. Historically, the economies of these areas were dependent on logging and mining, which have declined in recent decades. Tourism is now a dominant industry in both regions, although more people are still employed in forestry and mining than is the norm in the rest of their respective states. Because of the prominence of the tourism industry, these regions experience seasonal fluctuations in employment, which is highest in the summer due to the cold and snowy winters. Both regions lie in the remote northern reaches of their respective states, and are characterized by similar feelings of disconnection from and resentment of the state governments, and individualistic cultures based on perceptions of self-reliance and independence (Graham Jr 1991, Browne and VerBurg 1995, Vidon 2016).

Data

We used Breeding Bird Atlases (BBAs) from Michigan and New York to estimate species richness and biotic integrity of bird communities in our two study areas (McGowan 2008, Chartier 2011) (Table 1.1). Bird communities are frequently used to measure biodiversity because they are relatively easy to sample and because birds have been shown to be good indicators of overall environmental conditions (Järvinen and Väisänen 1979, Vielliard 2000). Both Michigan and New York have completed two BBAs, about twenty years apart, producing datasets that track bird species presence in both space and time (McGowan 2008, Chartier 2011).

Data were collected over the course of several years by researchers in the field who recorded bird presence and any evidence of breeding activity in a grid of square blocks, which measured three miles on each side. While the entire area of each state was divided into survey blocks, not all blocks were surveyed in every atlas. In the UP, where much of the habitat is homogeneous and access can be difficult, researchers were unable to survey every block. Instead, they surveyed a minimum of one block in every six- mile-by-six-mile survey township, or one in four blocks per survey township. Because each political township encompasses multiple survey township, every political township in our analysis was represented by multiple blocks. Surveys in New York covered nearly every block (McGowan 2008). Because the time periods and methodology of the atlases were similar in the two states, we used the data to compare between locations. Our analysis was carried out at the level of the town or political township (hereafter, "township") because this is the smallest unit of government for which data were available, and because township governments can be very influential in creating and enforcing land use regulations.

To measure species richness, we used ArcGIS (Environmental Systems Research Institute 2014) to aggregate BBA blocks according to the township in which they occur. Species richness was measured as the number of unique species in each township recorded as probable or confirmed breeders (McGowan 2008, Chartier 2011) (Figure 1.1, Figure 1.2). Blocks that had their area equally divided between townships were not used for this part of the analysis. Townships in which fewer than 10 species recorded were excluded due to presumed lack of sampling effort.

We calculated a biotic integrity score for each species based on the sensitivity of that species to human disturbance (Karr 1991). We recorded each species' membership in eight nesting and foraging guilds (O'Connell et al. 1998, Glennon and Porter 2005); the species' score was the number of these guilds of interest to which it belonged. We defined the biotic integrity score of each township as the sum of the biotic integrity scores of all species that were present (Table 1.2). Using both species richness and biotic integrity score was intended to differentiate between areas that were rich in generalist, rather than specialist, species.

We measured three policy variables that we hypothesized would affect avian diversity. These three predictor variables—public land managed for biodiversity, public land managed for multiple uses, and zoning-- were measured at the township level and represented various types of policy decisions. To calculate the amount of public land, we measured the percentage of land categorized as protected areas by the USGS Protected Areas Database (PAD) (US Geological Survey 2012). The PAD classifies protected areas into 4 categories. Categories 1 and 2 are lands that are permanently protected from conversion of natural land cover into anthropocentric uses and managed to protect their natural state. Because the management goals of these two types of land are very similar, we collapsed them into one category, which we refer to as land managed for biodiversity (MB). Category 3 lands are permanently protected from conversion throughout most of their area, with low impact or highly localized extractive uses permitted. We refer to this category as land managed for multiple uses (MU). Category 4 lands are publicly-owned lands, such as military bases, that are not protected from land conversion. We did not include this type of land in our analysis.

We collected zoning data for 167 of the 172 townships and cities in the UP and all of the 61 townships in the Adirondack Park. We determined whether a zoning plan was in place as of January 1, 2000 through publicly available data and direct communication with township officials. This date was chosen as a cutoff because the BBAs for both regions began in 2000. We assigned imputed values for zoning to the townships in the UP for which no data were available (van Buuren and Groothuis-Oudshoorn 2011, van Buuren 2018), and excluded the cities of the UP from the analysis. Cities in the UP are often very small sub-divisions of land that in New York would be included as part of a township; we excluded them because their small size made them outliers in terms of species present per unit area. We hypothesized that both types of protected land and the presence of a zoning plan would be positively related to biodiversity.

To control for differences in land cover, we calculated the percentages of five land cover types in each township in both study regions. These calculations were based on the National Land Cover Database (NLCD) classifications (Homer 2007): deciduous/mixed forest, coniferous forest, woody wetlands, agriculture, and urban/developed. We centered these variables by subtracting the percentage of each land cover type in a given township from the mean of the percentage of that land cover type across all townships in the region (Enders and Tofighi 2007, Robinson and Schumacker 2009). We hypothesized that anthropocentric land cover (agriculture and developed) would be negatively related to biodiversity, and that the other land cover types would have negligible effects. Finally, we included the area of the township as a covariate in the model, to account for the species-area relationship (Connor and McCoy 1979) (Table 1.3, Table 1.4).

Analysis

Our first objective was to test whether a region-wide, top-down approach to land-use policy results in higher biodiversity as compared to the more typical laissez-faire approach. To address this objective, we tested whether there were regional differences in either species richness or biotic integrity score when land cover and township-level policy were controlled. In other words, our conceptual model was that biodiversity is a function of which region a township is located in. Because one of the purposes of the Adirondack Park's land management plan is to preserve ecological integrity, we expected that townships in the Park would have, on average, significantly higher species richness and biotic integrity scores than townships in the UP.

We combined the data from both study regions, adding a categorical variable, "Region", to the data. We modeled the relationship between each of the biodiversity metrics and our land cover, region, and policy variables using generalized linear modeling with a negative binomial distribution. The negative binomial distribution is used to model count data in which the variance is greater than the mean, because it is defined by two parameters, the mean and the dispersion (O'Hara and Kotze 2010, Hilbe 2014, Warton et al. 2016). The model took the general form

$$Biodiversity_i \sim \alpha + \beta_1 Region_i + \beta_2 MB_i + \beta_3 MU_i + \beta_4 Zoning_i + \beta_5 Developed_i + \beta_6 Agriculture_i + \beta_7 Coniferous_i + \beta_8 Wetland_i + \beta_9 Deciduous_i$$

The variable *Biodiversity* was either a count of breeding bird species present in a township (species richness) or a weighted count of the breeding bird species present in a township that belonged to at least one of the eight guilds of interest (biotic integrity score). The variable *Region* was binary and represented the study area to which the township *i* belonged. The variable *Zoning* was binary and represented whether the township *i* had a township or county-level zoning plan in place as of 2000. All other variables represented the percentage of the land in the township *i* in each land cover or land protection type. To test for collinearity in the variables, we calculated variance inflation factors (VIFs) for the model. We determined that a VIF of 5 or above was too high to keep the variable in the model, and planned to eliminate variables with VIFs of over 5 stepwise, beginning with the variable with the highest VIF, until all VIFs were lower than 5 (Craney and Surles 2002, Robinson and Schumacker 2009). This process resulted in the elimination of deciduous forest from the model.

To test for the effects of public land and zoning in the context of each region-wide policy, we modeled the relationships between our biodiversity variables and the independent land cover and land management variables at the regional level. We expected to find that biodiversity was positively related to protected land and zoning presence and negatively related to developed land and agriculture in both study areas. The models took the general form

$$Biodiversity_i \sim \alpha+\beta_1 MB_i+\beta_2 MU_i+\beta_3 Zoning_i+\beta_4 Developed_i+\beta_5 Agriculture_i+\beta_6 Coniferous_i+\beta_7 Wetland_i+\beta_8 Deciduous_i$$

The variables were defined the same way as previously, but the data were separated by region, both for ease of interpretation and because the UP had more than twice as many townships as the Adirondack Park. If the data were not separated by region, this could have resulted in trends in the Adirondack Park being obscured by trends in the UP. The result was four models: one for each combination of biodiversity metric and study area. We again eliminated variables from the model that had a VIF of 5 or higher. Our goal was direct comparison between models, so if a variable was eliminated from one model, we eliminated it from the other models as well. This process resulted in the elimination of deciduous forest from all models.

After fitting each model, we checked for spatial autocorrelation in the residuals using the Moran's I statistic. If spatial autocorrelation was present in the model residuals, we re-ran the model using spatial negative binomial regression, which accounts for autocorrelation among adjacent survey townships using a spatial weights matrix (Fortin and Dale 2005). Spatial weights matrices were generated from shapefiles of BBA blocks using queen contiguity to define neighbors (Fortin and Dale 2005). Only immediate neighbors were included in the matrices and all were given a weight of 1. The residuals of both non-spatial models of the Adirondack Park data were spatially autocorrelated, so the final models each included a spatial term. None of the other combinations of location and biodiversity measure showed spatial autocorrelation. We used nonparametric bootstrapped confidence intervals to infer the significance level of each effect. By resampling with replacement from the original data, bootstrapping allows us to construct confidence intervals that are not based on any particular assumptions about the distribution of the data (Efron and Tibshirani 1994).

RESULTS

Regional-level policy

We analyzed a total of 205 townships in the combined model: 61 from the Adirondack Park and 142 from the UP. Species richness in these townships ranged from a minimum of 11 to a maximum of 169 (mean 115). Biotic integrity scores ranged from a minimum of 21 to a maximum of 350 (mean 241). We found no significant differences between regions in either species richness or biotic integrity score. The area of the township was the only significant variable in this model, and was positively related to both species richness and biotic integrity score. The coefficients for all covariates were similar between the biotic integrity model and the richness model.

Public land and zoning

In the UP, the biotic integrity model and the species richness model produced similar estimates for most covariates. In addition to the area of the township, the percent of land managed for biodiversity was positively and significantly related to biodiversity in both models. The percentage of woody wetland was significantly and negatively related to biotic integrity but not to species richness (see Table 1.5 for full results.)

In the Adirondack Park, the biotic integrity model and the species richness model differed from one another. In the species richness model, four covariates were significant: area, agriculture, wooded wetlands, and coniferous forest. These four covariates were also significant in the biotic integrity model, but the presence of a township-level land use plan was significant as well. The direction of the four covariates was the same in both models. Wooded wetlands were negatively associated with biodiversity, while coniferous forest, agriculture, and area were all positively associated with biodiversity. A township-level land-use plan was negatively associated with biotic integrity. The coefficients of the covariates were similar between models, except for the coefficient for wooded wetland, which was more strongly related to decreasing species richness than it was to decreasing biotic integrity.

The final models of both response variables in the Adirondack Park included a spatial term. However, the residuals of these models still showed spatial autocorrelation. The addition of the spatial term in the model of species richness in the Park did not reduce the level of spatial autocorrelation in the residuals. For the model of biotic integrity score in the Park, the addition of a spatial term reduced the amount of spatial autocorrelation in the residuals, but did not eliminate it entirely. The presence of autocorrelation in the residuals might cause the confidence intervals generated by these models to be too narrow, increasing the chances of type I error (Diniz-Filho et al. 2003).

DISCUSSION

Regional-level policy

The first objective of this research was to test whether an area employing a top-down, regional regulatory approach to land use policy has improved biodiversity outcomes as compared with a region with a less centralized approach. Using New York's Adirondack Park as a model for top-down regulation and Michigan's UP as a model of less-unified regulations, we showed that a regional regulatory approach appears to have no effect on biodiversity at this point in time. Both of our metrics of biodiversity, species richness and biotic integrity score, were similar between regions.

In this study, regional-level land use planning was not associated with higher biodiversity as compared a less unified approach in an ecologically similar area. Our study areas contained comparable amounts of protected land and similar population densities, showing that neither approach to planning is superior in terms of its effect on avian biodiversity conservation under these conditions. To our knowledge, this is the first study to test the effects of regional planning on biodiversity.

Previous research has shown that state-level land use planning is associated with reductions in sprawl and the overall rate of development as compared to baseline projections (Carruthers 2002, Bengston et al. 2004, Pannozzo et al. 2015). Because development has been found to lead to lower biodiversity (Miller and Hobbs 2002, Hansen et al. 2005, Leu et al. 2008, Maestas et al. 2010), we expected that regional planning would be associated with higher biodiversity. However, these previous studies were done at the statewide scale, and included significantly more developed land than in our study areas, which might account for the difference in results: an undeveloped landscape may not need regional-level planning to conserve biodiversity, while planning could be more effective when urban sprawl is already an issue. Alternatively, differences in implementation and enforcement could invalidate comparisons among different regional planning systems, even if they were done across comparable landscapes and scales.

It is important to note that previous research on state-level land use planning does not find that it prevents or reverses sprawl; only that it reduces the rate of sprawl. In contrast, the Adirondack Park Land Use and Development Plan is a plan to prevent sprawl from happening by limiting the amount of development permitted. While growth in the UP could reach a level that causes biodiversity to decline, this is less likely in the Adirondacks as long as the Land Use and Development Plan is in place. In this sense, the land use regulations that are in place in the Adirondacks are insurance against the kind of sprawl found in more developed areas. Rurality may be protecting both regions from biodiversity loss now, but if demand for land increases, the UP could be more vulnerable than the Park.

Public land and zoning

The second objective of this research was to evaluate the effects of public land and zoning on biodiversity within each regional policy context. By conducting our analyses separately for each region, we showed that regional policy context can change the effectiveness of these other land use regulations. In the absence of top-down regional planning, managing land for biodiversity appears to be an effective conservation strategy, as shown by the association between land managed for biodiversity and increased species richness and biotic integrity in the UP. In the Adirondacks, where top-down regional planning is present, there was no effect of land managed for biodiversity on either of our biodiversity metrics. This difference points to the important role that context plays in determining the value of public lands to biodiversity conservation. While the UP has a larger percentage of public land than the Adirondack Park, a significant proportion of that land is managed for multiple uses, including forestry, mining, and recreation. Another large amount of land in the UP is privately owned forestry land. In the Adirondacks, most of the public land is managed for biodiversity, with smaller proportions of private logged forest in the region. In addition, several larger population centers (population>10,000) are located throughout the UP, while the Adirondack Park has no population centers of this size. It is possible that the UP is beginning to exhibit trends in biodiversity that are characteristic of regions in which development is an important land use; namely, that management for biodiversity is proportionately more important in regions where biodiversity is under threat from development. Multiple studies of parks and other protected areas have shown that biodiversity inside park boundaries is higher than outside park boundaries (Naughton-Treves et al. 2005, Gaston et al. 2008, Greve et al. 2011, Peach et al. 2018), which is congruent with what our results show in the UP. However, the planning context of the Adirondack Park is different from almost anywhere else in the world. With the Adirondack Park system of zoning and land management proscribing intense development, there is less contrast between the most and least developed areas in the Park than there is in the UP and most other areas in the eastern US. The general rurality of the Park, established by the Land Use and Development Plan, might make management for biodiversity less necessary than it is in the UP. This pattern is reflected in other regions where land conversion is significant, and protected areas become both more ecologically distinct from, and ecologically threatened by, development outside their borders (Hansen and Defries 2007, Goodwin and Shriver 2014, Martinuzzi et al. 2015, Ament and Cumming 2016).

