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EMPIRICAL FOUNDATIONS FOR AGENT-BASED MODELING: HOW DO INSTITUTIONS AFFECT AGENTS' LAND-USE DECISION PROCESSES IN INDIANA?

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ABSTRACT

The use of agent-based modeling (ABM) has recently been extended to the study of natural resource management and land-use and land-cover change. Many ABM applications have been at a conceptual and abstract level, which helps scholars to recognize how macro patterns can emerge from simple rules followed by agents at a micro level. ABM has a greater potential than many other approaches to capture the dynamic relationships between social and ecological systems. This paper contributes to a larger effort to explore how individual decision making by a heterogeneous set of landowners, given local biophysical conditions, led to the particular aggregate pattern of land-cover change in Indiana, with an emphasis on forest-cover change. In our preliminary effort, we created a model structure that allowed examination of the institutional impact of government programs on individual land-use decisions. Our model is based on the concept that an initial condition endows an agent with a particular set of beliefs and desires that could lead to any number of intentions, actions, and outcomes. Institutions have the potential to intervene in an agent's decision-making process and alter its beliefs and desires by providing information and incentives. The next crucial step in our effort will be to extend this model to study the impact of other political institutions, such as taxation and zoning, as well as utilize the conceptual model to facilitate implementation of institutions in the agent-based model.

BACKGROUND

The use of agent-based modeling (ABM) has recently been extended to the study of natural resource management and land-use and land-cover change (Parker, et al., 2003; Janssen, 2003). Many ABM applications have been at a conceptual and abstract level, which helps scholars to recognize how macro patterns can emerge from simple rules followed by agents at a micro level. ABM has a greater potential than many other approaches to capture the dynamic relationships between social and ecological systems. This tool should be useful in helping to develop a theory that relates how institutions affect land-cover change because of ABM's power to model individual agent decision making over time. A crucial next step in our effort will be using ABM to understand the linkage between social and biophysical systems at multiple levels, thereby establishing a methodology that links empirical findings to model construction.

This paper contributes to a larger effort of the Biocomplexity Project of the Center for the Study of Institutions, Populations, and Environmental Change (CIPEC). As part of this project,

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we are developing an agent-based model of the decisions of rural landowners in Monroe County, Indiana, USA. Our objective is to use the model to explore how individual decision making by a heterogeneous set of landowners, given local biophysical conditions, led to the particular aggregate pattern of land-cover change in Indiana, with an emphasis on forest-cover change.

At the time of the first federal government surveys of Indiana in the early 1800s, 86% of the state's 22.9 million acres was forested (Lindsey, et al., 1965). During the next century, settlers cleared the forests to create homes, farmland, pastures, businesses, towns, and cities. By 1920, forested land had shrunk to 1.4 million acres, or only 6% of the land base. This deforestation process was followed by a period of gradual reforestation that still seems to be in progress (Schmidt, et al., 2000) (see Figure 1). Reforestation in Indiana has been cyclic and spatially nonuniform (Schweik, 1998). Much of the reforestation occurred in the early 1900s and was primarily due to localized processes like agricultural abandonment (Sieber and Munson, 1992), while deforestation due to metropolitan growth and urban sprawl continues to contribute to deforestation today (LeMaster, 1993). Currently, 19% of Indiana is forested, or approximately 4.2 million acres, and much of this land is private nonindustrial forest (Schmidt, et al., 2000). The complex dynamic interactions of people and forests are not unique to Indiana. Similar patterns have occurred in multiple eastern states and in some countries of Europe.

The effort to explain changes in forest cover over time is directly related to many of the major environmental issues of the day — how to maintain vital ecosystem services, protect

