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A Team-Based Approach to Social Learning Research in Natural Resource Management

Jonah Malachai Fogel
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a dissertation written by Jonah Malachai Fogel entitled "A Team-Based Approach to Social Learning Research in Natural Resource Management." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Natural Resources.

David Ostermeier, Major Professor

We have read this dissertation and recommend its acceptance:

Virginia Dale, Donald Hodges, Joan Rentsch

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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A TEAM-BASED APPROACH TO SOCIAL LEARNING RESEARCH IN NATURAL RESOURCE MANAGEMENT

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Jonah Malachai Fogel
August 2007

Dedication

To my wife, Elizabeth, I dedicate this work to you. To repay you for your patience these last few years will take a lifetime…if I'm lucky.

"Well done is better than well said."
- Ben Franklin

Acknowledgements

There are a number of people I would like to acknowledge as having been instrumental in the creation of this document. First, I would like to thank my friends and family. Without your support and guidance I never would have had the opportunity to attempt this work. Second, I would like to acknowledge my esteemed committee: David Ostermeier, Joan Rentsch, Virginia Dale, and Donald Hodges. Each, in your own way, has provided me with the mentorship that I needed to complete this work. I humbly thank you for helping me to become a professional not just a student. Thirdly, and most critically, I would like to thank the landowners of Morgan County that participated in my study. The commitment you showed to the project surprised a few people on campus (including myself). I largely credit Morgan County itself for attracting such high quality individuals. You've chosen a home like no other. And through your dedication to Morgan I expect it will remain an amazing place well into the future! Be well.

This project was supported by Initiative for Future Agriculture and Food Systems Grant no. 00-52103-9643 from the USDA Cooperative State Research, Education, and Extension Service.

Abstract

This thesis responds to the need to quantify social learning and its outcomes as it relates to natural resource management. Social learning enables individuals engaging in collective action to understand each other's perspectives, encourages integration of diverse knowledge bases, and the creation of new knowledge (Keen, Brown, & Dyball, 2005). However, the concept currently lacks a clear operational definition in natural resource management. The lack of an operational definition for social learning has stymied attempts to validate its espoused ability to improve civic discourse and, ultimately, resource governance (Pahl-Wostl & Hare, 2004). This report is composed of three papers that collectively offer a way forward for this area of research.

The first paper supplies an operational definition of social learning based on team cognition research in organizational psychology. One possible research framework for the assessment of social learning is provided. The second paper presents a case study using this framework. The case study takes place within the context of private forestlands management; a growing arena for collective action institutions. A pre-test and post-test quasi-experimental design is used to test for social learning resulting from a participatory research intervention. The third paper documents the results of the participatory research intervention, independent of the social learning framework.

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Part 1

Introduction

Introduction

This thesis responds to the need to quantify social learning and its outcomes as it relates to natural resource management. Social learning enables individuals engaging in collective action to understand each other's perspectives, encourages integration of diverse knowledge bases, and the creation of new knowledge (Keen, Brown, & Dyball, 2005). However, the concept currently lacks a clear operational definition in natural resource management. The lack of an operational definition for social learning has stymied attempts to validate its espoused ability to improve civic discourse and, ultimately, resource governance (Pahl-Wostl & Hare, 2004). This report is composed of three papers that collectively offer a way forward for this area of research.

The first paper supplies an operational definition of social learning based on team cognition research in organizational psychology. One possible research framework for the assessment of social learning is provided. The second paper presents a case study using this framework. The case study takes place within the context of private forestlands management, a growing arena for collective action. A pre-test and post-test quasi-experimental design is used to test for social learning resulting from a participatory research intervention. The third paper documents the results of the participatory research intervention, independent of the social learning framework.

Context

There are approximately 393 million acres of privately owned forestland in the United States. About 59 percent of private forest owners hold land for non-industrial purposes and are known as non-industrial private forest (NIPF) landowners (Birch, 1996). NIPF lands are under significant pressure to produce the nation's growing timber needs. NIPF lands historically produce about one-half of the country's roundwood timber supply (Harrell, 1989). However, pressure from population growth is increasingly impacting the availability of timberlands and quality of the forest (Binkley, 1981; USDA, 2002).

To conserve the privately owned forests of the United States, active management at the landscape scale is necessary to minimize the fragmentation of sensitive areas and mitigate the effects of presently parcelized lands. However, little can be done from a policy standpoint about the driving forces of parcelization such as rising incomes or intensifying urbanization (Mehmood & Zhang, 2001). Exceptions to this generalization include cost-sharing and careful local-level planning that may be used to slow parcelization rates.

To control forest fragmentation on private lands, there is a need for "neighbors to plan together and set common objectives. Working together, landowners can address issues like the buildup of forest fuel, which can lead to catastrophic interface fires" (USDA, 2002). As a necessity, landscape-scale management will include some kind of collective action between stakeholders to balance private property rights with the public benefits of private forest lands.

Study Background

The use of collective action approaches to natural resource management has been growing since the 1960's. Collective action, generally defined, refers to cooperation between divergent interest groups to manage public goods. The growing interest in collective action comes from an increasing number of environmental management problems that are poorly suited for "command-and-control" style governance.

Command-and-control refers to a procedural public policy process that places regulatory authority with government and limits the role of public involvement to that of consultation. Science is often used as a proxy for shared decision making between interests and is promoted as a means to impose impartiality onto a policy decision. Often this policy process is both effective and efficient. However, not all problems follow the assumption that command-and-control processes always provide technically correct or preferable prescriptions.

Environmental problems poorly suited to command-and-control management can generally be characterized as geographically diffuse, involving interdependent actions from numerous and diverse resource users, and likely spanning multiple ecological and administrative boundaries (Lubell, Schneider, Scholz, & Mete, 2002). These types of problems exhibit many of the characteristics of "wicked problems" (Rittel & Webber, 1973). Wicked problems are prone to cause conflicts because their management inherently requires trade-offs in benefits amongst stakeholder interests. The management of private forest lands is but one example of a wicked problem.

Private forest owners having a primarily economic interest may feel that regulations controlling negative environmental effects of the problem demand excessive regulatory costs, delays, inflexibility, and uncertainty of future coercive regulations as reasons for opposition to policies. Landowners with more environmental interests may claim continued environmental damage if concessions are made to economic interests that jeopardize environmental quality. When conflicts such as these are left unresolved, protracted legal disputes can occur, and the command-and-control public policy process becomes ineffective and costly relative to collective action policy processes.

Wicked problems require that tradeoffs among interests be negotiated through a deliberative process between stakeholders to arrive at a mutually agreeable collective action. "These processes are often undertaken to promote creativity, to resolve misunderstandings of fact, to surface value differences, and to seek mutually acceptable outcomes" (Daniels & Cheng, 2004). However, not every group that engages in collective action is successful. Collective action relies on civic discourse: "the thoughtful process of deliberating on complex and often controversial issues" (Daniels & Cheng, 2004). Unfortunately, most people do not have the experience, practice, and skills to effectively participate (Dukes & Firehock, 2001).

The fact that people generally lack these skills may inhibit the initiation of collective action. Furthermore, if collective action is initiated, there is a risk that the process will not yield effective results. If individuals have bad experiences with collective action, they could be expected to shy away from future participation in such processes. Ultimately, the lack of ability to engage in effective civic discourse is likely to inhibit the institutionalization of such approaches. There is an acknowledged need to increase the efficacy of discourse-based processes (Daniels & Cheng, 2004).

Study Justification

The primary research into the attributes of effective discourse falls under two methodologies. The first of these is a structuralist approach that uses survey questionnaires to identify common attributes of processes, organizational structures, and outcomes across cases. The second research methodology is a case study-based ethnographic approach to derive common attributes among cases (Daniels & Cheng, 2004).

Each methodology has reported insights regarding what constitutes a successful discourse. However, neither methodology has provided insights into the process by which coordination is achieved during successful collective action. A parallel line of research focuses on learning experienced by participants engaged in collective action as a means to improve deliberation.

Implicit in discourse-based approaches associated with collective action is the claim that coordinated action among stakeholders takes place as a result of "social learning". Social learning, as described in natural resource management, enables individuals to understand each other's perspectives, encourages integration of diverse knowledge bases, and promotes the creation of new knowledge. Social learning is said to occur during deliberation between individuals with "competing opinions and evidence" (Keen, Brown, & Dyball, 2005). Individuals may experience learning related to scientific facts and models, policy theories, technologies, preferences, behavioral norms, images and names or broad world views (Gunderson, Holling, & Light, 1995).

Proponents of social learning believe that it increases the opportunity for decision makers to find systemic solutions to resource management problems (Keen et al., 2005). The goal of social learning research is to improve the quality of public decisions by improving deliberation (Daniels and Walker, 2001). There is a lack of agreement within the social learning literature however regarding whether social learning is a cognitive process or a social change process (Pahl-Wostl & Hare, 2004). That is, sometimes social learning is referenced as a way we, individually, assimilate new information while other times it is referenced as a collective experience of working together in a more integrated way.

The lack of an operational definition for social learning has stymied attempts to validate its espoused ability to improve deliberation and, ultimately, resource governance (Pahl-Wostl & Hare, 2004). There is a need to clarify the definition of social learning in natural resource management if it is to provide insights into the improvement of civic discourse. Ultimately, the refinement of social learning research can lead to improved private forestland management via collective action. It is within the context of social learning research that this research exists.

The first paper of this dissertation creates an operational definition of social learning and provides one possible research framework for the assessment of social learning. The second paper presents a case study using this framework. The third paper presents the results of the case study's participatory research intervention. A final paper is provided to summarize the study's findings and implications.

Part 2

A team-based operational definition of social learning for natural resource management

Introduction

Social learning, as described in natural resource management, enables individuals to understand each other's perspectives, encourages integration of diverse knowledge bases, and promotes the creation of new knowledge. Social learning is said to occur during deliberation between individuals with "competing opinions and evidence" (Keen, Brown, & Dyball, 2005). Social learning is likely to occur during the course of collaborative activities where deliberation is common. Under these conditions individuals may experience social learning related to scientific facts and models, policy theories, technologies, preferences, behavioral norms, images and names or broad world views (Gunderson, Holling, & Light, 1995).

Proponents of social learning believe that it increases the opportunity for decision makers to find systemic solutions to resource management problems (Keen et al., 2005). However, there is a lack of agreement within the social learning literature regarding the process that creates this expected benefit. The term social learning carries great ambiguity because it is used interchangeably as both a cognitive process and a social change process (Pahl-Wostl & Hare, 2004). There is a need to clarify the definition of social learning in natural resource management.

The lack of an operational definition for social learning has stymied attempts to validate its espoused ability to improve resource governance (Pahl-Wostl & Hare, 2004). A specific process or set of validation tests is needed to determine the presence and quantity of social learning so that any person who wishes to research it can independently measure or test for it. This article provides a clarification of social learning by reframing the concept in terms of team performance using insights from the field of organizational psychology.

Teams are the most appropriate unit of study for social learning because they represent the smallest unit of collective, often collaborative, decision-making increasingly common in natural resource management. Teams are used in participatory research interventions such as Rapid Rural Appraisal (RRA), Rapid Appraisal of Agricultural Knowledge Systems (RAAKS), and Mediated Modeling (MM), in part to stimulate social learning among a diverse group of concerned stakeholders (Hitt, 1998; Townsley, 1996; Van den Belt, 2004).

Little research has been done however to describe the relationships between participatory research interventions, the basic cognitive process of learning, and the social changes generated by these processes. To make social learning operational in terms of intervention, learning, and performance outcomes, this article provides a research framework known as Team Member Schema Similarity (TMSS) (Rentsch & Hall, 1994). TMSS was originally developed to study the linkages between cognition and how effective teams are at performing their task (Rentsch & Hall, 1994). TMSS is used here to document that change to individual group members' cognitions that would indicate collaborative activities common to participatory research interventions are generating social learning. These cognitive changes at the individual level are then correlated with social changes shared between individuals.

In the following sections, this article reviews the ambiguity of current social learning literature and provides a case for a team-based operational definition of social learning. Next, team performance research is introduced as a means for exploring the linkages between participatory research interventions, social learning, and social change. Finally, the Team Member Schema Similarity is presented as one possible research framework to create an operational definition of social learning for research.

The Trouble with Social Learning

The governance of resources revolves around highly complex problems where uncertainty is high, there are a large number of often competing stakeholder interests, and problem causes and effects are separated in space and time (Woodhill, 2004). Increasingly, management decision-making processes are seen as deliberative processes that occur between concerned stakeholders (Schneider, Scholz, Lubell, Mindruta, & Edwardsen, 2003). The implication of an increased emphasis on deliberation is that resource management is becoming less about the search for an optimal solution to resource problems and becoming more focused on continual learning in a cycle of diagnosis, decision, action, and reflection (Keen et al., 2005).

Communication, perspective sharing, and development of adaptive group strategies for problem solving are given priority in deliberative processes. These priorities have become associated with the concept of social learning in natural resource management (Pahl-Wostl & Hare, 2004). Usage of the term 'social learning' however is often unclear because of two parallel lines of research. Social learning can refer to 1) a individual cognitive learning process and 2) a social change process (Pahl-Wostl & Hare, 2004).

In the first instance, social learning as a learning process, it is defined in terms of individual psychology. Social learning as proposed by Bandura (1977) refers to individual learning based on observation of others and their social interactions within a group. This definition "assumes an iterative feedback between the learner and their environment, the learner changing the environment, and these changes affecting the learner" (Pahl-Wostl & Hare, 2004). Social learning, in these terms, occurs to the benefit of the individual and is largely a psychological mechanism for behavior imitation and knowledge adoption.

In natural resource management, social learning has come to mean a continual decision making improvement at an organizational or societal level. The second notion of social learning, as a social change process, emphasizes that in the process of resource management, social involvement is as important as the content of knowledge being shared (Pahl-Wostl & Hare, 2004). In this interpretation, increasing the capacity of actors to solve conflicts and come to cooperative agreements is integral to the process of defining a problem, the search for its solution, and solution implementation (Keen et al., 2005; Pahl-Wostl & Hare, 2004; Institute of Urban and Regional Development, 2003). Increasing actors' capacity via social involvement is thought to enhance the flexibility of the governance system and its ability to respond to change (Gunderson et al., 1995; Wondolleck & Yaffee, 2000).

In response to the notion of social learning as a social change mechanism, participatory research interventions such as Rapid Rural Appraisal (RRA), Rapid Appraisal of Agricultural Knowledge Systems (RAAKS), and Mediated Modeling (MM) have been advanced as methods for balancing social involvement and content management (Hitt, 1998; Townsley, 1996; Van den Belt, 2004). However, neither notion of social learning presented here is able to fully explain how these interventions generate their observed benefits. Social learning as a learning process does not consider supra-individual effects such as increased governance capacity. Likewise, the notion of social learning as a social change process fails to offer a satisfactory explanation of the psychological mechanism at work that produces social change effects.

A full description of social learning in natural resource management should integrate the concepts that social learning is a psychological process that is measurable at the level of the individual and generates benefits across individuals, at higher social levels. This paper adopts a third position on social learning organized around the concept of team learning as used in organizational psychology.

Team learning is "the process of aligning and developing the capacity of a team to create the results its members truly desire. It builds on the discipline of developing shared vision. It also builds on personal mastery, for talented teams are made up of talented individuals" (Senge 1990, p. 236). To perform a task, team members develop a shared understanding of each other and the task. Their coordination is imperative to completing the task.

The following section describes how team members coordinate their communication and behaviors to perform a task. By examining these aspects of teams, some insights are generated about how to integrate the two strands of social learning theory in natural resource management. The TMSS research framework is then introduced as a means to make clear a new understanding of the relationships between participatory research, social learning, and social change.

Teams: A Review

The following review of team research literature is focused on providing an overview of teams and their function. The review begins with a definition of a 'team' and its development. The second half of the review provides an overview of the cognitive dimension of team work and how cognition can ultimately influence the ability of a team to perform a task effectively. In that section, specific attention is paid to the use of information during team work and its role in coordinating team members' efforts.

Understanding how teams use information is critically important to understanding how team members coordinate to perform a task. The ability of a team member to coordinate with others, in part, dictates how effectively the team as a whole may perform a given task. The purpose of reviewing the relationships between information, coordination, and team effectiveness is to provide a unified view of the two main social learning perspectives: cognitive process and social change perspective.

Teams and Their Development

A 'team' is a goal-directed group composed of members working interdependently to complete a task(s). Teams are themselves embedded in larger social systems such as a community or organization. The use of the term 'team' can be differentiated from the term 'group' in that members develop "a sense of shared commitment and strive for synergy among members" (Guzzo & Dickson 1996). The ability of a team to perform a given task may be influenced by the relationships between team members or by the external social system in which it is embedded. The focus here will be on the interdependencies between team members and corresponding effects on performance.

Because team members work interdependently of one another, their collective ability to perform a task is affected by how well members coordinate. Coordination is performed via interaction, communication, and socialization. During each of these activities, team members individually and as a group "process relevant and available information to perform intellectual tasks" (Hinsz, Tindale, & Vollrath, 1997). Team members negotiate their roles, work as needed to complete the task, coordinate their behavior, and adjust their coordination during task performance (Ilgen, Hollenbeck, Johnson, & Jundt, 2005). This 'team development' is not linear and finite but iterative and continually ongoing within a team (Ilgen et al., 2005).

Teams that either put little emphasis on their development or those that are time-pressured often find coordination difficult and engage in emotional conflicts that impede their ability to perform a task (Rentsch & Zelno, 2003). To perform effectively a team's members must perceive, interpret, and share a continuous stream of information about the task, each others roles, and the team's dynamic environment. The better the members of a team are at "processing" this information, the more effective the team will be (Hinsz et al., 1997).

Information Processing and Effectiveness

As teams develop, their members continually update their information processing capabilities (Hinsz et al., 1997; Ilgen et al., 2005). As team members strive to complete a collective task they are individually learning to coordinate through interaction, communication, and socialization (Hinsz et al., 1997). Individual learning involved in team development is inherently a social phenomenon and is analogous to the cognitive definition of social learning in natural resource management. As noted previously however, the cognitive perspective of social learning is insufficient to capture social effects above the level of the individual. To incorporate social change effects into an operational definition of social learning requires that individuals also be seen as being embedded in a larger social system –the team.

During team development, members ascribe similar meaning to information and structure that information in similar ways. The concept of shared (or similar) meaning has been described as ‘team cognition’ (Salas & Fiore, 2004). It is important to note that not all individual learning leads to a more effective team. Individual learning that results in team cognition enables coordination between members, and coordination enables team- level outcomes.

Team cognition enables the social changes expected by social learning theorists in natural resource management research. From a team-based perspective, social change is generated by team learning and can be evidenced by how ‘effectively’ a team performed. Team effectiveness can refer to a) group-produced outputs (e.g., quantity, speed, customer satisfaction), b) affective outcomes (e.g., improvements in worker satisfaction) and c) improvements in group processes (e.g., communication, knowledge sharing) (Guzzo & Dickson, 1996; Sundstrom et al., 1990; Hackman, 1987). Each of these measures of team effectiveness can be correlated with social change effects sought in learning-oriented natural resource management.

