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A CONCEPTUAL MODEL FOR EXPLORING THE INTERACTIONS BETWEEN LAND PRESERVATION AND LANDSCAPE CHANGE

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ABSTRACT: *Land preservation programs play an important role in shaping landscapes in many urbanizing areas in the United States. These preservation programs have arisen partially in response to real or perceived landscape change. However, the conceptualization, planning and implementation of these programs sometimes fail to recognize the nature and impact of continuing landscape change. Furthermore, the impacts of the programs themselves on the landscape are often not taken into account. In order the understand the full relationship between land preservation and the landscape in which it operates, the interactions between preservation programs, the landscape and landscape change must be considered. I propose a conceptual model that describes the relationship between preservation programs, their implementation and the landscape. The model explicitly separates the programs' conceptualization and goals from their implementation, and postulates the necessity of examining how both of these elements interact with the landscape. The model also postulates that the relationships between the elements are bi-directional, therefore the possibility of feedback between the elements must be considered. I explore the consequences of this model for studying the interaction of landscape change and land preservation, and examine the possibilities of generalizing the model to study any landscape intervention.*

INTRODUCTION

Landscape change is rapidly becoming an important area of inquiry in many fields. Researchers from disciplines as varied as geography, ecology, economics and planning have examined the causes and consequences of landscape change over a range of scales and at locations around the world (e.g. Antrop, 2004, Muir, 2003, Osaragi and Kurisaka, 2000, Zebisch et al., 2004) . Such attention is the result of a confluence of factors. The ubiquity and consequences of landscape change are undeniable. Landscape change has continued to accelerate with increasing human population (Krausmann et al., 2003). Compounding the increase in human population is an increase in per capita land consumption. In urbanizing areas the increasingly extensive nature of land use manifests itself most visibly as the diffuse form of development colloquially known as sprawl (Theobald, 2001), while deforestation and conversion of natural vegetation to agriculture production is common in rural areas (Turner, 2002). Growing awareness of landscape change and its consequences has also resulted from recent technological advances that have increased our capacity to monitor and analyze landscape change (Marceau et al., 2001). Satellite imagery provides a relatively inexpensive and continually updated source of land cover data. Geospatial technologies such as geographic information systems allow this data to be analyzed both alone and in conjunction with other data sources. New approaches to modeling landscape change have grown out of these new technologies as well (Bradshaw and Muller, 1998, Brown et al., 2002).

Given the ubiquity and consequences of landscape change, it is not surprising that a variety of social and political responses to landscape change have been implemented. Land preservation programs that preserve undeveloped land by purchase of the land or its development rights are particularly common in the United States (Alterman, 1997). These programs often focus on preserving farmland to retain agricultural capacity or on preserving undeveloped open space for recreation or conservation purposes. By purchasing properties or their development rights, these programs permanently preserve land in an undeveloped state and have long term effects on the landscape. This suggests that the relationship between landscape change and land preservation is not one-way, with land preservation programs implemented as a response to landscape change. Rather, it suggests a two-way interaction between landscape change and land preservation. Initially, land preservation programs may simply be responses to landscape change, but as they are implemented they themselves can influence landscape change. Any analysis of the spatial consequences of landscape change and land

preservation must take this two-way relationship into account. There also exists the possibility of feedback effects between landscape change and land preservation programs. As they alter the landscape and trajectories of landscape change by preserving land, the programs may also be influencing their capacity to be successfully implemented.

There are a number of reasons why the spatial consequences of land preservation programs and their interactions with landscape change should be studied. The amount of public funds being directed at land preservation exceeds several billion dollars annually and has been steadily increasing in the previous decade (Landvote, 2004). This figure does not include the value of lands or conservation easements donated to governments or non-profit groups, for which significant tax-savings are usually received. The magnitude of this expenditure of public money alone is enough to merit investigation. The public expects to accrue benefits from these programs (Kline and Wichelns, 1998). Since they are, in part, a response to landscape change, land preservation programs play an important role in many growth management plans. While managing growth, many land preservation programs are also designed to produce numerous environmental benefits, such as protecting groundwater and surface water quality and quantity, preserving rare habitats and species and providing aesthetic value (e.g. Hunterdon County Planning Board, 2000). Evaluating whether land preservation programs are meeting these goals obviously demands a spatially based analysis. The potential for interaction between landscape change and land preservation programs means that landscape change must be considered when analyzing the consequences of these programs.