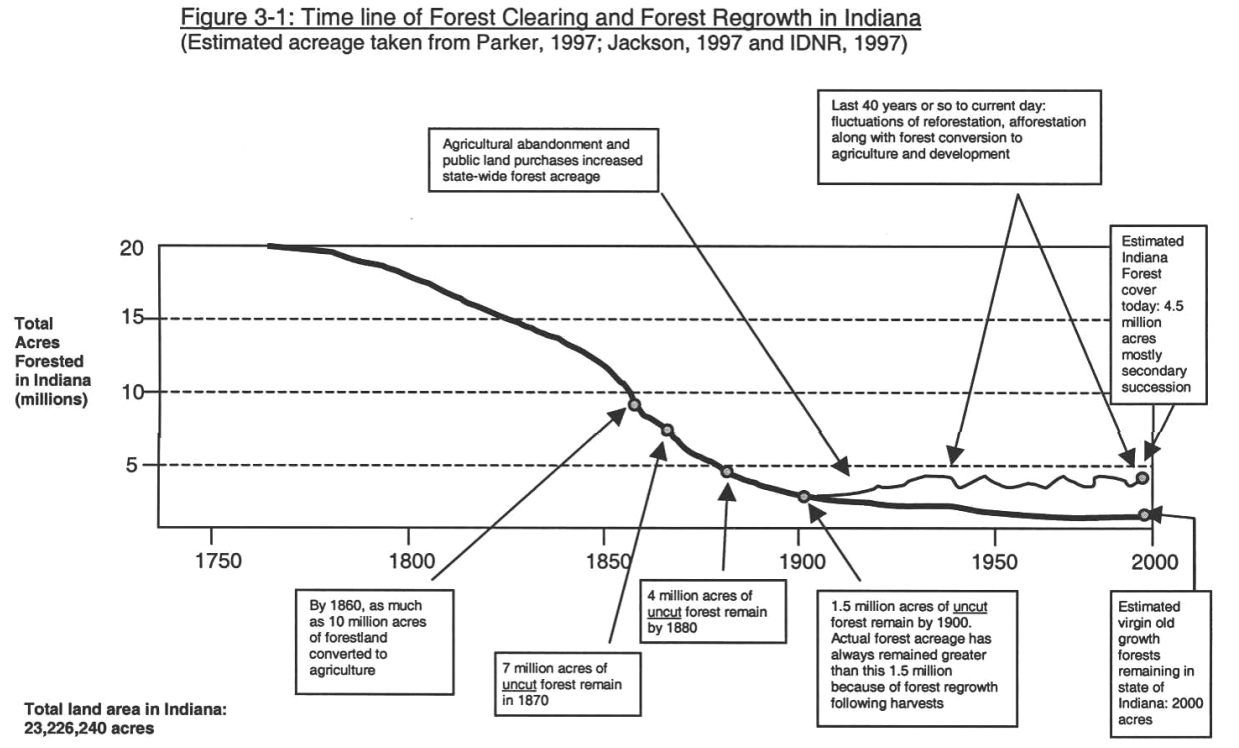

FIGURE 1 Indiana Land-cover Change (Source: Schweik, 1998, Chap. 3, p. 102, Figure 3-1)

biodiversity, and increase carbon sequestration so as to reduce global warming. The history of land cover in Indiana provides a good setting for developing ABM, as similar cyclic patterns of forest growth have occurred elsewhere and are desirable in many tropical countries currently undergoing massive deforestation. Further, relatively good historical data exist even though these data are located in scattered sources and have not previously been brought together as the foundation for a single project. If it is possible to understand the complex interactions among biophysical, social, and institutional factors affecting individual land-use and land-cover decisions in Indiana, many applications can be made to other locations.

THE INDIANA BIOCOMPLEXITY AGENT-BASED MODEL OF LAND-USE AND LAND-COVER CHANGE

Currently, our team is transforming a prototype model developed early in our project to provide an initial, very general ABM of land-use decision making without locating the agents in a "real" location. We are also creating a more realistic model in which the matrix of land-use characteristics is based on extensive acquisition and processing of data representing actual land cover in southern Monroe County from 1939 to 1997.[1] The agents in our model are private landowners who have the potential to "grow" forest on their lands or to use their land for agriculture or other purposes. In addition to the behavior of individual landowners, heterogeneity among biophysical (topography and soil quality) (Evans, et al., 2001) and socioeconomic (Koontz, 2001) factors influence the current spatial pattern of forest cover in Indiana. Thus, in our basic modular structure (Figure 2), individual landowners (agents) are in the center and interact with other modules that could potentially affect decision making.

The four basic modules are the social, economic, political, and the biophysical modules. Each module provides some constraints and opportunities that affect the decision space of the agents. Institutions can be a source of information, incentives, or sanctions that agents use in their land-use decision-making process. While our colleagues are developing the biophysical, economic, and social modules, we are attempting to obtain sufficient, detailed knowledge about government-sponsored inducements or sanctions that could potentially affect an agent's decision to form the basis for the political module. As we try to understand each module's impact on the agent's decision-making process, we are aware that the agent's actions or inactions may modify the structures of the modules, such as erosion of soil due to poor farming practices, which cause changes in the biophysical module and perhaps lead to the creation of new land-use laws. In the early stages of our work, we can only investigate how programs and policies may affect the agent and not the agent's impact on the programs and policies, other institutions within the political module, or other modules and their components.

Agents make decisions based on various characteristics of their household (e.g., size, age and gender distribution, income) within a biophysical, social, economic, and political setting. Institutions, which make up the political setting, are considered to be the *de jure* and *de facto*

[1] In this project, several models will be developed to address different questions. As data availability for other variables (e.g., economic, demographic, agricultural) varies greatly over time, some models will encompass the entire time series of land-cover data, whereas others will cover smaller periods, such as from 1972 to 1997.