Public land managed for multiple uses did not influence biodiversity in either region. This type of land may be used for logging, mining, or motorized recreation. In the UP, public land of this type is mostly designated as state forest, while public land managed for biodiversity is mostly national forest (US Geological Survey 2012). In the Adirondack Park, there is no federally-owned land, but the majority of state-owned land is managed for biodiversity (US Geological Survey 2012). Multiple-use public land, therefore, seems to occupy a middle ground: it is permanently protected from conversion or development, but is not currently different from privately-owned forest in terms of biodiversity according to our findings. In the UP, where significant conversion from forest to more developed uses on private land is still possible, we could eventually see a positive effect of multiple-use public land on biodiversity solely as a result of preserving the natural forest cover. In the Adirondacks, we would not expect to see an effect of multiple-use land on biodiversity in the future, due to the regulations preventing large-scale conversion or unsustainable logging practices on private forest land.

In both regions in this study, the presence of a township-level zoning plan was not associated with increased biodiversity. As a tool to regulate development, zoning has the potential to promote biodiversity by preserving open space (Butsic et al. 2010, Magliocca et al. 2012). Our results suggest that zoning is likely being used in other ways in our study regions. Other purposes of zoning include maintaining neighborhood character, separating industrial and residential uses, keeping property values high, and promoting single-family housing (Feiock 1994, Munroe et al. 2005, Liu and Lynch 2011). Because zoning laws are enacted and enforced by elected township (and sometimes county) officials (Carruthers 2003), these anthropocentric goals are likely to take precedence over preservation of open space. Minimum lot sizes and setbacks mold towns into a certain aesthetic, but they also fragment open space (Lewis et al. 2009, Liu and Lynch 2011), which is often converted to lawns instead of natural land cover. Large-lot zoning, which is commonly used to maintain the rural character of a community by preventing high-density development, can be particularly ecologically harmful, with the effect zone of buildings extending far beyond their actual footprint (Glennon and Kretser 2013). Zoning could therefore have either a positive or a negative effect on biodiversity, depending on the type of zoning and how it is enforced.

In this case, we saw a negative effect of zoning on both metrics of biodiversity in the Adirondack Park, suggesting that zoning decreases biodiversity. However, the role of township-level zoning in the Adirondacks is different than in other areas of the country. The entire Park is subject to a zoning plan created by the Adirondack Park Agency. Townships may be exempt from the Park-wide zoning plan only if they submit their own zoning plan to the APA for approval. Unlike in the UP, there are no townships in the Adirondacks that are truly without zoning, only those that have local, instead of state, zoning plans. In this context, lower biodiversity being associated with local zoning suggests that state-level regulation might benefit biodiversity. Other research has found ecological benefits arising from "bridging organizations," which increase communication between units of government and promote collaboration and connectivity (Folke et al. 2005, Rathwell and Peterson 2012). As state-run entity that works closely with local governments, the APA may be functioning in a bridging role, promoting larger-scale conservation than townships are able to plan for on their own and preventing "political fragmentation" (Carruthers 2003) among townships.

The effects of land cover on biodiversity in this analysis were also context-specific. Coniferous forest had a positive effect on both metrics of biodiversity in the Adirondacks, and a negative effect on species richness in the UP. These contrasting effects may result from the close relationship between coniferous forest and elevation in the Adirondack Park, where coniferous forest is concentrated in the mountainous interior. Areas rich in coniferous forest are therefore likely to be buffered from the effects of development and invasive species that are more prevalent at the park edges and near roads (Ewers and Didham 2005, Glennon and Porter 2005, Devictor et al. 2008b). In the UP, coniferous forest is more uniformly spread throughout the region. While species richness in the UP had a negative relationship with coniferous forest in our study, biotic integrity score did not. In other words, coniferous forests in the UP support fewer total species than other forest types, but birds found in coniferous forest in the UP are more likely to be habitat specialists than birds found in other forest types. The lack of more granular data on coniferous forest composition and configuration in these regions makes it difficult to advance an explanation for the patterns we observed, but the stark difference in trends between regions points to the importance of specific landscape context in determining how land cover and biodiversity are related.

Similarly, in the Adirondacks, agricultural land is associated with increased species richness but not increased biotic integrity. The increase in the number of species in agricultural lands is therefore driven by human-tolerant species rather than sensitive species. However, agriculture had no effect on either metric of biodiversity in the UP. Agriculture is commonly associated with lower biodiversity (Norris 2008, Polasky et al. 2011), but field edges can also provide a source of needed disturbance for early-successional birds in the northeastern United States (Drapeau et al. 2000). Once again, a variety of factors could explain the difference in the effect of agricultural land between locations, but insufficient data are available to advance any one explanation.

Woody wetlands had a negative effect on species richness in both locations as well as on biotic integrity score in the UP. However, the negative effect on species richness was stronger than the effect on biotic integrity. On the whole, these areas appear to provide suitable breeding habitat for fewer species of birds, but might be important for a few specialist species (Glennon 2014). While wetlands in general are associated with increased bird diversity and productivity (Nilsson and Nilsson 1978, Riffell et al. 2001, Hansson et al. 2005), the wooded wetlands of the Northern Forest are susceptible to invasion by multiple non-native species (Zedler and Kercher 2004, Likens and Franklin 2009, Moser et al. 2009), and the reduction in bird biodiversity we observed could result from overgrowth by these species (Lehikoinen et al. 2017). We were unable to examine characteristics of individual wetlands in this study, but the woody wetland land category encompasses many wetland types, which may vary significantly in productivity and habitat suitability (Homer 2007).

Our final land cover variable, developed land, had no effect on biodiversity in either location. We expected that development would negatively affect biodiversity, because this is a relationship that has been well-documented in the literature (Blair 1996, O'Connell et al. 2000, Hansen et al. 2005, Kowarik 2011). However, it is possible that the detrimental effects of development are cancelled out in this analysis by the increased bird diversity associated with slightly disturbed habitat as predicted by the intermediate disturbance hypothesis (Connell 1978, Lumpkin and Pearson 2013). It is also worth noting that this analysis excluded the most highly-developed population centers in the UP. Outside of cities, the

Adirondack Park and the UP have similar amounts of development. Perhaps a threshold exists beyond which more development leads to lower biodiversity (DeLuca et al. 2004), but development levels in the townships we analyzed have not reached that threshold yet.

The comparison between study locations is an important assumption of this research, and we recognize that the two study areas have differences that go beyond policy, which may complicate the results presented here. However, because it is not possible to study a counterfactual location in this case, we believe that this comparison is a valid step toward understanding the region-wide effects of policy. Research in this area could benefit from smaller-scale or qualitative research capable of elucidating the role of variables we were not able to quantify on the scale of this study, such as the role of policy enforcement and compliance or the specifics of zoning plans. We also were unable to account for variations in land management within different categories of land, for example, we assumed that all land designated by the USGS as “managed for biodiversity” was managed in the same way. On private land in particular, this assumption is likely inaccurate, but it was necessary to enable us to study policy on the regional scale. Again, finer-scale research could clarify the effects of management on biodiversity across a broader spectrum of management types.

Conclusions

We have shown that top-down land use planning and regulations are not necessary for biodiversity conservation in the Northern Forest, and that other types of regulations may be more or less effective depending on whether regional-scale planning exists. The effects of land cover on biodiversity were significantly different between our two study regions, again highlighting the importance of context even in apparently-similar regions. We expect that the results of this analysis would be similar in other rural, forested areas, as long as the amount of development is low. Based on previously-published literature, we would expect public land, especially land managed for biodiversity, to become more important in predicting biodiversity when the amount of development is higher (Hansen and Defries 2007, Goodwin and Shriver 2014, Martinuzzi et al. 2015, Ament and Cumming 2016), and for regional land use planning to increase biodiversity through conservation of open space when development is more prevalent (Carruthers 2002, Bengston et al. 2004, Pannozzo et al. 2015). We would also expect different results in a rural region that is dominated by agriculture. Nevertheless, this analysis is one of few in the United States to analyze the relationships among regulations and biodiversity on large mixed-use landscapes.

The heterogeneity of these results should encourage managers to carefully consider ecological and political context when deciding how to promote biodiversity on a large rural landscape. When region-wide, ecologically-focused land management is in place, as in the Adirondack Park, land management on individual parcels may be less important, and local zoning may be detrimental to ecological health. When land management plans are more piecemeal, the effort to manage specifically for biodiversity seems to pay off. Policy makers should be cautious when determining how to change regulations to benefit biodiversity; although biodiversity is an important ecosystem service, other services such as water filtration and cultural values should be considered (Hansson et al. 2005, Hein et al. 2006, Chan et al. 2012). In some cases, forest cover could provide all of these services, regardless of whether it is maintained by market forces or regulations. In others, it is necessary to manage land with biodiversity as a goal. Decision-makers will need to allocate resources based on what is likely to work on each specific landscape and on their objectives for how the land should be used. The Adirondack approach—top-down regulation based on the long-term goal of "Forever Wild" set forth in the state constitution—ensures that the resource of open space will be stable over the long term, and not subject to highly variable market or political trends. The UP model—multi-level decision-making within a loosely-regulated market—has to this point in time been effective at conserving biodiversity while infringing less on property rights. However, it leaves open the possibility of large-scale land conversion (Baldwin et al. 2009), similar to the large-scale deforestation in the region early in the 20th century (Dempsey 2001).

This study shows that there is room for flexibility when it comes to how land should be regulated. None of the regulations we studied were universally beneficial or detrimental to biodiversity. There is broad consensus, however, that without policy action, significant amounts of open space will be developed and biodiversity lost. The policy actions examined in this study (regional land use planning, public lands acquisition, and zoning) represent some possible avenues for conservation, but there are many others, including market-based policies (Lambin et al. 2001, Beaudry et al. 2013, Lawler et al. 2014). Our two study regions have achieved comparable levels of biodiversity and open space conservation using different policy approaches, and there may be other approaches that are equally effective, but policy makers should pay attention to landscape context when using these or any other frameworks. In demonstrating that there is no single policy or land cover characteristic that is responsible for conservation in two very similar study locations, we have also shown that creating policy to balance human and conservation needs is likely to be a long-term challenge. Until more research further illuminates the relationships between land use policy and conservation in other contexts, we cannot recommend a single approach to conservation policy. Combinations of policies that prevent habitat destruction seem likely to promote conservation in most contexts (Hanski 2011, Jantz et al. 2015), but the specifics of the policies appears to be less important than the outcome of habitat conservation.

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Chapter 2: Land use policy and economic wellbeing in two Northern Forest regions

INTRODUCTION

Controversy over land-use regulations has accompanied advances in land conservation in the United States since the early days of the environmental movement. Conservationists argue that land-use regulations are important tools for conserving biodiversity and ecosystem services (Convention on Biological Diversity 2018, IUCN 2018). As the worldwide human population grows, these tools become even more necessary to preserve land for wildlife, recreation, and other non-consumptive uses (Polasky et al. 2011, Lawler et al. 2014). Public land acquisition, although opportunistic in the early 20th century, is now seen as an indispensable tool for conservation and recreation (Shands and Healy 1977, Dempsey 2001, Miller 2012). Other government programs encourage private landowners to maintain natural resources, such as forests, on their properties (USDA 2018). And zoning, which changes land markets through restrictions on use or building density, is often used by local governments to control the effects of sprawl, preserve natural amenities, and shape more attractive communities (Butsic et al. 2010, Locke and Rissman 2015).

However, land-use regulations also have many staunch opponents, who argue that regulations are an example of government overreach, economically burdensome for local communities, or both (Nelson 1995, Dobbs 1996, Penney 2009, Miller 2012). In a country with strong ideas about private property rights, any weakening of those rights to protect common resources can be controversial, particularly when imposed by larger units of government, which are seen as less responsive to constituents' concerns (Culhane 2013). The negative effects of land-use regulations are thought to come in many forms. The decline of extractive industries, such as forestry or mining, in the northern United States is often blamed on increased environmental regulations, although this view is contested (Freudenburg et al. 1998, Lewis et al. 2002). In addition, the prohibition of development on public land or land under conservation easements means lost opportunities for job-creating development, which could attract residents and improve local economies (Shands and Healy 1977, Johnston and Emerson 1984, Lewis et al. 2002, Keal and Wilkie 2003). Zoning has been shown to have variable effects on property values, creating a possibility that some landowners' property may be worth less once a zoning ordinance is in place (Liu and Lynch 2011, Magliocca et al. 2012). Finally, the benefits of land use regulations are spread among a broad swath of the population, whereas the costs are thought to accrue locally. Thus, local landowners may feel that they are being asked to pay for conservation initiatives that primarily benefit others (Coad et al. 2008).

Despite the opposition to land-use regulation, conservationists assert that not enough is being done to protect land. The Convention for Biological Diversity, for example, has set a goal of protecting 17% of the planet's land area and 10% of its marine area—an increase of 2% and 6.5% respectively over 2014 levels (Convention on Biological Diversity 2011). Conservationists point to increasing development as a threat to biodiversity, requiring growth management and land protection strategies to maintain ecosystem function (Nelson and Moore 1996, Nelson 1999, Hansen et al. 2005, Lumpkin and Pearson 2013). Land protection advocates also argue that public land has been shown to be valuable for economic and social reasons. The US Forest Service estimates that visitors to its land contribute 13 billion dollars to the US economy annually (United States Forest Service 2017). Forestry on public land supports 77,000 jobs in the state of Michigan alone (Michigan Department of Natural Resources 2017), in addition to the jobs created by public land conservation, research, and tourism activities. Finally, public land provides valuable ecosystem services such as water filtration, soil retention, wild-harvested food, and flood prevention, and ensures that these services will be provided to future generations (Polasky et al. 2011, Schippers et al. 2015, Yang et al. 2015) .

In the early decades of the 21st century, demand for housing in the United States has expanded rapidly (Peterson et al. 2013). Along with a growing population, this means that more and more land will be converted to developed uses if regulations requiring land conservation are not instituted, or if existing regulations are rolled back. Those who oppose environmental regulations have found an ally in the Trump administration, which has removed regulations that are perceived to impede industrial development at an unprecedented rate (State Energy and Environmental Impact Center 2019). In this anti-regulatory, pro-development atmosphere, it seems increasingly important to understand the relationship between land conservation and human wellbeing, so that decision-makers can more accurately assess the costs and benefits of conservation.

The purpose of this research is to evaluate whether increased or stricter land-use regulations lead to decreased human wellbeing. To answer this question, we examined several aspects of wellbeing in two ecologically similar regions with different approaches to policy. The Adirondack Park of northern New York, USA and the Upper Peninsula (UP) of Michigan, USA share many aspects of ecology and environmental history, as well as human culture. The stringent, top-down approach to land-use policy taken in the Adirondacks stands in contrast with the more ad-hoc approach that characterizes the UP, allowing us to evaluate whether one kind of policy is associated more with lowered human wellbeing. In addition, each location is a mix of public and private land in units of local government that have varying levels of involvement in land-use policy. Because of this, we can compare human wellbeing both between regions and between localities within each region to determine whether public land ownership and zoning, in addition to region-level policy, affect human communities. The objectives of this project were to (1) evaluate whether human communities are significantly worse-off in a region with more stringent land-use regulations and (2) test if the presence of public land and zoning laws have a detrimental effect on human wellbeing.

METHODS

Study Areas

We chose two study areas exemplified by their different approaches to land-use planning and policy. The Adirondack Park is a rare example of a park in the United States that has historically encompassed both human and natural communities (Nash 2014). Established in 1885, the Park today is comprised of approximately equal parts private and state-owned land (Porter et al. 2009). The public land is protected in New York's constitution as "Forever Wild," and all the land within the Park's boundary (including privately-owned land) is overseen by the Adirondack Park Agency (APA), a central planning agency established by the State of New York (State of New York 1987). The APA establishes regulations that apply to all private and public land within park boundaries, including several categories of allowed uses and maximum building densities. It also oversees building permits for both private and public land (Adirondack Park Agency 2019). While much of the state-owned land in the Park was acquired through tax default, throughout the last 40 years, the APA has strategically acquired land that has desirable natural features, or that would establish contiguity between parcels.