EXPLORING INTERACTIONS

The above introduction suggests that there can be feedback between landscape change and land preservation programs. Such a relationship is depicted in Figure 1. The literature examining the spatial consequences of land preservation programs on landscapes is sparse, but existing studies do not seem to have recognized the potential for such interaction. For example, Brabec and Smith (2002) investigate how different farmland preservation mechanisms affect the fragmentation of agricultural land. They limit their study to the examination of how preservation mechanisms have influenced the current spatial configuration of agricultural lands. They clearly show that land preservation programs influence spatial patterns of land use where they are implemented. By influencing spatial patterns, these programs influence subsequent landscape change. Brabec and Smith (2002) briefly mention the implications of these patterns with respect to future change and preservation, but do not fully consider the consequences of landscape change on the capacity of the preservation programs to meet their goals.

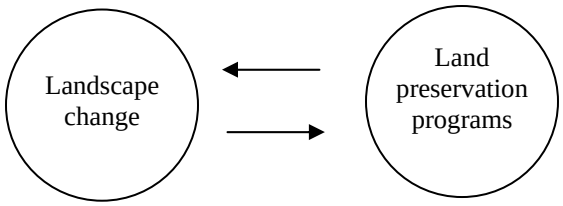

Figure 1. Conceptual model illustrating a bi-directional relationship between landscape change and land preservation programs.

Why have no studies explicitly and fully considered how landscape change and land preservation programs interact? Some clues to this omission may be found in the literature concerning the evaluation of land-use plans. Brody and Highfield (2005) discuss some of the problems surrounding the empirical evaluation of plans and their implementation. They posit four main obstacles to plan evaluation: difficulty of determining plan outcomes, difficulty of measuring plan effectiveness, lack of agreement on what constitutes plan success, and lack of longitudinal datasets and agreed-upon research methods. Because land preservation programs implemented by governments tend to have specific goals and criteria for preserving land, the first three issues should not pose significant difficulties when studying land preservation programs.

The last issue raised by Brody and Highfield (2005), however, is of great concern when investigating any aspect of landscape change. Without multitemporal landscape data, such as land-use/land-cover information, it is impossible to substantially address the causes or impacts of landscape change. Multitemporal land-use/land-cover data sets require expertise and resources to create, limiting their availability. Even if commensurable multitemporal land-use/land cover data is available, it must also be from appropriate time periods for studying the policies under investigation. For example, if a researcher wishes to

investigate how a particular land preservation policy has influenced the nature of landscape change, at least three land-use/land-cover data sets would be needed: one from before the policy is implemented, one concurrent with policy implementation, and one sufficiently long after implementation for policy effects to be noticeable. The first two land-use/land-cover data sets provide a baseline for landscape change that can be compared to the post-implementation change provided by the latter two data sets.

SEPARATING IMPLEMENTATION FROM PROGRAM POLICIES

The model in Figure 1 provides a useful starting point for conceptualizing interactions between landscape change and land preservation programs. However, representing land preservation programs as a monolithic entity prevents the model from achieving its full analytical potential. As Brody and Highfield (2005) point out, the impact of a plan's implementation may or may not achieve the policies of the plan that were laid out when it was formulated. This suggests the necessity of considering their implementation separately from their policies.

This potential disjuncture between land preservation goals and their implementation arises from the nature of the implementation. The land preservation programs discussed here are implemented through the acquisition of property or development rights from property owners. These acquisitions are directed by goals and criteria that were generated during the program's formulation. Usually these goals include a target total acreage for acquisition, and the criteria include desirable environmental conditions, proximity to currently preserved land, usefulness for active or passive recreation and other such property characteristics (e.g. Hunterdon County Planning Board, 2000). However, barring the use of eminent domain, the acquisitions are contingent on the presence of a willing seller. This means that land preservation programs result in spatial configurations of preserved and unpreserved land that can not be predicted from the program goals and criteria alone. Furthermore, the precise impacts of the acquisitions on both the program goals and on continuing landscape change are a direct consequence of the specific characteristics of the lands preserved. Therefore separating implementation from preservation (Fig. 2) provides a more complete understanding of landscape change – land preservation interactions.