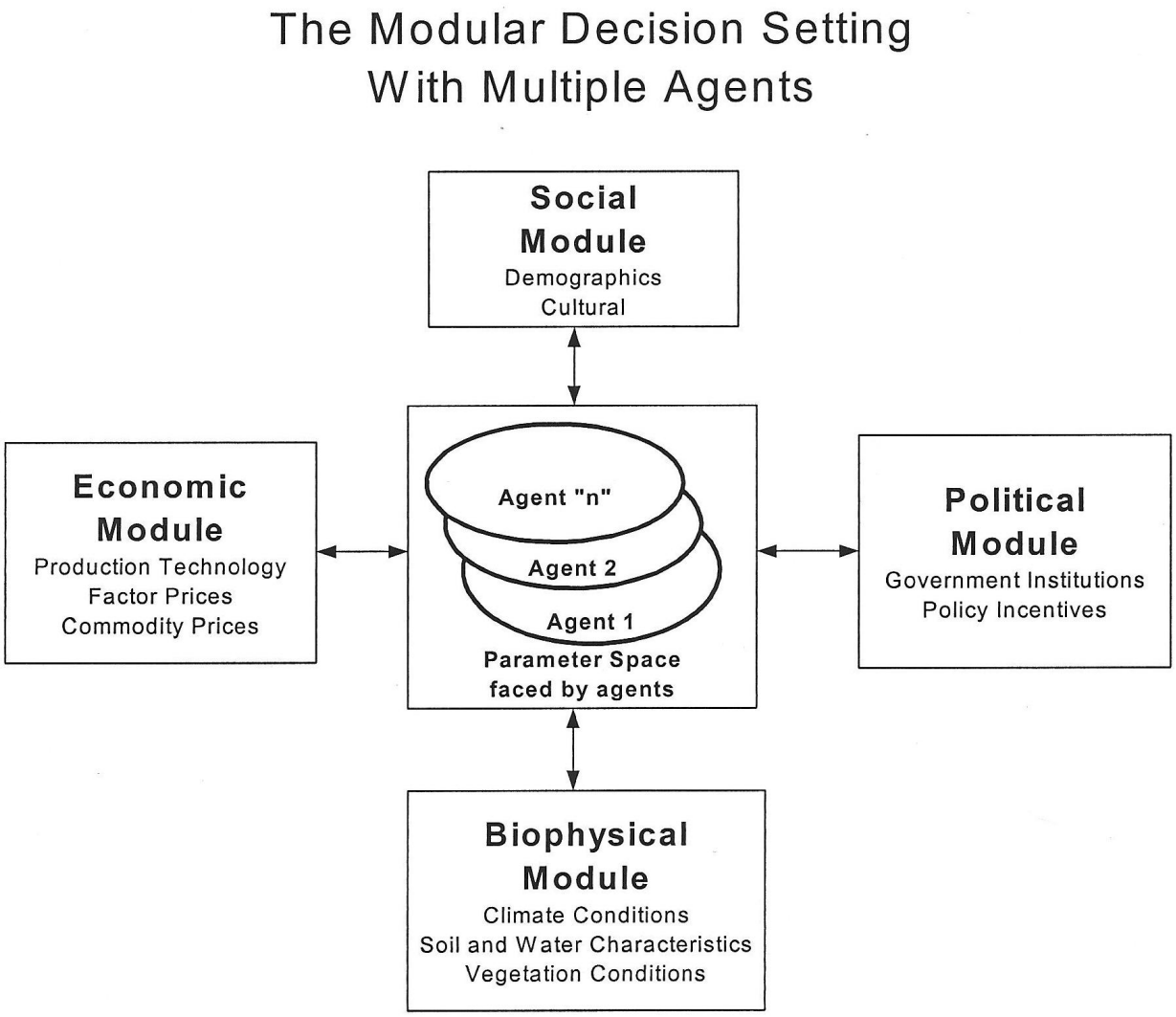

FIGURE 2 The Basic Model of the Biocomplexity Project (Source: Hoffmann, et al., 2002)

rules created by multiple levels of governments that attempt to establish incentives and sanctions for land-use management decision making. Rules as used here are actions and/or outcomes that are required, prohibited, or permitted, as well as the sanctions that are authorized if the rules are broken (Crawford and Ostrom, 1995). Many organizations in the public and private realm have programs that could potentially affect the de/reforestation process in Indiana. These include professional organizations, such as farming cooperatives; nongovernmental organizations, such as stewardship and conservation groups; and government programs, both state and federal.

At this time, we are trying to learn about and understand the potential connections between policy initiatives of diverse governmental and nongovernmental programs and the agent in the biocomplexity model. Initially, we focused on governmental programs because information about these programs is more easily obtained, and the rules are highly formalized, simplifying the effort to use them in our model. We have started to gather information on about 100 or more such programs and have acquired more detailed information about 30 state and federal governmental programs related to land use (see Appendix 1). In this paper, we begin with a conceptual model of potential interactions between these programs and agents. We then investigate in some depth one governmental program, The Indiana Classified Forest Program, in an effort to understand how these programs affect landowner decisions.

AN UNDERLYING CONCEPTUAL MODEL

It is useful to sketch a broad conceptual model that eventually may be implemented in the Indiana Biocomplexity ABM. The aspiration adaptation framework of Selten (1998) is particularly helpful. In this framework, an agent has multiple aspirations but does not have a complete preference order for them. In fact, the agent makes slight adjustments to increase progress toward different goals. Which action an agent takes depends on the feasibility and the urgency of the actions. The interesting element of this theory is that different types of goals do not have to be translated in one aggregated utility function, since the agents move in a landscape of different goal variable changes and try to make local improvements.