The Adirondack Park encompasses approximately 61 townships in an area of 19,700 km^2. It is located in the northern part of New York State, near one of the most heavily populated regions of eastern North America, and borders Vermont in the east along Lake Champlain. Elevations range from 30 to 1600 m. Average annual summer temperatures in the Park range between 18 and 21 °C, with winter temperatures between −1 and 5 °C. Average snowfall is between 102 and 356 cm (Glennon and Porter 2005). Population centers in the Park are small, with the largest hamlets containing a year-round population of just over 5,000 people. Larger cities lie just outside of the Park's boundary. Population density is approximately 6.6 people per km^2.

In contrast to the centralized planning and oversight of the Adirondack Park, the Upper Peninsula is managed under a patchwork of state, local, and federal regulations, with historically little planning for land acquisition (Dempsey 2001). In total, about 68% of the Upper Peninsula is publicly owned, with much of the public land acquired by default or opportunity, rather than in planned acquisitions. Individual townships set zoning regulations, although a few counties also have their own zoning systems to which unzoned townships are subject.

The UP is comprised of about 147 townships in an area of 42,416 km^2. It is located in the far north of the state of Michigan, with borders on Lakes Superior, Michigan, and Huron, as well as a land border with Wisconsin. Elevations range from about 176 to 603 m. Average summer temperatures range between 16 and 19 degrees C, with average winter temperatures between -9 and -6 degrees C. Average snowfall is between 125 and 530 cm. Towns are scattered throughout the region, with the largest population centers (with populations of 10,000 to 20,000 people) concentrated on the shores of Lakes Michigan and Superior. Population density is about 7.34 people per km^2.

The population of both locations is seasonally variable, with many more summer residents and tourists than year-round residents. Historically, the economies of these areas were dependent on logging and mining, which have declined in recent decades. Tourism is now a dominant industry in both regions, although more people are still employed in forestry and mining than is the norm in the rest of their respective states. Because of the prominence of the tourism industry, these regions experience seasonal fluctuations in employment, which is highest in the summer due to the cold and snowy winters. Both regions lie in the remote northern reaches of their respective states, leading to similar feelings of disconnection from and resentment of the state governments, and an individualistic culture based on perceptions of self-reliance and independence (Graham Jr 1991, Browne and VerBurg 1995, Vidon 2016).

Data

We studied 5 variables measured by the 2010 US Census at the township level to represent dimensions of social and economic wellbeing (Table 2.1). These variables were chosen in consultation with stakeholders from our two study regions and published literature (Lewis et al. 2003, Conceição and Bandura 2008, Adirondack Association of Towns and Villages 2009, Dolan and Metcalfe 2012, Long and Bauer 2019). Our choice of these response variables reflects stakeholder concerns that local populations are aging (measured as the percentage of the population younger than 30) and shrinking (measured by the percent population change), as well as the fear of increased poverty rates due to the decline in traditional extractive jobs that pay a middle-class wage (measured as the poverty rate.) We also included variables intended to illuminate the changing income distributions and cultural issues that may accompany the transition from an industrial to a service economy (measured as the Gini coefficient and the percentage of seasonal homes.)

We also measured 4 policy and infrastructure variables that we hypothesized would affect the wellbeing variables discussed above, based on the common assumption that regulations are bad for human wellbeing. These four predictor variables—two types of protected land, presence of a zoning plan, and travel time to the nearest population center-- were measured at the township level for all townships in each of our two study areas and represented various types of policy decisions. Specifically, we measured the percentage of land categorized as protected areas by the USGS Protected Areas Database (PAD) (US Geological Survey 2012). The PAD classifies protected areas into 4 categories. Categories 1 and 2 are lands that are permanently protected from conversion of natural land cover into anthropocentric uses and managed to protect their natural state. Because the management goals of these two types of land are very similar, we collapsed them into one category, which we refer to as land managed for biodiversity (MB). Category 3 lands are permanently protected from conversion throughout most of their area, with low impact or highly localized extractive uses permitted. We refer to this category as land managed for multiple uses (MU.) Category 4 lands are publicly-owned lands, such as military bases, that are not protected from land conversion. We did not include this type of land in our analysis. We collected data on zoning for 167 of the 172 townships in the UP and all 61 townships in the Adirondack Park. We determined whether a zoning plan was in place as of January 1, 2000 through publicly available data and direct communication with township officials. This date was chosen as a cutoff to ensure that zoning had enough time to affect development patterns by the time our dependent variables were measured in 2010. We assigned imputed values to the townships in the UP for which no data were available (van Buuren and Groothuis-Oudshoorn 2011, van Buuren 2018). Finally, we calculated the travel time from the centroid of each township to the nearest town of population 10,000 or more using Google Maps. We expected that wellbeing would decrease in association with restrictions on land use (both types of protected land and zoning) and that wellbeing would increase as travel time to the nearest population center decreased, due to greater levels of economic activity in larger towns (Goetz et al. 2018).

To control for differences in land cover, we calculated the percentages of 5 land cover types in each township in both study regions. These calculations were based on the National Land Cover Database (NLCD) classifications (Homer 2007): deciduous/mixed forest, coniferous forest, woody wetlands, agriculture, and urban/developed. We centered these variables by subtracting the percentage of each land cover type in a given township from the mean of the percentage of that land cover type across all townships in the region (Enders and Tofighi 2007, Robinson and Schumacker 2009). We hypothesized that the effect of land cover type would be negligible, except for developed land, which we hypothesized would have a positive effect on our wellbeing variables.

Analysis

To address our first objective, we tested whether there were regional differences in our five aspects of wellbeing, when land cover and township-level policy were controlled. Four of our variables—Gini coefficient, percent population under 30, poverty rate, and second home percentage—were bounded by 0 and 1. We modeled the relationship between each of these variables and our land cover, region, and policy variables using generalized linear modeling with a beta distribution. Beta regression produces fitted values that respect the bounded nature of proportions, the results can easily be back-transformed to the scale of the original metrics (Hallgren et al. 2014), and it is suitable for modeling data that are skewed (Smithson and Verkuilen 2006). We rescaled these four response variables to fall on the open unit interval (0,1), making it possible to analyze the data using beta regression. This transformation compresses the data so that values of exactly 0 or values of exactly 1 can no longer occur, without otherwise changing the shape of the distribution (Smithson and Verkuilen 2006, Zimprich 2010). Our fifth variable, population change, ranged from -1 to 1. We modeled its relationship with our land cover, region, and policy variables using linear modeling with a Gaussian distribution. The model took the general form

$$Wellbeing_i \sim \alpha + \beta_1 Region_i + \beta_2 MB_i + \beta_3 MU_i + \beta_4 Zoning_i + \beta_5 Developed_i + \beta_6 Agriculture_i + \beta_7 Coniferous_i + \beta_8 Wetland_i + \beta_9 Deciduous_i + \beta_{10} TravelTime$$

The variable *Region* was binary and represented the region to which the township *i* belonged. The variable *Zoning* was binary and represented whether the township *i* had a zoning plan in place as of 2000. The variable *TravelTime* represented the number of minutes it takes to get from the township centroid to the nearest population center. All other variables represented the percentage of the land in the township *i* in each land cover or land protection type. To test for collinearity in the variables, we calculated variance inflation factors (VIFs) for the model. We determined that a VIF of 5 or above was too high to keep the variable in the model, and planned to eliminate variables with VIFs of over 5 stepwise, beginning with the variable with the highest VIF, until all VIFs were lower than 5 (Craney and Surles 2002, Robinson and Schumacker 2009). This process resulted in the elimination of deciduous forest from the model.

We used nonparametric bootstrapped confidence intervals to infer the significance level of each effect. By resampling with replacement from the original data, bootstrapping allows us to construct confidence intervals that are not based on any particular assumptions about the distribution of the data (Efron and Tibshirani 1994).

To address our second objective, we tested whether there were within-region differences in wellbeing that were associated with land cover and township-level policy. The model took the general form

$Wellbeing_i \sim \alpha + \beta_1 MB_i + \beta_2 MUi + \beta_3 Zoning_i + \beta_4 Developed_i + \beta_5 Agriculture_i + \beta_6 Coniferous_i +$

$B_7 Wetland_i + \beta_8 Deciduous_i + \beta_9 TravelTime$

The variables were defined the same way as previously, but the data were separated by region, both for ease of interpretation and because the UP had more than twice as many townships as the Adirondack Park, which could have skewed the results. This resulted in ten models: one for each combination of wellbeing metric and study area. We tested for collinearity among all predictor variables using variance inflation factors (VIFs), and eliminated covariates with a VIF of 5 or higher, a relatively conservative threshold (Craney and Surles 2002, Robinson and Schumacker 2009). We eliminated deciduous/mixed forest from the analysis because of its high collinearity with the other two forest types. To reduce complexity of the comparisons between variables and sites, we sought to minimize the number of models tested, and we analyzed only the full models for each response variable using package betareg (Cribari-Neto and Zeileis 2010) in R (R Core Team 2017)**.** If spatial autocorrelation was present in the model residuals, we re-ran the model using spatial negative binomial regression, which accounts for autocorrelation among adjacent survey townships using a spatial weights matrix (Fortin and Dale 2005). Spatial weights matrices were generated from shapefiles of BBA blocks using queen contiguity to define neighbors (Fortin and Dale 2005). Only immediate neighbors were included in the matrices and all were given a weight of 1.

RESULTS

Combined model

By pooling the data and including Region as a covariate, we tested whether differences in our wellbeing variables could be predicted by the region in which the township was located; in other words, whether regional-level policy affected wellbeing (our first objective.) While we included land cover variables in the model to control for differences in land cover between regions, we were unable to test for the effects of land cover on wellbeing using the pooled data because the UP has more than twice the number of townships as the Park. There were no significant differences found between regions in two of the response variables, Gini coefficient and poverty rate, showing that residents of townships in both regions were similar in terms of their income distributions and people living in poverty. The other three variables were significantly different between regions. The percentage of second homes and the population under 30 were lower in the UP as compared to the Adirondack Park, and the UP lost population while the Adirondack Park gained population (Figure 2.1) despite its more stringent land use policies.

Regional models

We modeled each region separately to test the effects of zoning and public land on wellbeing in the context of each regional policy (our second objective.) Each of the regional models showed differences between regions in the relationship of the response variables to the predictors. No predictor had a significant influence on all response variables in either region (Figure 2.2). However, the land cover variables (agriculture, developed land, coniferous forest, and woody wetland) typically had larger effect sizes as compared to the policy/infrastructure variables (MB, MU, travel time, and zoning.)

Only one covariate-response pair showed a similar relationship in both regions: poverty was lower in townships with a high percentage of public land managed for biodiversity (MB) in both regions. In the UP, the percentage of younger people (population under 30) was higher in townships with more agriculture or developed land, and that were closer to the nearest large city (as measured by travel time to the nearest large town.) Poverty was also lower in the UP in townships with higher percentages of multiple-use public land (largely state-owned land), but higher in townships with more woody wetland cover. The percentage of seasonal homes in the UP was significantly lower in townships with more developed land, and higher in townships with more woody wetland and coniferous forest cover. In the Adirondack Park, the percentage of younger people (population under 30) was lower in townships with more public land managed for biodiversity (MB) and that had township-level zoning. The percentage of seasonal homes was lower in townships with larger amounts of coniferous forest. Townships that were farther from the nearest large town and that had township-level zoning also had a higher percentage of second homes. All other covariate-response relationships were insignificant (Table 2.2.)

DISCUSSION

Regional-level policy

The first objective of this research was to test whether an area employing a top-down, regional regulatory approach to land use policy has worse human wellbeing outcomes as compared with a region with a less centralized approach. Using New York's Adirondack Park as a model for top-down regulation and Michigan's UP as a model for a less centralized approached, we showed that restrictive regional land use policies are not associated with lowered human wellbeing in a rural region. Townships in the two regions had comparable poverty rates and income distributions (represented by the Gini coefficients). The Adirondack Park gained population, while the UP lost population. The percentage of the population under age 30 was higher in the Park, as was the percentage of second homes, compared with the UP (Table 2.1).

Local residents frequently oppose restrictions on land use, especially for the purposes of conservation, on the grounds that they represent a trade-off between humans and nature. No such trade-off is evident in the Adirondack Park, which is perhaps one of the most heavily-regulated rural regions in the United States (Graham Jr 1991). Residents of the Park are as well-off, or better-off, than residents of the UP on four of the five metrics of wellbeing that we studied. The fifth metric, second home percentage, could be said to be either detrimental or beneficial to wellbeing.

We did not detect any effects of the Park-wide regulatory structure on poverty rate or income distribution. The Gini coefficients of townships in the Park were similar to those in the UP, and the regional averages of both locations were lower than their respective states, representing a more equal income distribution. The average poverty rates in both locations were lower than in their respective states, and also lower than the national average, suggesting economic commonalities between our two study regions that go beyond simple remoteness.

Despite concerns about the population size and structure in the Park, the region has gained population faster than the State of New York as a whole, and maintained a relatively high under-30 population. The population growth in the Park during the time we studied could be due to exogenous factors, such as an influx of retiring Baby Boomers or population growth in the state overall. However, because the overall rural population of the United States fell slightly during the time period we examined (Pew Research Center 2018), it seems likely that the qualities of the Park itself are drawing people there. The quality of the Park that differentiates it from other rural areas the most is its vast amount of wild land, and the Forever Wild provision that will keep the land wild in perpetuity. Thus, the APA, often blamed for stifling development by restricting land use, might actually be promoting population growth and the retention of young people relative to other rural areas.

The percentage of second homes was significantly higher in townships in the Adirondack Park than in the UP. This could be considered detrimental to the wellbeing of full-time Park residents. Second homeowners often have different values from full-time residents, which can lead to culture clash (Armstrong and Stedman 2013). The market for second homes may also raise property values out of the reach of less-wealthy full-time residents. The Adirondack Park Regional Assessment Program (APRAP) report identified affordable housing as one of the issues facing Park residents, so this fear is not unfounded (Adirondack Association of Towns and Villages 2009). On the other hand, high-value second homes bring in tax revenue to local governments, which is used to fund public services that primarily benefit full-time residents. While part-time residents are less dependent on local services than are year-round residents, seasonal homeowners still shop at local stores, eat at local restaurants, and employ local construction workers (Green et al. 1996, Venturoni 2004, Garcia 2019). Because seasonal homes have these countervailing effects on communities' social and economic structure, we cannot categorize them as either detrimental or beneficial to wellbeing, but it should be noted that seasonal homes do have social and economic effects on local communities.

Our comparison between locations shows that more stringent land-use regulations do not lessen the wellbeing of Adirondack residents compared with residents of the UP. The fact that Adirondack residents are as well-off, or better off, than residents of the UP suggests that conditions created by the Adirondack regulations might increase wellbeing on some of the metrics we studied. In addition, land-use regulations are often intended to promote wellbeing in ways that are less tangible than those measured in this research. For example, zoning regulations are thought to preserve community character, and public land provides recreational opportunities for locals. Because we were unable to quantify these less-concrete benefits, we may be underestimating the positive impacts of land-use regulations on local communities. Communities that are under intense development pressure might especially benefit from land-use regulations that conserve open space and manage growth, like those measured in this study.

