Disturbance, response, and persistence in self-organized forested communities: over-time analysis of five communities in Southern Indiana

Paper to be presented at the Workshop on the Workshop, June 3-6, 2009, Workshop in Political Theory and Policy Analysis, Indiana University Bloomington. Workshop in Political Theory and Policy Analysis working paper W09-13.

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Abstract
In this paper we utilize Ostrom's (2007) diagnostic framework for socio-ecological systems to examine the factors that contribute to social responses to disturbances in a set of five Indiana, USA intentional communities over a fifteen year time frame. We argue that the concept of robustness is useful in understanding designed aspects of socio-ecological systems because it emphasizes the tradeoffs between achieving different goals, but is difficult to measure over long time-frames and across criteria. We thus introduce the concept of persistence as an empirically observable metric for long-enduring socio-ecological systems. We find that Communities with strong collective choice processes that reflect shared value are more able to respond adaptively to disturbances, and therefore have a higher probability of persisting over long time-frames.

Keywords: Socio-ecological systems, robustness, disturbance, response, intentional communities

Acknowledgements
We are grateful to the members of the five communities who are profiled in this study for allowing us to study their communities. We owe the existence of this dataset to the many IFRI scholars who have participated in data collection for this project over the last fifteen years, as well as to the database support of Julie England and Robin Humphries. Funding for the IFRI network has been provided by the Food and Agricultural Organization of the United Nations, the Ford Foundation, the MacArthur Foundation, and the National Science Foundation. We appreciate helpful comments and conceptual development from colleagues at the Workshop in Political Theory and Policy Analysis' Socio-Ecological Systems Working Group.

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INTRODUCTION

Socio-ecological systems (SESs) are coupled systems in which people interact with natural components over time. Although many studies have examined human-environment interactions, the complexity of coupled systems is not yet well understood, especially over time. Studies tend to focus on human-environment interactions from within either the human or the ecological system, rather than on the interactions between coupled systems. To increase the generalizability of findings from case studies, research on both site-specific studies and coordinated, long-term comparative projects across multiple sites need to be undertaken. The goal of this paper is to analyze how the social component of SESs anticipate and respond to, disturbances. We empirically analyze a variety of disturbances, responses, anticipated actions, tradeoffs and their impact on the persistence and robustness of five intentional communities in Southern Indiana. We do this by drawing on the SES framework proposed by Ostrom (2007).

Analysis is aided by selection of appropriate systems to study specific processes. We have chosen a set of five self-organized intentional communities that own forested land in south-central Indiana as our study system. The Fellowship for Intentional Communities defines an intentional community as, “an inclusive term for ecovillages, cohousing, residential land trusts, communes, student co-ops, urban housing cooperatives, alternative communities, and other projects where people strive together with a common vision (Fellowship for Intentional Communities, 1999).” While such self-organized communities have been studied as points of sociological and historical interest (Kanter 1972; Kanter 1973; Zablocki 1980; Janzen 1981; Laffan 1997; Brown 2002), the focus has been entirely on social dynamics, as contrasted to the communities’ relationship with the natural world. According to Zablocki, there have been waves of interest in self-organized, communal living situations in the United States, with the most

recent corresponding with the back-to-the-land movement of the late 1960s and 1970s (Jacob 1997). Zablocki found that, “most of these experiments fail; the few that succeed are usually drastically modified over time (p. 2).” Recent commentators have noted the small number of surviving communities from the 1960s and 70s (Oved 1999). Given the dramatic changes these communities have had to make to survive, self-organized communities that persist from this era, including the five in our study, offer useful lessons in understanding persistence and robustness. Because intentional communities in the US have substantial latitude to organize without interference from external authorities, they also provide an unusual opportunity to study dynamics of SESs whose behavior is largely shaped by internal dynamics rather than external disturbances.