These concepts are well captured in *belief-desire-intention (BDI) agents*, in which decision making depends on the manipulation of data structures representing the BDIs of the agent. The BDI architecture is based on the concept of practical reasoning (Bratman, et al., 1988). By practical reasoning, we mean reasoning that is directed toward actions. Practical reasoning agents weigh conflicting options. Considerations of their options are affected by the BDIs of the agent. A contrasting approach is deductive reasoning, where agents use purely logical reasoning (Woolridge, 2002). BDI architecture involves two key processes: deciding *what* goals an agent wants to achieve (deliberation) and deciding *how* an agent is going to achieve these goals (means-ends reasoning). The main idea is that an agent has limited resources to make decisions, in terms of time and knowledge. The beliefs represent information about the agent's current environment. Beliefs, together with desires, filter in a deliberation process the range of possible options to a set of intentions. The intentions may lead the agent to take various actions. Because of changes in the environment (affecting beliefs and/or desires), both the intentions and the actions that flow out of them may change. Thus far, BDI agents have been mainly applied for agents doing real-time activities, which differ greatly from the long-term dynamics of the land-use change we are attempting to capture. Nevertheless, the BDI framework provides a basic structure to implement the aspiration adaptation framework for agents in our project.

As previously stated, institutions can affect a landowner's decision-making process through a wide variety of incentives, sanctions, and information resources. A simple diagram helps to explain the potential role of a governmental program on the decision making of an agent (Figure 3). For various reasons, an agent may choose not to participate in the program after learning more about it. The agent may decide that the expected benefits (both financial

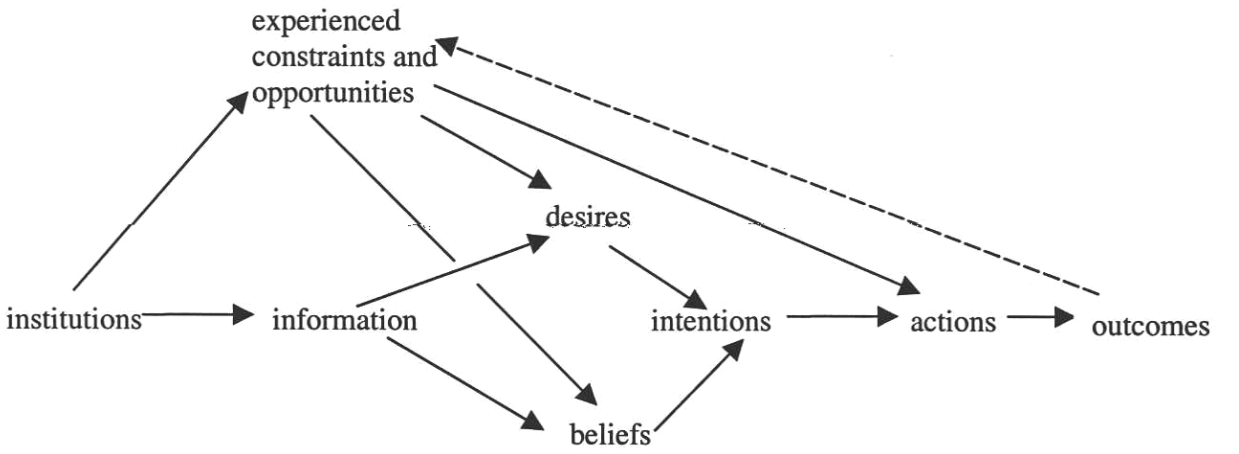

FIGURE 3 A General Conceptual Model of the Decision Process of a Landowner

and otherwise) are less than the expected costs of participation. We do not expect many agents to calculate this net benefit in the form of a utility function, either consciously or subconsciously, but rather as Selten (1998) theorizes, the decision may come from the evaluation of multiple aspirations. Agents may place little trust in the government and therefore decide not to participate in a government-sponsored program. Others may perceive that joining is too much of a hassle (i.e., potentially with surveys, registration fees, and other bureaucratic "hoops to jump through"). Agents may also evaluate the program information and determine that certain actions, such as clear-cutting, building homes, or subdividing the parcel, may not be allowed while participating. Perhaps the easiest explanation for nonparticipation is that some agents are not eligible.

Even a program participant does not necessarily change his/her behavior (intentions, actions and outcomes) with regard to land use. For example, some agents' existing management practices may have been in line with a particular program's guidelines. These agents may join the program to obtain additional benefits from an action that they would have already taken. Some agents, however, may modify their behavior once participating in order to meet the guidelines. Others may participate in the program but continue or begin unauthorized land use as defined by the program guidelines or rules. The level of compliance with program rules may depend on sanctioning and enforcement.

Even in the absence of governmental programs, landowners will have desires that affect what they do with their property. The desires are partly innate; that is, they depend on the personality and attitudes of the landowner. Private landowners value their property in different ways (including various economic, environmental, and amenity values) (Birch, 1996; Koontz, et al., 1998; Baughman, 2002). In a stratified, random sample of landowners in Monroe County, considerable variation was found among landowners in their evaluation of land attributes (Kauneckis and Novac, 2000; Koontz, 2001). We therefore expect that landowners differ in their initial desires and beliefs. These are in turn continually being shaped by experienced constraints and opportunities. For example, a developer approaches the agent with an offer to develop the property for a good price or the agent witnesses the neighbors selling timber for a hefty sum. In line with the framework of Selten, agents' desires adapt over time with these experiences (Selten, 1998). Like desires, beliefs can be affected by new information. These beliefs and desires ultimately result in intentions. These intentions may eventually lead to actions, depending on

other factors such as physical and financial restrictions, lack of sufficient time to realize intentions, or the emergence of new opportunities. Agents may or may not be aware of a particular institution, which further complicates analysis. Once an institution becomes engaged with an agent, it may provide new information (perhaps through rules) that affects beliefs, desires, or intentions. Therefore, the agent's information, BDIs, and actions may all be affected directly or indirectly through the institution.