Public land and zoning

The second objective of this research was to test the effects of public land and zoning in each regional regulatory context. There were few commonalities between regions in terms of how public land and zoning affected wellbeing; the presence of land use regulations were not consistently associated with either improved or decreased wellbeing in either context. In the UP, townships with more public land had lower rates of poverty, while public land did not affect any other metric of wellbeing that we studied. Zoning had no effect on any wellbeing metric in the UP. In the Adirondack Park, townships that had more public land managed for biodiversity had lower poverty rates. Townships with their own zoning had a smaller percentage of the population under 30 and a larger percentage of second homes. There were no other significant effects of public land and zoning on the metrics of wellbeing we studied.

Only one effect was consistent between regions: townships with more public land managed for biodiversity in both regions had lower rates of poverty. Two explanations are possible for this relationship. First, land managed for biodiversity might be responsible for job creation, most likely in the tourism industry (Albrecht 2004). Higher employment in areas with extensive land of this type could then bring down the poverty level. Alternatively, land managed for biodiversity could function as a natural amenity, increasing demand for and driving up property values of land nearby (Hunter et al. 2005). People living in poverty would then be priced out of living in the area, and would be replaced by wealthier residents. Given that this study also shows a decline in the under-30 Adirondack Park population associated with land managed for biodiversity, we find it more likely that the latter explanation is correct, as younger people are also likely to be priced out of expensive housing markets. In addition, previous research showed no relationship between employment and public land in the northern forest, again suggesting that the explanation of tourism creating jobs is unlikely (Lewis et al. 2002). Thus, land managed for biodiversity could be viewed as an economic asset, for drawing wealthier residents to a region, or an economic liability, pricing poorer residents out of the housing market. Finer-scale data, examining location choice of both high- and low- income residents, would clarify this relationship.

In the UP, townships with more multiple-use public land also had lower poverty rates. In Michigan, this type of public land is largely designated as state forest, and can be used for timber harvesting, motorized recreation, hiking, camping, and occasionally mining. While it is possible that multiple-use public land also acts as an amenity that raises property values, we find this explanation less likely than for land managed for biodiversity. Land managed for biodiversity is likely to be a more valuable environmental amenity, due to its stronger protections and fewer allowed uses, than multiple-use land.

If both types of land were driving up property values, we would expect to see a stronger negative relationship between land managed for biodiversity and poverty than for multiple-use land and poverty. Instead, the opposite is true. Little research exists specifically on the effects of multiple-use land on local people. Because the uses to which this land is put are heterogeneous in space, it is difficult to generalize about its impacts, other than to recognize that they might be different than those of other types of public land.

Zoning did not influence any variables in the UP, but was associated with a lower under-30 population and a higher percentage of second homes in the Adirondack Park. It is important to note that all townships in the Adirondacks are subject to Park-wide zoning. For a township to have its own zoning plan, the proposed plan must be approved by the APA. The township-level plan then replaces the Park-wide plan. Thus, township-level zoning in the Park represents *less* restrictive regulations than the status quo, whereas township-level zoning in the UP represents *more* restrictive regulations than the status quo (which is an absence of zoning). In Wisconsin, rural townships have been shown to adopt zoning only after a period of rapid growth (Locke and Rissman 2015). Despite differences in the zoning systems, this could be the case in the Park as well. The higher percentage of second homes and the lower proportion of people under 30 in townships with zoning in the Park suggests a higher-cost real estate market. Township-level zoning might be a response to housing growth driven by the second-home market, or an attempt to slow the rising cost of homeownership. Regardless, these relationships show that devolution of authority to more local levels of government is not always an unalloyed good for local communities: in townships where the state-level authority (the APA) has devolved planning responsibilities onto the township government, the population of younger people is lower than in townships where the APA has retained planning responsibilities.

Again, non-quantifiable benefits of land-use regulations were not examined in this study, so we likely underestimated the actual positive effects of such regulations. At the least, we can conclude that public land acquisition or zoning implementation will not appreciably lessen the wellbeing of a township, except possibly in the area of affordable housing. The relationships among public land, housing prices, and poverty could benefit from further investigation to clarify the extent of this possible effect.

While the intention of this research was to study the effects of policy on wellbeing, we also tested the effects of several land cover variables. Land cover variables were significant predictors of wellbeing about as many times as land use policy variables, but the effect sizes were generally larger. The effects of land cover on wellbeing were different in each region, suggesting that the effects of land-use regulations at the township level are highly dependent on contextual factors, and cannot be easily extrapolated from one region to another. We observed large differences between regions in terms of which land cover covariates influenced which wellbeing metrics. For example, both the population under 30 and the percentage of second homes were strongly responsive to the percentage of developed land in the UP, while the percentage of developed land did not significantly influence any metric in the Adirondack Park. We believe that most of these differences between regions are due to nuances of the landscape context for which we were not able to account in the analysis.

Further contextual differences are highlighted by the effects of coniferous forest cover on second home percentage in each region. In the UP, more coniferous forest is correlated with more second homes. The opposite is true in the Adirondacks. In this case, the spatial configuration of coniferous forest is likely more important than the forest type itself. Coniferous forest in the Adirondacks is concentrated in the mountainous interior of the Park, farther from popular (and more easily accessible) vacation destinations like Lake George (Jenkins 2004). Thus, forest type may be acting here as a proxy for topography.

Other studies are congruent with the idea that factors besides land-use policy can bear more significant responsibility for determining the social and economic wellbeing of a region. These factors can include proximity to urban areas (Gustafson et al. 2005), environmental amenities (Hunter et al. 2005), and non-land-related policies such as those that influence education and crime (Reese and Ye 2011). Land cover type could be another such factor. Land cover might be associated with specific economic opportunities, such as agriculture or forestry, or it might affect housing markets by making it difficult to build houses in some areas, like wetlands. "Place luck" (Reese and Ye 2011) and history also likely play large roles in influencing the wellbeing of rural areas.

The comparison between study locations is an important assumption of this research, and we recognize that the two study areas have differences that go beyond policy, which may complicate the results presented here. However, because it is not possible to study a counterfactual location in this case, we believe that this comparison is a valid step toward understanding the region-wide effects of policy. Research in this area could benefit from smaller-scale or qualitative research capable of elucidating the role of variables we were not able to quantify on the scale of this study, such as the role of policy enforcement and compliance or the specifics of zoning plans. The wellbeing variables we studied were a small subset of many possible metrics, and other metrics might show different results. Our intent was to look for broad trends in the relationships between policy and wellbeing. Finer-scale research might be able to discover the driving forces behind some of the patterns described here.

Conclusions

This research demonstrates that stringent, top-down regulation of land does not harm several dimensions of a region's wellbeing, and that land use regulation can help a township attract residents, as well as providing amenity, recreation, and ecosystem service values. Large-scale quantitative research into the relationship between land-use policy and human community wellbeing is rare, and this study is the first of which we are aware to statistically compare multiple dimensions of wellbeing across different policy paradigms. Based on research in these and other study systems (Lewis et al. 2002, Keal and Wilkie 2003, Lewis et al. 2003, Jakus and Akhundjanov 2018, Sims et al. 2019), we knew that land protection is unlikely to cause economic harm; now we have shown that regulations may actually benefit community wellbeing in some ways.

These results should encourage conservationists and local governments to work together to find ways in which land conservation could benefit human communities in other locations. The effect of amenity-driven migration has been documented, particularly in the western United States (Marcouiller et al. 2002, Saint Onge et al. 2007), but high housing prices and cultural conflict frequently follow an influx of new residents (Venturoni 2004, Saint Onge et al. 2007, Armstrong and Stedman 2013). Careful planning is likely needed to balance conservation of natural amenities with the wellbeing of both longtime and new residents. In this sense, the Adirondack Park is fortunate to have a dedicated planning commission. Other efforts, like the Lake Tahoe Regional Plan, demonstrate that large-scale land use planning is achievable and may be necessary for the sustained wellbeing of some regions.

Policy makers should be wary of accepting the common framing of conservation as being detrimental to human communities. Conservation initiatives may have positive, neutral, or negative impacts on a community, and we find it unlikely that any one policy will have the same impacts in every location. We suggest instead that the benefits of conservation accrue locally as well as globally, and that reflexive opposition to conservation could cause economic harm to communities like those in the Adirondacks. The outcomes of conservation policy are complex, and policy makers should work to understand how a policy would affect their community rather than assuming that people and nature are in opposition to one another.

Many rural communities in the US have seen similar social and economic problems to those in the UP and the Adirondack Park—outmigration of young people, persistent poverty, and a loss of jobs, to name just a few (Weber et al. 2005, Ryser and Halseth 2010, Goetz et al. 2018). Because most public land exists in close proximity to rural communities, land regulations become a convenient scapegoat. This research shows that the cause of declines in rural wellbeing lies elsewhere. In the Northern Forest, land use regulations are an important tool that maintain the provision of ecosystem services, recreational opportunities, and the rural character of communities, while at the same time potentially contributing to the wellbeing of local residents.

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Chapter 3: Policy effectiveness and conservation in a full world

INTRODUCTION

It is more important than ever to build effective conservation policy. As development accelerates around the world, less land is available for use as wildlife habitat and for conserving important ecosystem services (Huang et al. 2010, Crist et al. 2017). While some conservation organizations have set a goal to increase the planet's protected land area, protected areas are often not ecologically representative or large enough to provide habitat for all the species that need it (Groves et al. 2002, Convention on Biological Diversity 2011, Jantz et al. 2015, Venter et al. 2018). Conservation solutions therefore must also include land that is used for anthropocentric purposes, which necessitates the integration of large-scale land use planning with land protection, zoning, and economic incentives (Doremus 2003). Using land for both anthropocentric purposes and conservation is important for human and non-human species; the increasing human population will continue to need land for agriculture and homes, but relies on undeveloped and biodiverse systems for ecosystem services like water and air filtration (Polasky et al. 2008, Nelson et al. 2009, McShane et al. 2011, Mace et al. 2012, Yang et al. 2015). Policy makers must find a way to ensure the continued co-existence of these competing land uses.

Despite the competing claims of advocates and detractors of land use regulations, little research exists on the overall effectiveness of land use policy when it comes to conserving biodiversity on mixed-use landscapes over the long term, especially in the United States. Most information on policy effectiveness comes from studies comparing multiple sites at one point in time, or a single site at multiple times (Bruner et al. 2001, Crosby 2017, Peach et al. 2018). However, research shows important temporal dynamics at play that affect landscapes in a dynamic and context-specific way, so effective policy also has to consider the future. The objective of this paper is to analyze the elements of effective land use policy both in theory and in practice.

POLICY EFFECTIVENESS IN CONSERVATION

To be effective, a conservation policy has to have a positive ecological outcome. Scientifically, this is easy to accomplish; it is well-known that habitat conservation is paramount to conserving wildlife (Hoffmann et al. 2010, Hanski 2011, Segan et al. 2016). However, the participation of humans in the system complicates this picture. Policies or regulations that conserve natural land cover might be controversial to the point where humans ignore them, or push for their repeal. Regulations that are routinely violated are not successful. If conservationists were to achieve an effective conservation outcome (for example, establishment of a protected area), we would expect that the protected area would be maintained in natural land cover, ideally with connections to other protected areas or open space. We would further expect that people would comply with the land use restrictions on the area, and would not lobby their elected officials to reverse the area's protected status. A less-successful protected area might be subject to extensive illegal uses, like motorized recreation, that are detrimental to wildlife conservation. Even if enforcement in the less-successful protected area was at a level that ensured high compliance, the political pressure to reverse at least some of the protections would make the protected area less likely to persist over the long term.

In other words, conservation policy has to be effective both from an ecological standpoint and from a human, or socio-political, standpoint. It is not enough for a policy to conserve biodiversity in the lab or in controlled field trials; it must also work in practice, which means taking into account the socio-political aspects of conservation effectiveness. The following literature review discusses both of these aspects of effectiveness, and how they interact.

Biodiversity conservation requires unconverted, mature habitat (Blair 1996, Devictor et al. 2008a, Bouchard and Garet 2014, Betts et al. 2017) with intermittent disturbed spaces (Faccio 2003, Campbell et al. 2007). Conversion of land to anthropogenic uses, whether agriculture or development, is generally detrimental to biodiversity (Benton et al. 2003, DeLuca et al. 2004, Betts et al. 2017), so policies that keep land from being converted to more developed uses are likely to promote biodiversity. The question for policy makers is how to create or maintain these kinds of landscapes. Land protection is a favorite approach of many conservationists, and global conservation organizations have set a goal of protecting 17% of the world's land area by the year 2020 (Convention on Biological Diversity 2011). Protected areas preserve natural land cover and allow for management with biodiversity as a goal. In general, previous research supports the claim that biodiversity is higher on protected than non-protected land (Devictor et al. 2007, Gaston et al. 2008, Greve et al. 2011, Goodwin and Shriver 2014, Ament and Cumming 2016), although much of the effectiveness of protected areas depends on their context within the larger landscape (Naughton-Treves et al. 2005, Ament and Cumming 2016, Peach et al. 2018).

High-quality wildlife habitat can also be maintained outside of protected areas, on private land, through a combination of market forces and policy actions. Conservation easements are an increasingly popular way to keep land in private ownership without the risk that it might be converted into a more developed use (Rissman et al. 2007, Fishburn et al. 2009, Pocewicz et al. 2011). Sustainable logging on private land can maintain a shifting mosaic of small-scale disturbances, contributing to landscape-scale biodiversity (DeGraaf and Yamasaki 2003, Campbell et al. 2007, Forsman et al. 2010). Landowners may choose to keep their land undeveloped for timber production, aesthetics, hunting, and other purposes, or simply because there is no financial incentive to convert it. At the regional scale, it can be difficult to determine why land remains unconverted, which also makes it difficult to understand how to keep it from being converted in the future. However, many states and the federal government offer incentives for keeping land in its natural cover, while allowing hunter access, practicing sustainable land use, or other conservation-friendly actions (Doremus 2003, United States Department of Agriculture 2012, Sorice et al. 2013, Kamal et al. 2015). Globalization of timber markets is also likely playing a role: in the United States, more land is being converted to forest than is being deforested while the opposite happens in the tropics, suggesting that US-grown timber is being replaced in the global market (Ince et al. 2007, Kimbell 2007, Song et al. 2018, Rudel et al. 2020).

Some habitat conservation initiatives work by containing urban sprawl and exurban development. Urban containment policies restrict the amount of development that can happen beyond a certain boundary. These policies have a mixed record of actually containing development, which is partly dependent on their specific provisions (Wassmer 2006). Several states have implemented state-level growth management plans, which commonly state sprawl reduction as a goal. While these plans are not specifically designed to promote biodiversity, exurban development is a major cause of habitat destruction and biodiversity loss (Hansen et al. 2005, Glennon and Kretser 2013, Lumpkin and Pearson 2013). Reduction in the extent of exurban development is likely to also reduce the rate of biodiversity loss. State-level growth management plans have been shown to be effective at slowing the rate of exurban development relative to states without growth management plans (Nelson and Moore 1996, Carruthers 2002, Wassmer 2006) and relative to local-led growth management plans (Boyle and Mohamed 2007).

Zoning is a tool for shaping land use that is typically controlled by local governments in the United States. As with urban containment and growth management, biodiversity conservation may or may not be one of the stated goals of zoning. The effects of zoning on habitat conservation are heterogeneous, due to the variety of goals and enforcement mechanisms used by local governments (Esparza and Carruthers 2000, Munroe et al. 2005, Butsic et al. 2010, Magliocca et al. 2012). However, if open space conservation is a goal and if the zoning plan is formulated and enforced effectively, local-level zoning can slow land conversion into anthropocentric uses, thereby conserving biodiversity. Conservation zoning, an increasingly-popular take on this well-known planning tool, is specifically designed to contain development and has been shown to be positively related to biodiversity (Odell et al. 2003, Mockrin et al. 2017). However, other research shows zoning ordinances to be more likely to be adopted reactively rather than proactively, reducing their effectiveness in conservation (Locke and Rissman 2015).