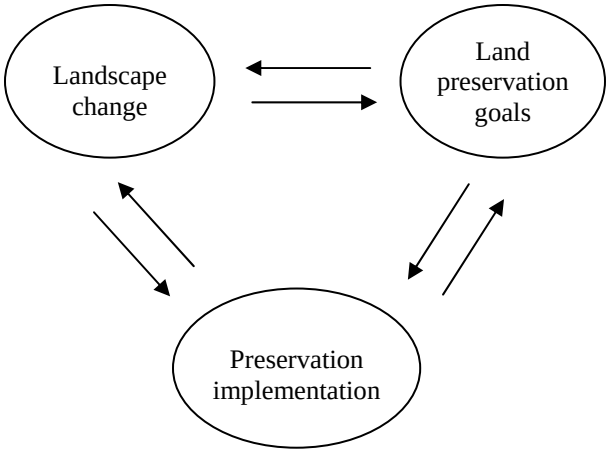

Figure 2. A fully articulated conceptual model separating land preservation program policies from their implementation.

EXPLORING THE MODEL THROUGH A CASE STUDY

Creating a conceptual model of how landscape change and land preservation programs interact provides a structure for developing research questions and a framework for data analysis. This section provides examples to illustrate the interactions between landscape change, land preservation program goals and land preservation implementation by using Hunterdon County, New Jersey as a case study. In doing so, it provides justification for the separation of program goals from program implementation.

Hunterdon County is a 437 sq. mile county located in northwestern New Jersey, about 15 miles from the state capitol, Trenton, 45 miles from the city of New York and 30 miles from Philadelphia. The county is sparsely populated by New Jersey standards (121,989 people or 278 people/sq. mile vs. 8,414,350 people or 1,121 people/sq. mile for the state), but has experienced significant population growth in the past few decades (13.9% from 1990 to 2000, compared to 8.85% statewide). Concomitant with this growth has been an increase in developed area. From 1985 to 2001, the area of the county in residential, commercial or industrial development has increased 23.7% (Lathrop, 2004). The growth in both population and development has been one of the main forces leading the country to adopt an open space, farmland and historic preservation plan

(Hunterdon County Planning Board, 2000). Examples from this plan will be used to illustrate the analytical utility of the model.

Landscape change can impact policy responses in number of ways. Perhaps most fundamentally, changes or the perception of the changes in the landscape are one of the initiators of preservation programs. Different types of real or perceived change can lead to different program goals and criteria. The type of landscapes perceived to be most at risk from landscape change will most likely receive the strongest efforts and protections. For example, agricultural lands in rapidly developing locales in New Jersey were the focus of locally sponsored systematic preservation programs before such programs were developed for conservation areas. Hunterdon initiated a farmland preservation program in 1980, before the state had such a program (Hunterdon County Planning Board, 2000), in part a result of the agricultural nature of much of the county.

Another important consideration is the impact of landscape change that occurs after program formulation, during the implementation period. Such landscape change may be overlooked by the planners and citizens that create preservation programs. It has the potential, however, to have significant impacts on preservation programs. This is the case in Hunterdon, where no recognition is given to ongoing landscape change in their preservation plan (Hunterdon County Planning Board, 2000). This is despite the fact that ongoing landscape change can make the goals of preservation programs more difficult to attain. Hunterdon seeks to preserved 50,000 acres of farmland, however, that is the amount of farmland eligible for conservation in the county according to their eligibility rules (Myers, 2004). Any conversion of that farmland to development makes it impossible for the county to meet its preservation goals without revising its eligibility criteria. More subtly, residential development may tend to occur in areas with characteristics that make them especially attractive for preservation.

The goals, structure and criteria of a preservation program can influence landscape change independent of the implementation of the program. By targeting for acquisition one type of land use, such as agriculture, or properties with particular characteristics such as proximity to preserved open space, as does the Hunterdon Plan, programs can influence property values and land owner decisions concerning property management or transfer (Irwin, 2002). Property values can have an influence on landscape change, encouraging speculation and development or even preservation. Management decisions such as mowing regimes, forest management plans and fallowing schedules can have an impact on landscape change on natural and agricultural lands.

Preservation program goals and structure have an obvious impact on the implementation of the program through land acquisition. Ideally, the goals lead to criteria that properties should meet before they are eligible for preservation. This could be a codified, quantitative scoring system based on property attributes, as in Tulloch et al. (2003), or more simply the presence of desirable property attributes such as rare species habitat, or even just location within a specific geographic area of concern (as in the Hunterdon Plan). Goals and criteria therefore affect implementation by restricting the set of properties eligible for acquisition.

Preservation goals are impacted by implementation in several ways. The most straightforward manner is that the specific properties acquired through implementation determine whether the goals of a program are met. If progress assessments are made during the course of a program there is another way that implementation can impact goals. The assessment of the acquisitions may indicate that some goals are not being met. If so, it may be necessary to adjust the goals of a program. The need for a model that fully considers interactions between goals, implementation and landscape change is highlighted by the fact that programs may not be meeting their goals because of changes in landscape structure or composition, as in the case of farmland preservation in Hunterdon County mentioned above.