This research was undertaken by researchers at the International Forestry Resources and Institutions (IFRI) program. IFRI researchers use a common set of interdisciplinary methods to study forests, the people who use the forest resources, and their institutions (rules for use and management) (Ostrom and Wertime 2000; Poteete and Welch 2004). Data for this study was collected over a fifteen-year period, where each community was visited three times. Comparable ecological conditions hold across the five sites and each intentional community manages its forests collectively, albeit through a variety of arrangements. Having overtime date on several different communities grants us the unparalleled opportunity to look at issues related to resilience, such as disturbances, responses, persistence, and tradeoffs.

THEORETICAL FRAMEWORK

Our theoretical framework draws on the literature on resilience and robustness. These concepts have been used to describe the ability of SESs to respond to disturbances. We address the concepts of resilience, robustness, disturbance, and response. We argue that the concept of robustness is useful for understanding the tradeoffs inherent in responding to

disturbance in the human designed elements of SESs, but that the concept is difficult to operationalize in our cases because we have not yet observed system failure, a problem recognized by Anderies, Jannsen, and Ostrom (2004). Instead, we measure the persistence of communities, which would indicate robustness over longer time frames than we have observed.

The concept of 'resilience' originates in ecology where it has evolved in meaning through extended debate and application (Turner et al. 2003). The concept has been used to characterize a system's ability to bounce back to a reference state after a disturbance (DeAngeles 1980; Pimm 1984) and the capacity of a system to maintain certain structures and functions despite disturbance (Holling 1973; Harwell et al. 1977; Turner et al. 2003). Although the concept of resilience has been very useful in ecological studies, it has proved difficult to apply in social settings where humans are able to design rules and anticipate disturbances (Carpenter, Walker et al. 2001; Anderies, Janssen et al. 2004).

Robustness, or robust design, has been suggested as an alternative for use in studying social ecological systems and their capacity to deal with disturbances due to the fact that the term, which originated in engineering, refers to maintenance of *designed* systems (Anderies, Jannsen, and Ostrom, 2004). Robust systems have the capacity to continue to meet a performance objective in the face of uncertainty and shocks due to conscience human decisions (Anderies and Jannsen, 2007). Although the ability to respond to disturbances is at the core of both robustness and resilience paradigms, the literature does not clearly identify the meaning of disturbance and response in the context of socio-ecological systems.

In ecology, disturbance is any relatively discrete event that damages or disrupts community, ecosystem, or population structure and function, resulting in changes to resources, substrate availability, or the physical environment (White and Pickett 1985; Huston 1994). Because this definition is primarily used to describe events occurring to or within the natural

environment, and doesn't adequately capture the complexity of coupled social-ecological systems, we develop a working definition of disturbance within a socio-ecological system. We draw from ecology's recognition of the inherent complexity and multi-scalar dimension of disturbances through space and time. We define disturbance as: a relatively discrete event that disrupts social or ecological communities, resulting in changes to the physical or social environment. It is important to recognize that disturbances to the social system may arise from changes in either social or ecological variables and may vary spatially and temporally, existing on continuums of magnitude, (from minor disagreements to major social conflict or natural disaster) and temporal scale (from a flash flood that lasts hours to a drought that lasts years).

Responses can be understood as actions and events that occur as a result of disturbances. Social responses to disturbances differ from biophysical responses. Biophysical systems respond through selective pressure – aspects of a system that fail cease to exist, and those that work remain. In social systems, humans have the capacity to plan, anticipate, and consciously design their societies and physical surroundings. An adaptive response allows the system to "better cope with, manage or adjust to some changing condition, stress, hazards, risk, or opportunity" (Smit and Wandel 2006). Along the same lines, maladaptive responses hinder the ability of the system to cope with, manage, or adjust to a change in condition, stress, hazard, risk, or opportunity. In addition, there may be neutral changes or responses which do not alter the ability of the system to cope with, manage, or adjust to a change. Not responding to a disturbance is also a response, in the sense that it represents a decision to not take action as a result of disturbance. In a world of complex causality, it is entirely possible that a response or anticipatory change may be adaptive in some ways, maladaptive in others, and neutral in others. Thus, the existence of trade-offs is a fundamental aspect of the process of adaptation.