These tools can be used individually or collectively to shape landscapes that contain large areas of natural habitat, and all are relatively well-known in both science and policy. The fact that large areas of natural habitat are disappearing, rather than being conserved, speaks to the second aspect of policy effectiveness. For various reasons, most societies have not chosen to prioritize conservation of land and therefore wildlife. We know the outcomes of effective conservation policies, but the process that would put these policies in place is carried out by humans, who often have conflicting priorities. In the next section of this review, we discuss the human aspects of conservation effectiveness.

For habitat conservation to be successful, it needs to be long-lived, funded, and enforceable. Each of these aspects of conservation is effected through the policy process, which is influenced by democracy in much of the world. In other words, ordinary people, acting through their elected officials and on their own, determine how effective a policy will be. Popular opposition to habitat conservation might mean that conservation policies are never implemented or quickly repealed. It might also mean that policies are frequently ignored or that maintenance of habitat and enforcement of use restrictions are underfunded. It is therefore important to examine the factors that influence popular support for or opposition to conservation policies.

The process by which policy is made affects people’s perceptions of the policy itself. Good governance is cited as having important effects on the ways people view conservation actions (Schenk et al. 2007, Lockwood 2010, Bennett et al. 2019). Good governance, while defined in a variety of ways, generally refers to the idea that decisions are made effectively, reasonably, and fairly, with input from and accountability to affected people (Miller et al. 2013, Warren and Visser 2016, Bennett et al. 2019). Some components of good governance—including legitimacy (Paloniemi and Vainio 2011, Turner et al. 2016, Meinard 2017) and fairness (Smith and McDonough 2001, Gross 2007) have been independently associated with acceptance of conservation actions.

Participation in decision-making, another component of good governance, has received extensive attention in the conservation literature. Participation has been related to compliance, acceptability, legitimacy, and overall effectiveness of conservation regulations (Kellert et al. 2000, Schusler et al. 2000, Burby 2003, Andrade and Rhodes 2012). However, participation in management decisions does not always increase the acceptability or effectiveness of conservation actions. In some cases, acceptability of protected areas has been shown to be independent of participation (Depraz and Laslaz 2017, Engen et al. 2019). Differences in values among stakeholders and stakeholder groups can be the reason why participation does not translate into acceptance of or support for conservation. In a case study of German national parks, researchers found that emphasis on participation resulted in resources being shifted from conservation to provision of services to the public (Dupke et al. 2018). Stakeholder groups may be willing to accept damage to the environment for economic benefits (Engen et al. 2019). Differences in the effect of participation on conservation also differ based on geographical, historical, and political context (Kellert et al. 2000, Campbell and Vainio-Mattila 2003, Kohler and Brondizio 2017).

Participation of stakeholders in the decision-making process is often seen as a component of legitimacy and good governance more generally (Reed 2008). However, which stakeholders should participate can be a source of contention, and can affect perceptions of the fairness or legitimacy of the process (Smith and McDonough 2001, Suškevičs 2012). For example, there is intense debate regarding who should be part of the decision-making process when it comes to the use and management of public land in the United States. While public land, by definition, belongs to the public at large, locals or other land users have argued that their voices should matter more in management than those of farther-off stakeholders. In one headline-making case, local land users claimed that the Federal government does not have the right to charge grazing fees on public land, despite this decision having been made through the democratic process (Bartrum 2017). In other words, they felt that the process by which grazing fees were levied was illegitimate because non-local actors had taken part in the decision-making and had overruled the wishes of some local resource users. A similar refusal to recognize the interests of the broader public in Federal land management drove the Sagebrush Rebellion of the 1970s (Cawley 1993).

The case of federal lands management has similarities to many other conflicts over natural resources. Federal land, by statute, belongs equally to all citizens, but those who live most closely to federal lands are the most affected by management decisions. These local residents see themselves as having a larger stake in land management, but have to share decision-making power with more distant users who are less affected by the decisions that are eventually made (Gross 2007, Cinque 2015). This dynamic may be one reason why proximity to a resource is associated with opposition to conservation of that resource (Bonaiuto et al. 2002, Karlsson and Sjöström 2007, Chambers et al. 2017).

Because local stakeholders are more likely to be opposed to conservation actions, a broader stakeholder base may make conservation policy more effective through political support. If a policy is supported by a majority of stakeholders, it should persist over the long term, even if local stakeholders oppose it. Here we see a paradox: inclusion of more distant stakeholders causes local stakeholders to perceive the process of conservation policy less favorably, but it also is likely to make the policy more resistant to change. Thus, inclusion of a broad base of stakeholders could make a policy more effective by making it harder to change while also making it less effective by making it seem less legitimate to local stakeholders. Policy makers should consider both of these possible effects when deciding who should participate in decision-making processes.

In some cases, the process by which a conservation policy is implemented is more important to stakeholders than the outcomes of the policy (Sarewitz 2004, Bennett et al. 2019). Other factors also affect whether people will support conservation policy, including pre-existing values (Ives and Kendal 2014) and political ideologies (Sarewitz 2004, Bliuc et al. 2015), as well as the way the policy affects human communities. The perception of economic harm stemming from conservation policy is common, and can persist regardless of whether demonstrable economic harm has been caused (Bennett and Dearden 2014, Jakus and Akhundjanov 2018, Sims et al. 2019). Incentive programs such as payment for ecosystem services are built around the intuitive idea that demonstrable benefits from conservation will help increase the acceptability of conservation actions (Börner et al. 2017, Blundo-Canto et al. 2018). But because opposition to conservation regulations stems from multiple sources, incentives alone are often insufficient when it comes to increasing local acceptance or compliance (Nelson et al. 2008, Rode et al. 2015, Börner et al. 2017).

Political ideology is associated with support for or opposition to land use planning in the United States (Hurley and Walker 2004, Golding 2012). Political ideology further complicates the factors that determine acceptance of conservation because it is not independent of the other variables. For example, someone with a conservative ideology in the United States might oppose conservation policy because they believe that all regulations negatively affect the free market. It would be difficult to determine whether that person opposed conservation policy on political, process, or economic grounds. Conservationists and policy makers who hope to advance conservation policy should work to understand how these factors interact in their own communities. While some opposition will be difficult to dispel, it is likely that the use of good governance principles, including engaging key local stakeholders, can improve the socio-political effectiveness of conservation action (Schenk et al. 2007).

Effective conservation policies are characterized by a combination of ecological accomplishments, public acceptability, and robustness to change. Therefore, what policies are effective depends in part on the human context in which they are made. Scale affects effectiveness: a state-mandated policy that is unacceptable locally may be robust to change if it is popular statewide. Human culture also could change policy effectiveness, for example, policies in cultures where noncompliance is socially acceptable could be less effective than the same policies in cultures where compliance is expected (Jagers et al. 2012). Sometimes actions that increase a policy's socio-politically acceptability make it less ecologically effective, as in the case of German national park management (Dupke et al. 2018), where public participation is popular but leads to fewer resources being dedicated to conservation. In many systems, there is likely a point at which socio-political acceptability and ecological effectiveness intersect to produce the maximum amount of conservation benefits possible.

CASE STUDIES OF LAND USE POLICY EFFECTIVENESS

Little research exists on large-scale land use policy effectiveness, perhaps in part because, once a policy is implemented, it is difficult to tell what would have happened if it had not been implemented. Conservation policy must often be in place for a significant amount of time before it is possible to evaluate its effectiveness, and it can be hard to separate the effects of policy from the effects of external conditions. To examine how land use policy works under different sets of external conditions, we turn to the field of scenario studies.

Scenarios are plausible stories about alternative future conditions that allow examination of potential management actions when uncertainty and uncontrollability are both high (Figure 3.1). Under these conditions, predictions about future conditions become less effective, and planning for several different scenarios becomes worthwhile. Rather than predict one most likely future, scenarios represent a range of futures under which actions can be analyzed (Peterson et al. 2003). Comparisons among the scenarios provide insight into the dynamics of the system being studied and allow researchers to identify actions that are applicable across futures or that lead to a more desired future state (Thompson et al. 2012). With uncertainty in both the human and non-human conditions that determine the effectiveness of conservation policy, we believe that scenarios are a tool that can help us better understand a range of possible futures under different policy paradigms.

There are many methods for building and using scenarios (Mahmoud et al. 2009). In this research, we use a common scenario building method in which researchers select two important driving forces of change, each of which can be visualized as a continuum (Rowland et al. 2014). The two drivers are then combined to form a matrix of four plausible futures (Figure 3.2). The choice of the driving forces behind the scenarios is extremely important. We discarded drivers that are considered highly likely (for example, climate change and population change), and drivers that focused on the effects of a single policy, in favor of drivers that were uncontrollable and would affect a variety of aspects of the future. We looked for drivers that could realistically increase or decrease from the current baseline (Peterson et al. 2003). Finally, we focused on drivers that created the most relevant scenarios to our research question.

In searching for drivers that met these criteria, we first considered how the ecological and socio-political effectiveness of conservation policy could change in the future. The factors that make conservation ecologically effective seem unlikely to change much; conservation of continuous habitat will still probably be paramount in the future world. Climate change will likely only intensify the effects of land cover change on wildlife (Mantyka-Pringle et al. 2015). As the effects of change in temperature and precipitation grow more marked, climate may increasingly become a primary driver of extinctions (Pimm 2008). However, ensuring areas of continuous habitat or habitat patches connected by corridors will make range shifts possible for smaller or less-mobile species (Nuñez et al. 2013, Alagador et al. 2016). In other words, climate change may make habitat conservation more important, but it will likely not change the nature of the conservation policies that are effective.

Similarly, some of the factors that make conservation socio-politically effective are unlikely to undergo major changes. People will continue to value fairness and respect legitimacy, and oppose actions that they view as harmful to them personally. People are still likely to value short-term benefits over long-term conservation due to their tendency to discount benefits that occur in the future (Hardisty and Weber 2009). However, changes in some economic or demographic characteristics might affect how people view conservation or how much they value conservation in relation to other goals.

Environmental concern is one aspect of socio-political effectiveness that has the potential to change over time. There has been significant historical change in how people view the environment, and how important they think it is to conserve the natural world. The early white settlers in North America viewed wilderness as a threat to be destroyed; later generations saw it as a resource to be treasured (Nash 2014). In more recent decades, polls have asked Americans various questions about their environmental values and concerns. Variance in the responses over time suggest that concern for the environment fluctuates significantly, and that the number of Americans who believe the environment should be prioritized over other concerns has increased in the past decade (Newport 2018). With climate change increasingly in the news, it seems plausible to expect that concern for the environment could continue to grow. On the other hand, environmental concern declined during the Great Recession of 2008, suggesting that a similar economic downturn could lead to Americans prioritizing other issues (Newport 2018). Concern for the environment can affect how people vote (and therefore what policies are implemented) (Davis and Wurth 2003) and how people behave (Hedlund 2011), both of which could change the effectiveness of conservation policy in the future. For these reasons, we selected environmental concern as one of the drivers of change for our scenario exercise.

The second driver we selected was economic in nature. Affluence affects individuals' behavior through their spending choices; affluent individuals consume more resources per capita (De Bonis and Silvestrini 2012), and have more capacity to make choices, such as owning large homes or second residences, that affect land use. In addition, the generation known as Millennials (currently adults from the ages of about 25 to about 40, or those born between 1981 and 1996) is significantly less affluent than previous generations were at similar ages (Dimock 2019, Ingraham 2019). As older individuals retire, Americans' consumption patterns could be affected by this disparity in wealth. It is also plausible to imagine that Millennials will close the wealth gap as they age, either with the help of government programs or without (Kelly 2019). Not only will affluence affect individual behavior, but it is also likely to affect markets: if affluence is high, demand for land is likely to be higher as well, pricing some actors out of the land market and making regulations that restrict development harder to pass.

The combination of these two drivers, environmental concern and affluence, formed the basis for our four scenarios (Figure 3.3). These are, of course, not the only two drivers we might have chosen, but the scenarios they create are plausible, divergent, and relevant to our research questions. We gave each scenario a name to differentiate it easily from the others, and envisioned how outcomes for biodiversity would be different under each scenario.

These four scenarios illustrate the big picture of conservation policy in the United States. However, conservation policy varies state-to-state, region-to-region, and even township-to-township. We chose to apply the four scenarios to two study areas in order to see how the policy framework of each area affected conservation outcomes. We chose two study systems that are ecologically similar but politically different, and on which we have previously conducted research: New York's Adirondack Park and Michigan's Upper Peninsula (UP).

The Adirondack Park is a rare example of a park in the United States that has historically encompassed both human and natural communities (Nash 2014). Established in 1885, the Park today is comprised of approximately equal parts private and state-owned land (Porter et al. 2009). The public land is protected in New York's constitution as Forever Wild (1971), and all the land within the Park's boundary (including privately-owned land) is overseen by the Adirondack Park Agency (APA), a central planning agency established in 1987 by the state (State of New York 1987). The APA establishes regulations that apply to all private and public land within park boundaries, including several categories of allowed uses and maximum building densities. It also oversees building permits for both private and public land (Adirondack Park Agency 2019). While much of the state-owned land in the Park was acquired by default, in recent decades New York State has begun to strategically acquire land that has desirable natural features, or that would establish contiguity between parcels.

In contrast to the centralized planning and oversight of the Adirondack Park, the UP is managed under a patchwork of state, local, and federal regulations, with historically little planning for land acquisition. Much of the state-owned land was acquired through forfeiture after logging companies failed to pay property taxes on the land once the timber had been harvested (Dempsey 2001). There are also two large national forests in the region. In total, about 68% of UP land is publicly owned. Individual townships set zoning regulations, although a few counties also have their own zoning systems to which unzoned townships are subject.

Our research in Chapters 1 and 2 of this dissertation showed these systems to have similar levels of biodiversity despite a policy structure in the Adirondack Park that is intended to conserve wildlife habitat. In addition, the more restrictive land use policies in the Adirondacks appear to have led to higher, not lower, economic wellbeing there as compared to in the UP. This snapshot of conditions prompts us to ask whether the conservation policy structure in the Adirondacks is really necessary, as it seems to not be associated with greater biodiversity. However, it is possible that this policy system will be effective, not in the present, but in the future of the Adirondack Park. Conversely, the less-unified policy structure in the UP might cause future conditions quite unlike those we see today. In the next section of this paper, we expand and analyze each of the scenarios in Figure 3.3. We examined the four futures under each of our policy paradigms (the Adirondack Park and the Upper Peninsula) to identify how each policy would affect conservation if that future came to be. While scenario development is often done by groups of stakeholders in collaborative workshops, this scenario building project was carried out by the lead author alone as an outgrowth of research into these study systems (Davies et al. 2015). The details of the scenarios were based on what the author thought were the likely implications the scenario drivers (Figure 3.3) for development, governance, and biodiversity.

Scenarios

Scenario 1: Greenish growth (increased affluence, high environmental concern)

In this scenario, Millennials are able to close the wealth gap with their parents as they approach middle age. This increased buying power translates into demand for housing. More states have adopted growth management plans, and eco-friendly zoning is growing more popular, so some of the new housing demand is satisfied through high-density development near transit corridors. Exurban development still continues, but more slowly than at the turn of the millennium. The vacation-home market remains strong, especially in rural areas rich in undeveloped land. Eco-friendly development is trendy, including use of renewable energy and building materials, but strong limits on growth are unpopular due to high property values and demand for land. New public land acquisitions have not been possible, as land is too expensive, but public land is generally popular, and public lands management is sufficiently funded.