It is not surprising to find that program implementation has impacts on landscape change, given the intent of the land preservation programs. Assessment of landscape change during the course of a program is one method of testing whether a program is having the intended effect. However, the potential exists for more problematic impacts to arise, even ones that may be contrary to the goals of the program. For instance, many preservation programs seek to build large blocks of contiguous preserved land. Unfortunately for preservation programs, preserved open space has been found to increase the value of nearby properties (Correll et al., 1978, Riddel, 2001) and many people find preserved open space to be a desirable neighbor. This may lead to open space acquisitions attracting development to their margins, undermining the ability of the preservation program to build large blocks of contiguous open space.

Finally, landscape change can impact implementation in a number of ways. Conversion to residential development or other uses are not conductive to preservation. Landscape change adjacent to a property worthy of preservation may

make that property more or less desirable for preservation. Hunterdon County considers the both the condition of the land to be preserved and the uses of the neighboring properties when considering preservation purchases (Hunterdon County Planning Board, 2000). Therefore, changes in the land being considered for preservation or its neighbors have a direct impact on implementation of preservation programs in Hunterdon County. Landscape change might also increase the value of a property, making it more difficult to acquire for preservation in light of limited program budgets and other acceptable but cheaper properties. An often overlooked impact of landscape change is on the preserved land itself. Ongoing change may alter the preservation value of a property after it is acquired. This is especially true considering that many preserved properties, at least in New Jersey, are subject to minimal management.

The above examples make it clear that the model requires the separation of program implementation from program goals in order to achieve maximal utility. The fully articulated model provides a very useful analytical framework for exploring interactions between open space preservation and landscape change. By making clear the pathways for interaction between its elements, the model aides in the interpretation of research results. Importantly, the model also suggests new avenues for research that might not be so readily developed in its absence. The question of whether open space preservation attracts development is a relatively obvious one. By highlighting the potential impact landscape change can have on preservation goals, the model also leads us to ask whether such development might be undermining one the main goals of many preservation programs, that of building contiguous blocks of preserved land. For example, Hunterdon County's open space goals include extending contiguous areas of preserved land and connecting preserved areas (Hunterdon County Planning Board, 2000).

PROSPECTS FOR MODEL GENERALIZATION

Given the demonstrated utility of the model in aiding the understanding of landscape change-land preservation interactions, it is reasonable to consider if the model can be extended to other situations. The model is fundamentally concerned with landscapes and human responses to them. More specifically, the responses examined here are interventions (see Steiner (2004) for more discussion concerning landscape interventions) intended to have explicit effects on the landscapes they target. Can the model used here be generalized to accommodate a large variety of these landscape interventions?

Taking each element of the model separately, the prospects for generalization become evident. Whereas the discussion above concerned landscape change, this portion of the model can be generalized to represent a landscape or landscape element of interest. A landscape element could be a particular land use or land cover type, or an environmental characteristic which has a spatial extent (e.g. the habitat of an endangered species or a groundwater recharge area). A landscape element could also be a process which occurs on a landscape, such as the general land use/land cover change considered here. More specific processes could as be represented, such as the fragmentation of agricultural land and the conversion of forest to residential land. Geomorphic processes that generate human interventions, such as beach erosion, could also be represented by this portion of the model.

The portion of model in Fig. 2 that represents land preservation policy can be generalized to cover any land management goal or intent. In some cases, these goals will be explicitly quantitative, such as preserving a target acreage of agricultural land or replenishing a beach to a given width or dune height. In other instances the goal or intent may not be absolutely numerical. For example, a plan to slow forest fragmentation in a developing rural region may not specify a specific target rate of fragmentation, seeking simply to reduce the rate from current levels.

The third portion of the model, which in Fig. 2 represented preservation program acquisitions, can be extended to cover any implementation of the goals or intents of the intervention represented in the second portion of model. This element represents the actual management or intervention activity undertaken to meet the stated goals.

The types of activities represented here obviously depend on both the intervention goals and the target landscape or landscape element. Combining all of these generalized elements together results in the model depicted in Figure 3.