We find the concept of robustness useful because it emphasizes tradeoffs between optimization for a specific set of criteria and longevity of performance (Anderies, Jannsen, &

Ostrom, 2004). In fact, increased robustness in one component of the system is likely to bring failure in another. Anderies and Janssen argue that only through short term failure is long-term robustness achieved (Anderies and Janssen, 2007). Although we measure the robustness of our study communities to particular disturbances, we cannot operationalize a measurement of long-term robustness. Since we have not observed system failure in our communities, we cannot differentiate between communities that have survived because they are robust and communities that have survived because they have not faced severe disturbance and failed.

What we can measure is persistence. The Oxford English Dictionary defines persistence as "continued or prolonged existence or occurrence; duration; continuance." Persistence is like robustness, in that it refers to continuing in a particular state, however it can be operationalized in our cases because we know that our study communities have continued for the duration of our study, even though we don't know if they are robust to future disturbances.

There are different types of actions or processes that occur in anticipation of or in response to disturbances. We draw on the ontological framework developed by Ostrom (2007) to identify socio-ecological system variables (Table x) that explain the nature of disturbances and responses within the five communities. Ostrom's 'diagnostic approach' aims to build a conceptual, ontological framework to improve our understanding of the relationships between proximate and underlying variables influencing the management and use of common-pool resources (CPR). This framework has been applied by Basurto & Ostrom (2009) to understanding the determinants of collective action, and we extend it here to the study of persistence and robustness.

METHODS

The International Forestry Resources and Institutions (IFRI) program was started in the early 1990s by scholars interested in understanding how institutions facilitated collective action to enable communities and government agencies to successful manage their forests (Ostrom and Wertime 2000; Poteete and Ostrom 2004; Wollenberg, Merino et al. 2007; Poteete and Ostrom 2008). Although there had been many case studies of human interaction with forests, and several competing theories were developed to explain why some areas experienced deforestation, others stability, and others forest regrowth, these studies suffered from two shortcomings. First, as individual case studies their findings could not easily be generalized. Second, scholars from diverse disciplines used inconsistent terminology and data measurement techniques, hindering a synthesis that could contribute to generalized theory. IFRI aimed to remedy these shortcomings by developing a consistent methodology measuring both social and ecological conditions which could be applied across many sites to develop a large-n database. The IFRI program is the only research program in the world that gathers data on both forest conditions and social variables over time using a set of common research instruments. To date, the IFRI program has collected data at over 250 sites in 15 countries. The primary goal of the IFRI program was to gather over-time data on social-ecological systems that would allow testing of generalized hypotheses as well as to explore questions raised by the empirical findings of the studies themselves.

Although the focus was on forests in developing countries, IFRI researchers quickly realized that in order to insure methodological consistency, there would need to be training courses. Beginning in the mid-1990s, IFRI training courses have been offered annually at Indiana University, where the IFRI network was based until recently.[8] The training courses consist of theory and methods components, along with a complete IFRI study of a forest community. The five sites analyzed in this study were selected as training sites due to their

[8] In 2006, the IFRI network's administrative headquarters moved to the University of Michigan. Training courses are now offered at the University of Michigan and Indiana University in alternate years.

proximity to Indiana University's Bloomington campus, as well as to their similarity to the sorts of forest institutions studied in many developing countries.