Beyond simply producing conservation plans or policy recommendations, team produced outputs may include other measures. First, and most obviously, effective plans satisfy diverse interests of various concerned stakeholder groups. Second, those team members who feel their participation is satisfying and worthy of continuing support (e.g., an affective outcome) help to increase 'social capital'. Definitions of social capital vary but generally refer to the extent that a group of people are networked together (see Keen et al., 2005). And thirdly, improvements in group processes are consistent with the previously stated need of maintaining adaptive 'capacity' in governance structures (Institute of Urban and Regional Development, 2003).

In summary, it is possible to reframe social learning by recording the cognitive changes team members experience over the course of their development during collaborative activities common to participatory research interventions. These cognitive changes represent social learning at the individual level. And cognitive changes that span across team members may produce team cognition. Increases in team cognition can then be correlated with social changes at the team level such as measures of team effectiveness.

The next section of this article introduces the Team Member Schema Similarity (TMSS) as a research framework for social learning. TMSS research is currently used to capture "snap shots" of team members' cognitions and their relationship to team effectiveness. This article expands the use of TMSS to capture changes in individuals' cognitions over time. By examining cognitions over time, TMSS can be used to investigate the relationships between collaborative (i.e., team) activities common to participatory research interventions, social learning, and social changes.

Team Member Schema Similarity (TMSS)

Team Member Schema Similarity is presented here as a research framework capable of meeting the criteria set forth earlier in this paper of uniting the two threads of social learning research. It was stated that such a research framework would require observing cognitive changes at the level of the individual and providing explanatory power to the concept of social learning as social change at larger social levels (e.g., teams, organizations, etc.).

By assuming that team learning can act as a proxy for social learning it should be possible to study changes in team cognition across time as an empirical measure of social learning, as might be found in the collaborative activities of participatory research interventions. Furthermore, observed changes in team cognition can then be correlated with effectiveness improvements sought by researchers who claim social learning to be a social change process. This section of the article begins by introducing the concept of 'schema'. Then the TMSS research framework is presented.

Schema

To test for team cognition, a method for comparing individuals' cognitions is needed. Cognition is a complex phenomena depending heavily on how individuals make meaning from their experiences. 'Schemas' are used in cognitive research to document how individuals generate meaning from their experiences.

Schemas are “complex knowledge structures that facilitate an individual’s understanding of the world by organizing or imposing a structure on the information acquired through experience. This knowledge may be about the self, about other people, and about typical events” (Rentsch & Hall, 1994). Schemas help us understand and deal with common situations, thereby reducing the energy we expend for common tasks and events. Also, they help us store and retrieve information from memory and direct actions.

Schemas are represented by their contents and structure. A piece of information composes a node. Pieces of information can be connected to one another via linkages. A schema can be conceptualized as a web of nodes and links. The totality of a person’s knowledge can be represented by interconnected cognitive units, or schema. Information can be part of several schemas at once or unique to a single schema. Schema can also be embedded in other schema (Rentsch & Hall, 1994) (Figure 1).

Similarities in either structure or content between two individuals’ schema represents a certain amount of team cognition present between team members. The term ‘schema similarity’ is used to connote a level of commonality between two (or more) persons’ schemas. A distinction of the Team Member Schema Similarity research framework compared to others of the ‘shared cognition’ literature is that there is no expectation that team members will attain full cognitive consensus. Rather each individual has some similarity (i.e., overlap) with each other team member’s schemas but also retains some unique aspects (Rentsch & Hall, 1994).

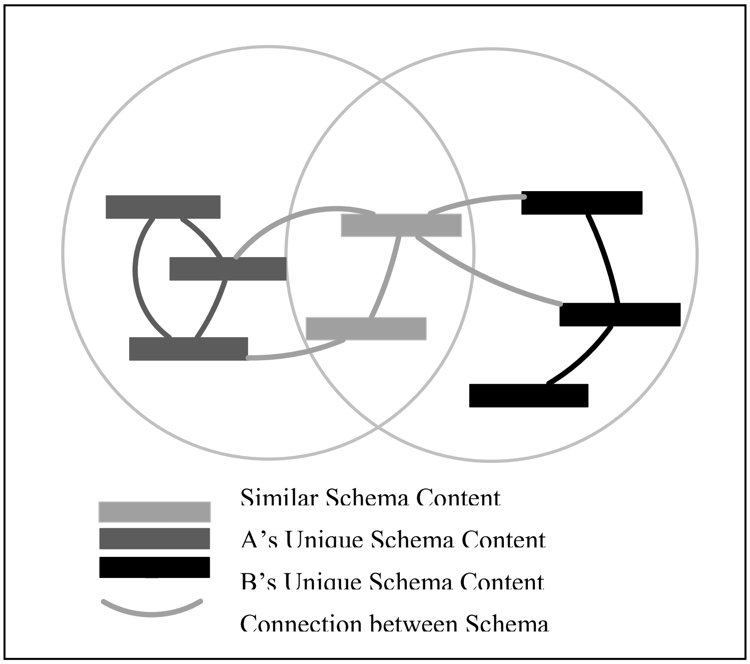


Figure 1: Schema Similarity

TMSS

Team Member Schema Similarity (TMSS) can be used to hypothesize about relationships between team members’ cognitions and team effectiveness. TMSS can be used to explain how having similar schema leads indirectly to team effectiveness by improving ‘team processes’ (e.g., trust, conflict management, information sharing) and by improving the quality of a team’s task performance (Rentsch & Hall, 1994; Rentsch & Klimoski, 2001). Team members rely on team processes for their coordination.

An example of how schema similarity may lead to improved effectiveness would be when a novice joins a group of experts. Initially, the novice has his/ her personal schema for the team’s task(s) and other team members. But through communication (i.e., interaction) with the experts and sharing experiences (i.e., socialization or training sessions) with them the novice’s schemas become more similar to the experts. As team members' schemas become more similar their teamwork could be expected to become more efficient and effective (Rentsch & Hall, 1994).

TMSS asserts that when team member schema related to teamwork become more similar communication is improved, members can better anticipate each others behavior, and it helps members monitor the team's situation better thereby allowing members to compensate and substitute for one another (Rentsch & Hall, 1994). When schema related to the team's task become more similar, the team becomes more efficient because there is agreement on the proper strategy to take and the standards the team is expected to work towards (Rentsch & Hall, 1994).

Research related to the TMSS framework is most often constructed as a post-test only experimental design with replication over several teams and various treatments. Teams are asked to perform a predetermined task with varying levels of familiarity with their team members and the task itself. Schemas related to teamwork and taskwork are pre-selected based on the task, and hypothesis being tested. Schema could range from expectations individuals hold for their teammates' behavior or how the task should be carried out to be successful (Cannon-Bowers, Salas, & Converse, 1993).

After performing the assigned task, subjects are asked to provide their schema, and team effectiveness data are collected. Schemas are elicited from subjects via various sampling methods such as questionnaires, interviews, or card sorting exercises. Schema similarities are then analyzed using mathematical techniques such as multidimensional scaling, Pathfinder, or cognitive mapping (Mohammed, Klimoski, & Rentsch, 2000).

Once schema similarities have been determined correlations can be made to with the team effectiveness measures.

Recent empirical TMSS research suggests schema similarity improves information sharing behavior, conflict management, trust, communication, coordination, team effectiveness, and adaptability (Rentsch, Delise, & Hutchison, in press). However, the number of TMSS studies is limited, and research has only been conducted in highly controlled experimental settings. Further research is required to validate research conclusions and the research framework itself. Currently, little research has been done to examine exactly how schemas become similar. The study of social learning is likely to offer insights into this process.

TMSS and Social Learning

As outlined in the last section, insights into team effectiveness are generated using TMSS by asking individuals to complete a team-oriented intervention, examining the extent of schema similarity, and correlating schema similarity with measures of team effectiveness. TMSS can also be used to understand the relationships between team cognition and social changes related to social learning. In the following two sections, an integration of social learning is facilitated by TMSS. A subsequent section presents an example of how TMSS may offer new insights into social learning research.

To measure learning using TMSS, a different experimental design is needed. An operational definition of social learning requires measuring changes in schema similarity, across individuals, both before and after periods of possible social learning. Rather than a post-test only design social learning research requires that each team members' schema be measured before and after a participatory research intervention.

A pre-test and post-test analysis reveals changes in an individual's cognitions derived from their involvement in a participatory research intervention. When team members' schema similarity becomes significantly more similar, in the statistical sense, team cognition increases may be used to indicate social learning. Increases in team cognition can then be correlated with measures of social change. Such measures of capacity, social capital, and team outputs (i.e., team effectiveness) represent possible social changes.

If team research and the TMSS framework are to deepen our understanding of social learning they should provide new insights and clarity to established social learning literature. To achieve these ends, the collaborative activities common to participatory research interventions offer opportunities for the study of social learning in great detail. Participatory research interventions such as Rapid Rural Appraisal (RRA), Rapid Appraisal of Agricultural Knowledge Systems (RAAKS), and Mediated Modeling (MM) rely heavily on participants working collectively, often collaboratively, to make better resource management decisions.

"Collaboration involves interdependent parties identifying issues of mutual interest, pooling their energy and resources, addressing their differences, charting a course for the future, and allocating implementation responsibility among the group" (Daniels & Walker 2001). Successful collaboration requires conflict management skills; visioning systemic solutions to overlapping problems; and building increased capacity to overcome institutional constraints, power relationships, conflict situations, money shortages, and knowledge limitations associated with traditional issue focused problem solving (Wondolleck & Yaffee, 2000). Collaboration may fail due to mistrust, irresolvable differences in values, organizational norms and culture, lack of support for collaboration, unfamiliarity with the process, a lack of process skills, and the restrictions imposed by other ongoing efforts (Wondolleck & Yaffee, 2000). (Underlining is used to emphasize important topics covered in both collaboration and team research literatures.)

Many of the above mentioned requirements of successful collaboration (e.g., conflict management skills) are analogous to team work processes in TMSS research. To avoid failures of collaboration, emphasis is given to work processes because much of the work in collaboration is 'deliberative'. Deliberation is defined here as social interaction initiated by a problematic situation in which stakeholders "communicate in a learning-oriented way" (Woodhill, 2004). It is in the context of "learning-oriented" social interaction that TMSS can be employed to observe changes in subjects' schema that represent social learning. The following section presents an example of how TMSS and team research can be used to better understand social learning. The example looks at the need for improved conflict management skills during collaborative activities.

Conflict: An example of TMSS and social learning

The role of conflict in collaborative natural resource management has become a central theme of research. One claim made is that some approaches to conflict are beneficial and others are not (Daniels & Walker, 2001). Deliberation is a form of beneficial conflict because it creates opportunities for social learning (Keen et al., 2005).

The differentiation between beneficial conflict that deliberation seeks to promote and detrimental, often emotional, conflicts that lead to breakdowns in collaborative activities is made explicit in team research.

Conflicts that are directly related to performing a task or 'task conflicts' are thought to have beneficial consequences for team effectiveness (Rentsch & Zelno, 2003). Task conflicts (sometimes referred to as cognitive conflict) may include disagreements concerning the allocation of resources, policies, or roles, among other issues. The benefits of task conflicts are closely aligned with the goals of social learning in collaborative management and include integration of diverse perspectives, an increased commitment to the team and its underlying decisions and behaviors, and sense of group identity (Rentsch & Zelno, 2003).

Conflicts involving relationships or 'socio-emotional conflicts' result in detrimental consequences for team effectiveness because time is spent arguing non-task and non-teamwork related information or may result in a failure to share information thereby hindering the collective information processing of the team. Topics of socio-emotional conflict may include differences in norms, values, and identity (Rentsch & Zelno, 2003).

One caveat of team research is that often conflict is typically expressed in terms of intra-organizational contexts where culture is somewhat homogenous. Conflict in natural resource management is often inter-organizational and cross-cultural. There is a need to formally recognize this difference and negotiate a common culture before task negotiation can begin to prevent causing unintended offense.

To improve team performance, it is desirable to increase task conflict and simultaneously reduce socio-emotional conflict (Rentsch & Zelno, 2003). In reality achieving this condition is somewhat difficult because humans tend to misinterpret the intentions of others during communication (Daniels & Walker, 2001). For example, person A may critique a policy recommendation offered by person B, and rather than acknowledge the critique as a task conflict person B may interpret person A's critique as a personal attack; the interpretation not the critique itself becomes the basis for socio-emotional conflict (Rentsch & Zelno, 2003).

To prevent unintended detrimental conflicts, individuals must be able to interpret the intention attached to communications. Teamwork schemas offer a cognitive mechanism to better understand how individuals interpret information during collaboration. Understanding the cognitive dimension of communication may also offer insights into conflict management strategies in support of social learning.

TMSS researchers focus on teamwork schema because they contain knowledge about how teammates should behave. Behaviors such as active participation in discussions, attending to others, being influenced by teammates, assisting teammates, correcting errors, pooling information, and integrating perspectives are hypothesized to support cooperative task completion (Rentsch & Zelno, 2003). Also, behaviors encouraging constructive normative behavior such as sharing information, expressing opinions, raising doubts, airing objections, challenging ideas, and evaluating ideas of others are hypothesized to help support task conflict (Rentsch & Zelno, 2003). When teammates hold similar schemas that support these behaviors task conflict is expected to increase because each individual is engaged in similar task conflict behaviors.

To avoid socio-emotional conflict a team member must also correctly interpret their teammates' task conflict behaviors as such and not as personal attacks. To avoid misattributions, team members would also have accurate schema of their teammates' schema. As schema accuracy increases detrimental socio-emotional conflict is expected to decrease (Rentsch & Zelno, 2003).

In summary, when teams maximize task conflict and minimize socio-emotional conflict, they are thought to increase their performance. Rentsch & Zelno (2003) hypothesized that to support this optimal condition the team should strive to increase their teamwork schema congruence and accuracy. To increase schema congruence teams need to share similar experiences. Again, similar experiences can occur during socialization, interaction, or training activities. To increase schema accuracy teams need to increase trust, reduce social anxiety, and increase the openness of the team (Rentsch & Zelno, 2003).

To facilitate teamwork schema similarity, natural resource managers engaged in collaborative activities can 1) model task conflict behaviors, 2) conduct team building activities (i.e., training sessions), or 3) when dealing with computer-mediated collaboration, use technology that prompts team members to engage in "good" behaviors (Rentsch & Zelno, 2003). TMSS can be used to evaluate the effectiveness of various team building activities. Using pre- and post- test quasi experimental designs, TMSS may be used to verify the efficacy of participatory research interventions and team building techniques. Also, TMSS may be used to monitor teamwork schema similarity and, thereby, predict the likely effectiveness of a team's task performance.

Conclusion

Proponents of social learning believe that it increases the opportunity for decision makers to find systemic solutions to resource management problems (Keen et al., 2005). However, the lack of an operational definition for social learning has stymied attempts to validate its espoused ability to improve resource governance (Pahl-Wostl & Hare, 2004). In this article the TMSS research framework has been presented as a specific process to determine the presence and quantity of social learning so that any person who wishes to research it can independently test for it and its effects. This article has provided some clarification of social learning by reframing the concept in terms of team performance using insights from the field of organizational psychology.

From a team based perspective, social learning occurs at the level of the individual, but its effects are generated by cognitive similarities across individuals. Team cognition enables the social changes expected by social learning theorists in natural resource management. Therefore, social learning research requires observation at two levels: 1) changes of single individuals' cognitions across time, and 2) changes of cognition amongst individuals' cognitions across time.

In considering how to carry out team-based social learning research, a number of decisions must be made to accurately measure the phenomenon and its effects. First, the determination of what schemas are to be measured during an experiment is dependent on the work processes, task, and people involved. In turn, these factors are dependent on the defined goal(s) of the participatory research intervention. The goal of the intervention is defined by the management situation or problem that generated the need to organize the team itself. Finally, the goal of the intervention also defines the team effectiveness measures that should be tested against the schema being measured.

The decision process described here offers only a glimpse of the possible hypotheses that could be tested through a replicable, reliable, testing process. Over time a catalog of relationships between interventions, learning, and outcomes may be developed. The catalog of relationships would then serve as documentation of empirical observation and validation of social learning theory.

TMSS offers one such testing process. For example, various participatory interventions may advertise similar benefits. However, only by monitoring social learning over the course of the intervention can the facilitator know for sure that the intervention has achieved its pre-determined goals. There is a need to link specific participatory interventions to specific tasks or governance needs (Stringer, Dougill, Fraser, Hubacek, Prell, & Reed, 2006). TMSS offers a process to meet that need.

Part 3

A Cognitive Approach to Assessing Social Learning in Collaborative Natural Resource Management

Introduction

Participatory research interventions such as Rapid Rural Appraisal (RRA), Rapid Appraisal of Agricultural Knowledge Systems (RAAKS), and Mediated Modeling (MM) are used in part to stimulate social learning in natural resource management decision making (Hitt, 1998; Townsley, 1996; Van den Belt, 2004). Social learning enables individuals to understand each other's perspectives and encourages integration of diverse knowledge bases thereby increasing the opportunity for decision makers to find systemic solutions to resource management (Keen, Brown, & Dyball, 2005). However, the relationship between participatory research interventions and the basic cognitive process of social learning is not well understood. That is, various interventions may stimulate social learning differently. Furthermore, the relationships between social learning and decision making improvements are poorly understood (Gunderson, Holling, & Light, 1995).

This article focuses narrowly on the relationship between intervention and social learning. The objective of this paper is to answer the research question, "How do participatory research interventions stimulate social learning during collaborative activities?" A research framework known as Team Member Schema Similarity (TMSS) is introduced as a means to observe social learning from a cognitive perspective (Rentsch & Hall, 1994). TMSS is used to document the changes to individual group members' cognitions that would indicate collaborative activities common to participatory research interventions are generating social learning.

A case study is presented using TMSS to test a hypothesis about the efficacy of a participatory research intervention to stimulate social learning. The case study is a Mediated Modeling intervention designed to generate a shared understanding of landscape change among a diverse group of private forest landowners from Morgan County, Tennessee. The following sections of this paper describe in more detail social learning, the TMSS research framework, and the Mediated Modeling case study. Anecdotal evidence from the case study is presented related to the ability of social learning to promote improvements to participants' collaborative capacity. A final section discusses limitations and implications of the TMSS research framework related to social learning research.

Social Learning

The governance of resources revolves around highly complex problems where uncertainty is high, there are a large number of often competing stakeholder interests, and problem causes and effects are separated in space and time (Woodhill, 2004). Increasingly, management decision-making processes are seen as deliberative processes that occur between concerned stakeholders (Schneider, Scholz, Lubell, Mindruta, & Edwardsen, 2003). The implication of an increased emphasis on deliberation is that resource management is becoming less about the search for an optimal solution to resource problems and becoming more focused on continual learning in a cycle of diagnosis, decision, action, and reflection (Keen et al., 2005).