In this future Adirondack Park, the supply of housing has not increased with demand. When some large private landowners subdivided their property into large lots for vacation-home development, the APA intervened. The Adirondack Park Land Use and Development Plan (1973) was revised to make large-lot development more difficult, angering development interests and large local landowners. However, support for the action from some residents, environmental groups, and downstate recreationists was instrumental in its implementation. Park residents are still divided about this and other pro-environment actions, but are more supportive than in previous decades. As the pace of development has slowed (but not stopped), housing prices have increased, leading some locals to worry about the gentrification of the Park. The state legislature has allocated more funding for enforcement of Park rules, invasive species removal, and land management, which has helped state land maintain its biodiversity and wilderness character as recreational use increases. As development in the rest of the state outpaces that in the Park, the Park becomes more distinct from its surroundings, characterized by low population density and large amounts of open space. While the boreal bird species of the park have mostly shifted north, new southern species have replaced them, leaving overall biodiversity about the same as it was.

In this future UP, the population decline of the early millennium has been reversed. Climate change has brought consistently milder winters to the region, making it more attractive to year-round residents. Most of the population growth has taken place near the larger towns of the region, but exurban development has grown within half an hour's drive to downtown Marquette and Sault Ste. Marie. Upper Peninsula townships were slower than the rest of the state to adopt growth management measures like conservation zoning, due to their unpopularity with the mostly conservative residents. As a result, a significant amount of private forestland was subdivided and developed before residents realized the extent of potential development and conservation zoning became widespread. Vacation home development has grown along the shores of the Great Lakes but second homes still don't make up the majority of housing in any county. Public lands remain public, but demand for services has seen the building of more roads and the development of more inholdings. Forest obligate birds decline, and the new species moving in from the south are more likely to be generalists. The large amount of forest means that the region is still more biodiverse than the southern part of the state, but overall biodiversity is lower than in the 2010s.

Scenario 2: Maximum sprawl (increased affluence, low environmental concern)

In this scenario, Millennials are able to close the wealth gap with their parents, resulting in a strong demand for development. Due to public opposition, no states have recently implemented growth management regulations, and conservation zoning never really caught on nationwide, so exurban growth continues to increase at a fast pace. The vacation-home market remains strong, both for new and existing homes, especially in rural areas rich in undeveloped land. New public land acquisitions have not been possible, due to both high land prices and the unpopularity of the public-lands concept. Funding for management and research on public lands has been cut.

In this future Adirondack Park, land use regulations are essentially unchanged since the 2010s. Due to strong vacation-home demand, some landowners have been able to subdivide their land and sell it off at a significant profit, and others are considering doing the same. While the pace of new development is slower inside the Park than outside, nearly all new developments are eventually approved. APA regulations have held off most new infrastructure construction, but the new residents are starting to lobby for more roads and increased public services. Long-time residents are worried that the Park is losing its wilderness character, noting that the Park is becoming more similar to the counties surrounding it. Funding for maintenance of state land hasn't kept up with the increase in recreational use that began decades earlier, and illegal motorized use in wilderness areas is common. Due to climate change, the boreal bird community has shifted north out of the park, and has been mostly replaced by more southern species. Forest obligates are becoming rare, and invasion by nonnative parasites like cowbirds and predators like house cats is on the rise along travel corridors. Overall biodiversity is a bit lower than in the 2010s, but still higher than in surrounding counties, which have developed faster.

In this future UP, housing growth is spread fairly evenly across the landscape. New year-round residents, drawn by the milder climate and low cost of housing, are concentrated within an hour's drive of the larger towns, like Marquette and Sault Ste. Marie, and in a few newer population centers. In the meantime, vacation-home owners are each trying to claim a piece of lakeshore or an isolated spot in the woods. New roads are being built to accommodate the new residents, and a few towns are beginning to expand their water and sewer systems. This new infrastructure construction further fragments the landscape and creates travel corridors for nonnative species, like cowbirds and house cats. Most townships have kept their zoning plans that favor the development of single-family homes over higher-density housing, so the building footprint per new resident is relatively high. Local governments tout the economic benefits of construction. Some long-time residents are disappointed that the UP is coming to resemble the rest of the state more closely, but their concerns, and those of the environmental community, take a back seat to the pro-growth mindset. Recreational use of public land has grown, and most public lands are now open to motorized vehicles. The bird community is becoming more homogenized across the region, with forest obligates mostly being replaced by generalists from the south. Biodiversity is significantly lower than in the 2010s.

Scenario 3: Smart de-growth (decreased affluence, high environmental concern)

In this scenario, Millennials' lack of affluence persists throughout their adult lives, as the national economy slows and the middle class shrinks. Without a lot of disposable income, this generation has prioritized their spending to the detriment of several industries, including home construction. As more and more jobs move to cities, following trends from the turn of the millennium, population growth follows them. A spate of pro-environment regulations encouraged high-density growth rather than single-family homes in the suburbs, so many people are opting for apartments where they can walk or take transit to work, and which are more affordable to maintain. Helped along by growth management plans that have been adopted by most states, exurban growth has slowed to a halt. The second-home market has nearly collapsed, since very few people have enough money anymore to afford a vacation home. Because demand for rural land is low, states have been able to acquire new public land for conservation and recreation.

In this future Adirondack Park, land use regulations have been strengthened to prevent subdivision of privately-owned forest land, but there's not as much pressure to develop as there once was. The real estate market has done better here than most other places, since the Park's proximity to the population centers of the East Coast still makes it a destination of choice for vacationers, especially the areas of the Park that have invested in sustainable tourism. Still, the smaller towns are struggling to hang on because of population loss. The larger towns have actually grown slightly in population, accommodating the new residents through building more densely, rather than developing forest or agricultural land. The number of structures in the Park has decreased since the 2010s, and the new land use regulations have led to stricter requirements for new construction on private land. The state has been able to purchase some ecologically-sensitive parcels, such as river- and lakefront properties, and bring them in to public ownership. While climate change has meant that the boreal birds that once lived in the Park have moved north, they've been replaced by an even more diverse suite of more southerly species. Rare forest obligates thrive in the more remote parts of the Park, and careful management encourages early-successional birds in gaps near old logging roads. Some long-time residents lament the loss of the smallest villages, and of nearly all the logging jobs, but others are more relieved that the scenarios of sprawl anticipated in the 2010s never came to pass, and that the Park remains rural and well-managed.

In this future UP, the population decline of the early millennium has been reversed. Climate change has brought milder winters to the region, making it more attractive to year-round residents, nearly all of whom are concentrated in the larger cities and towns. UP townships were slower to adopt conservation zoning than townships in other places, but the sprawl that might have resulted was mitigated by the adoption of a state growth management plan and lower demand for second homes. Without the second-home residents, some small towns are struggling to hang on, particularly those further from the population centers. The number of structures in the UP has decreased slightly, and a few rural roads have been decommissioned. The state has been able to purchase some ecologically-sensitive parcels and bring them in to public ownership, although not enough to significantly change the amount of state landholdings. Climate change has led to the loss of boreal birds across the region, but they've been replaced by an equally diverse suite of more southerly species. Rare forest obligates thrive in the more remote areas, and careful management encourages early-successional birds in gaps near old logging roads, so that overall biodiversity is slightly higher than in 2016. Recreational use of public land has grown, but the regulations that prohibit motorized recreation have kept the ecological damage to a minimum. Long-term residents in the most rural areas struggle economically, but the larger towns are vibrant and the rural identity of the region remains strong.

Scenario 4: Stagnation (decreased affluence, low environmental concern)

In this scenario, Millennials' lack of affluence persists throughout their adult lives, as the national economy slows and the middle class shrinks. Attempts to jump-start the economy and pursue growth at all costs resulted in significant deregulation of the environment, including land use. Jobs are increasingly moving into larger cities, continuing a trend started in the early 2000s, but it is hard to find affordable housing due to old large-lot zoning laws in many of the close-in suburbs. The increasing number of people who work remotely opt for homes in the exurbs, where land is cheap. Development isn't happening quickly, but it is spread somewhat evenly across exurban and rural landscapes. The second-home market is equally slow, with fewer people able to afford vacation homes, but prime real estate, like waterfront lots, is easier to come by than it used to be. Still, very little new public land has been acquired because the public support is lacking, and some states are even looking at selling off some of their land to fund other programs.

In this future Adirondack Park, few new land use regulations have been implemented, but the build-out some people feared has not come to pass due to the lack of demand. The real estate market has done better here than most other places, since the Park's proximity to the population centers of the East Coast still makes it a destination of choice for vacationers. Privately-owned lakeshores and riverfronts are largely still developed, but some of the smaller towns have disappeared as their residents moved downstate in search of jobs. Demand for local timber hasn't increased, so many of the logging jobs that existed a couple decades earlier are gone, despite political efforts to kick-start the industry. Local governments are discussing tax breaks and other incentives to encourage large-scale resort development to attract foreign visitors to the Park, while environmental groups protest. The bird community has been changed by the warming climate but is about as diverse as in the 2010s. Long-time residents lament the loss of the smallest villages and the slow degradation of the environment caused by the repeal of air and water quality standards. Others point to the lack of development as a win for the environment but worry that the Park is losing its identity as a community where humans and nature co-exist.

In this future UP, housing growth is approximately nonexistent. Land is less valuable than it was in the 2010s, as there is little demand for either development or local timber. An exception is the lakeshores and riverfronts, which are being purchased by foreign investors, but a number of the smaller towns have disappeared as their residents moved downstate in search of jobs. The larger towns, while not exactly thriving, are more economically stable than the rural areas, with slight population growth even as the region as a whole has lost population. Two new mines have opened in the area, enabled by deregulation and local governments' efforts to bring in new jobs. Long-time residents are disheartened at the population loss and the failure of most of the pro-growth initiatives in the region. The boreal birds that used to live here have mostly disappeared with the warming climate, and have been replaced by more southern species, although a lack of funding for forest management has led to a decline in early-successional species. Public lands remain popular for recreation, but the lack of funding for maintenance and enforcement results in the spreading and widening of RV trails, creating corridors for non-native species. Overall biodiversity is higher than in the rest of the state, but slightly lower than in 2010. Long-time residents are disheartened at the population loss and the failure of most pro-growth initiatives in the region.

Scenario interpretation

By comparing the plausible outcomes of each scenario between regions, we start to see how policy can influence conservation under various sets of external conditions. The Adirondack Park has a set of policies in place that are intended to conserve open space, and that are extremely resistant to change because they are in part built into the state's constitution. We did not consider it plausible, under any of the combinations of assumptions examined here, that environmental regulations in the Adirondacks would be weaker in the future than in the present. While the UP has some regulations intended to conserve open space, such as large amounts of national forest, its zoning and state forest management regulations are designed to manage land for multiple uses. In addition, these policies are easier to change through the legislative or regulatory process than those in the Adirondacks. These differences in policy are likely to lead to different outcomes in the future, under multiple assumptions about external conditions.

Because regulations in the UP are more flexible, forces that act on land use nation- or state-wide are likely to be influential in the UP as well. Zoning regulations can be tightened or relaxed, depending on how township officials react to changed demand for land. In these scenarios, we have assumed that township governments in both locations are generally more concerned about promoting economic growth than they are about conserving open space (Cox and Mair 1988, Munroe et al. 2005). However, in the Adirondack Park, township governments have fewer options to relax zoning regulations, because the APA provides a baseline zoning plan for the Park as a whole. In addition, the state of Michigan could potentially sell off land in the UP into private ownership, while the state of New York is constitutionally prohibited from selling public land in the Adirondacks. Because of these less-flexible regulations, the Adirondack Park cannot follow national or state trends in land use as closely as the UP can in some of the scenarios.

These scenarios illustrate differences in potential outcomes for biodiversity based on the policies that are in place now. In particular, conservation in the Adirondack Park benefits from having a policy structure that is extremely resistant to change, while conservation in the UP is more dependent on outside political and economic forces. Under some circumstances, including current conditions, biodiversity conservation in both locations is about the same. However, the UP has the potential for greater change in land use than the Adirondacks, which could significantly affect biodiversity if conditions change.

The policy process

The scenarios above deal primarily with the outcomes of past policy making. However, our literature review found strong evidence of the importance of the policy process itself to determining policy effectiveness in conservation. Little research exists on the role that process plays on large terrestrial landscapes, and even less exists on our study areas specifically. Still, differences in the policy process between the two locations can help illustrate how governance works under different policy paradigms.

Previous research has found that the quality of governance is important in determining popular support for policies. We are not aware of any research into the perceptions of the quality of governance in either of our study regions, but we can infer some information from the levels of transparency and participation in each region. The Adirondack Park Agency (APA) is a convenient focal point of controversy in that region, but it does not necessarily follow that it promulgates less effective regulations than the various agencies in the UP. By statute, full-time Adirondack residents make up almost half of the APA board, which gives Adirondackers significant influence over the decisions of the APA. Local governments also have significant decision-making authority over land use; recent changes to Department of Environmental Conservation policy (the agency that manages state land in the Park) allow townships affected by new public land acquisitions to veto those acquisitions, and townships can develop their own planning and zoning ordinances to replace the park-wide Land Use and Development Plan within their borders. Together, these various powers and influences suggest that Adirondack residents have more opportunities to participate in governance in their region than do most other residents of rural America, even though some of those opportunities are mediated through local elected officials.

Residents on the UP do not have similar avenues to express their support for, or opposition to, state-imposed land use regulations. Without representation on an agency board, like Adirondack residents have, UP residents are reliant on decisions made through the legislature, in which their representatives are a minority. Employees from the Department of Natural Resources (DNR) work with municipalities on some land use management issues, and townships may be consulted on land use decisions on state or federal land. However, townships in the UP do not have veto power over new acquisitions in the way local governments do in the Park. Thus, although neither of our study regions are governed by truly participatory processes, it appears that Adirondack residents have more influence over land use in their region than do UP residents.

UP residents have more regulatory flexibility than Adirondackers within each township. As of 2000, many townships in the UP had forgone zoning altogether. Even townships that have zoning are free to adopt land use plans without any conservation benefits. In the Adirondacks, township-level zoning must be approved by the APA and cannot be less stringent than the Land Use and Development Plan.

Transparency in governance is equally difficult to measure. However, the existence of the APA, as controversial as it has been, may have actually improved transparency in the Adirondacks. APA meetings are open to the public and each includes time for public comment, enabling citizens to provide input on decisions and witness how each member of the APA board votes. Having a single agency do much of the decision-making means that information is centralized and citizens know who is responsible if something goes wrong. In the UP, a variety of governments and agencies are responsible for decision-making and it may be difficult for the average citizen to determine where to get information and how to participate outside of their township's government. Decisions may be made by technocrats in state or federal agencies who are less accountable to the public than the members of the APA board. From a perspective of both transparency and participation, the Adirondack Park appears to have better governance than the UP.

Perceptions of fairness in conservation policy making seem to be similar in both regions. Although we were again unable to find formal research on this subject, conversations with stakeholders in each region touched on similar feelings of unfairness and disenfranchisement in how our study regions are governed. Both regions are located in the sparsely-populated northern reaches of their respective states, and can feel disconnected, culturally and politically, from the rest of the state. State government is the main avenue for UP residents to affect land use policy decisions, because the state is one of the most important landowners in the UP. While representatives from the UP are a minority in the legislature, the actions and opinions of one former state senator from the UP provide a window into attitudes toward conservation policy in the region.