The IFRI research design combines standard techniques for forest mensuration with tools drawn from Participatory Rural Appraisal (Chambers 1994), including participatory mapping, focus groups, and semi-structured interviews. All information is entered onto standard IFRI coding forms (Wertime, Ostrom et al. 2007), and then entered into a relational database.[9] In addition, participants in IFRI training seminars prepare reports on their research that are shared with the communities. Each of the sites in this study has been visited three times, at approximately 5 year intervals, between 1994 and 2008. Our analysis is based on the reports, information stored in the IFRI database, and our own experiences visiting the five communities. The names of the communities have been changed at their request to protect their identities, however the names are the same as those used in previous publications based on this research (Gibson and Koontz 1998; Donnelly, Ostrom et al. 2004; Poteete and Welch 2004)

We draw on the ontological framework developed by Ostrom (2007) to identify socio-ecological system variables (Table 1) that explain the nature of disturbances and responses within the five communities. Six sets of variables affect collective action are defined by Ostrom (2007) (Table 1): *(1) resource system (RS),* e.g. such as the clarity of the system's boundaries, its size, its productivity, and the predictability of its dynamics; *(2) resource unit characteristics (RU),* e.g. their mobility, regeneration rate, and economic value; *(3) governance system (GS),* i.e. the prevalent institutions and norms at different scales (local, national, etc.) and the structure of the network of users; *(4) user or group characteristics (U), such as* group size, socio-economic heterogeneity, history of use of the system, leadership, social capital, and mental models*; (5) the social, economic and political setting (S)*, e.g. level of economic development,

[9] Copies of IFRI coding forms and information on access to the IFRI database are available from the IFRI Center at the University of Michigan (http://www.sitemaker.umich.edu/ifri/home)

demographic trends, and political stability; and *(6) related ecosystems including larger scale water and weather systems.* Given the immense complexity that results from the existence of multiple and conjunctural factors that affect collective action, the key for any analysis is to carefully specify a particular context and identify variables which are most likely to be relevant for that context (Basurto & Ostrom, 2009; Ostrom 2007; Forthcoming). In this study, we use Ostrom's framework in precisely this way, identifying relevant factors in each community (Table 1), which then allow us to provide explanations of why each community has different responses to similar disturbances and shows different degrees of persistence

(Table 1 about here)

Results

Shared Disturbances

Although each of these communities has a unique history, there are common patterns in the types of disturbances the communities have experienced, the variables influencing their responses, and the contexts in which they operate. These common patterns are the basis for our selection of second tier variables from Ostrom's (2007) framework (starred variables in Table one) which we find contribute to community responses to disturbance, and which should be analyzed in future cases to understand why some communities are better able to respond to disturbances than others, and in turn, why some are more persistent than others.

(Table 2 about here)

All of the five communities share a generally supportive context for self organization. This is captured in the framework variable S3, political stability. Property rights and the rule of law in the region are strong. So far no community has faced attempts by governments or other powerful actors to take their land through legal or extralegal means, and there is a supportive

legal structure for self-organization. This is a striking contrast to the situation faced by community forests in developing countries which are subject to predatory action by governments and other powerful figures (Larson and Ribot 2007), and which exist in a legal environment which is unsupportive of community property rights and self-organization in general (White and Martin 2002; Agrawal, Chhatre et al. 2008; Sunderlin, Hatcher et al. 2008). In addition, the members of the communities are participants in a relatively prosperous regional economy which generally enables them to earn a living without exploiting the natural resources on their land. This is captured in framework variable S1, Economic development. As a result, the primary land uses are non-consumptive. This does not mean the land is not important – in fact, community members clearly value their forests very deeply, and in some cases the forest has a deep spiritual value, analogous to sacred groves found in many parts of the world, including China, Ghana, India, Mexico, Nepal, Thailand, Uganda, and Zimbabwe (Ostrom 2005 p. 235). No variable in the existing framework adequately captures these spiritual values, however framework variable RU4, economic values, could be modified to capture these spiritual values which are difficult to integrate into an economic framework. Table two describes the main features of the five communities such as origin, size of the area, group characteristics, governance structure, and experienced disturbances.