It is difficult to separate the effect of an institution from that of original BDIs, as well as the mitigating factors mentioned above. It is clear then that it is extremely difficult to relate land-use change directly to activities sponsored by institutional programs. Therefore, ABM, in combination with empirical data regarding participation rates and attitudes, enables us to explore potential impacts on land use in Indiana.

It is useful to examine the structure of various land-use programs to evaluate their potential impact. From this array of available government programs, we hope to acquire sufficient information to help create a set of institutional variables that potentially will impact landowner beliefs, desires, intentions, and actions in our model.

GOVERNMENTAL PROGRAMS IN INDIANA

A vast array of Indiana and federal governmental land-use programs have been in place throughout the state's history. In the late 1800s, clearing of forest land in Indiana did not occur without concerns regarding the conservation of forest. Historical records from the late 1800s identify various organizations such as the Indiana Horticultural Society, debating the needs for conservation of timber resources (Clark, 1987). The concern for the continued loss of forest land and erosion of soil due to land clearing eventually led to the passage in 1899 of House Bill 436, Indiana's first forest classification, which gave participants a tax reduction on one-eighth the area of their woodland, with the following restrictions: cut no more than 20% of their timber, limit grazing in the woodland, and replant every tree that was cut (Clark 1987). A revised Forest Tax Classification Act passed in 1921 required a forest management agreement with the State Forestry Department and allowed unlimited woodland acreage to be assessed at $1 per acre (Clark, 1987).

Today, more than 101 programs exist in Indiana. Of these, 76 state and federal governmental programs and 25 nongovernmental programs may affect a landowner's decisions. These programs offer a variety of services — from information and ideas to funding — to help landowners manage natural resources. From these 101 programs, we have collected detailed information from 30 state and federal governmental programs that are directly and indirectly targeted at creation and maintenance of forest cover on private lands in Indiana (Appendix 1).

Information about governmental programs is spread through various channels of knowledge diffusion. Among the 30 identified programs, most advertise through various media, such as news bulletins and newsletters, although frequently this information is targeted to landowners already participating in the program. Many have their own Web sites with annual reports discussing missions, participation rates, and funding, as well as links to other information

resources for potential participants. For landowners, the most utilized and trusted source of information about assistance programs is often word-of-mouth.[2]

Many of the 30 programs are educational programs (e.g., the Lake & River Enhancement Program) or are not focused on individual landowners (e.g., the Arbor Day Grant). The effect of these programs is difficult to evaluate because the focus is mostly on altering agents' beliefs and desires through information with no sanctions and few incentives. In comparison, a few voluntary programs are directly related to private landowners' land-use decision making. Some of these institutions offer a property tax assessment reduction as a financial incentive for participation. One such program is the Indiana Department of Natural Resources (IDNR) Division of Forestry's Classified Forest Program (CFP). The following section examines this program in detail in relation to our conceptual model.

THE CLASSIFIED FOREST PROGRAM

The CFP was established by the Indiana Classified Forest Act 6-1.1-6 in 1921. This program was developed to encourage people to keep areas in forest land or create forest lands, by planting trees, for the purpose of forest conservation. The IDNR Division of Forestry sums up the Classification Act as (IDNR, 2002):

1. Both native timberland and land planted to acceptable tree species are eligible for classification.

2. A Classified Forest must be protected from domestic livestock and fire.

3. Timber may be cut at any time and sold or used as the owner desires, provided that such cuttings or sales of timber are not so severe that they will destroy or seriously set back the timber-producing values of the forest.

4. No dwellings are permitted in a Classified Forest, but owners may maintain a sawmill or operate a sugar camp.

5. The land must be posted with signs provided by the Division of Forestry.

6. An annual report must be made to the state forester regarding the condition of each Classified Forest.

7. Once classified, the forest must remain in the program indefinitely unless withdrawn. If withdrawn, the landowner could be subject to paying back taxes and a 10% penalty.

CFP landowners receive a property tax assessment of $1 per acre for general property taxation purposes. Woodland that is not in a Classified Forest is assessed at 20% of value determined by the soil productivity map (State Board of Tax Commissioners, 1992). Since the

[2] Many program officials mentioned that word-of-mouth is the best publicity. Landowners responding in the Monroe County Landowner Survey frequently stated that positive information from neighbors and friends regarding governmental programs led to their participation.

1960s, agricultural land in Indiana (which includes any land parcel of 10 acres or more with no commercial or industrial use) has been assessed for tax purposes at $495/acre (Kelly and Wuensch 2000). This amount is adjusted according to a soil productivity factor[3] and reduced by 80% if the land is wooded, so the greatest assessment reduction for CFP landowners is approximately $126/acre. Owners with Classified Forest in agriculturally productive soil receive a greater reduction in tax through participation than those with poorer soils.