Communication, perspective sharing, and development of adaptive group strategies for problem solving are given prominence in deliberative processes. These priorities have become associated with the concept of social learning in natural resource management (Pahl-Wostl & Hare, 2004). Usage of the term 'social learning' however is often unclear because of two parallel lines of research. Social learning can refer to 1) a learning process and 2) a social change process (Pahl-Wostl & Hare, 2004).

In the first instance, social learning as a learning process, it is defined in terms of individual psychology. Social learning as proposed by Bandura (1977) refers to individual learning based on observation of others and their social interactions within a group. This definition "assumes an iterative feedback between the learner and their environment, the learner changing the environment, and these changes affecting the learner" (Pahl-Wostl & Hare, 2004). Social learning in these terms occurs to the benefit of the individual and is largely a psychological mechanism for behavior imitation and knowledge adoption.

In natural resource management social learning has come to mean a continual decision-making improvement at an organizational or societal level. The second notion of social learning, as a social change process, emphasizes that in the process of resource management, social involvement (e.g., the generation of social capital) is as important as the content of knowledge being shared (Pahl-Wostl & Hare, 2004). In this interpretation increasing the capacity of actors to solve conflicts and come to cooperative agreements is integral to the process of defining a problem, the search for its solution, and solution implementation (Keen et al., 2005; Pahl-Wostl & Hare, 2004; Institute of Urban and Regional Development, 2003). Increasing actors' capacity via social involvement is thought to enhance the flexibility of the governance system and its ability to respond to change (Gunderson et al., 1995; Wondolleck & Yaffee, 2000).

In response to the notion of social learning as a social change mechanism, participatory research interventions such as Rapid Rural Appraisal (RRA), Rapid Appraisal of Agricultural Knowledge Systems (RAAKS), and Mediated Modeling (MM) have been advanced as methods for balancing social involvement and content management (Hitt, 1998; Townsley, 1996; Van den Belt, 2004). However, no notion of social learning presented here is able to fully explain how these interventions generate their observed benefits. Social learning as a learning process does not consider supra-individual effects such as increased governance capacity. Likewise, the notion of social learning as a social change process fails to offer any explanation of the psychological mechanism at work that produces social change.

A full description of social learning in natural resource management should integrate the concepts that social learning is a psychological process that is measurable at the level of the individual and generates benefits across individuals, at higher social levels. This paper adopts a third position on social learning organized around the concept of team learning as used in organizational psychology. Team learning is "the process of aligning and developing the capacity of a team to create the results its members truly desire. It builds on the discipline of developing shared vision. It also builds on personal mastery, for talented teams are made up of talented individuals." (Senge, 1990, p. 236) The following section describes team learning as an integration of the two strands of social learning theory with applications in natural resource management. The TMSS research framework is then introduced as a means to better understand the relationships between participatory research and social learning, and social learning and social change.

The Team Member Schema Similarity (TMSS) Framework

Team researchers in organizational psychology study the cognitions of team members to understand how team members' capacity for communication and coordination affect the whole team's effectiveness. Effectiveness in team research may indicate one or more of the following outcomes: 1) group-produced outputs (e.g., quantity, speed, customer satisfaction, 2) affective outcomes (e.g., improvements in worker satisfaction) and 3) improvements in group processes (e.g., communication, knowledge sharing) (Guzzo & Dickson, 1996; Sundstrom, DeMuese, & Futrell, 1990; Hackman, 1987). There is a growing consensus that team learning occurs at the level of the individual and overlapping or cognitive similarity accounts for increased coordination among team members (Hinsz, Tindale, & Vollrath, 1997; Cannon-Bowers, Salas, & Converse, 1993; Klimoski & Mohammed, 1994; Rentsch & Klimoski 2001). The TMSS framework was originally conceived to study the effects of cognitive similarity on the effectiveness of teams in the workplace (Rentsch & Hall 1994).

One form of cognition known as 'schema' has grown in interest to team researchers because the concept is able to link individual knowledge to team level effects. Schemas are commonly thought of as web-like structures of knowledge "that facilitate an individual's understanding of the world by organizing or imposing a structure on the information acquired through experience. This knowledge may be about the self, about other people, and about typical events" (Rentsch & Hall, 1994). Schemas help us understand and deal with common situations thereby reducing the energy we expend to complete common tasks and events. Also, they help us store and retrieve information from memory and direct actions (Rentsch & Hall, 1994).

Organizational theorists claim that when individuals hold similar schema (a related notion is 'mental models'), they are able to define, mobilize, and channel the collective aspirations and knowledge of the group (Senge, 1990). The term 'schema similarity' is used to connote a level of commonality between two (or more) persons' schemas. The Team Member Schema Similarity (TMSS) research framework uses this concept as the foundation for studying two aspects of team performance: 1) the effects of input variables (e.g., team composition, technology, resources) on the generation of schema similarity and 2) the effects of schema similarity on team effectiveness (Rentsch & Hall, 1994).

A general model of team effectiveness from the perspective of TMSS can be summarized by stating that team members learn from one another to better coordinate their work processes such as information sharing, conflict management, or trust building. As team members are better able to work together, they are likely to become more effective (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000; Rentsch & Klimoski 2001). For example, when team members develop similar schema for information sharing, conflict, and trust building, they are more likely to anticipate each others informational needs, avoid negative conflict, and build trust. Empirical TMSS research has been related to improved information sharing behavior, conflict management, trust, communication, coordination, team effectiveness, and adaptability (Rentsch, Delise, & Hutchison, in press).

It should be noted that the simplicity of the schema similarity concept as presented here belies the true complexity of TMSS research. However, this basic representation of the framework is adequate for explaining its potential use for studying the effects of participatory research interventions. For a more thorough discussion of the TMSS framework, see Rentsch & Hall (1994) and Rentsch et al. (in press).

TMSS meets the criteria of being able to integrate social learning as a learning process by observing cognitive changes at the level of the individual while providing explanatory power to the concept of social learning as social change at larger social levels (e.g., teams, organizations). By making the assumption that team learning can act as a proxy for social learning, it should be possible to study changes in schema similarity across time as an empirical measure of social learning, as might be found in the collaborative activities of participatory research interventions. Furthermore, observed changes in schema similarity can then be correlated with work process improvements sought by researchers who claim social learning as a social change process. In this study a single hypothesis is proposed to test the assumption that participatory research interventions generate social learning. Using a Mediated Modeling case study, participants were asked to generate a shared understanding of landscape change in Morgan County, Tennessee. The hypothesis tested is:

Hypothesis: If participatory research interventions cause social learning then participants of a Mediated Modeling project will have increased schema similarity of landscape change (i.e., the focus of the participatory research intervention).

And while no formal hypothesis is proposed to test the effects of social learning anecdotal evidence is presented from the case study that provides an indication that social learning may produce team level capacity building effects. The case study is presented following a short discussion of the Mediated Modeling participatory research method.

Mediated Modeling

Environmental decision making requires the integration of complex interactions between ecological, economic, and social dimensions. The three intertwined objectives of conserving ecological, economic, and social capital are sometimes referred to as the 'triple bottom line' of sustainable development (Daily, 1997). Unfortunately, the 'triple bottom line' defies simple management prescriptions and is rife with political conflicts. Environmental decision making then requires good science and technical information but also consideration of the values of all concerned interests. The values of decision makers defines what ought to be honored, protected, sustained, or developed (Forester, 1999). To avoid excluding any political interest requires the active participation of all relevant stakeholders and their early involvement in the process.

Decision processes that rely solely on scientific and technical assessment techniques done by professional analysts are problematic because they often are exclusionary, promote divisive conflicts, and promote economic interests ahead of other perspectives (Cortner & Moote, 1999; Forester, 1999). The usefulness of developing participatory research interventions such as Rapid Rural Appraisal (RRA), Rapid Appraisal of Agricultural Knowledge Systems (RAAKS), and Mediated Modeling (MM) has been the acknowledged benefit of for increasing the equity, trust, and representativeness of decision processes (Antunes, Santos, & Videira, 2006).

Mediated Modeling as used in this research has been successful at addressing these issues (Stave, 2003; van den Belt, 2004). Mediated Modeling was developed in the field of system dynamics modeling. Systems dynamics modeling is a method for learning and managing complex feedback systems such as occur between environmental and social systems. This form of modeling, grounded in control theory, assumes that the behavior of a system derives from its structure. System dynamics models are used to study the feedback relationships, which determine the behavior exhibited by the system as a whole (Antunes et al., 2006).

The systems dynamics methodology is composed of a number of steps that together flow as a continuous problem solving process (e.g., Ford, 1996; Richardson & Pugh, 1989). The five core steps of this process are as follows:

1) define the problem
2) describe the system
3) develop the model
4) build confidence in the model
5) use the model for policy analysis

To begin the model building process, a problematic behavior is described. Problematic behaviors in systems dynamics are generated as part of the endogenous structure of some system of interacting parts. Problems are described in terms of behavior over time. Next, the causation of the problematic behavior is described as a systemic narrative or diagram as to why the problematic behavior exists and the factors that guide its behavior over time. Third, the systemic representation is converted into a dynamic mathematical model that generates the observed behavior over time of the system in question (Sterman, 2000).

The model is then tested to verify its behavior under a range of historical and extreme conditions. Also, the model is often presented to clients to verify transparency in the modeling process and to generate support for future findings. Lastly, the model is put to use by testing policies expected to yield improved behavior of the problematic condition as well as unintended consequences in other areas of the system (Sterman, 2000).

Although these five steps represent a full modeling project, not all modeling projects undergo each of these steps. Often the greatest benefit to clients is the learning that takes place during the qualitative system description phase of a project (Vennix, 1996). Therefore, systems modeling projects that do not include each of the five steps presented here are not dismissed as incomplete but rather they fit within a diversity of possible project outcomes depending on project goals and objectives.

Systems models are often built independently by dedicated researchers but can also be built collectively as a participatory process. When completed as a participatory process "systems dynamic models can help managers communicate information about the structure of the system and show stakeholders, visually and with a minimum of technical jargon, the consequences of different actions. Using a model in an interactive forum can engage participants in discussions that foster a common understanding about the system and consensus about management actions" (Stave, 2003). When constructed collaboratively the group modeling process is often referred to as 'mediated modeling' (van den Belt, 2004).

There are many techniques that may be used to elicit the information needed to build a model. Sometimes individuals are asked to supply information via interviews, surveys, concept mapping, or workbooks. Alternatively, a group will collectively provide information via facilitated workshops (Vennix, 1996). The efficiency of each elicitation technique varies and may be selected by a researcher based on the level of detail the systems model needs to produce and available resources (e.g., time, effort, and budget).

Many projects have been conducted to improve sustainable land-use decision making using Mediated Modeling and Group Model Building. Rouwette, Vennix, & Mullekom (2002) report that Group Model Building interventions have been used to discover beneficial changes in organizational environments and explore policy impacts. Group Model Building has also been used to increase public participation (den Exter 2003). Most relevant to this project, Group Model Building has been used in collaborative planning of forest resources (Purnomo, Mendoza, & Prabhu 2004).

In the case study presented here, the method was thought to be applicable as a social learning process for investigating the diversity of understandings that landowners may have about landscape change in their locality. In addition, the Group Model Building literature may benefit from this research because of an acknowledged need to empirically validate that systems modeling methods do, in fact, create a shared vision among group modeling participants (Vennix, 1996, Doyle, 1997). This research helps to addresses that deficiency.

A Case Study

Background

Morgan County is situated on the eastern edge of the Cumberland Plateau, a physiographic province located near the middle of Tennessee (Figure 2). The topography of the main body of the Cumberland Plateau is somewhat dissected and rolling and gets its character from an underlying sandstone caprock. In the northeast end of Morgan County, this sandstone cap has been worn away exposing a more erodable lithology below. This more highly eroded portion of the formation, known as the Cumberland Mountains, gives much of Morgan County a highly dissected topography (NCASI, 2006).

In the early 20^{th} century, the area was heavily used for timber and coal production. However, as these industries moved out of the region, they left a low quality forest and depressed economies in their wake. The difficult terrain combined with a depressed economy has kept Morgan County largely isolated for much of its history. Today, the recovering forests and unique culture of the Cumberland region including Morgan County is threatened by new biological and human-caused changes across the landscape.

Previous research has identified through focus groups and interviews, the main threats perceived in Morgan County (Ostermeier, Fly, Muth, Pavey, & Steiner, 2002). Threats to the area include: forestlands which are slowly recovering from exploitive harvesting practices early in the 20^{th} century, severe and irreversible changes through

Figure 2: Morgan County Tennessee

land parcelization for residential development, and disease and pest outbreaks. Additional concerns raised include limited returns on forest products, increased wild fire risk, forest fragmentation, conflicting cultural values (between traditional landowners, in-migrants, and government agencies), and a lack of capacity to deal with these changing cultural and biological conditions.

Collectively these research results suggest a community that does not have a shared vision for its desired future condition or the abilities necessary to define one. Given these results, a participatory research program was implemented to help the community define itself and increase community capacity to make choices about its future. As part of that approach, this project was proposed as a social learning opportunity for landowners to come together, collectively research the dynamics of landscape change in their county, and generate a shared understanding of the issue.

Methods

Sample

Participants were chosen from local civic organizations and previous research efforts. As described in the background section of this paper, the culture, beauty, and biological integrity of Morgan County are being threatened by biological and human caused changes to the landscape. Several civic groups have come into being to address perceived problems. However, little coordination exists between these groups. Participants were solicited from organizations including Save Our Cumberland Mountains (SOCM), The Morgan County Forestry Development Association (MCFDA), the Emory River Watershed Association (ERWA), and the Emory-Obed Forum (EOF). Word of mouth help to draw additional participants from Tennessee Citizens for Wilderness Planning (TCWP). In addition, un-affiliated landowners (i.e., landowners who are not active in any of these groups) were solicited from prior research efforts to ensure a maximum diversity of perspectives.

These organizations and individuals represent a diversity of perspectives and interests of landowners concerning the landscape of Morgan County, TN. Each participant selected for this study, however, shares a common interest in maintaining or improving the landscape of the county's land owners. To capture as full a cross-section of landowner's perspectives as possible for the modeling project participants were selected to represent a wide diversity of interests and perceived causalities of countywide landscape change.

In keeping with proposed guidelines for maximum group size given by Vennix (1996) a total of 15 individuals were selected to participate in three model building workshops. The second of the three workshops was proposed as a one day event but was continued into a second day to complete the proposed work. Also, workshop three activities have developed into an ongoing series of planning and group development meetings.

Twelve of the original fifteen participants completed the entire workshop series. Two participants who did not complete the workshop series did so because of waning interest. The third partial-participant was dismissed after failing to agree to the preconditions of the workshop series. The preconditions for participation were an open and learning oriented approach to group dialog. Additionally, because of prior commitments and/ or diminished interest participant attendance varied for each workshop. In total fifteen participants were asked to participate. However, only twelve completed to workshop series and pre- post-test activity. Workshop #1 involved twelve participants, workshop #2 had ten attendees, and the planning workshops (i.e., originally workshop #3) had approximately eight participants depending on the occasion.

Participants were selected for the study via convenience sampling. A convenience sample is a non-random sampling design drawn by choosing available individuals who meet the set selection criteria for participation. For this case study, the diversity of participants' views of landscape change was important. Therefore an effort was made to assemble a group with differing land ownership tenures, varying parcel sizes, occupations, and ownership motivations. All participants owned acreage in Morgan County, owning at least three acres, with at least one acre in forest cover.

The workshop attendees (12 participants) were a highly diverse group. For example, six members own less than 50 acres in Morgan County. The smallest ownership was five acres while the largest was 1300 acres. Four participants have owned their Morgan County property for less than ten years while four have had family owned land in Morgan for more than 50 years. Three participants have their PhD degrees. Two participants raise livestock and two others have family owned, revenue generating, tree farms. Participants' ages ranged between 25 and 74 years old. The group contains a diversity of ownership motivations including income generation, spiritual, aesthetic, and quality of life reasons with five of the twelve participants reporting income generation as a major motivation for owning their forestland.

Procedures

The mediated modeling process was designed as a set of three workshops: 1) an organizational workshop, 2) a modeling workshop, and 3) a planning workshop (Figure 3). A pre-test causal mapping exercise was conducted with each participant between the first and second workshops. A post-test causal mapping exercise was conducted between the second and third. Additionally, a short written survey was conducted in conjunction with the post-test to assess capacity building. The timeline of the workshops and tests are provided in Figure 3.

The purpose of the organizational meeting was three fold: 1) to introduce the project and its methods, 2) to have the group develop a list of factors that explain landscape change in Morgan County, and 3) to begin building trusting relationships among participants. To elicit factors participants felt influence changes in Morgan County's landscape, participants were led through a brainstorming session that utilized a nominal group technique. A nominal group technique for elicitation enables individuals to express all of their personal beliefs about why the landscape is changing without interference from the beliefs of others.

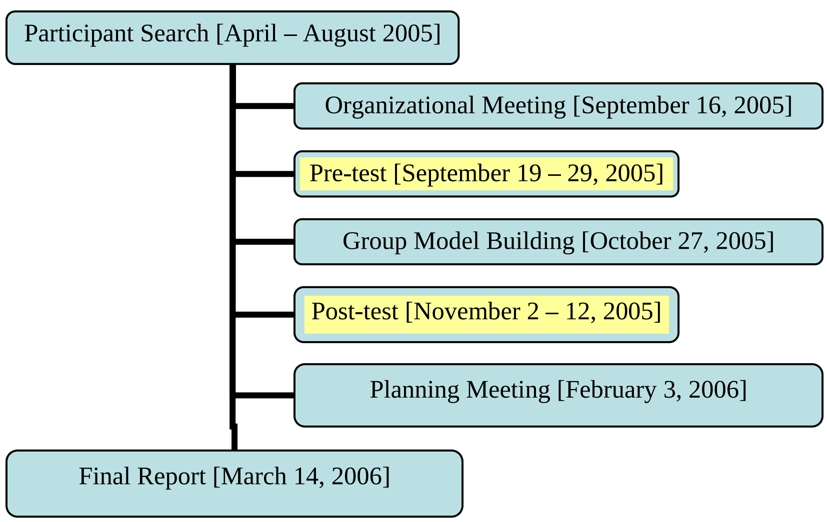


Figure 3: Project Organization

The purpose of the modeling workshop was to have the group collectively construct a causal loop diagram. A causal loop diagram is a graphical representation of perceived causality that gives rise to a system's behavior over time. The purpose of causal loop diagramming is to explore why a system behaves the way it does and to encourage group discussions about system behavior over time. The theme of the causal loop diagram for this project was chosen by the group after reflecting on the list of factors compiled during the organizational workshop. The group formed a consensus quickly around the issue of 'land parcelization caused by residential development'.

The purpose of the third workshop was to review work conducted in the previous two workshops and to determine if mitigating measures were possible to control the subdivision of land parcels (i.e., parcelization) and its associated effects in Morgan County. The causal loop diagram generated in the group model building sessions was dissected into causal trees to identify points of leverage to mitigate negative effects on the community. As a result of the workshop series, a new community group has formed around the mission of fostering sustainable landscape change in Morgan County. The third workshop was used to craft a mission statement for the group. This effort is described in detail in the discussion section of this paper.