The disturbances experienced by the communities can be classified into five broad types, each of which will be reviewed separately in the remainder of this section. Three types of disturbance originate inside of the community: controversy over tree cutting, controversy over leadership, and membership transitions. Two types of disturbance are external to the communities: conflicts with neighbors and natural disasters. Although natural disasters and tree cutting have clear ecological components, we focus here on the social components of these disturbances, because, as discussed in the introduction, these have not been well studied in previous work on socio-ecological systems. Disturbances range in time scale from discrete

events such as floods, to long processes, such as membership transitions, as well as some irresolvable controversies. They also range in magnitude from very mild, such as the cutting of a small number of trees that violates community norms, to very severe, such as a fire that destroyed a young community's only building and nearly led to the community's dissolution.

Where communities have faced similar disturbances, their responses can be seen as indicative of their differing ability to engage in adaptive behavior. Four of five communities have faced serious disturbances related to the cutting of trees that went against community rules and norms. Two communities have faced serious disturbances related to leadership, while the other three appear to have prevented such disturbances, although it is difficult to tell if this is due to anticipatory behavior or good luck. Although property rights in the US are strong, all five communities have faced disturbances related to trespassing, illegal harvesting of non-timber forest products, and relations with neighbors. All five communities have faced disturbances related to changing membership, particularly as it relates to generational change. Finally, two communities have faced serious natural disasters.

Cutting of trees that violates rules or norms

(Table 3 here)

The forests owned by all five communities are managed primarily for nonconsumptive uses, with tree-cutting either prohibited or severely restricted. One disturbance that four of the five communities have faced has been cutting of trees that violated non-consumptive norms. These disturbances have ranged in size from the cutting of a small number of trees to build a house addition at Maple to clearcutting several acres at Oak.

In three of the four cases, a major contributory factor leading to disturbance was a lack of formal rules (GS5) to back up existing norms against tree cutting. Following Ostrom & Crawford's (Crawford and Ostrom 1995; Ostrom 2005) definition, a norm is an institutional

prescription for behavior, while a rule is an institutional prescription for behavior accompanied by an “or else” statement. In Box Elder, where the forest is considered sacred and a strong norm existed against tree cutting, trees were cut by a group of volunteers who claimed to be unaware of this norm, pointing to the importance of shared understanding of norms (U6). At Tulip Poplar, where tree cutting was unregulated on private plots, the community first became aware of potential externalities from tree cutting when a private landowner cleared a steep slope adjoining the lake, leading to severe erosion. Prior to this, the community’s knowledge of the SES (U7) did not include the possibility that behavior on houselots could negatively impact the lake, and there had been no rules or norms regarding tree cutting. Similarly, at Oak, there were no formal rules regarding tree cutting, although there was a norm against tree cutting. When the community privatized land in order to increase membership (U1), new landowners did not share norms about forest use (U6). The cases of Oak and Box Elder indicate that there may be a tradeoff between inviting outsiders in to increase group size (U1) and maintaining shared norms (U6). The flip side of this tradeoff can be seen at Twin Oaks, where there have been no tree-cutting disturbances due to the combination of a very small community with very strongly shared norms, but where small size threatens the long-term viability of the community. Maple had anticipated the problem of tree cutting on privatized home sites and created formal rules restricting tree cutting on private plots, however a landowner building an addition onto their house intentionally violated this formal rule.

Community responses to the disturbance of tree cutting can be divided into two categories. First, two communities (Twin Oaks and Maple) acted in ways that anticipated and prevented disturbance. At Twin Oaks, this was an unintentional byproduct of the decision to stay small, while at Maple this was the result of a conscious effort to control land uses on semi-privatized home sites (Gibson and Koontz 1998). Unfortunately, as the experience at Maple demonstrates, the existence of a formal rule does not guarantee adequate enforcement –

although there were rules regulating land use on home sites, the rules were violated, and a broader norm of maintaining community harmony (U6) appears to have prevented the community from enforcing the “or else” clause of the rule. Two communities responded adaptively, by creating formal rules to prevent unwanted tree cutting. At Box Elder, the new formal rule simply reinforced an existing norm, making it more legible to less involved members of the community, while at Tulip Poplar the formal rule (and accompanying enforcement mechanism) built on an existing institution at the collective choice level (GS6), a committee that already governed land use on commonly owned lands, to regulate tree cutting on private land. Finally, Oak responded to the first instance of this disturbance, in 1993, by taking to court the landowner who clearcut his lot, taking advantage of the nested nature of community governance within a broader collective-choice legal structure (GS6). The court case was unsuccessful because the community did not have the right to challenge land use on private lands. The judge suggested that for the future, the community change their rules to put an easement on future privatized land that would prevent tree cutting. The community did not follow his advice, and the disturbance recurred in 2003, however the community did not respond the second time.