CFP landowners file a written Forest Stewardship Management Plan (FSMP) created by their district forester and signed by the owner. The plan must adequately describe the present condition of the forest and prescribe a plan of action meeting the objectives of the owner, while following the guidelines for inclusion in the classified forest land program. Timber extraction is allowed on CFP land and is, in fact, often encouraged by the management plan. The Classified Forest Act requires the Classified Forest owner to follow minimum standards of good timber management as prescribed by the FSMP. In addition to property tax breaks, landowners receive forestry literature and periodic free inspections by their district forester while the forest is enrolled in the program. The FSMP may be revised periodically to meet changing landowner objectives and forest conditions. Therefore, upon joining the CFP, landowners receive a flexible management plan designed around and potentially changing the current set of BDIs through information and resources (see Figure 3).

The only sanction that the CFP authorizes is IDNR removal of the property from the program and collection of back taxes with 10% interest. According to IDNR officials, this has rarely been done. Overall, the limited rules and sanctioning, as well as the limited amount of eligible land, may decrease the statewide impact of the CFP on landowners' decision making. Alternatively, the lack of restrictions, beyond the eligibility requirements, may increase the participation levels for owners with 10 continuous acres of forest, as it may already fit with their current BDIs.

Currently, more than 8,300 pieces of property, covering nearly 410,000 acres, are enrolled in this voluntary program, with an average growth rate of approximately 10,000 acres per year (IDNR, 2002). A glance at Figure 4 shows that the number of acres of Classified Forest has increased steadily since the beginning of the CFP. However, it is unclear if the success of the CFP is a cause or a consequence of the general reforestation trend in Indiana (Figure 1).

As mentioned earlier, landowners that have decided to maintain forest cover may join the CFP for the tax benefit after making their land-use decision. Eligible landowners that participate may or may not follow through with the management practices outlined in their plan. These owners may not want to actively manage their land or may decide to cut their forests without direction from the plan. On the other hand, a landowner may start participating in the program attracted by the tax relief, but due to increased information after developing a management plan, the landowner may become inspired and may perform more or less active management of the property than previously intended. Thus, joining the program may or may not affect the intentions, actions, and outcomes of an agent's land-use decisions.

[3] The highest soil productivity factor in Indiana is 1.28 (Wuensch, et al., 2000).

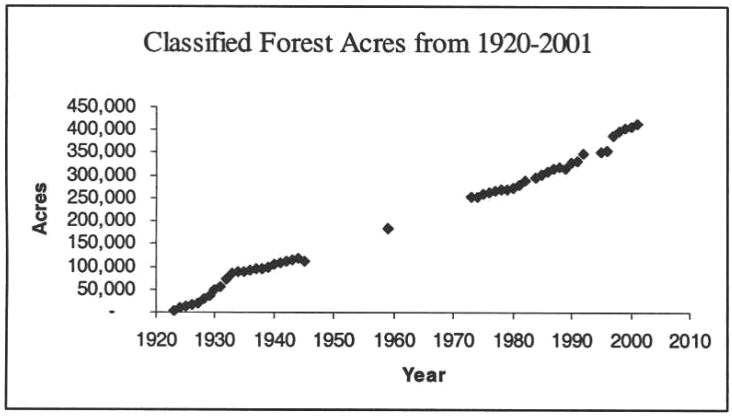

FIGURE 4 Classified Forest Acreage over Time (Source: Data adapted from IDNR Division of Forestry information)

FINAL THOUGHTS

We have started to obtain key information about various national and state policies and programs that may impact landowner decisions about land cover in diverse ways. One of our first findings is that a plethora of programs could potentially impact landowner decisions. It was rather challenging to find consistent information about each program by searching Web pages, published reports, and eventually contacting public officials to gain more information. If researchers who are well equipped with access to libraries, the Web, and email find it difficult to obtain information, we can imagine that citizens without such equipment find it even more challenging. This assumption is supported by information obtained from a 1998 survey of landowners that shows many of these programs are unknown to Indiana landowners (Summers, 1998). If unknown, an institution is not likely to generate information affecting desires and beliefs, as these affect intentions and actions. Thus, our immediate task is to focus on a smaller set of programs that have a higher chance of affecting desires, beliefs, intentions, and actions.

In a closer investigation of one program (the CFP) that has substantial participation, we have shown through the use of our conceptual model its potential to influence some landowners to change their land-use decisions. However, because of the eligibility requirement for the program of 10 continuous acres of forest land, an increasing number of landowners with smaller parcels or discontinuous coverage (biophysical constraints) are ineligible, and the impact of the program is minimized. Conversely, the flexibility of the program may attract a group of agents with a more varied set of beliefs and desires, which may or may not eventually be affected by the opportunities and constraints of the program. Likewise, changes in land prices due to nearby development or decreased agricultural commodity prices change the economic constraints that agents face and impact the program's effect on land use. Thus, intentions, actions, and outcomes may be altered or only facilitated by the institution itself. To understand the impact of the institution on the agents' behavior, we must understand the condition without the institution (e.g., the property tax assessment without the reduction) — another aspect of the political module or the initial set of, or the initial set of beliefs and desires created by an agent's experienced constraints and opportunities. Institutions have the potential to intervene and alter the beliefs and desires of an agent through provision of information and incentives. We have described our

initial efforts to create a model structure by which we can examine institutional impacts on individual land-use decisions. Our model is based on the concept that an initial condition endows an agent with a particular set of beliefs and desires that may lead to any number of intentions, actions, and outcomes. We plan to extend this model to study the impact of other political institutions, such as taxation and zoning, as well as utilize the conceptual model to facilitate implementation of institutions in the agent-based model.