The workshop series was held at a meeting hall located in the Morgan County Central School Office. The meeting hall was well appointed having large empty wall spaces, a nearby kitchenette, a flexible furniture system, high speed internet access, and an overhead projection system. At each workshop session participants were provided meals and refreshments throughout the day, including breakfast and lunch. Meetings were convened beginning at approximately 9am and concluded by 4pm. A facilitator led each workshop while a record keeper helped to manage workshop logistics and record group process information.

Design

To verify hypotheses proposed by TMSS, researchers require schema elicitation and analysis methods that document 'structural cognition.' That is, a schema is represented as pieces of knowledge (i.e., nodes) connected together by meaningful relationships (i.e., links) to form an interconnected network of nodes. To analyze a schema TMSS researchers require methods that document not only the content of cognitions (i.e., the nodes) but also their network structure.

The most common type of structural assessment method is paired comparison ratings used with a concept mapping technique. Concept maps are made up of variables (i.e., the nodes of a schema) linked together into a network of action-oriented argumentation (i.e., beliefs that form a basis for intervening in the world, explanations of why assertions hold true, and expectations as a result of the assertion) (Eden & Ackerman, 2004). For this method an individual is asked to provide relatedness ratings for pairs of concepts. Every concept is paired with each other concept until all pairs have been documented. Relatedness ratings are then typically subjected to either network analysis or multidimensional scaling analysis (Markoczy & Goldberg, 1995; Rentsch, Small, & Hanges, in press).

For the case study presented here, participants' schema were documented using a form of concept mapping called 'causal mapping', as proposed by Markoczy and

Goldberg (1995). To monitor effects of social learning, individuals were asked to complete a pre- and post-test causal mapping exercise to monitor their schema of landscape change. A post-test interview was also conducted to assess the effects of the social learning process on the group's capacity.

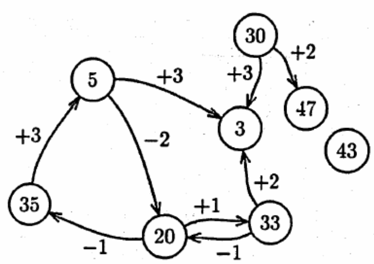
Causal maps are composed of nodes (or variables) and arrows that combined represent a network pattern much like schema themselves. However, it should be noted that all concept mapping techniques are subject to the limitations of participants' ability to recount their schema. It is likely that knowledge is embedded in schemas that cannot be voiced by participants because it is 'tacit.' Tacit knowledge is experiential and is difficult to disassociate and describe outside of the experience. This limitation is omnipresent in inductive social research methods and is an accepted part of research practice.

Nodes in causal maps are text statements that describe conceptual ideas important in the description of some system's behavior. To facilitate the elicitation of constructs in this project, the word 'node' has been replaced with 'factor' because it is easier to understand 'factors' that cause a problem rather than 'nodes' of a problem. The change in nomenclature deviates from the standard naming convention held by the current literature as stated above. The direction that an arrow points implies perceived causality (i.e., Factor A causes Factor B).

Two additional attributes sometimes used in Cognitive Mapping are the 'influence' of a causal relationship and the 'strengths' of those relationships. Influence relationships are depicted by either a plus (+) sign or a negative (-) sign. Plus signs indicate a positive correlation (i.e., if A increases (decreases) then B will increase (decrease) in correspondence with A). Or, if the sign is negative, then the causality is oppositional (i.e., as A increases (decreases) then B decreases (increases)). 'Strengths' of those relationships can be assigned as weak, moderate, or strong; written as 1, 2, and 3 respectively (Figure 4).

For participants to build models that can be compared across individuals, a consistent administration of the technique must be followed. The method developed by Markoczy and Goldberg (1995) was adapted for this project. With this method, participants build their models from a pre-determined list of factors. These factors are elicited during the organizational meeting.

Factors were elicited by asking participants to answer the question, *"What factors most influence changes to the landscape of Morgan County?"* Participants were given ten minutes to answer the question on an individual basis. Their answers were then collected and posted by a facilitator in the front of the room for all participants to see.



3 Vision and strategic direction 5 Market share
20 Competition in market 30 Leadership in organization
33 Knowledge of market needs 35 Brand recognition
43 Bank connections 47 Efficiency/productivity

Figure 1. Diagrammatic Presentation of Causal Map

	30	47	3	5	33	43	20	35
30	0	2	3	0	0	0	0	0
47	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
5	0	0	3	0	0	0	0	0
33	0	0	2	0	0	0	−1	0
43	0	0	0	0	0	0	0	0
20	0	0	0	−2	1	0	0	−1
35	0	0	0	3	0	0	0	0

3 Vision and strategic direction 5 Market share
20 Competition in market 30 Leadership in organization
33 Knowledge of market needs 35 Brand recognition
43 Bank connections 47 Efficiency/productivity

Figure 2. Association Matrix Presentation of Causal Map

Figure 4: Example cause maps. Taken from Markoczy and Goldberg 1995

After all factors were posted, one at a time, the group was asked to supply additional factors that they had thought of during the posting phase. The total number of factors generated during the organizational meeting was 75, which included a number of duplicate factors. A "master list" of factors was created for use with the pre-test causal mapping by combining near duplicate factors. The master list was reduced to a total of 57 factors for use as the pre-test (Figure 5).

A post-test "master list" was created following the modeling workshop (i.e., workshop #2). The post-test master list was complied by adding new factors to the pre-test master list that were generated during the modeling exercise. Also those factors that were not selected from the pre-test master list during the pre-test casual mapping were removed from the post-test master list. This yielded a total of 56 factors for the post-test master list. The pre and post-test master lists were allowed to be different for this experiment because similarity comparisons occurred at the group level. That is, a group level similarity score was for the pre-test data and post-test data respectively and individual cause maps were not compared across pre and post-test data sets. Had similarity ratings been generated for individuals across pre and post-tests the master list would have needed to be exactly the same for statistical comparison. The notation 57 (56) is used here to denote pre-test and post-test data, respectively.

An effort was made to collect data as quickly as possible following the workshops to prevent differences among participants from occurring due to memory effects (i.e., the failure to recall thoughts shared in the workshops). Pre-tests and post-test were collected

Education

- environmental education
- effectiveness of environmental education

Tourism

- value added agriculture/ agritourism
- ecotourism pressure
- entertainment trends
- recreational development

Economic development

- niche market agriculture
- entrpreneuralism
- natural resource development
- demand for natural resources
- natural resource utilization

Infrastructure

- infrastructure development
- transportation technology
- improved communication via technology
- road development

External Factors

- national economy
- global economy
- regional economy
- energy costs
- long-range weather conditions
- energy supply
- neighboring county activities

Land use

- residential development
- immigration into county
- profitability of forestry
- profitability of agriculture
- public land ownership
- land sales
- price/ acre
- land parcelization
- forest fragmentation
- parcel size
- land appreciation rate
- urbanization

Disturbance

- wildfire fuel
- fire frequency
- diease/ pests

Demographics

- population density
- population growth
- avg. income
- level of education
- avg. age

Industry

- regional industrial park
- type of industry
- industrial recruitment
- industrial development

Politics

- political pressures
- political ability/ influence
- political lobbying
- political will
- tax structure
- regulation

Values

- socio-cultural forces
- mindset of landowners
- respect for property rights
- conservation organizations
- desire for rural life
- biodiversity
- precived desirability of Morgan (people)

Figure 5: List of Factors

within two weeks following their respective preceding workshops. To collect pre- and post-test data participants were individually presented with the final factor list and asked to choose the 10 factors that they felt were *"...most clearly related to landscape change in Morgan County."* It should be noted that factors not chosen during this process could not be considered as a non-belief of the participant but rather it can only be said that there were other potentially more influential factors.

Once a participant had selected 10 factors, each was written on index cards. Next, factors were presented to the participants in pairs. Participants were asked with each pairing whether the card on the left caused the card on the right, positively (+), negatively (-), or not-at-all (0). Also, if the participant answered either positively or negatively she/he were then asked how strong the association was (1. weak, 2. moderate, or 3. strong). Then the order of the cards was reversed (i.e., right to left) and the questions were asked again. Pairs of factors were presented until all pairing combinations were presented. For each participant pre- and post-test responses were tabulated in matrix format having a size of 10x10. To enable comparison in a statistical software package, pre-tests and post-tests respectively were compiled into participant-by-attribute matrices where each participant was represented as a row and each relationship between factors was preserved in a separate column.

Measures

Pre and post-test data were analyzed using Ucinet 6 for Windows (Borgatti, 2006). Ucinet is a software package primarily used for social network analysis. However, it was used here because of its ability to compare similarities between valued matrices, as is necessary to determine schema similarity using causal maps. Participant-by-attribute matrices previously compiled were submitted to three data analysis procedures.

First, to prepare test data for statistical comparison, a within-matrix similarity index was generated for both pre and post-test matrices. This procedure computes similarities among the participants (i.e., rows) using Pearson's product-moment correlation. The result provides a square matrix of similarity correlations between participants for pre and post-tests, respectively. Next, the pre and post-test similarity matrices were submitted to a QAP statistical correlation procedure to determine if the pre and post-test similarities were significantly different (alpha=0.05).

The null hypothesis for a QAP analysis is that the two matrices being tested are similar. A rejection of the null hypothesis would indicate that the pre and post tests were significantly different from one another. However, if the null hypothesis is rejected, the significance value computed for the QAP is meaningless. Therefore, if the pre and post tests are found to be dissimilar using the QAP analysis, a final analysis is needed to determine if the difference between the pre and post test was a convergence (i.e., social learning) or divergence of team members' schema.

To determine if team member schema became more similar or less, a mean correlation value is calculated from the pre and post-test similarity matrices, respectively. The mean similarity correlation serves as an aggregate measure of schema similarity for the team. Evidence that social learning has occurred exists when the mean correlation for the post-test is larger than the mean for the pre-test.

To determine in what ways participants' schema became more similar or dissimilar a post-hoc analysis of pre- and post-test data was performed on the frequency of participants' factor selections. Factor frequency data provides anecdotal evidence that indicates in what ways participants' schema had become similar. Frequency data would indicate that post-test data converge on a smaller group of factors that together indicate the core content of the shared schema.

In addition to schema convergence anecdotal evidence for increased management capacity was evaluated by recording actions taken by the group following the close of research. An indication would be, participants being more willing and able to work collectively to mitigate changes to the landscape that they perceived as being negative for Morgan County. Results of the cause mapping and evidence for capacity building are provided in the results section.

Results

The results are presented in two sections. The first section details the hypothesized change in schema similarity. The second section highlights anecdotal evidence for increased management capacity resulting from the mediated modeling intervention. Pre-test and post-test similarity matrices (Table 1 and 2) illustrate changes in schema similarity among individuals.

Schema Similarity

It was hypothesized that if participatory research interventions cause social learning then participants of a Mediated Modeling project will have increased schema similarity of landscape change. To test this hypothesis, a QAP correlation was computed

Table 1: Pre-test Similarity Matrix

	pre1	pre2	pre3	pre4	pre5	pre6	pre7	pre8	pre9	pre10	pre11	pre12
pre1	1.00											
pre2	-0.01	1.00										
pre3	0.05	-0.01	1.00									
pre4	0.05	-0.01	-0.02	1.00								
pre5	0.05	-0.01	-0.01	0.08	1.00							
pre6	0.05	-0.01	-0.01	0.00	-0.01	1.00						
pre7	-0.01	-0.01	0.00	0.08	0.04	-0.01	1.00					
pre8	0.01	0.07	0.10	0.06	-0.02	0.08	0.13	1.00				
pre9	0.03	0.01	0.01	0.00	0.00	0.00	-0.02	0.01	1.00			
pre10	0.05	-0.01	0.03	0.07	-0.01	0.09	-0.01	0.02	0.01	1.00		
pre11	0.00	0.00	-0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	
pre12	0.26	0.16	-0.01	0.04	0.00	0.01	0.02	0.00	0.23	0.01	0.00	1.00

Table 2: Post-test Similarity Matrix

	post1	post2	post3	post4	post5	post6	post7	post8	post9	post10	post11	post12
post1	1.00											
post2	0.02	1.00										
post3	0.04	0.12	1.00									
post4	0.04	0.36	0.23	1.00								
post5	0.03	-0.01	0.05	0.08	1.00							
post6	0.00	0.01	0.07	0.09	0.00	1.00						
post7	0.08	0.00	0.06	0.04	0.25	0.01	1.00					
post8	-0.01	0.05	0.28	0.15	0.07	0.01	0.08	1.00				
post9	0.00	0.16	0.06	0.23	0.10	0.05	0.03	0.08	1.00			
post10	0.14	0.00	0.02	0.07	0.02	0.07	0.05	0.00	0.02	1.00		
post11	0.00	0.10	0.06	0.04	-0.01	0.03	0.00	-0.01	0.00	0.01	1.00	
post12	0.14	0.21	0.08	0.27	0.05	0.07	0.00	-0.01	0.09	0.08	0.10	1.00

across pre and post-test similarity matrices (Table 1 and 2, respectively). The QAP correlation provided a measure of team-level schema convergence (or divergence). That is, the output of the procedure gives an aggregated correlation for the entire group. For this case study, the QAP analysis provided evidence that the pre and post-test similarity matrices were not significantly correlated ($p<0.05$); $p= 0.053$, $r=0.24$. A lack of correlation suggests that participants' schema changed as a result of the intervention.

To determine if social learning (i.e., schema similarity had increased) had taken place, mean correlations were computed from the pre and post-test similarity matrices. The mean correlation increased from 0.024 in the pre-test 0.069 in the post-test. This increase in the mean correlation indicates an increase in schema similarity within the group towards a shared understanding of landscape change and provides evidence that social learning had been the result of the participatory research intervention.

These results, however, are in relation to the team-level of analysis. Not all individuals could be expected to learn to the same extent or even the same information. That is, individual learning could be expected to be different between individuals. A post-hoc analysis of nodes would be necessary to parse out individual level learning. Unfortunately, node level analysis (i.e., who learned what) is not possible with the procedure used in this experiment. Because the post-test master list was updated (i.e., contained different factors) following the modeling workshop comparison between an individual's pre and post-test cause maps was not possible.

A conscious choice was made in the design of this experiment to enhance the sensitivity of the causal mapping method to detect social learning at the cost of reduced sensitivity to individual level learning detection. Future research methods should attempt to correct this issue. To determine how similarities among individuals changed between the pre and post-tests in this case study, the number of times a factor was selected can be used as a proxy for individual level learning. Individual similarity increases can be estimated with a post-hoc analysis of factor frequency data.

The pre- and post-test master lists of factors were compiled into frequency tables (Tables 3, 4, and 5). These tables each show the total number of times a factor was selected in the pre and post tests, the number of times a factor was selected for each the pre and post-tests, and the difference between pre and post test frequency for each factor. Cells marked “N/A” in the pre-test column (6 factors) indicate that the factor was added to the post-test master list following the mediated modeling intervention and was therefore not present on the pre-test list (Tables 3 and 5). Cells marked “N/A” in the post-test column (8 factors) indicate that the factor was removed from the pre-test master list before administering the post-test data collection. Only factors that were not selected by any of the participants during the pre-test were removed from the master list (Table 5).

During the pre-test, participants selected 44 of the possible 57 total factors on the master list or 77% of the total master list. Participants used 39 of the possible 56 possible factors from the post-test master list or 69% of the total master list (Table 6). This result indicates a 7.5% reduction in factors used by the group to describe their landscape change schema.

Additional evidence that participants began to share a common understanding of landscape change was that the post-test data showed an increase in the size of opinion

Table 3: Factors of equal and increased importance

Factor	Pre-test	Post-test	Total	Difference
price (dollars/acre)	N/A	6	6	N/A
residential land demand	N/A	4	4	N/A
availability of land	N/A	4	4	N/A
land parcelization	N/A	4	4	N/A
working lands demand	N/A	2	2	N/A
residential land sales	N/A	2	2	N/A
residential development	8	9	17	+1
regional economy	4	6	10	+2
immigration into county	3	5	8	+2
profitability of forestry	3	5	8	+2
parcel size	2	4	6	+2
Regulation	1	3	4	+2
political will	1	3	4	+2
energy costs	1	2	3	+1
desirability of Morgan (people)	1	2	3	+1
Demand for natural resources	4	4	8	0
population density	2	2	4	0
national economy	2	2	4	0
land appreciation rate	2	2	4	0
infrastructure development	2	2	4	0
old timers die/ kids sell	2	2	4	0
global economy	1	1	2	0

Table 4: Factors of Decreased Importance

Full List of Factors	Pre-test	Post-test	Total	Difference
desire for rural life	6	5	11	-1
public land ownership	6	5	11	-1
population growth	5	4	9	-1
road development	4	3	7	-1
industrial development	3	2	5	-1
neighboring county activities	3	2	5	-1
energy supply	2	1	3	-1
political ability/ influence	2	1	3	-1
long-range weather conditions	1	0	1	-1
environmental education	1	0	1	-1
effectiveness of env. ed.	1	0	1	-1
natural resource utilization	1	0	1	-1
conservation organizations	1	0	1	-1
regional industrial park	1	0	1	-1
profitability of agriculture	4	2	6	-2
land fragmentation	4	2	6	-2
diease/ pests	3	1	4	-2
transportation technology	3	1	4	-2
Demographics	3	1	4	-2
tax structure	3	1	4	-2
Wildfire fuel	2	0	2	-2
natural resource development	2	0	2	-2
political pressures	2	0	2	-2
improved communication via technology	2	0	2	-2
recreational development	4	1	5	-3
economic development	4	1	5	-3
socio-cultural forces	3	0	3	-3
mindset of landowners	5	1	6	-4

Full List of Factors	Pre-test	Post-test	Total	Difference
Urbanization	0	0	0	0
Tourism	0	0	0	0
entertainment trends	0	0	0	0
ecotourism pressure	0	0	0	0
Biodiversity	0	0	0	0
purchase of adjacent parcels	N/A	0	0	N/A
niche market agriculture	0	N/A	0	N/A
political lobbying	0	N/A	0	N/A
Respect for property rights	0	N/A	0	N/A
industrial recruitment	0	N/A	0	N/A
type of industry	0	N/A	0	N/A
fire frequency	0	N/A	0	N/A
Entrepreneurialism	0	N/A	0	N/A
value added agriculture/ agritourism	0	N/A	0	N/A

Table 5: Factors elicited but unused by participants

Opinion sub-groups	Pre-test	Post-test
# factors all 12 used	44	39
# factors unique to an individual	11	10
# factors shared by 2 people	33	29
# factors shared by 3 people	21	16
# factors shared by 4 people	12	13
# factors shared by 5 people	5	7
# factors shared by 6 people	3	3
# factors shared by 7 people	1	1
# factors shared by 8 people	1	1
# factors shared by 9 people	0	1

Table 6: Opinion Sub-groups

sub-groups within the team. That is, more people chose the same factors from the master list after the mediated modeling intervention than before. Table 6 indicates that there were fewer small groups of people who had chosen the same factors in the post-test data. Also, there was a slight increase in the number of large sub-groups. The maximum sub-group size was nine of 12 people who agreed that ‘residential development’ was clearly related to landscape change in Morgan County. No factor was chosen by all 12 participants (Table 6).