Gibson & Koontz (1998) argued that tree cutting at Oak was the result of a failure to develop rules that enforced existing values and norms. Why did Oak fail when the other four communities were able to either anticipate or adaptively respond to tree cutting disturbances? The answer may lie in the different formation processes of the communities. Unlike the other four communities, the residents of Oak received their land as a gift from a wealthy landowner, and recruited new members by inviting people hanging out in a city park to join them. As a result, there were neither shared experiences, shared values, nor pre-existing rules to tie community members together (U6). While both Oak and Maple allowed privatization of homes as a way to allow members to transition to a more typical American lifestyle, and at Oak, in an attempt to attract members, Maple carefully developed rules to insure that community norms

would be followed on semi-private home sites, while Oak has passed up repeated opportunities to develop rules that would enforce community norms on privatized sites.

Leadership

(Table 4 here)

Two of the five communities have suffered disturbances related to leadership: Oak and Box Elder. Failures to develop or adhere to collective choice rules (GS6) appear to be major contributing factors to disturbance related to leadership. Although Oak's original bylaws established a leadership council of seven members (U5), loss of membership led to informally-established leadership via a president, secretary, and treasurer (GS6). Two internal factions developed as different mental models of the community (U7) grew regarding land use and membership rules, which produced a conflict as two different leaders emerged. When the community was unable to resolve the conflict internally, the issue was taken to court to be resolved externally by the legal system. Although the existence of strong external institutions (i.e. the U.S. legal system) led to the resolution of the conflict, the community incurred considerable financial losses as a result of legal fees, and also saw a further decline in membership.

Oak's response differed greatly from Box Elder's, the other community that faced leadership challenges. The Box Elder community was initially led by a charismatic founder and spiritual leader, however this man became increasingly conflictive, misused community funds, and was under investigation for involvement with illegal drugs. The personal character of this leader (U5) was a factor in this disturbance, as were the operational and collective choice rules which gave one individual the power to commit such abuses. In recognition of this fact, the community responded through the existing elected Council of Elders by removing this person from power and enacting significant changes to their by-laws to adjust internal governance. The

community reorganized as a 501C(3) non-profit, which requires a governance structure that includes a president, secretary, and treasurer, and introduces federal government oversight. In addition, the community converted decision making in the Governing Council from consensus to majority rule and began holding monthly meetings and weekly “office hours”, allowing greater flexibility and transparency as well as increasing opportunities for member involvement. The community was able to take such action because of collective choice rules and constitutional rules that gave the community the power to make change happen internally. In contrast, Oak’s abandonment of its collective choice rules hindered the community’s ability to effectively respond internally.

The three communities that have not faced leadership disturbances may merely have benefited from good luck. However, it would appear that a combination of shared norms and values (U6) in Twin Oaks & Maple, clear collective choice rules that fostered constructive decision-making and long-term flexibility in community structure (GS6) in Maple & Tulip Poplar, and leadership systems that distribute power between members (U5) and encourage transparency in all three make these communities less vulnerable to leadership disturbances. While these arrangements have avoided leadership conflicts among the three communities, they also come with tradeoffs. Twin Oaks’s small size, which has allowed transparency and shared norms to persist, also threatens its longevity. Tulip Poplar’ large size and reliance on democratic processes has avoided leadership dilemmas, but has produced complaints typical of bureaucracies, including the slow pace of decision making.