In 2012, Michigan's legislature passed a law limiting the amount of land that the state could own in northern Michigan, including the UP (Williams 2013b). Introduced and championed by a UP lawmaker and landowner, Senator Tom Casperson, the bill was controversial in the rest of the state, and a plan for state land use was approved in 2018 that removed the cap (State of Michigan 2018). The same senator authored other controversial land use bills aimed at opening up more land for motorized recreation and re-focusing state forest management away from the conservation of biodiversity (Alexander 2012, Williams 2013a). While it is impossible to extrapolate from one lawmaker to an entire region, Senator Casperson's agenda appeared to be popular in the UP (he was reelected in 2014 before being forced from office by term limits.) In an interview, the senator stated that he was interested in capping public land because of the economic harm it did to municipalities, according to local officials (Casperson 2012). However, research in the region failed to find evidence of economic harm stemming from public land (Lewis et al. 2002, 2003).

Local officials in the Adirondack Park also express the belief that public land harms municipalities economically, despite quantitative evidence to the contrary (Keal and Wilkie 2003, Long and Bauer 2019). The persistence of this belief may stem from political ideology or identification, or may be a result of perceived unfairness in the process of policy making. As minorities in their respective states, residents of these two regions may resent the influence of outside stakeholders in policy that primarily affects local residents. Because they have negative perceptions of the policy process, they could be more likely to attribute negative outcomes to the policy as well. The inclusion of non-local stakeholders may make local stakeholders feel that the process is less legitimate. However, without the influence of more distant, pro-regulation stakeholders, it is unclear what, if any, conservation policies would be in place at all. The inclusion of non-local stakeholders therefore both makes conservation policy effective from the perspective of the conservation *outcome*, while making it less effective from the perspective of the policy *process.* Conservation in these two areas, then, is a paradox in which conservation outcomes are in tension with the policy process: the regulations that are most effective ecologically are those that are less effective from a human standpoint. Effective regulations, like those in the Adirondacks, have not stood the test of time because they are seen as popular, transparent, or fair (although they may be all of these things) but because they were made very difficult to change. Regulations that are less difficult to change, like those in the UP, may be made more effective through legitimate and transparent processes. However, a consensus on what kind of process is legitimate is likely to be difficult to find, especially as the polarization of political ideologies increases.

CONCLUSIONS

The balance between ecological outcome and political process determines the effectiveness of conservation policy. Policies that are focused primarily on public acceptance will probably be less effective ecologically (Dupke et al. 2018, Engen et al. 2019), while policies that are ecologically ideal are more likely to be politically untenable. The balance is dependent on social and political context, values, ideology, and any number of other variables, so it is likely impossible to identify with any accuracy.

To be effective, a policy must be persistent through time. A persistent policy could, as in the Adirondack Park, be codified into law in such a way as to make it difficult to change. Alternatively, a policy could persist by being popular among stakeholders, which depends in part on it being promulgated through good governance processes. Of course, these two categories are not mutually exclusive: good governance processes might result in a policy that is extremely resistant to change, but policies that are easy to change and not perceived as legitimate, transparent, or fair are much more likely to fail. In our scenario exercise, the resistance of policy to change was arguably the most important factor in determining future biodiversity in each region. Conservation policy made in the Adirondacks closes off some possible future paths of development, while the more flexible policy framework in the UP leaves more options open.

Making conservation policy that is ecologically effective through a transparent and participatory process is extremely difficult at the state or national scale. Conflict over who should participate in such a process is likely to arise, with the involvement of some stakeholders making the process seem less legitimate to others. Even at smaller scales, efforts to accomplish conservation via good governance principles frequently fail (Kellert et al. 2000). We were unable to find an example of a national government that had attempted large-scale participatory conservation. However, processes can be made more participatory by expanding the role of local governments, or requiring consultation with key stakeholders, as is done on the APA board. Even non-participatory processes can be made more transparent, for example, by centralizing information or holding public meetings. Policy makers or managers hoping to advance conservation should consider incorporating good governance principles into their planning processes, even if it is not possible to make the process entirely participatory or transparent.

In the United States, we expect that the legitimacy of conservation planning processes will frequently be called into question. Ideological conflict over the role of the federal government in land management makes consensus about legitimacy less likely, and probably precludes a national land-use planning effort. Even at the state level, as seen in our case studies, some stakeholders are likely to view others as illegitimate participants in land use decision making. However, policy often must be made at the state or federal level to effectively conserve large-scale resources, like watersheds, that cross traditional political boundaries. Some research suggests that transparency is an important component of legitimacy (Meinard 2017). In light of this, it seems even more important that decision-makers allow stakeholders to access information about the process of conservation.

Fully inclusive conservation that is ecologically effective and persistent through time may not be an achievable goal, given the world's large-scale conservation needs, governmental structures, and differences in values. Still, incorporation of principles that make the conservation policy process more inclusive are also likely to make it more effective overall in many contexts.

Epilogue

The purpose of this research was to better understand the ways in which land use policy affects human and non-human communities on multi-use landscapes. Specifically, I wanted to determine whether restrictive land use policies are necessary to conserve biodiversity, and what the effects of those policies are on human communities. In the first chapter, I demonstrated that a region with a highly restrictive land use policy framework does not exhibit higher biodiversity than a region with a less restrictive framework, and that the effects of public land and zoning on biodiversity are highly dependent on the regional context. In the second chapter, I found that a region with a highly restrictive land use policy framework has as good or better outcomes in terms of human wellbeing than a region with a less restrictive framework, and that the effects of public land and zoning on human wellbeing are also highly dependent on the regional context. These two chapters combine to show that land use policy does not necessarily create trade-offs between biodiversity and human wellbeing. In the third chapter, I showed that the more restrictive land use policy framework resulted in less biodiversity loss over time, while also being relatively robust to social and political pressures.

From this research, I draw several conclusions about the question of how to create land use policy that contributes to conservation. The first is that more regulation isn't always necessary, but it also isn't always harmful. While the policy framework of the Adirondack Park (the more restrictive framework in this study) did not result in higher biodiversity than in the Upper Peninsula (the less restrictive framework) at the current time, it also did not result in worse outcomes for local human communities. Secondly, I conclude that the effects of land use policy are highly context-dependent, based on the different effects of public land and zoning on biodiversity and human wellbeing in each of our study areas. Managers and policy makers will need to carefully consider the context of their region before implementing policy with a particular conservation goal. My final conclusion is that, while restrictive land use policy might not appear to make a difference to biodiversity at the present time, social, political, and demographic changes make it highly likely that such a policy framework will help conserve biodiversity in the future. Policy makers looking for long-term conservation benefits should consider a more centralized approach to planning than is currently in use in most of the United States.

Areas of future research to inform our collective understanding of the relationships I investigated in this dissertation could include comparative studies of biodiversity and growth in exurban (rather than rural) areas under different policy systems, quantitative longitudinal studies of biodiversity, and smaller-scale spatial studies of human wellbeing variables to elucidate the details of the complex relationships uncovered here. Research in these areas could further clarify how land use policy operates to conserve biodiversity, and how it may unintentionally affect human communities through issues such as rural gentrification. As remote rural areas like the two we studied become increasingly subject to development pressure, monitoring of biodiversity will also grow more important in order to proactively avoid significant biodiversity loss. Further research could also be helpful in describing how conservation policy is made and implemented in rural multi-use regions and in understanding compliance and non-compliance with conservation regulations in industrialized countries.

APPENDICES

APPENDIX A:

Tables

	Years of BBA	#townships included in analysis
ADK	2000-2005	61
UP	2001-2008	142

Table 1.1: Breeding bird atlas years and number of townships used in this analysis for the Adirondack Park (ADK) and Upper Peninsula (UP).

Variable	Mean (ADK)	Standard deviation (ADK)	Mean (UP)	Standard deviation (UP)
Species richness	117.27	14.15	114.39	30.62
Biotic integrity score	249.52	37.02	237.54	65.31

Table 1.2: Descriptive statistics for dependent variables in the Adirondack Park (ADK) and the Upper Peninsula (UP).

Name	Description	Measurement unit	Mean	Range	Std dev
MB	Public land managed for biodiversity	Percent of township land area	0.40	0.90	0.27
MU	Public land managed for multiple uses	Percent of township land area	0.018	0.47	0.062
Zoning	Township-level zoning ordinance	Presence/absence	0.24	1	0.43
Con	Coniferous forest	Percent of township land area	0.25	0.38	0.095
WW	Wooded wetland	Percent of township land area	0.046	0.14	0.028
Ag	Agriculture	Percent of township land area	0.019	0.26	0.043
Dev	Developed	Percent of township land area	0.026	0.15	0.024
Area	Area of the township	Square kilometers	225.59	1166.09	236.68

Table 1.3: Descriptive statistics for predictor variables in the Adirondack Park (ADK).

Name	Description	Measurement unit	Mean	Range	Std dev
MB	Public land managed for biodiversity	Percent of township land area	0.20	0.95	0.27
MU	Public land managed for multiple uses	Percent of township land area	0.14	0.86	0.18
Zoning	Township-level zoning ordinance	Presence/absence	0.4	1	0.49
Con	Coniferous forest	Percent of township land area	0.10	0.28	0.059
WW	Wooded wetland	Percent of township land area	0.29	0.65	0.16
Ag	Agriculture	Percent of township land area	0.047	0.39	0.068
Dev	Developed	Percent of township land area	0.037	0.11	0.019
Area	Area of the township	Square kilometers	302.10	1522.69	188.58

Table 1.4: Descriptive statistics for predictor variables in the Upper Peninsula (UP).

	Species richness		Biotic integrity score	
	ADK	UP	ADK	UP
MB	-0.08	0.26**	-0.03	0.26**
MU	0.25	0.23	0.27	0.23
Zoning	-0.05*	0.02	-0.07**	0.03
Coniferous	0.37**	-0.77*	0.44*	-0.68.
Woody wetland	-1.46**	-0.28.	-1.01*	-0.3*
Agriculture	0.80*	-0.30	0.66.	-0.38
Developed	-0.66	2.71	-1.06	2.17
Area	0.15**	0.23**	0.18**	0.24**

Table 1.5: Relationships among two metrics of biodiversity (species richness and biotic integrity score) and eight landscape and policy variables in the Adirondack Park (ADK) and Upper Peninsula (UP). *Results show that the effects of policy and land cover are affected by the policy context of the region.*
***=significant at 0.01 level; *=significant at 0.05 level*

Variable	Mean (ADK)	Standard deviation (ADK)	Mean (UP)	Standard deviation (UP)
Gini coefficient	39.4	4.34	39.3	5.89
Percent population under 30	29.83	6.27	28.6	8.84
Percent population change, 1990-2010	4.09	13.1	-3.43	14.2
Poverty rate	7.73	5.08	8.22	5.83
Second home percentage	45.03	21.2	33.77	22.63

Table 2.1. Descriptive statistics of 5 variables related to human wellbeing in the Adirondack Park, NY, USA (ADK) and the Upper Peninsula, Michigan, USA (UP.)

	Seasonal homes		Gini coefficient		Poverty		Under 30		Population change	
	ADK	UP	ADK	UP	ADK	UP	ADK	UP	ADK	UP
MB	0.77	-0.05	-0.03	-0.15	-0.94*	-0.72*	-0.29**	0.02	-0.14	-0.08
MU	-0.61	0.01	-0.2	-0.31	-0.45	-1.47*	-0.15	0.14	0.17	0.02
Zoning	0.8**	-0.06	-0.03	-0.01	-0.14	0.002	-0.19**	-0.02	-0.03	-0.0004
Travel time	0.01*	0.003	-0.0004	0.001	-0.003	0.08	-0.002	-0.003*	-0.001	0.02
Developed	-2.69	-31.94**	1.14	0.34	0.34	-2.84	-0.9	6.19**	-0.79	0.35
Agricultural	-3.61	-0.99	-0.06	-0.13	-4.54	-0.4	0.02	0.75*	-0.18	-0.17
Coniferous	-3.02**	3.84**	0.12	0.2	-0.71	1.72	0.83.	-0.95	0.25	-0.23
Woody wetland	4.5	1.38	-1.15	0.1	-1.14	1.13*	0.29	-0.41	-0.21	-0.04

Table 2.2: Effects of 8 covariates on 5 metrics of human wellbeing in the Adirondack Park, New York, USA (ADK) and the Upper Peninsula, Michigan, USA. ***=significant at 0.01 level; *=significant at 0.05 level*

APPENDIX B:

Figures

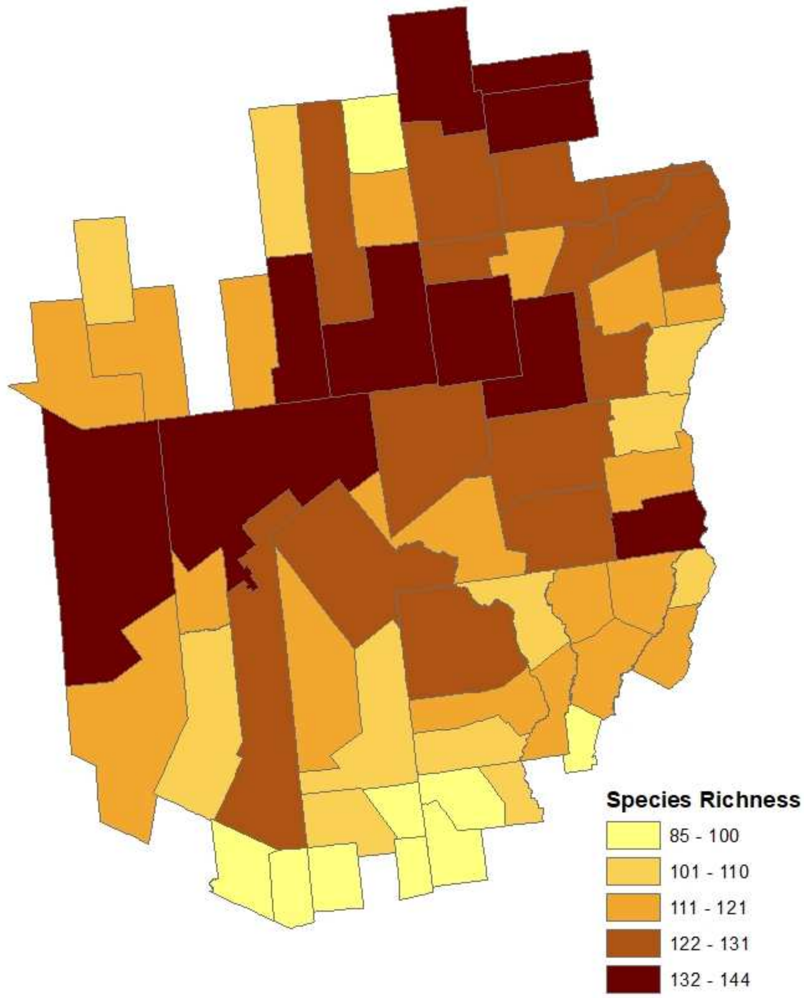

Figure 1.1: Species richness in 61 townships in the Adirondack Park (ADK).