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REFERENCES

Baughman, M., 2002, *Landowner Survey of Forest Stewardship Plan Implementation*, University of Minnesota, Minneapolis, MN.

Birch, T., 1996, *Private Forest-Landowners of the Northern United States,* U.S. Department of Agriculture, Northeastern Experiment Station, Randor, PA.

Bratman, M.E., D.J. Israel, and M.E. Pollack, 1988, "Plans and Resource-bounded Practical Reasoning, *Computational Intelligence* **4**:349–355.

Clark, D.L., 1987, *Entrepreneurs in Hardwoods: A Study of Small Business Strategies*, Indianapolis, IN: White Arts, Inc.

Crawford, S., and E. Ostrom, 1995, "A Grammar of Institutions," *American Political Science Review* **89**:582–600.

Evans, T.P., G.M. Green, and L. Carlson, 2001, "Multi-scale Analysis of Landcover Composition and Landscape Management of Public and Private Lands in Indiana," pp. 271–287 in A. Millington, S.J. Walsh, and P. Osborne, eds. *GIS and Remote Sensing Applications in Biogeography and Ecology*, Boston, MA: Kluwer Academic Publications.

Hoffmann, M., H. Kelley, D. Parker, and J.M. Walker, 2002, *Agent Based Models: Alternative Decision Making Strategies*, Center for the Study of Institutions, Populations, and Environmental Change, Bloomington, IN.

IDNR: See Indiana Department of Natural Resources.

Indiana Department of Natural Resources, Division of Forestry, 2002, *Private Landowner Assistance*, Sept. 10. Available at http://www.in.gov/dnr/forestry/.

Janssen, M.A., ed., 2002, *Complexity and Ecosystem Management*, Cheltenham, UK: Edward Elgar Publishers, Dec.

Kauneckis, D., and C. Novac, 2000, "Preferences on the Landscape: How Much Do Individual Values Matter?" *Constituting the Commons, the 8th Annual Conference of the International Association for the Study of Common Property*, Bloomington, IN.

Kelly, F., and J. Wuensch, 2000, "Assessment Reform in Indiana: One Step Forward, Two Steps Back," *Land Lines: Newsletter of the Lincoln Institute of Land Policy* **12**:1–3.

Koontz, T.M., 2001, Money Talks — But to Whom? Financial versus Nonmonetary Motivations in Land Use Decisions," *Society and Natural Resources* **14**:51–65.

Koontz, T.M., L. Carlson, and C. Schweik, 1998, *The Role of Institutions in Shaping Land Use: An Exploratory Study of Southern Indiana Non-Industrial Private Forests*, Center for the Study of Institutions, Populations, and Environmental Change, Bloomington, IN.

LeMaster, D., 1993, *Forest Policy Issues in Indiana.* Department of Forestry and Natural Resources, Purdue University, Lafayette, IN.

Lindsey, A.A., W.B. Crankshaw, and S.A. Qadir, 1965, "Soil Relations and Distribution Map of the Vegetation of Presettlement Indiana," *Botanical Gazette* **126**:155–163.

Parker, D., S.M. Manson, M.A. Janssen, M. Hoffmann, and P. Deadman, 2003, "Multi-agent Systems for Simulation of Land-use and Land-cover Change: A Review," *Annals of the Association of American Geographers*.

Schmidt, T., M.H. Hansen, and J.A. Solomakos, 2000, *Indiana's Forests in 1998*, U.S. Department of Agriculture, Forest Service.

Schweik, C., 1998, *The Spatial and Temporal Analysis of Forest Resources and Institutions*, Center for the Study of Institutions, Population, and Environmental Change, Bloomington, IN.

Selten, R., 1998, "Aspiration Adaptation Theory," *Journal of Mathematical Psychology* **42**:191–214.

Sieber, E., and C.A. Munson, 1992, *Looking at History: Indiana's Hoosier National Forest Region: 1600 to 1950*, Bloomington, IN: Indiana University Press.