Boundaries and Neighbors

(Table 5 here)

Although the U.S. is known for having some of the world’s strongest institutions for land based private property rights (GS4), all five communities have faced disturbances related to

maintaining boundaries (RS2) and relations with neighbors. Trespassing to hunt, fish, drive all-terrain vehicles (ATVs), or poach morel mushrooms (*Morchella spp*) and wild ginseng (*Panax quinquefolius*) occurs at all five sites. All communities have made efforts to address these problems. The fact that no community has been very successful at addressing these concerns reflects three characteristics. First, morels and ginseng are patchily distributed seasonal non-timber forest products with very high market values (RU4), making them both difficult to monitor (GS8) and rewarding targets for poachers (Poteete and Welch 2004). Second, the damage from poachers and trespassers appears to be small relative to the cost of imposing effective monitoring (although one poacher at Maple was caught with $20,000 worth of ginseng). While Twin Oaks and Box Elder have both made efforts to fence and walk the property to prevent all-terrain vehicles from entering, these efforts appear to have been too small to be effective, particularly since most community members work, and thus spend most of the day, outside of the community, and both communities have few residents (U1). Even Tulip Poplar, which has several volunteers on a dedicated security committee, continues to have problems with fishermen trespassing to fish on the two lakes in the community. While it is conceivable that a full-time guard or guards could prevent trespassing, this would be very expensive even relative to the cost of stolen ginseng. Third, norms (U6) in rural southern Indiana are not conducive to strict regulation of resource system boundaries (RS2). Rural residents are accustomed to walking, gathering non-timber forest products, and even driving ATVs across boundaries, and local authorities are reluctant to enforce laws, particularly when doing so might favor rural residents who are perceived to be different from their neighbors. These norms likely reflect a 19th century institutional tradition in which forests were managed largely as open-access commons throughout much of North America (Freyfogle 2007).

Two communities, Box Elder and Maple, have faced serious conflicts with neighbors resulting from perceived cultural differences between traditional rural communities and the

"hippie" communities. This has been a bigger problem for Box Elder. Box Elder's festivals attract crowds and are noisy. The community has suffered vandalism, has been accused by local newspapers of performing satanic rituals, and was at one point confused with a terrorist organization due to similarities in their names. Both communities have worked hard to reach across perceived cultural divides and improve relations both with neighbors and local governmental authorities. This work has created new networks of connection between the communities and their neighbors (GS3). Box Elder has also changed rules to decrease the noise impacts of their festivals on neighbors.

Membership Transitions

A fourth common disturbance type is related to transitions in membership as a result of the aging, dying, or leaving of members. Unlike many of the other disturbances we have discussed, these transitions tend to be slow-moving processes, but this does not mean that their effects are not large. Land is a long term commitment. Reduced membership can mean less available resources to cope with future disturbances, and if members continue to leave, the community will eventually disappear. Membership declines may also present opportunities for greater community cohesion if members who leave do not share the majority's values.

Two communities in our study, Maple and Oak, experienced substantial decreases in population from an original core group of about 40 people. In Maple, 23 members are left, while in Oak, only 10 are left. Departures at Maple followed a major natural disaster (discussed below), and it appears that only the most committed stayed, strengthening the shared norms (U6) that contribute to Maple's ability to address many problems effectively. Those who left Oak were people who remaining members labeled as 'trouble makers,' however their departure, rather than leading to greater cohesion, led the remaining members to cease meeting as they no longer had to deal with the problems created by trouble-makers. Since the community no longer has a regular forum for making collective choice rules (GS6), its ability to respond to

future disturbances may be even more impaired than what it was during the past period of conflict.