Several factors were chosen by only one individual (Table 6). This may indicate that although there is general agreement on some of the basic core beliefs about landscape change many unique perspectives still exist about its core dynamics. This does not mean that some people are more accurate than others in their perception. Alternatively, the consistent number of uniquely chosen factors may reflect the large complex nature of landscape-change dynamics. Arbitrarily choosing ten factors may not adequately capture all of the beliefs necessary to capture the entirety of the schema. A set of shared beliefs was forming at the time of post-testing however.

Several factors increased in importance following the mediated modeling intervention. Also seven factors were defined during the modeling and added to the post-test master list. Six of the seven factors introduced to the master list were selected by at least two participants. One of the added factors (price) was chosen by six participants. Three other added factors (residential land demand, availability of land, and land parcelization) were selected by four participants. Together these frequencies indicate that group dialog during the intervention helped to uncover central beliefs not realized during the more independent thinking of the brainstorming exercise.

Many factors decreased in importance for participants. However, it is important to note the difference between decreased importance and decreased consensus as used here. For example, two factors (desire for rural life and public lands ownership) both experienced a decrease in importance (-1) but remained important beliefs for the group, having been selected by five of the participants in the post-test. Alternatively, one factor (mindset of landowners) was important in the pre-test data being selected by five participants. But it experienced the largest decline in the group's consensus by only being selected by one person in the post-test. This indicates that other beliefs became more clearly related to landscape change in Morgan County.

Looking more broadly at the list of factors it is difficult to decipher what the shared understanding of landscape change was. However a narrative account of the mediated modeling intervention results helps to organize the themes found in the pre and post-test data. Essentially, participants determined that landscape change in Morgan County was resulting from residential development. Residential development in rural areas such as Morgan County has become common where in-migration to the area is currently being driven by an aging population looking to build retirement housing and vacation homes (USDA, 2002).

Residential development often requires that historically large tracts of land be subdivided into smaller parcels. When land is subdivided in a heavily forested area it is likely that residential development will cause the forest to be fragmented into smaller patches. The subdivision and subsequent forest fragmentation was the focus of the mediated modeling intervention.

In their group-built model participants' determined that residential development was a function of the supply and demand of residential land. Essentially, the model states that land appreciation acts as a cue to land speculators to buy low-priced land that is in high demand. Speculators buy purchases in large volume and sell off smaller subdivided parcels as residential properties at a higher price per acre than the speculated price. Also, current landowners may sell pieces of large holdings for development. Land sales reinforce the appreciation rate of properties, and the rate of parcelization increases in a reinforcing cycle of behavior.

Simultaneously parcelization is limited by demand for residential land. When land prices grow too large, demand drops because other counties offer similar quality land for lower prices. This balancing force explains why parcels do not reach a zero-acre size (e.g., a landscape full of apartment buildings) or infinitely high land prices. The group's modeling objective was to understand parcelization and how to minimize it in Morgan County while not inhibiting economic growth and simultaneously protecting the unique local culture of the area.

Capacity Building: Anecdotal Data

Organizational theorists claim that when individuals hold similar schema they are able to define, mobilize, and channel the collective aspirations and knowledge of the group (Senge, 1990). Therefore it was hoped that if increases in schema similarity were detected that participants would be willing and able to work together, collectively, after the close of research. Although no data was collected to support the claim empirically the actions of the group provide anecdotal evidence.

During the third workshop session eight of the 12 participants decided to establish themselves as a new community group dedicated to improving local decision making for landscape conservation. The group is now known as the Morgan County Sustainable Development Alliance (MCSDA). The mission of the MCSDA is to promote community dialog on land-use planning. The group hopes to hold landowner discussions to evaluate both the positive and negative consequences of land-use planning proposals and provide information on sustainable development to county leaders. The MCSDA now works to protect the rural character and culture of Morgan County, conserve its resources, and promote sustainable local economic development.

The MCSDA has already begun to work toward their goals. Upon completion of this research project, the MCSDA met with the mayor of Morgan County. In their presentation the MCSDA reviewed the issue of parcelization, presented their workshop findings, and facilitated a dialog with the mayor and the chamber of commerce. During the discussion, the MCSDA was invited to attend the county's monthly community and economic development committee meeting.

The MCSDA was also granted the approval of the mayor to act as a member group of a larger land-use planning effort known as the Alliance for the Cumberlands. The Alliance for the Cumberlands is a regional planning effort whose mission is to generate a regional vision for the Cumberland Plateau and support collaboration among its member groups.

Lastly, the MCSDA has initiated a community-based research effort. The group seeks to advance a collaborative effort between citizens, university researchers, the tax assessor's office, and land developers. The research is being designed to quantitatively monitor the extent and pace of parcelization in the county. Additionally, the research would help to facilitate multi-perspective discussions to identify points of consensus for working towards a shared vision of future landscape conditions.

Discussion

The objective of this article was to propose a cognitive approach to the quantitative study of social learning in natural resource management based on team learning as used in organizational psychology. Team Member Schema Similarity (TMSS) is used in this article to design and test hypotheses related to the relationships between participatory research interventions, social learning, and social change.

A TMSS case study was presented that used causal mapping to detect social learning resulting from a mediated modeling process. Analysis of pre and post-test data verified that social learning did occur and resulted in a shared understanding of landscape change among participants. The experiment as designed did not allow for study of the relationship between schema similarity increases and capacity building. However, anecdotal evidence for this relationship was provided by noting the consequences that the project had for its participants. A summary of TMSS studies that have observed correlations between schema similarity and team work processes can be found in the forthcoming article by Renstch et al. (in press).

The experimental results produced by the present TMSS case study have been generally encouraging with regard to the effectiveness of participatory research interventions' ability to stimulate social learning. Although the present study was quite simplistic and narrow in scope, it did posses attributes of note. First, this study is an example of how to integrate TMSS experimental procedures into field study conditions.

There is a need to expand TMSS research beyond laboratory settings to aid in theory development. Simultaneously, there is a need to provide the benefits of participatory research interventions to natural resource decision makers. However, integrating causal mapping procedures into field studies is difficult because of the necessity of separating experimental measurement procedures from learning procedures. That is, if participants' schemas are altered by learning that occurs as part of the workshop process before pre-tests are administered, measurements will not capture the true pre-intervention benchmark. To separate measurement from improvement in this case study, the first workshop utilized the group's collective brainstorming ability to generate the master list of factors but stopped short of suggesting linkages between factors to prevent influence to individuals' schema before pre-tests were administered. This integration reflects a practical method for participants to build relationships by working together but minimize the influence of others on pre-tests.

Second, by conducting pre- and post-tests in the days following intervention workshop it was possible to measure changes in individual participants' schema in isolation, outside of the influence of the group. The time lag between workshop and data collection avoids two measurement errors 1) memory effects and 2) influence of interaction between individuals. Causal mapping is easily influenced by the input of others by cuing one or another part of a schema as being more or less important to the overall causality. Therefore by generating pre- and post-tests on a one-on-one interview rather than a group setting, participants were more likely to offer their personal beliefs about the causality of landscape change. Also, the time lag provided short term effects of the workshops to be avoided. Only that information that was retained (i.e., learned) from the model building intervention entered long-term memory and was then reflected in post-test results.

Last, the TMSS research framework, in general, provides a theoretical basis that avoids self-reported learning. That is, causal mapping and hypothesis testing provide more objective measures of learning than if participants were asked to judge their own level of social learning. Furthermore, quantitative measures of schema change allow for comparison between participants.

The method used to generate the quantitative data was somewhat cumbersome however. Quantitative causal mapping methods such as the one proposed by Markoczy and Goldberg (1995), should seek to balance experimental control with external validity. In most cases methods that increase external validity, decrease experimental control, and vice versa (Doyle et al., 1998). In this case the Markoczy and Goldberg (1995) method enables a high degree of experimental control. The benefit of this control was somewhat outweighed by the limited external validity of the elicited schema. Schema elicited using this method lack realism because of the constraints imposed by maintaining control for the sake of comparability. The selection of an arbitrary number of factors from a pre-approved list inhibited capturing the realism of schema.

Another limitation of the method was that it was time and effort intensive. In fact, one researcher has gone as far as to call the method “complex and tedious” (Hitt et al., 1998: p. 30). A decision was made early in the proposal of this research to trade ease of use for methodological rigor because of the necessity to add “science to the art” of comparing schema (Richardson et al., 1989, p. 355; Vennix, 1995). Future research should seek methods of maintaining experimental control while decreasing the time and effort necessary to collect causal maps with high degrees of realism.

By maintaining a high degree of comparability between individuals’ causal maps (e.g., 10 factors each, from a defined list) it was expected that statistical analysis of similarity could be conducted quite easily. This was not the case however. Little guidance exists for analyzing causal map data. Because the data are relational in nature, complex algorithms (e.g., QAP) are necessary to judge the level of similarity between individuals.

This study proved especially difficult because the data was not only three dimensional (i.e., actor, attribute, attribute) but also valued and directed to represent causal direction and relational strength (i.e., -3 to 0 to +3). Causality represented in this way differs from other valued and directed datasets related to cognition in that values are not a rank order. Negative values are qualitatively different than positive values; not simply a lesser value but a different relationship entirely (i.e., opposite causality).

Two final limitations of the case study design itself were the related issues of sample size and replication. The final sample size for this case was twelve. The sample size was simply a matter of group dynamics. The fact that no replication of the intervention was performed was a matter of practicality. To expand the number of trials would require the efforts of more than one researcher.

A major cautionary note attached to the results of this study is that only one trial of the mediate modeling intervention was performed. In future research issues of replication should be addressed to validate the results of this study. Small group studies, such as this, rely heavily on replication because sample size must be limited within each trial due to group dynamics concerns.

In addition to replication future research should seek to investigate the efficacy of different participatory research interventions. In the case study presented here little attention was paid to what aspect of the intervention was important to generating the observed social learning. For example, was the deliberation around the modeling process more or less influential than other parts of the mediated modeling process? Or would social learning have been increased by using another participatory research method all together? It is likely that different participatory interventions are more or less effective depending on the stated goals of their use. The implication here is that TMSS can be used to test hypotheses that influence when and why interventions generate social learning.

Finally, it is hoped that the work presented here adds to the growing dialog about social learning within the natural resource management community. Theory development within this area of interest is proceeding rapidly and from various perspectives. The TMSS research framework offers an integrative perspective that allows for hypothesis testing. The implication of this research is that TMSS can provide evidence-based refinements to social learning theory. In a more practical sense, the research presented here can be used to refine the use of participatory research interventions. Using TMSS to optimize schema similarity is likely to improve the effectiveness of research interventions.

Participatory research interventions that enable diverse groups of individuals to discuss the complex causation of natural resource problems have been shown to lead to innovative strategies for management of resources. Improving these interventions by encouraging social learning is an important aspect of natural resource management research. TMSS, as presented in this paper, has proven useful for detecting social learning and may be used to improve participatory research interventions in order to optimize social learning, encourage capacity building, and thereby promote flexible and innovative decision-making.

Part 4

A Simple Model of Landscape Parcelization

Introduction

System dynamics has been noted for its ability to engage clients by encouraging them to deepen their understanding of complex problems (van den Belt, 2004). Modeling methods such as Mediated Modeling and Group Model Building have expanded this concept as a multi-stakeholder process emphasizing learning as an outcome of the experience (Vennix, 1996; van den Belt, 2004). Additionally, these methods have been used to improve decision making. Rouwette, Vennix, & Mullekom (2002) report that Group Model Building interventions have been used to discover beneficial changes in organizational environments and to explore policy impacts. Natural resource management is an emerging research area for the use of such methods. Group Model Building and Mediated Modeling have been used as participatory research interventions to increase public participation (e.g., den Exter, 2003) and to conceptualize collaborative planning of forest resources (e.g., Purnomo, Mendoza, & Prabhu, 2004).

In the context of Mediated Modeling this article presents a case study designed to study the impacts of different policy scenarios on landscape change. Mediated modeling was chosen over other less participatory modeling methodologies to encourage participants, all private forest landowners, to work collaboratively to construct a shared understanding, in this case a shared understanding of landscape change. Private land management often calls for collaborative or cooperative management across multiple privately owned parcels of land (USDA, 2002). Furthermore, presently the majority of management actions take place on single ownerships not across multiple ownerships (Dedrick, Johnson, Hall, & Hull, 1998).

Low levels of cross-ownership management are likely in the study area of Morgan County, Tennessee because of conflicting cultural values between long-tenure landowners, in-migrants, and government agencies (Ostermeier, Fly, Muth, Pavey, & Steiner, 2002). Also, low levels of ecological education found in the area imply a lack of capacity to deal with these changing cultural and biological conditions at the landscape scale (Ostermeier et al., 2002). A number of landscape level threats to forest quality were noted including pine bark beetle outbreaks, increased wildfire risk, and forest fragmentation (Ostermeier et al., 2002).

By constructing a shared understanding of landscape change via Mediated Modeling landowners are likely to communicate similar land management goals and objectives for their county and therefore be more likely to work collaboratively. This objective is tested in a forthcoming article by Fogel (2006). The objective of the present article is to communicate the results of the modeling process and lessons learned.

As part of the highly participatory purpose of the case study, the objective of the model itself was defined largely by project participants. Within the scope of exploring policy impacts on landscape-change model building, participants were able to choose a subject of mutual interest to a diversity of landowners. Participants chose to model the causality of landscape 'parcelization' or subdivision of land for residential use in their county, Morgan County, Tennessee. Three policy scenarios were modeled to demonstrate how various policies may impact the rate of parcelization in Morgan County, including: 1) current development conditions, 2) increased economic development from proposed eco-tourism, and 3) the introduction of land-use regulation through a minimum parcel size ordinance.

By exploring policy effects on parcelization, participants hoped to identify acceptable policies for residential development. While parcelization rates in Morgan County have historically been quite low, participants acknowledged that a dramatic increase currently exists in the pressure to subdivide land holdings during land sales. The consequences of excessive parcelization may include changes to local culture, historical economies, and a loss of forest land. To protect the resources and character of Morgan County socially acceptable policies that control parcelization will need to be identified.

In the following section, parcelization is discussed in detail. Previous modeling approaches are considered, and specific contextual issues unique to parcelization in Morgan County are noted. The case study is then presented including the modeling process and a comparison of the three policy scenarios. Lastly, lessons learned and implications of the case study are discussed.

Project Description

There are approximately 393 million acres of privately owned forestland in the United States. About 59 percent of private forest owners hold land for non-industrial purposes and are known as non-industrial private forest (NIPF) landowners (Birch, 1996). NIPF lands are under significant pressure to produce the nation's growing timber supply needs. NIPF lands historically produce about half of the country's roundwood timber supply (Harrell, 1989). However, pressure from population growth is increasingly impacting the availability of timberlands and quality of the forest (Binkley, 1981; USDA, 2002).

Population growth can be described in terms of an area's "natural increase" (i.e., net birth rate) and the in-migration rate. Natural increases and in-migration increase the demand for urbanized land. In-migration in the southern United States has become dramatically higher than historic levels because of the changing lifestyles of the aging population. The southern United States has experienced the highest in-migration rate of any region in the country (USDA, 2002).

In the year 2000, the natural increase across the southern United States was an estimated 600,000 people per year. This increase is out paced by an in-migration rate of 815,000 per year, as estimated in 1998 (USDA, 2002). The rate of in-migration, excluding illegal immigration, is expected to continue to increase because of an aging population. Several studies indicate NIPF owners, in general, are becoming older, wealthier, and have a high degree of education (Hull, Robertson, & Buhyoff, 2004; Kluender & Walkingstick, 2000; Erickson, 2001). Much of the population growth in southern Appalachia has been due to people attracted by the region's high quality of life, rural mystique, and expanding and diverse economy (Cordell, Helton, & Peine, 1996). Many of them have moved to rural areas around the region's two national parks (Great Smoky Mountains, and the Shenandoah), the Appalachian Trail, the Blue Ridge National Parkway, the Little River Canyon National Preserve, eight national forests, and along the banks of the region's many lakes and rivers (Cordell et al., 1996).

A second and equally important migration pattern is that of out-migration of rural families toward urban centers. Migration from rural areas to cities is largely driven by employment opportunities. As individuals move to cities to find work, family lands are being sold. Also, as the older generation dies, heirs often sell off all or portions of their holdings for tax reasons, to pay off estate debt, or due to lack of interest (Mehmood & Zhang, 2001).

Older landowners are likely to have long ownership tenures, and long tenure land is more likely to be of large parcel size (Birch, 1996). However, current residential development demand favors smaller parcels in the exurban areas to accommodate retirement and second homes of in-migrants. It is the subdivision of land or 'parcelization' dynamic that is the focus of the case study presented here.

As a consequence of large parcels being subdivided, the usage of those parcels has become more diverse. Large contiguous tracts of forest are being fragmented and mixed with houses, commercial properties, industrial parks, and expanded agricultural lands (Broussard, 2001). The fragmentation of forest lands can reduce the resilience of forests both to natural and anthropogenic disturbances (Forman & Godron, 1986). More specifically, fragmentation is an indicator of reduced biodiversity from over harvesting and habitat alteration, increased edge effects, increased likelihood of invasive plants and animals, fire suppression, and increased cost of mitigation after disturbances (Kapos, Lysenko, & Lesslie, 2000; Forman & Godron 1986; Shafer, 1999; Dramstad, Olsen, & Forman, 1996).

Increased parcelization may have implications for the national timber supply also. The increase in small parcels means that owners are more likely to not harvest their wood. Transaction costs of harvesting are difficult to recoup from small acreage harvests (Birch, 1996). This may lead to an increased standing stock but also greater risk of wildfires because of increased fuel loads. While fire itself is a useful tool for managing the quality of a forest, it is not generally acceptable where humans are present (USDA, 2002).

To conserve the privately owned forests of the United States, active management at the landscape scale is necessary to minimize the fragmentation of sensitive areas and to mitigate the effects of presently parcelized lands. However, little can be done from a policy standpoint about the driving forces of parcelization such as rising incomes or intensifying urbanization (Mehmood & Zhang, 2001). Exceptions to this generalization include cost-sharing and careful local level planning that may be used to slow parcelization rates.

To control forest fragmentation on private lands suggests a need for "neighbors to plan together and set common objectives. Working together, landowners can address issues like the buildup of forest fuel, which can lead to catastrophic interface fires." (USDA, 2002) As a necessity, landscape-scale management will include some kind of collaboration between stakeholders.

Presently, however, management is more likely to occur on single properties than across two or more adjacent properties (Dedrick et al., 1998). Spies et al. (2003) points to, among other factors, social opposition as an impediment to acceptance of cross-ownership management practices. Social opposition comes from misperceptions about the dynamics of the ecological situation, mistrust of skilled land managers, a lack of time and resources, and concerns about infringements to private property rights (Erickson, 2001; Spies et al., 2003, Dedrick et al., 1998). Social opposition severely restricts the establishment of landscape-scale management.