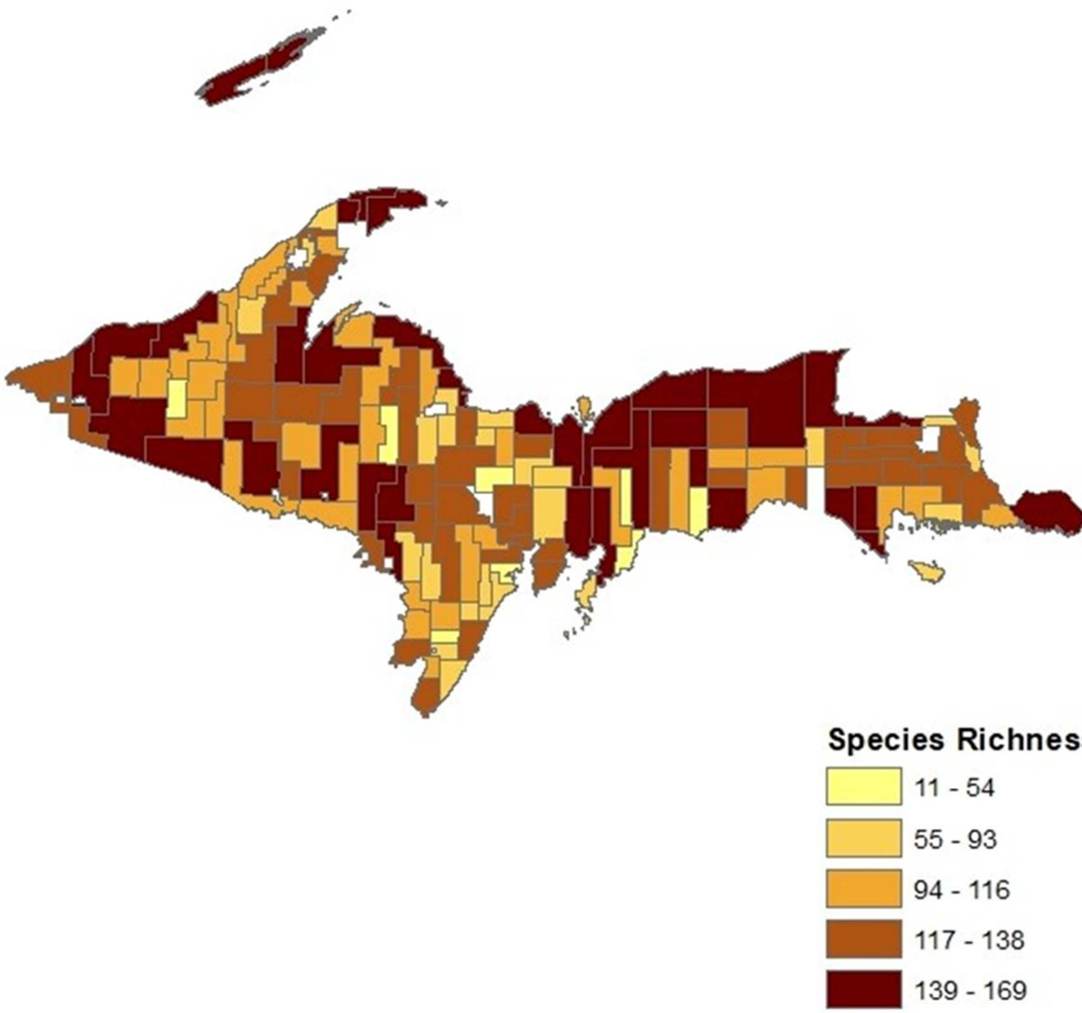

Figure 1.2: Species richness in 142 townships in the Upper Peninsula (UP).

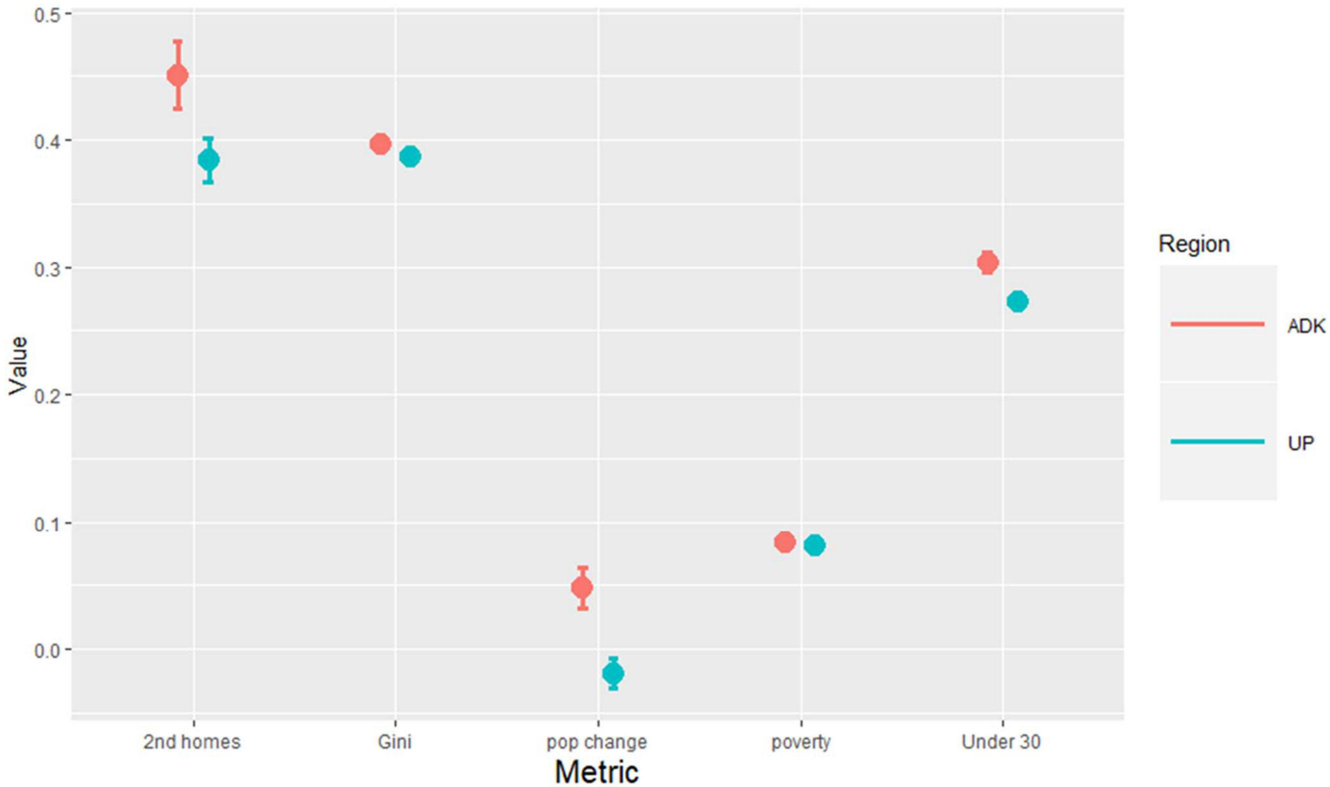

Figure 2.1: Comparison of five wellbeing metrics between the Adirondack Park of New York, USA and the Upper Peninsula of Michigan, USA. *All variables are expressed as proportions ranging from 0 to 1, except the Gini index, which is an index ranging from 0 to 1*.

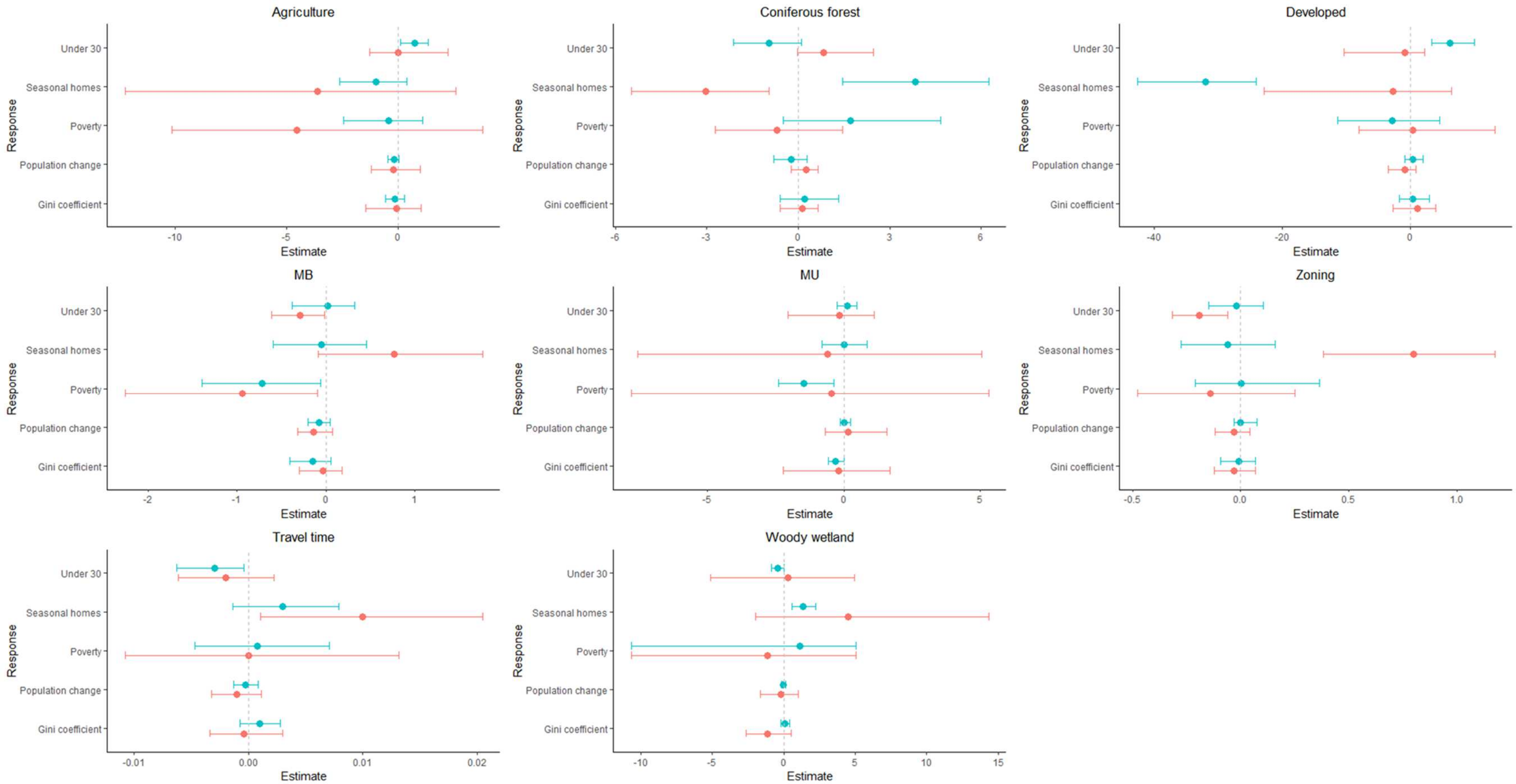

Figure 2.2: Effects of 8 covariates on 5 metrics of wellbeing in the Adirondack Park, New York, USA (ADK) and the Upper Peninsula, Michigan, USA (UP.) *Effects of covariates on wellbeing are different between regions.*

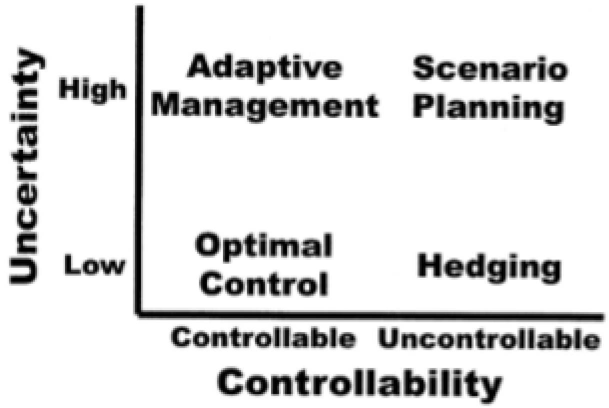

Figure 3.1: Scenario planning is an appropriate strategy when uncertainty is high and controllability is low. *Reproduced from Peterson et al 2003.*

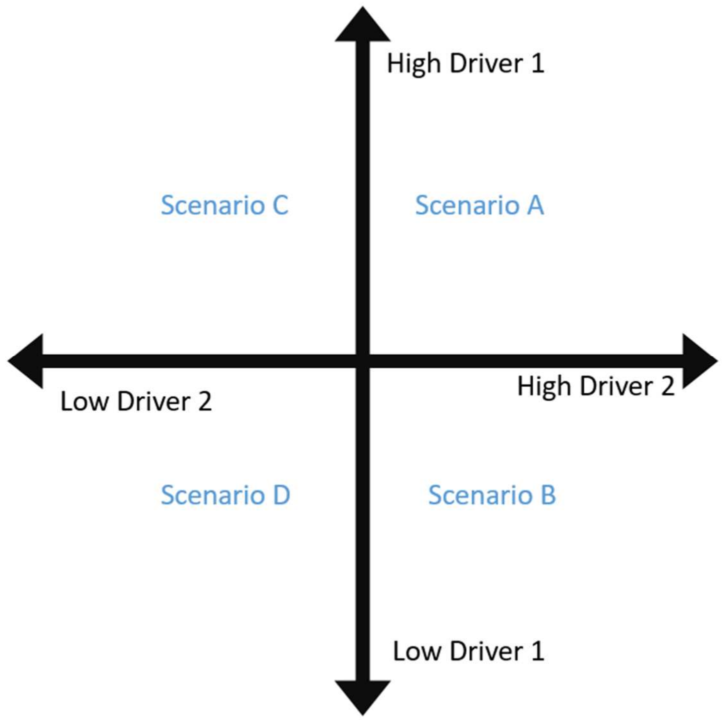

Figure 3.2: Method of producing four scenarios using two crossed drivers.

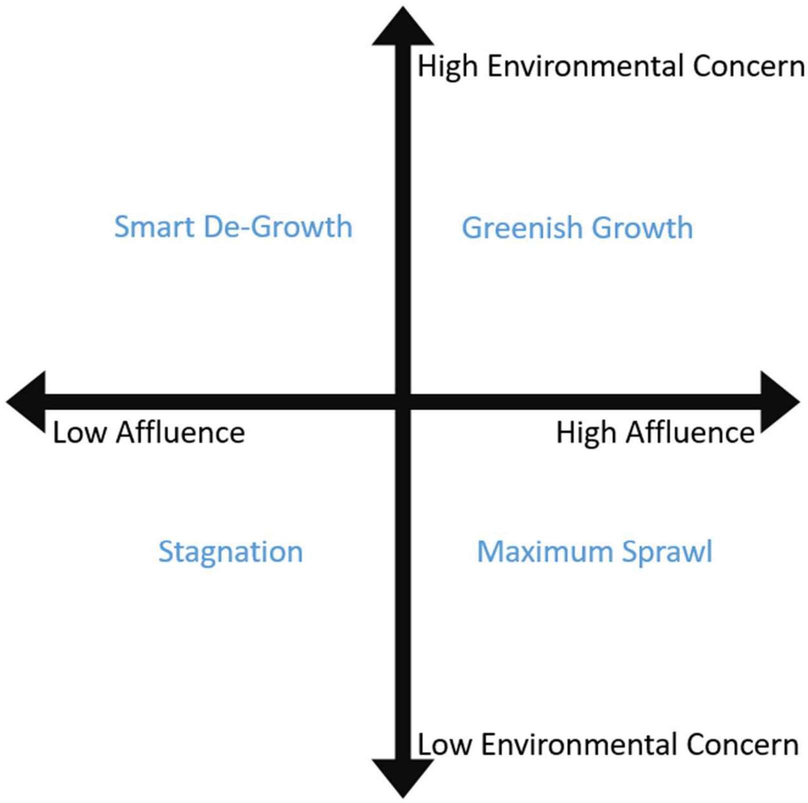

Figure 3.3: Four scenarios produced by drivers of affluence and environmental concern.

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