APPENDIX 1: Land-use–related Programs in Indiana[a]

Program	Purpose	Members	Funding Source	Information Diffusion
Agricultural Conservation	To protect erosion on land	100 annual	A portion of state cigarette tax and $5.00 lake and river enhancement fee on boats	Bulletins and publication through USDA county offices
Arbor Day Grant	To encourage urban forest	1,000 schools annual	State funded	Letters sent to schools by December or January
Best Management Practice Cost Share	To help manage logging practice	NA	Environmental Protection Agency (EPA) grants	Web site and media publications
Classified Forest Program	To keep Indiana's forest	8,339 landowners with nearly 410,000 acres	From Division of Forestry (86% Timber Sale Tax and Seedling)	Web sites and brochures
Clean Water Indiana	To reduce water pollution from NPS	Counties	1999 State Assembly designed for 3 years with $1 million	County offices
DNR Clean Water Indiana	To protect erosion and water resources	92 counties (farmers and land owners)	State budget ($3 million)	Web site, publications, radio programs
Conservation of Private Grazing Land Initiative	To help manage grazing land	1,590 (2001), 854 (2000), 725 (1999)	USDA Technical Assistance Allocated Fund	News articles, TV, and radio programs
Conservation Reserve Enhancement Program	To remove land from agricultural production (land retirement)	16,000 participants with 330,000 acres	Commodity Credit Cooperation Acre ceiling (federal)	County-level office, some national, farm publication, agricultural newspapers
Cooperative Forestry Assistance/Management Program	To provide forest stewardship	NA (county offices maintain)	State (22%), dedicated fund (78%), t-sale, mail tax, federal programs	Sister agencies (network) recommendation, word-of-mouth, articles in local papers, no budget for ads
Emergency Conservation Program (ECP)	To help farmers in natural disasters	NA (county offices maintain)	Funds appropriated from Congress/ Community Credit Cooperation funding	County offices

Program	Purpose	Members	Funding Source	Information Diffusion
Environmental Education Grants Program	Financial support for environmental education to landowners	7,001 in three nongovern-mental organiza-tions maintained by program	EPA grants $190,000 per year from Congressional Appropriation for all of Region 5 states.	Mailing list and Web site
Environmental Quality Incentives Program (EQIP)	To provide technical, financial, and educational assistance	NA	Federal (USDA)	Form publication, county office, some federal information sources
Farmland Protection Program	To keep land in agricultural use	NA	USDA fund	Web site and newsletters, county affair events
Farm Loan Program	To provide financial help to farmers in land management	Vary by county	USDA general fund	Web site, state/ county USDA offices
Farm Mediation/Farm Counseling	To provide financial advice to farmers	500–700 per year	Grants from Office of Commission of Agriculture and federal sources	Farm bureau, Purdue extension, community agriculture association, county extension office
Five Star Restoration Program	To restore streams and wetland	NA	$500,000 annual federal funds through EPA	Participants' network
Flood Mitigation Assistance Program	To eliminate long term risk of flood damage	NA	$160,000 annually from FEMA	County-level office, national flood insurance program
Flood Hazard Mitigation and Riverine Ecosystem Restoration Program	To conserve wetlands and to restore flood plains	NA	1999 Water Resources Development Act designated fund	Web sites
Forest Legacy Program (FLP)	Congress 1990 Farm Bill to identify and protect environ-mentally important forest lands	Six legacy areas in IN. FLP buys development rights from landowners.	Federal funding can be used for up to 74% of the purchase price (no exact dollar amount)	Web site, state and county DNR-Forestry offices, newsletter
Forestry Incentives Program also known as Forest Improvement Program	To support forest management practices	200 private land and forest owners (32 granted in 2000; 20 cannot be funded for lack of funds)	USDA fund	NRCS Web site

Program	Purpose	Members	Funding Source	Information Diffusion
Forest Stewardship Incentive Program	To encourage stewardship for privately owned woodlands	NA	USDA fund	Web site, grant proposal announcements, county offices
Hoosier Homestead Program	To encourage keeping farms in family	4,500 Indiana Fund	Department of Agriculture	Web site
Indiana's River Friendly Farmer Program	To decrease water pollution	20 in 1999, 2000, 60 in 2001	Farm bureau ($4,000 annually)	County-provided promotional items
Lake & River Enhancement Program	To reduce sediment and nutrient pollution in Indiana's watersheds	NA	$1.1 million per fiscal year from $5 cigarette tax; some cost share	Promotional letters sent to lake association and county officials/posters
Resources Conservation and Development Program	To accelerate conservation and development of natural and historic resources	NA	USDA fund	Web sites, USDA – NRCS offices
State Wetland Protection Grant	To protect wetlands in Indiana	NA	EPA Region 5	EPA offices and Web site
Tree Steward Program Grants	To provide educational training for tree care	NA county manage	Equal match of $500–1,000 is available for a grant proposal from state.	Web site, county offices, application announcements
Urban Forest Management	To help communities manage urban forests	NA	U.S. Forest Services ($2,000 to 20,000 grants)	Web site and DNR newsletters
Watershed Protection and Flood Prevention Program	To prevent floods and to increase proper utilization of land in watershed areas	NA	USDA – NRCS fund	Web sites
Wildlife Habitat Incentive Program	To provide financial incentives for fish and wildlife on private lands	NA	USDA – NRCS fund	Web sites

[a] Information about these programs was collected through Web sites, telephone calls, and e-mail communication. First, we collected all possible information about these programs through Web sites. Second, if needed, we called program offices and asked for background information missing in the Web sites. Finally, if we were unable to reach a person by telephone, we sent them an e-mail. For federal programs in Indiana, we often called the offices in DC to seek information about programs in Indiana. We then called or e-mailed the state contacts provided by the DC offices. We used a uniform template of background information sheet to collect information about these programs.