To reduce social opposition resource professionals will require new ways of reaching landowners, communicating with stakeholders, both individually and collaboratively, who hold diverse values (USDA, 2002). The case study presented in this article uses Mediated Modeling to reduce social opposition by having participants seek consensus on the complex feedbacks involved in managing parcelization. The resulting system dynamics model serves as a foundation for building consensus views of the rate of parcelization under various policy conditions. The shared vision of landscape change is intended to increase the likelihood that cross-ownership management will develop.

Current issues for Morgan County, TN

Beginning in 2001 the University of Tennessee commenced work in the Emory-Obed watershed near the eastern boundary of the Cumberland Plateau region in Tennessee. Morgan County sits on the eastern edge of the Cumberland Plateau and is predominantly within the Emory-Obed watershed (Figure 6). A project known as "Sustaining Private Forests of Tennessee" was undertaken to better understand the threats to the forests of the central hardwoods region of the United States. This research was conducted with funding from the Initiative for Future Agriculture and Food Systems

Figure 6: Morgan County, TN

(IFAFS) program of the United States Department of Agriculture's Cooperative State Research, Education and Extension Service (CSREES) program.

A major contribution of the IFAFS project has been the determination that any management proposal that would seek to confront the perceived challenges of timber quality, sustainable residential development, or mitigating the effects of disease and pest outbreaks would also simultaneously need to address residents' skepticism of government assistance, conflicts between new and traditional landowners, and lack of social capacity within the community, and depressed economic conditions. This determination led IFAFS researchers to adopt participatory management strategies for the project area (i.e., the Emory-Obed watershed). The social factors listed here should be considered at least as important to creating sustainable forests as the biological factors.

In seeking policy conditions that minimize forest fragmentation, policies must respect the places in which they are to be used. In this case Morgan County does not have any zoning regulations per se. Outside of town boundaries no zoning ordinances exist. County residents have chosen this policy condition and would likely vote down land-use regulations unless a demonstrably worse lifestyle scenario was presented if the regulation was not enacted. Additionally, if regulations are proposed-they should acknowledge the depressed economic conditions in which they will be implemented.

County leaders are interested in fostering eco-tourism in their county, but this may bring with it additional in-migrants, an unintended consequence. While economic progress is sorely needed, the effects of excessive parcelization (if it should occur) would have consequences of its own by possibly fanning the flames of conflict between stakeholders. These factors were considered in the selection of policy scenarios that were to be modeled and compared.

Previous Modeling Approaches

Despite the importance of parcelization to forest conservation, little empirical exploration has been conducted to study the dynamics of parcelization. Many of the driving forces have been identified, as noted above. However, little is known about the effects of parcelization on forest dynamics (Ko, He, & Larson, 2006). Furthermore, feedback structures between policy scenarios and parcelization rates have not been simulated. As is the purpose of this case study, the construction of a simple system dynamics model will qualitatively enhance the understanding of feedbacks between policy choices and the rate of parcelization.

Most common parcelization is not studied directly but is assumed during broader land use modeling simulations. That is, land-use models predict the likelihood of a land cover occurring, and output includes information on patches of forest versus other land cover types. A patch is an ecological classification and should not be confused with parcel size, which is a social classification. Direct analysis of parcel size dynamics rather than land cover patch size dynamics are largely absent in the literature.

Two studies are of notable exception. Mehmood & Zhang (2001) describe a linear regression model of parcelization which includes seven variables thought to drive parcelization: 1) state death rates, 2) estate and inheritance tax dollars per acre, 3) percent urban population, 4) median family income, 5) level of environmental regulation, 6) percent of gross state product attributable to forestry, 7) and the presence or absence of cost-share programs in a state (Mehmood & Zhang, 2001). The results of the study indicated that only taxes and financial contributions of forestry were insignificantly related to parcelization.

The second study of note, by Ko, He, & Larson (2006), provides a spatial model of landscape ownership fragmentation. The Forest Land Ownership Spatial Simulation (FLOSS) uses mathematical algorithms to place parcels on a "landscape." The landscape in this model is grid of pixels that approximates an observed landscape. The size and frequency of parcels to be placed in the landscape is determined by a Weibull distribution curve created from observed data (Evans, Hastings, & Peacock, 1993).

Projected parcel distributions are calculated by shifting the Weibull distribution by a linear factor. In the article's case study, the shift term was calculated by subtracting the mean patch size of the landscape in the year 1993 from the mean patch size in 1973. The attributes of the FLOSS simulated landscapes were compared to observed landscapes using FRAGSTATS version 3.3 (McGarigal & Marks, 1994). FLOSS was able to generate landscapes with spatial characteristics similar to actual landscapes, suggesting that it can simulate different levels of ownership fragmentation (Ko, He, & Larson, 2006).

Authors of both studies note limitations encountered in their modeling approaches. Both studies note a lack of applicable data. For example, Mehmood & Zhang (2001) were unable to generate state-level estate and inheritance tax data solely for forested properties since no database was available. As a proxy they used all tax records regardless of land cover thereby introducing error into their model. Ko, He, & Larson (2006) acknowledge the time and expense of obtaining data, namely ownership boundary data, for large geographic regions. This expense is compounded when digitization of records are necessary for use with a geographic information system (GIS). Lastly, an assumption of both modeling approaches is that the growth pattern of parcelization is presumed to be linear. That is, the rate that land is parcelized is assumed to be constant.

In reality urbanization takes place in a more bell-shaped curve than a linear pattern of constant growth. A recent study points out that "as a county increases in percent urban land the increase in percent urban land over time also increases. This increasing percent urban land tends to occur until the county is mostly urbanized and then the increase in percent urban slows because most of the available land is already urban and there is relatively little room to expand." (Nowak & Walton, 2005)

In systems dynamics a bell-shaped growth curve is indicative of "overshoot and collapse" dynamic (Sterman, 2000). This pattern implies that the system favors exponential growth until a limiting factor inhibits such growth. An example of this growth pattern can be observed in predator-prey models. Predators are known to exploit an abundant prey resource enabling them to increase their numbers. This growth may continue until such a point that predators have over-exploited their prey resource and their numbers drop dramatically in response to a lack of food.

This growth pattern is observed in the rate of urbanization as well. Forrester (1969) includes the overshoot and collapse dynamic in his lauded book entitled *Urban Dynamics*. However, Forrester assumes that each parcel added during urbanization remains of constant size (e.g., one acre). The growth process continues until some fixed acreage of land approaches a built-out condition. In the simulation model created for the case study presented here, an effort was made to address the issues raised by previous modeling approaches, namely: 1) intensive data requirements, 2) the lack of available data, and 3) the non-linear dynamics of parcelization.

The following sections present the case study including the model development process and the model's use. Three policy scenarios are explored that represent the effects of 1) current development conditions, 2) increased economic development from proposed eco-tourism, and 3) the introduction of land use control through minimum parcel size regulation. Lastly, lessons learned and implications of the case study are discussed.

The Case Study

The case study presented here was conducted within a larger participatory framework of natural resource management being conducted by the University of Tennessee's Department of Forestry Wildlife and Fisheries. Therefore the project was designed in way to maximize opportunities for participants to interact and build relationships. However, the objective of the present article is to discuss the modeling process and lessons learned from the model. To organize the current discussion, the case study is presented in three interrelated sections.

First, the results of the mediated modeling intervention are presented. The mediated modeling intervention was used to generate a shared understanding of parcelization in Morgan County. A causal loop diagram was collectively constructed by participants depicting this shared understanding. Second, the model building process that converted the causal loop diagram generated in the mediated modeling intervention into a simulation model is presented. Simulation models enable relative differences between policy scenarios to be compared. Lastly, the modeling results of three policy scenarios are presented. The policy scenarios show how different policies may affect the rate of parcelization in Morgan County.

The Mediated Modeling Intervention

In this section the steps to building a shared understanding of parcelization in Morgan County are described. To begin the process, a project facilitator gave a presentation to participants of Morgan County's natural resources, culture, and economy.

Following this presentation, the group was asked to co-define what the boundary and scope of the simulation model would be.

The first activity individuals were asked do was to individually draw the 'reference mode' of forest cover in Morgan County for the next 50 years. Reference mode graphs are used to establish the boundaries of the system in question and to form a dynamic hypothesis as to what may be causing the behavior of concern. In this case the reference mode graph depicted the expected behavior of forest cover over time based on each individual's perception of the forces driving landscape change.

Next, individuals were asked to draw an additional line on their reference mode graph depicting the trend in forest cover that they would like to see in the coming 50 years. This was called the 'desired conditions' graph. Remarkably, each of the participants drew quite similar reference mode and desired conditions graphs. A typical participant's reference mode graph is depicted in Figure 7.

Nearly all of the participants expect forest cover to decline in the coming years. Also, the desired trend for forest cover, regardless of landowner's motivations for owning their land, was to increase or at least retain the forest cover in Morgan County. The similar graphs indicated an underlying consensus across a diversity of land ownership motivations concerning what the problem to be modeled was and its underlying dynamics.

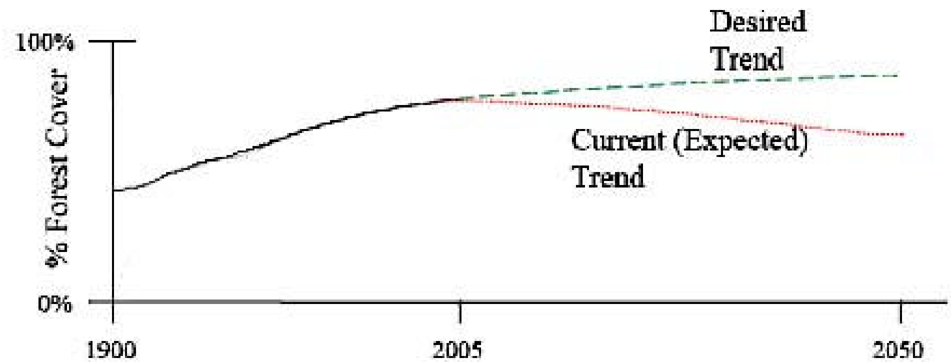


Figure 7: Typical Reference Mode and Desired Conditions Graph

To place a name on this consensus, the group was led in a series of exercises to capture the problem definition that would further refine the system boundary to be used in the simulation model. Following the reference mode and desired conditions graphing exercises, the group was led in a facilitated discussion about why each person's graph was so similar. This discussion was used to lead into a brainstorming session that utilized a nominal group technique to elicit factors participants felt influence changes in Morgan County's landscape.

The nominal group elicitation technique asks each person to privately write down factors until they exhaust all possible ideas. Then all of the factors are collected from each participant and presented by the facilitator one idea at a time until all of the factors are posted in the front of the room. A nominal group technique for elicitation enables individuals to express all of their personal beliefs about why the landscape is changing without interference from the beliefs of others (Delbecq, Van de Ven, & Gustafson, 1975).

Duplicate factors were grouped together. If a factor's wording was unclear the group was asked for clarification. Once the full list of factors was presented the group was collectively queried for additional factors that were not yet posted. The fully complied list was composed of 57 distinct factors in 11 distinct categories (Figure 8). This list served as the foundational knowledge base for the causal loop diagramming exercise.

Each individual was then separately asked to provide the ten factors that were, for them, most clearly related to landscape change in Morgan County. Tallying the results from this exercise provided a clear indicator for the subject of the modeling process. The loss of forest cover from residential development was selected as the subject of the causal loop diagramming exercise. Restated, the phrase "to minimize the loss of forest cover from residential development in Morgan County" represents the problem definition reflecting a consensus as to what the project should address and what the boundaries of the simulation model should be.

A causal loop diagram (CLD) captures the underlying causes and effects of feedback structures that explain complex behaviors. The purpose of causal loop diagramming is to explore why systems behave the way they do (Sterman, 2000). CLDs are useful for encouraging group discussions about how a system might react to policy changes that alter the levels of the variables within the diagram (Vennix, 1996).

Causal relationships are composed of variables and arrows. The variables are written as single nouns or short phrases. Arrows are unidirectional and depict an expected change in the level or amount of a variable. For instance, when variable A is

Education

- environmental education
- effectiveness of environmental education

Tourism

- value added agriculture/ agritourism
- ecotourism pressure
- entertainment trends
- recreational development

Economic development

- niche market agriculture
- entrprenueralism
- natural resource development
- demand for natural resources
- natural resource utilization

Infrastructure

- infrastructure development
- transportation technology
- improved communication via technology
- road development

External Factors

- national economy
- global economy
- regional economy
- energy costs
- long-range weather conditions
- energy supply
- neighboring county activities

Land use

- residential development
- immigration into county
- profitability of forestry
- profitability of agriculture
- public land ownership
- land sales
- price/ acre
- land parcelization
- forest fragmentation
- parcel size
- land appreciation rate
- urbanization

Disturbance

- wildfire fuel
- fire frequency
- diease/ pests

Demographics

- population density
- population growth
- avg. income
- level of education
- avg. age

Industry

- regional industrial park
- type of industry
- industrial recruitment
- industrial development

Politics

- political pressures
- political ability/ influence
- political lobbying
- political will
- tax structure
- regulation

Values

- socio-cultural forces
- mindset of landowners
- respect for property rights
- conservation organizations
- desire for rural life
- biodiversity
- precived desirability of Morgan (people)

Figure 8: List of Factors

increased variable B responds by decreasing or increasing its level. The appropriate response (e.g., increase or decrease) in the affected variable is depicted by plus or minus sign.

A plus sign (+) is used to depict that when an increase (or decrease) in A occurs it would draw a corresponding behavior in B (i.e., if A increases then B increases). However, if B responds to an increase (or decrease) in A with an opposite response (i.e., if A increases then B decreases) then the arrow carries with it a minus sign (-). Causal relationships form chains of variables and arrows to form feedback structures called 'loops'.

Loops either reinforce system behaviors or oppose behaviors. 'Reinforcing' feedback loops are depicted by an "R." Loops that oppose reinforcing behavior are called 'balancing' feedback loops and are depicted as a "B" in CLDs.

The basic structure of the Morgan County group's model is described by two loops depicting the supply and demand for residential land. Figure 9 illustrates the basic structure of the group's shared understanding of this parcelization dynamic. Essentially, the rate of land appreciation acts as a cue to land speculators to buy low priced land that is in high demand. Speculators buy in large volume purchases and sell off smaller subdivided parcels as residential properties at a higher price per acre than the speculated price. This reinforces the appreciation rate and the parcelization feedback loop builds (i.e., loop R1).

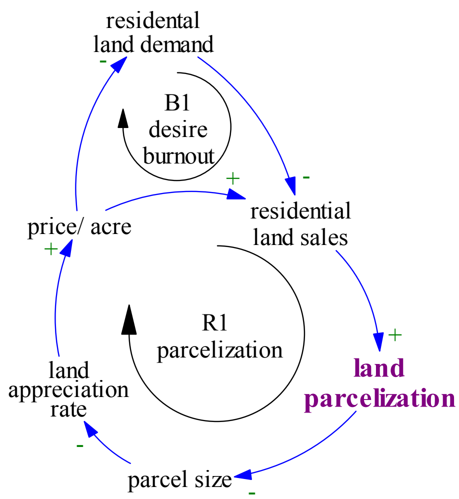


Figure 9: A shared understanding of parcelization dynamics

Simultaneously parcelization is controlled by demand for residential land. Current land prices and amenities offered by Morgan County are attractive relative to surrounding counties. Where land prices grow larger, supply tightens relative to that of surrounding counties, offering similar amenities then demand drops relative to the pace set by R1. This balancing loop (i.e., loop B1) explains why parcel size does not reach zero-acres size (e.g., a landscape of apartment buildings) or infinitely high land prices.

The core model was then expanded to include more detail of the group's perceptions of forces that slow the rate of parcelization (i.e., additional balancing loops). Figure 10 presents the group's finished causal loop diagram. A second reinforcing loop, Loop R2, was also added to detail how land becomes available to land speculators.

Loops B2 and B3 explain how parcelization is slowed by the behavior of current landowners (both public and private) purchasing available parcels surrounding their current holdings. This behavior increases the size of their current holdings effectively

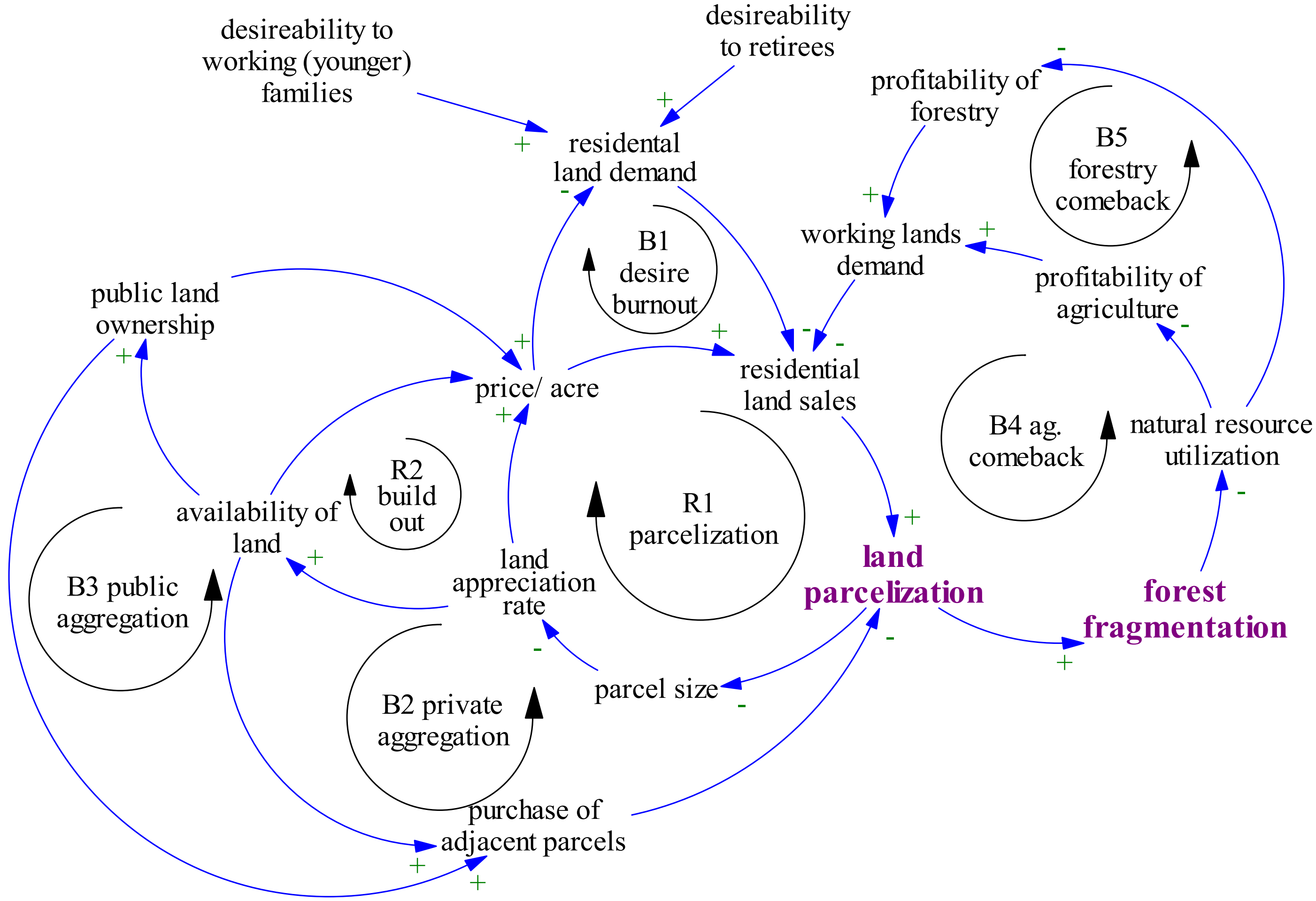


Figure 10: A completed group built diagram of parcelization dynamics

reversing a fraction of the parcelization that would otherwise occur. It is not uncommon for existing landowners to seek additional adjacent parcels to increase their landholdings.