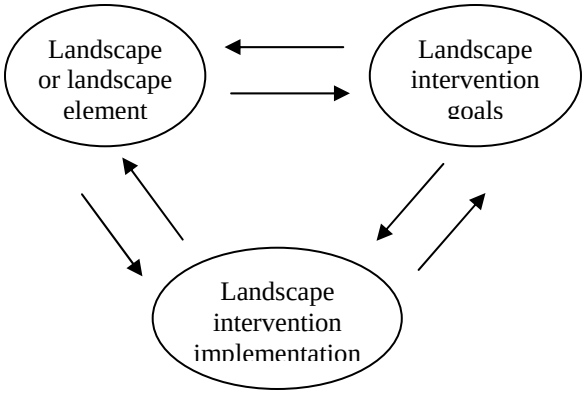

Figure 3. A generalized model for studying interactions between landscapes and landscape interventions.

INTEGRATING WITH OTHER MODELS

Planners have long been concerned with potential feedback between plan goals and plan implementation. The rational comprehensive (or synoptic) model of planning is an empirical, rational approach to planning comprised of four elements: "(1) goal setting, (2) identification of policy alternatives, (3) evaluation of means against ends, and (4) implementation of policy" (Hudson, 1979, p.388). It explicitly includes feedback loops in the monitoring of planning impacts for the purpose of evaluating and adjusting plans during their implementation. While rational comprehensive planning is considered the traditional approach, alternative models do exist. These models tend to take a more bottom-up approach to planning than the rational comprehensive model, preferring to set goals and implement plans based on significant input by those community members who have a stake in the planning process, rather than solely on the empirical assessments of planners (Briassoulis, 1989). Regardless of the model or models utilized for plan formulation and implementation, the assessment of plan impacts is a necessary part of successful implementation. This always requires an examination of the feedback between plan goals and implementation.

The model presented here represents, in part, an exploration of the implications these potential feedbacks have for land preservation programs. However, the model also extends the relationships involved by incorporating landscape change into the feedback loop. As described above, this is necessary for a full understanding of the impacts of land preservation on landscape patterns and processes. This inclusion presents one way to link landscape change science with planning and other decision making sciences. The integration of landscape change science and decision making is considered an emerging area of landscape change science research (Rindfuss et al., 2004), one which the model may help further by bringing the two together in an analytical framework. Assessment of policies and plans may be a particular good place to explore this integration, since academics often have expertise that is needed for such assessments (Johnston and Pullman, 2005).

The model can gain additional utility and power by integrating with other models that explore the impact of policy and planning on the environment. For instance, a common procedural model for environmental impact assessment (Westman, 1985) contains two procedures for post-impact analysis of policies and actions that affect the environment. These procedures are the monitoring of the effects of the action and the modification/mitigation of the action based on the results of the monitoring. Modification or mitigation of the action creates the need for further monitoring, *ad infinitum*. The landscape intervention model proposed here can be used to render explicit the relationship between the monitored environmental condition, the effects of the action on that condition and the intended goals of the action. Because the landscape intervention model separates actions from goals, it can help clarify precisely how the actions may be failing to meet goals in a way that the original procedural model may fail to elucidate. Similarly, there is also significant potential for the model to be integrated into conceptual or process models of land use change, ecosystem dynamics or human-environmental interactions.

CONCLUSION

A better understanding of the functioning, efficiency, efficacy and impacts of land preservation programs can be gained by exploring how land preservation programs interact with changing landscapes. Such an understanding is vital because these programs use significant public funds, play important roles in growth management and environmental protection, and are intended to have permanent impacts on the landscape. The conceptual model presented here can significantly further this understanding by providing a framework for asking more fruitful research questions and a structure for

more insightful analysis. Much of the power of the model comes from its separation of program goals from program implementation. This is necessary because the specifics of implementation may or may not actually further the goals of the preservation program, and can interact with landscape change differently than the program goals. The separation is also important given the inherently unpredictable nature of land preservation program implementation, which tends to rely on willing sellers of eligible property.

The model also shows promise for generalization to other situations as well as integration with other models. Land preservation programs can be thought of as one form of landscape intervention. Landscape interventions are programs, policies or plans intended to affect a target landscape or landscape element in a specific manner. The model can be adapted to a wide variety of interventions, including but not limited to beach replenishment, erosion control, habitat restoration and surface water quality protection. As in the specific case of land preservation, the model gains analytical power by separating the goals of an intervention from its implementation and by allowing interactions between all the elements of the model. The generalized version of this model could be adopted in many environmental management research areas. It should prove useful in the analysis, assessment and understanding of many landscape interventions. In particular, its use in the assessment of landscape interventions could help increase the efficacy and efficiency of those interventions. Such benefits could also accrue if the model is integrated into models of ecosystems dynamics, landscape change and environmental planning analysis.

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