Lastly, loops B4 and B5 were proposed as balancing loops that will slow the likelihood that all timber production lands and agricultural lands will be sold for residential purposes. The participants felt that eventually agriculture and forestry land uses would become competitive with residential uses as the percentage of forest decreased across the landscape. The reasoning behind B4 and B5 was the group's feeling that the cost of production would one day favor local rather than global production. The group acknowledged that B4 and B5 are not of any consequence in the current planning horizon (i.e., 50 years).

As previously noted, the purpose of the mediated modeling intervention was to build a shared understanding of landscape change in Morgan County. A simulation model was constructed based on this representation of the system. The model building process and results of the policy scenarios are presented in the following section.

The Model Building Process

Upon completion of the mediated modeling intervention, a simulation model was constructed by the researcher based on the original work of participants. While CLDs offer many insights into the causality of the model, they lack the ability to depict quantities or accumulations of objects and the flow of objects (or information) between variables (Sterman, 2000). For instance, CLDs are unable to depict the changing monetary value of an acre of land. For this a simulation model is required. In this section we discuss the objectives and process of building the simulation model. The model is then validated using historical data. Lastly, the comparison of three policy scenarios is presented.

The simulation model discussed here attempts to address three issues raised by earlier modeling approaches: 1) intensive data requirements, 2) the lack of available data, and 3) the non-linear dynamics of parcelization. First, to reduce intensive data requirements the realism of the model was reduced. The decision to reduce the realism of the model was in keeping with the goal of the project and needs of the participants. Data needs were reduced in three ways.

First, the model is not spatially explicit and requires no digitization of ownership records or GIS. Secondly, parcelization is defined in the simulator as the division of any given parcel in half. Re-division of a parcel is based on an iterative process. This reduces the need to pre-process data using distribution curves. However, this also greatly reduces the realism of the model.

Lastly, the driving forces of parcelization are not made explicit (e.g., death rate, tax rates, etc.) but rather are aggregated into a single attribute that dictates the pressure felt in the community to subdivide available land. 'Parcelization pressure' is defined as the total acreage of land previously subdivided over the total land available in the county. Using parcelization pressure as a proxy for the combined effect of all driving forces allows a drastic decrease in data required to project parcelization rates.

In addition to dramatically reducing the data requirements of the model the parcelization pressure variable also greatly generalizes the type of data needed to simulate parcelization pressure. The current simulation model requires only county level tax assessment data, US Census data, and expected population growth trends in the study area, in this case Morgan County. These data are publicly available and readily accessible via the internet.

Because of the aggregation of variables, the case study model is best described as a 'scoping model' rather than a policy testing model. A scoping model is a model of moderate realism and moderate precision. To fulfill its purpose the model generated for this project required only that landowners discuss the causality of landscape change in moderate detail and be capable of representing only the relative differences between policy scenarios. To better predict the parcelization, the county leadership would need to move beyond the current scoping model with its aggregated parcelization pressure variable to a more detailed analysis that would enable precise analysis of the parcelization pressure dynamic. Such pressure may be made more explicit in studies that quantify housing needs of the county (i.e., a supply and demand study).

Finally, to address the non-linear dynamics of parcelization the model uses a systems dynamics archetype to capture the overshoot and collapse dynamics observed in urbanizing areas. The model generated for the case study presented here is a deviation from Forrester's (1969) model. The core structure of the simulation model was built on the 'Susceptible-Infected-Recovered' (SIR) model archetype. The SIR model is most often associated with understanding the spread of infectious diseases through a population or the adoption of a new technology or fad product. The basic components of the archetype include the subdivision of the whole population into three sub-populations including: a susceptible population (S), and infected population (I), and a recovered population (R).

The spread of an infectious disease through a population is characterized by the susceptible population (S) becoming exposed to the infected population (I). Simultaneously the infected population (I) is recovering from the illness (R). The rate at which susceptible people become infected depends on how easily the disease is spread (i.e., its infectivity), the number of contacts an infected person has while infected, and the duration of time a person is infected.

An additional component is sometimes added to this basic model to show that recovered persons can become re-infected. This dynamic is often found in models depicting consumer behavior (e.g., to buy a new tube of toothpaste when I run out). The rate at which a person (or object) becomes re-susceptible to "infection" is governed by the length of time the object remains infected.

Applying the SIR archetype to parcelization the "susceptible population" under consideration becomes each individual acre that may possibly be used for residential purposes. Morgan County has an area of approximately 344,000 acres. By subtracting commercial, industrial, public lands, and lands currently in residential use the estimated acreage 'susceptible' to parcelization from residential development totals approximately 270,000 acres (i.e., 'S').

Acres that are currently in residential use (approximately 10,000 acres) serve as the currently "infected population" (i.e., 'I'). Lands that are currently 'infected' may be re-parcelized as they come up for sale (i.e., 'redivisible lands') or they may be reclassified as part of a parcel that is as subdivided as it is able to become. This fraction is called ‘maximally subdivided acreage’ (i.e., ‘R’). This SIR archetype is depicted on the right side of Figure 11.

The rate of “infection” is controlled by the ‘subdivision pressure’ current owners are likely to experience. The basic structure of this variable states that when little subdivision is taking place in the county there is little pressure to subdivide. However, as the landscape trends toward build out (i.e., maximum subdivision), the pressure to parcelize a given acreage increases.

To determine how many acres are subdivided per year, the model estimates the percentage of susceptible land sold per year. Only residential land involved in a land sale is susceptible to parcelization in any given year. The sales rate is estimated based on the population growth rate for the county. While the population of the county itself has fluctuated with in- and out-migration patterns, the growth rate of the county has remained at approximately 1% since 1990 (Center for Business and Economic Research, 1999). However, this growth rate is modified by the expected increases in parcelization pressure (a non-historical trend) and possible increases in ‘attractiveness.’ Attractiveness is a general measure that is used to modify population growth stemming from increased amenities (e.g., new tourist attractions, increased road capacity, etc.).

‘Subdivision capacity’ is the fraction of susceptible lands divided by total residential lands. Subdivision capacity inhibits run away population growth. As the fraction of susceptible land diminishes because of parcelization, the cost of buying

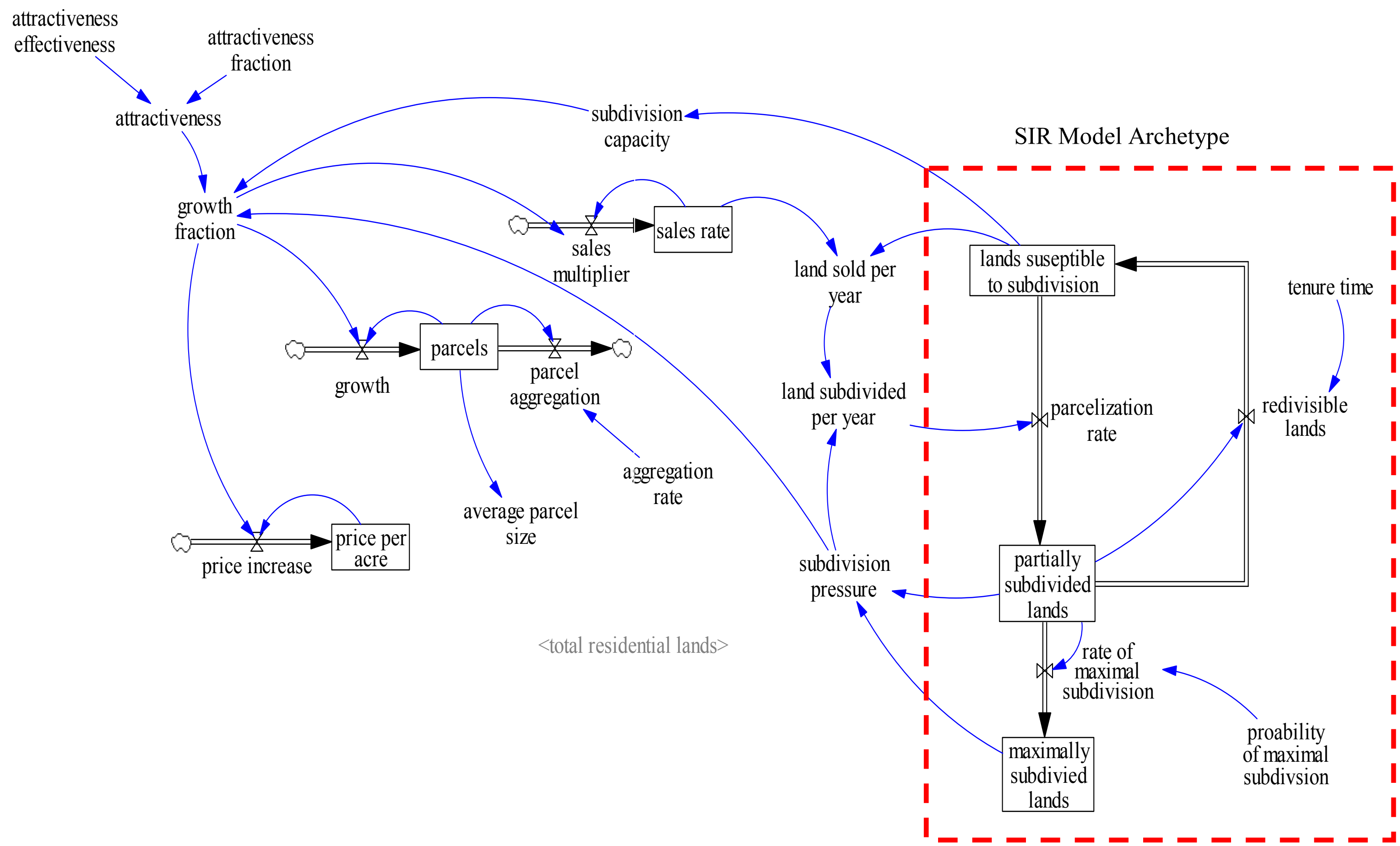


Figure 11: A stock and flow "scoping" model of residential parcelization

property in Morgan County will continue to rise. As the cost of buying land increases, the demand for land (i.e., population growth) will decrease relative to other surrounding counties or regions. This balancing feedback loop mirrors the core dynamic proposed during the mediated modeling workshop.

Model Validation

To prepare the model for simulation, its output is validated against observed trends. This section reports the results of the validation procedures. To validate the model, the initial conditions were set using year 2000 data and run forward to check for accuracy with year 2004 data. The model was validated for variables including the number of parcels generated in the model, price per acre, and growth rate. This limited validation procedure is thought to be sufficient for the model's purpose. That is, the simulation model is intended to demonstrate the relative trends of various policies and not to provide high resolution output for policy testing.

Parcels in the model are generated as a function of the growth rate. The growth rate in the model is given in terms of percent population growth per year as provided by US Census data. Additional information about population growth was collected from Population Projections for Tennessee Counties and Municipalities 2000 — 2020 (Center for Business and Economic Research, 1999). The growth rate for Morgan County historically has been between 1% and 2% (US Census). Future population growth through the year 2020 is anticipated to remain within historic levels. The model projects results consistent with the observed and anticipated population growth trends. Model output provides a population growth of 2% for year 2020 whereas expected population growth rate for 2020 is 1.3% (Center for Business and Economic Research, 1999).

To validate the number of parcels generated by the simulation model, output was compared to current actual parcel data that was available from the State of Tennessee Division of Property Assessments. Year 2000 data for Morgan County provides a model starting point of 11,517 parcels. This is a summation of parcels listed as residential, farm, and agricultural land use designations. The summation of parcels under these land uses was meant to capture all potential residential lands. For the year 2004 data show a total of 12572 parcels (TCT, 2004). The model output for year 2004 provides a projection of 12182 parcels, a difference of 390 parcels or 3%.

Price per acre data was also collected from the State of Tennessee Division of Property. Year 2000 data provides an initial condition of $6453 for residential parcels. The scoping model projects price per acre as a direct function of the growth rate. The actual 2004 residential parcel price per acre was $8630 (TCT, 2004). The model projected price per acre is $6938, a difference of $1692 or 20%. While the projected value is different from the observed value the model will be used for examining the relative effect of different policy scenarios. Therefore the model is thought to be valid within the confines of its intended purpose.

Lastly, a simple sensitivity analysis was conducted to better understand the model output. In the model two variables, 'probability of maximal subdivision' and 'attractiveness', are used to define policy scenarios. Attractiveness is a general measure that is used to modify population growth stemming from increased amenities (e.g., new tourist attractions, increased road capacity, etc.). The ‘probability of maximal subdivision’ controls how quickly the landscape becomes built-out. A higher probability indicates that subdivisions of land are more likely to become as subdivided as possible. Both are measured in terms of percent probability.

Manipulating each of these two variables independently during simulation runs provides an understanding of how each affects model output. ‘Attractiveness’ was found to affect model output more dramatically than ‘probability of maximal subdivision.’ That is, any increment of change to ‘attractiveness’ has a greater influence over the model results than an equal increment of change to the ‘probability of maximal subdivision’. This finding indicates that even a small change in ‘attractiveness’ of Morgan County can potentially have significant effects on parcelization rates of the landscape. Validation of this relationship requires further study beyond the scope of the current investigation.

Results from using the model

This section of the article discusses the results from testing different policies, using the simulation model. As noted earlier, the purpose of this case study is to understand the impacts of different policy scenarios on parcelization rates in Morgan County, Tennessee. Three policy scenarios are explored in this section that represent the effects of 1) current development conditions, 2) increased economic development from proposed eco-tourism, and 3) the introduction of land use control through minimum parcel size regulation. For simplicity these policy scenarios will be referred to as ‘current’, ‘ecotourism’, and ‘zoning’ respectively. The reasoning for including each of the chosen policies is discussed before presenting modeling results.

The initial conditions of each policy scenario are set in the model by adjusting the values of two variables: 'attractiveness' and 'probability of maximal subdivision.' The 'attractiveness' variable is used to modify population growth stemming from increased amenities (e.g., new tourist attractions, increased road capacity, etc.). The 'probability of maximal subdivision' variable provides a relative measure of how likely a land sale is to produce the smallest possible or a maximally subdivided parcel. It is expressed as a percent probability.

The 'current' policy scenario is used as a base run which other policy scenarios are compared. Under current conditions 'attractiveness' is set to zero. Setting attractiveness to zero means that no improvements will be made to ecotourism or utility infrastructure beyond those currently planned. That is, the 'attractiveness' of Morgan County remains constant relative to surrounding counties.

The second policy scenario, 'zoning' was constructed to represent a minimum parcel size ordinance. No local zoning ordinances currently exist in the county. Only an urban growth boundary was set for the town of Wartburg, the county seat. The urban growth boundary was mandated by state legislation and provides no guidance to development outside a small area surrounding Wartburg. This policy was developed to demonstrate unintended consequences of some zoning ordinances and the need for additional modeling.

For the zoning policy scenario, attractiveness was set to zero. The introduction of a minimum parcel size ordinance could be expected to have negligible effects on population growth relative to surrounding counties. The probability of maximal subdivision however was increased to 90%. This is done to highlight a common misconception about parcelization and land use planning. Setting a minimum parcel size increases the fraction of the total landscape must be developed to accommodate a rising population (VanLandingham, Hollis, & Caravona 2003). Increasing the probability of maximal subdivision in the model demonstrates the unintended consequences of setting a minimum parcel size.

Lastly, the 'ecotourism' scenario was developed to demonstrate the effect of increased attractiveness of the county to potential in-migrants. With increased visitor traffic and successful local business that would be expected from successful ecotourism-attractions comes increased desire by a fraction of those visitors to reside in Morgan County. By exploring the potential impact of increased attractiveness from ecotourism, residents can examine potential increases in unregulated residential development.

Comparing each scenario side by side enables differences between scenarios to be seen more clearly. Of greatest priority are the differences between the policy's parcelization rates. As simulated in the scoping model, parcelization remains quite low between the year 2000 and 2035. During this time differences between scenarios are not evident. After 2035 differences become apparent. Increases in attractiveness appear to promote parcelization more than either current or zoning conditions. Parcelization under ecotourism conditions appears to cause more acres to be involved in parcelization, and maximum parcelization occurs sooner, in year 2059 (Figure 12).

Likewise, by instituting a minimum parcel size zoning ordinance, maximum parcelization occurs sooner than under 'current' conditions, in year 2062. However,

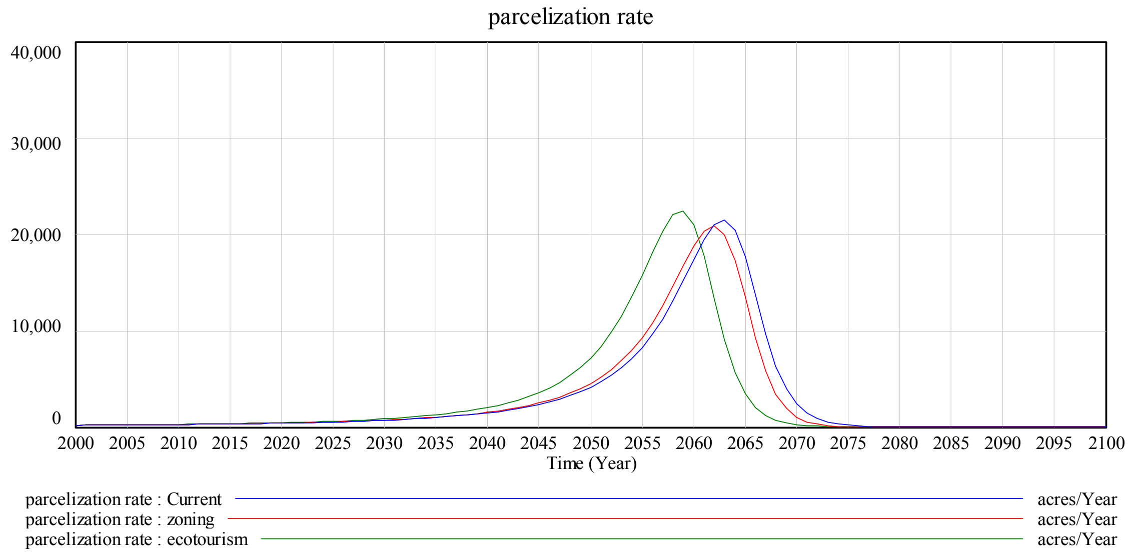


Figure 12: Parcelization Rate Comparisons

fewer acres are re-subdivided over time. Restated, the trend means that a higher percentage of acres that are parcelized are subdivided fewer times yielding a maximum subdivision curve that shows "built out" conditions occurring sooner than under 'current' conditions (Figure 13).

Lastly, under current conditions maximum parcelization occurs in year 2063. This is the most delayed maximum parcelization of the three policy scenarios. But parcelization itself is more intense than under minimum parcel size zoning conditions. The parcelization rate is a function of the 'land sales' rate which is determined by population growth (i.e., the growth fraction) and subdivision pressure. Population growth is used to estimate the rate that land prices will increase. As seen in Figure 14 the 'ecotourism' policy yields the highest land prices per acre followed by 'current' conditions and the minimum parcel size 'zoning' policy.

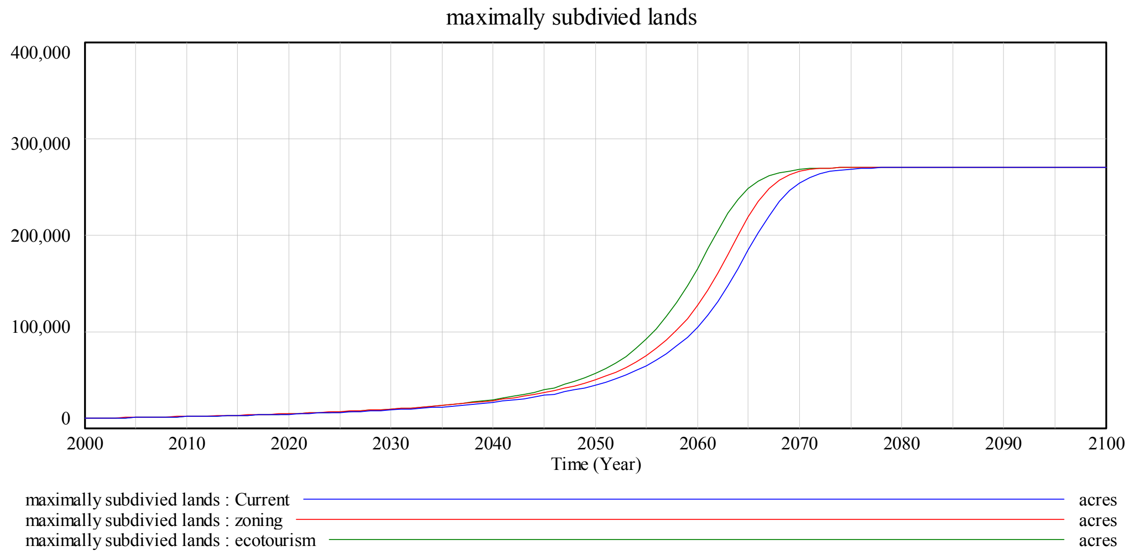


Figure 13: Maximum Subdivision Comparison

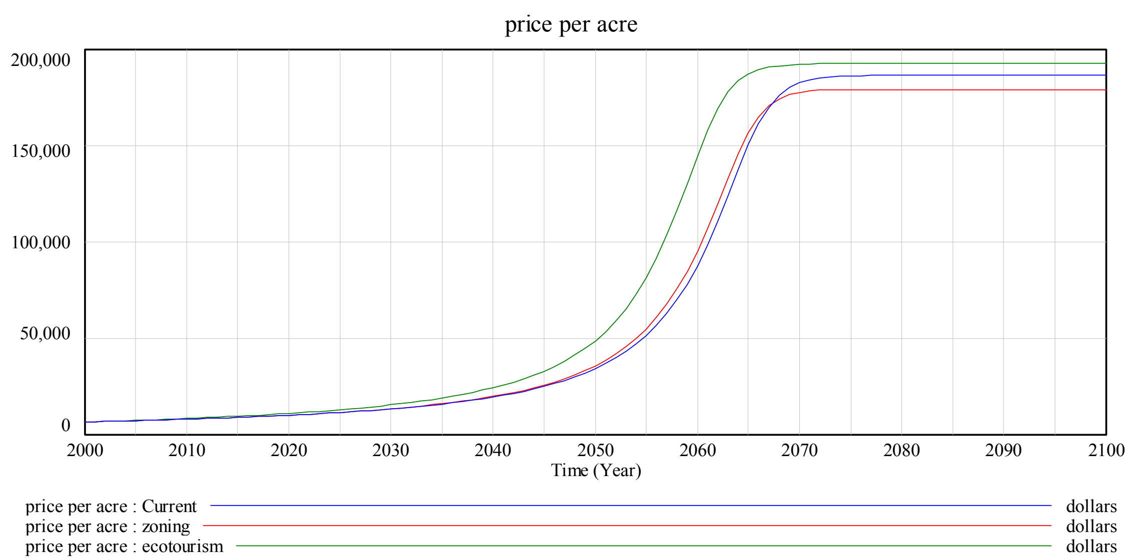


Figure 14: Price per Acre Comparison

An examination of total number of parcels generated by each policy reveals that the 'ecotourism' policy will generate a great number more parcels than under current conditions (Figure 15). The dramatic rise in number of parcels may indicate that forest cover would be at risk of becoming more perforated than it otherwise would under the current economic climate, assuming no additional land use controls. Clearly, there is an economic benefit of ecotourism both in terms of improved economic conditions and property tax revenues. However, it should be noted that ecotourism may also bring the unintended consequence of forest fragmentation if no additional land use control measures are taken.

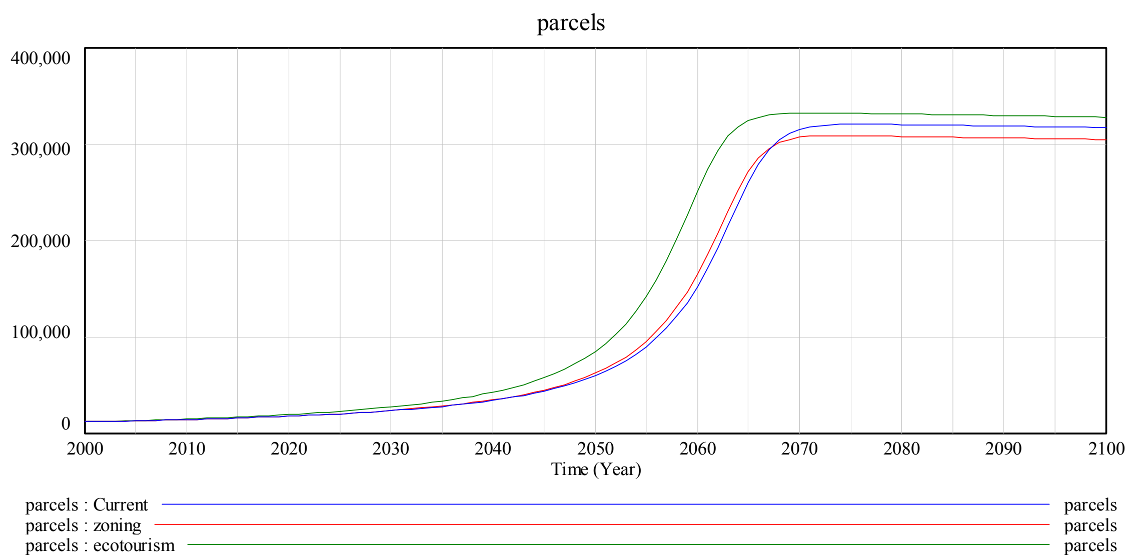


Figure 15: Parcel Volume Comparison

Using a simulation model to study the relative effects of various policies on parcelization rates enables landowners and county level decision makers alike the ability to discuss the costs and benefits of each scenario. Even a simple model such as the one used here can introduce individuals to the idea of parcelization and its possible effects.

Discussion

Natural resource managers continue to struggle to engage private landowners in landscape scale resource management strategies. A diversity of management motivations, low levels of ecosystem knowledge, and private property rights are seen as challenges to cross-ownership planning efforts (Spies et al., 2003). Determining how individual actions might be coordinated to define and implement larger landscape conservation goals requires that landowners form a consensus about the desired future resource conditions and an understanding about the consequences of different policy options. A participatory management framework is necessary for landowners to co-define desired future conditions within their community. By participating in such processes landowners are expected to increase their capacity to work together and become more willing to do so.

System dynamics modeling is being proven to be a useful participatory technique for achieving these goals. Used interactively in a public forum, a system dynamics model can be used as a social learning process to explore the resource system and illustrate the effects of strategies proposed by managers or suggested by forum participants (den Exter, 2003). In the case study presented, a group of landowners worked together to establish a shared understanding of landscape change in Morgan County, Tennessee.

The group worked collaboratively to produce causal loop diagram that depicts parcelization from residential development. While the ultimate purpose of the mediated modeling intervention was to help landowners learn from one another and to encourage cross-ownership land management, the process also provided participants to voice their collective understanding of a problem. The model captured the relevant structure of the system, thus enabling a simulation model to be constructed. However, the causal relationships used in building the CLD were sometimes inaccurate. For example, the relationships depicted in B4 and B5 are not accurate (Figure 10). In reality, the transaction costs to harvest and produce locally would continue to increase as forest cover decreases and the demand of working lands would continue to decline.

The group's shared understanding that landscape change is governed by supply and demand is accurate however. The CLD exercise was successful at capturing the major concerns of the group and the basic dynamics that govern parcelization. With this in mind, the CLD was used to construct a simulation model that would be capable of showing relative differences between three policy scenarios.

In developing the simulation model, an attempt was made to address three issues raised by earlier parcelization modeling approaches: 1) intensive data requirements, 2) the lack of available data, and 3) the non-linear dynamics of parcelization. As discussed earlier the model was constructed around a SIR system archetype to capture the basic dynamics of parcelization. This simple model structure enabled data requirements to be reduced to commonly available public data such as county property tax summaries and state level population projections.

The model was able to produce data indicative of observed parcelization process (Nowak & Walton, 2005). However, the validity of projections is highly suspect. This is mentioned as a word of caution. The intended purpose of the model is as a teaching aid to study the relative effects of various policies. Within the scope of its intended purpose the model is a useful tool. Findings show how economic development and land use controls affect the rate of parcelization.

Future research should build on the structure provided here to elaborate on individual factors that comprise the parcelization pressure variable. Adding realism to this model may help to provide more accurate estimates of parcelization. Also, a more detailed analysis of land prices may help to refine the expected land use values of the area. The model currently estimates land prices based on population growth.

In evaluating the project, landowners reported an enjoyable collaborative experience that enabled them to better understand an important issue in their community. As a result of this experience, eight of the twelve participants decided to form a new community group. The purpose of this group, now known as the Morgan County Sustainable Development Alliance (MCSDA), is to increase awareness of parcelization in the county and foster sustainable land use in their community.

In conclusion, mediated modeling proved to be effective for engaging landowners in a debate about landscape change and helped to foster cross-ownership coordination. The simulation model will remain available for MCSDA members to simulate additional policy scenarios if they choose. This model represents a first step in understanding parcelization from the perspective of local residents versus policy makers or researchers.

Remarkably, landowners understand the basic dynamics of the system. However, many participants in this study felt unable to affect the rate of parcelization in their area. Continual understanding can be built by refining the model and working with additional stakeholders in the area. The case study was designed to include various perspectives of landowners only. However, to move the problem towards a solution would require expanding the group to include multiple perspectives (e.g. local business owners, developers, county administrators). A more diverse set of interests may lead to insights that can help to identify socially acceptable policies.

Part 5

Conclusion

Study Summary

Proponents of social learning believe that when decision makers engage in social learning the opportunities to find systemic solutions to resource management problems increase (Keen et al., 2005). However, the lack of an operational definition for social learning has stymied attempts to validate its espoused ability to improve resource governance (Pahl-Wostl & Hare, 2004). This dissertation has provided some clarification of social learning by reframing the concept in terms of team performance using insights from the field of organizational psychology. The Team Member Schema Similarity (TMSS) research framework was introduced as a specific means to determine the presence and quantity of social learning so that any person who wishes to research it can independently test for it and its effects.

Team Member Schema Similarity (TMSS) can be used to define and test hypotheses related to the relationships between participatory research interventions, social learning, and social change. A TMSS case study was presented that used a causal mapping technique to detect social learning resulting from a mediated modeling process. In the case study, a group of landowners worked together to establish a shared understanding of landscape change in Morgan County, Tennessee. Analysis of pre and post-test data verified that social learning did occur and resulted in a shared understanding of landscape change among participants.

The experiment did not study of the relationship between schema similarity and capacity building (i.e., social change). However, anecdotal evidence for this relationship was provided by noting the consequences that the project had for its participants. Eight of the twelve participants elected to establish themselves as a new community group dedicated to improving local decision making for landscape conservation. The group became known as the Morgan County Sustainable Development Alliance (MCSDA).

While the ultimate purpose of the mediated modeling intervention was to help landowners learn from one another and to encourage cross-ownership land management, the process also provided a model of the relevant structure of a system, thus enabling a simulation model to be constructed. Participants collaboratively built a causal loop diagram that depicted land parcelization from residential development. The simulation model created from this conceptual model represents a first step in understanding parcelization from the perspective of local residents versus policy makers or researchers.

Significance and Implications

Participatory research interventions that enable diverse groups of individuals to discuss the complex causation of natural resource problems have been shown to lead to innovative strategies for management of resources. Improving these interventions by encouraging social learning is an important aspect of natural resource management research. TMSS, as presented in this paper, has proven useful for detecting social learning and may be used to improve participatory research interventions to optimize social learning, encourage capacity building, and thereby promote flexible and innovative decision-making.

The work presented here adds to the growing dialog about social learning within the natural resource management community. Theory development within this area of interest is proceeding rapidly and from various perspectives. The TMSS research framework offers an integrative perspective that allows for hypothesis testing.

The implication of team-based research could be wide reaching in natural resource management. With the ability to understand the factors that lead to effective teamwork researchers evidence could be sought to determine how large a role work processes play in management decisions. For instance, trust, conflict, and information sharing among individuals in a collective action setting are expected to greatly influence the innovation of management policies and the ability of decision-makers to be effective.

Identifying team attributes and fostering those attributes among individuals can lead to efficacious collective action. Furthermore, team research is likely to aid the institutionalization of efficacious deliberative processes in management agencies and organizations. Research that demonstrates the necessity of high performing teams within a collective action setting will solidify the importance of building strong relationships to achieve management goals, in collective action policy settings.

Cognitive social learning research is also complementary to collective action research concerned with the influence of organizational structures on decision making (e.g., Ostrom). This is because collective action often exists within an organizational context that influences, and is influenced by, team member interactions. A deeper understanding of these interactions can encourage responsive organizations regardless of organizational design.

Limitations and Future Research

While participants in the intervention were able to detail the basic dynamics of parcelization, many individuals felt unable to immediately affect the rate of parcelization in their area. There is clearly more to affecting change than simply increasing deliberation within a community. However, the participatory intervention used in the case study was only meant to increase the likelihood that collective action among stakeholders would emerge.

Deliberation itself is embedded within a larger context of decision making. The greatest limitation of this study was the exclusion of discussion about team inputs on team performance. Team inputs include the characteristics of the task to be performed, the elements of the context in which work occurs, and the attitudes brought forth by its members to a team situation (Hackman, 1987; Ilgen, 2005).

By not acknowledging the larger context within which a team acts, it is unlikely that a full accounting of social learning could be constructed. Factors such as how teams are formed (i.e., natural versus constructed), the social networks that individuals represent and their associated resources, and power relationships between individuals can ultimately decide the ability of a team to perform a task. The case study presented here did not address these factors. Future research should be conducted to better understand the relationships between organizational design and inter-personal processes such as social learning.

A second limitation of this work is its lack of experimental replication. Essentially, the case study presented here was only one trial without replication. Future research should attempt to conduct similar investigations with several teams. Without replication, experimental conclusions are unreliable. The findings of the case study in this report are promising, but tenuous. Variation in the results across trials would indicate how likely the results of the experiment were due to chance or some underlying probability of occurrence.

Had this experiment been replicated, variation would be seen among individual schema within any given trail. The variation at the individual level would likely lead to the expression of variation in each team's understanding of the problem. With all 'soft' system models, such as the one constructed in this study, the final model produced by the team is subjective (Checkland & Scholes, 1999). The subjective nature of group modeling is well known and purposeful because of its ability to structure a problem situation into a shared understanding (Vennix, 1996). Well defined problems (i.e., hard systems) such as the operation of a manufacturing plant, do not require deliberation understand their structure.

Replication would also reveal that some teams are closer to an "expert model" (i.e., a model that reflects the best available scientific understanding of the issue) than others. Some literature suggests that expert models can be used to train teams on how to perform more effectively (Smith-Jentsch, Cambell, Milanovich, & Reynolds, 2001). Using expert models to as educational tools could lead to support of policy recommendations that would otherwise be dismissed as politically untenable or counterintuitive.

Difficulties future researchers will face in natural resource management studies of social learning are the cost, effort, and opportunity for replications to TMSS research.

To date, few TMSS experiments have been conducted outside laboratory conditions. This is because rigorous research with TMSS requires many teams, conducting the same task, with similar team member inputs. In field studies, not unlike the case study presented here, it is uncommon to find situations in which these requirements may be met. Furthermore, if such a scenario was developed, the cost and effort to collect data is prohibitive. Future TMSS research in natural resource management will be required to overcome the barriers to data reliability. New data elicitation techniques and analysis tools are needed to reduce costs.

Outside of these limitations, participatory research can be a powerful tool for encouraging civic discourse. For instance, the models created during the case study may serve as a starting point for community wide deliberation. Continual improvement in conceptual understanding can be built by refining the model and working with additional stakeholders in the area. Expanding the group to include multiple perspectives may lead to insights that can help to identify effective and socially acceptable policies. Additionally, adding more diversity to the group will improve the accuracy of the simulation model and its output in a continual learning cycle.

The need to encourage social learning is not unique to natural resource management. However, natural resource management differs from other managerial settings because of its need to span across organizations, cultures, and academic disciplines to manage situations in which collective action is necessary. Therefore, a deeper understanding of that process and its associated effects is necessary too. This research represents one step along that path.

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Vita

Jonah Fogel currently holds a Bachelor's degree in hydrogeology from Western Michigan University and a Master's in landscape architecture from Virginia Tech. Throughout his schooling, Jonah's research interests have centered on the interactions between human decision making and ecological systems. His PhD research, at the University of Tennessee, investigated the utility of collaboration in managing private forestlands.

Mr. Fogel is currently employed by Virginia Cooperative Extension service as a Community Viability specialist. Jonah focuses on helping communities to develop a vision for their development and build the capacities necessary to carry out their vision. In this work, he emphasizes issues related to community planning and economic opportunity development. Jonah often partners with local Extension units, community officials, agencies, and other groups, to assess their needs, provide education, and assist their ongoing efforts.