While none of the other communities have experienced such large reductions in groups size, they are not free from membership transitions. While Box Elder has a stable group of core members, their strategy of drawing in less-involved members and visitors (in the hundreds) to participate in annual festivals has led to a different variant of the group size tradeoff – visitors bring in resources, but cause larger environmental impacts. Box Elder is trying to manage this problem by enforcing a ban on fuelwood collection by visitors during Festivals (GS5, GS8). Tulip Poplar, which has relatively open membership, manages the issue of turnover by having a much more complicated system of formal rules than the other communities at both the collective choice (GS6) and constitutional (GS7) level. Finally, Twin Oaks, which has been successful at maintaining shared norms by remaining very small (U1), now appears to be in danger of disappearing, as one community member died recently and the remaining community members are aging, and do not have children.

Natural Disasters in the five communities

While most of the disturbances described in this paper illustrate how users and governance systems interact with each other, and effect the natural environment, natural disasters illustrate how resource systems can impact users and governance systems. Southern Indiana has a low frequency of major natural disasters, and modern societies are largely able to buffer themselves from major ecological disturbances (Kates 1971). There have been only two natural events that have had important impacts. The first was a house fire that occurred at Maple in 1980, fifteen years before our first site visit. The second was a major flood that occurred at Tulip Poplar in the summer of 2008.

The house fire at Maple burnt down what was then the main building at the community. For a group of young people whose communal finances were relatively precarious, this was a major disaster. As described in the previous section, many community members left the community after the fire. Rather than re-building the communal building, the remaining members of the community began building separate private dwellings. This represented a major departure from the previous focus of the community on living together. A smaller community might not have been able to survive the loss of members, and a community with a weaker sense of collective action might have been crippled by the movement towards increased private land. Instead, Maple went through a transformation, remaining a community but becoming a community with substantially different goals.

The flood at Tulip Poplar was the result of an unusual series of very intense rain storms which led to widespread flooding in Southern Indiana. Damages to community-owned infrastructure, including roads and a dam spillway amounted to five to six times the annual budget. The community has tried to take advantage of nested structures by applying for state and federal disaster assistance, however private homeowners associations such as Tulip Poplar are not generally eligible for such funding, which is generally restricted to governmental agencies or non-profit organizations. At the time of our last site visit, in October 2008, the community was considering restructuring its governance arrangements so that in the future it might be better able to take advantage of inter-governmental linkages.

Discussion:

Integrating our cases allows us to identify factors from Ostrom's (2007) framework that played important roles in avoiding and responding to disturbance in several communities. Shared norms and values (U6) helped communities establish effective collective choice processes and hold together in the face of internal disturbances. Maple and Box Elder are examples of communities whose strong values have led to strong rules, which have enabled the

communities to respond adaptively to most challenges they have faced. The lack of shared values at Oak, a product of its history, hindered the community's ability to deal with new challenges. Bringing in new users, who did not necessarily share the group's values appears to be particularly challenging, but while Tulip Poplar and Box Elder managed these situations effectively, at Oak they exacerbated the community's decline. Twin Oaks small size has meant few challenges from heterogenous values, but also means that when the current members die, the community will cease to exist.

Conclusion:

Our analysis has illustrated how Ostrom's (2007) ontological framework can be applied to understanding the persistence of socio-ecological systems through successive disturbances through anticipatory changes and responses on the part of the social actors in the system. The framework was originally proposed as a diagnostic framework for avoiding panaceas by enabling analysts to identify specific components of socio-ecological systems. Basurto & Ostrom (2009) applied the framework by examining the emergence of self-organization and robustness. This paper takes a step forward by applying the framework to the over time analysis of disturbances, responses, persistence, and robustness. Communities with strong collective choice processes that reflect shared values, such as Maple, Box Elder, and Tulip Poplar are usually able to respond adaptively to disturbances, and appear likely to persist for some time to come. Communities where collective choice processes are weak or do not reflect shared values, as at Oak, or where capacity is low, may persist for some time, but appear to have much less ability to respond adaptively to disturbances.

We can distinguish between proximate and deeper causes of successful responses. Most adaptive responses to disturbance occur through changes in the governance system, and particularly through changes in rules at the operational and collective choice levels. In the

context of self-organized intentional communities in the U.S., which have substantial latitude to design their own governance systems without interference from higher authorities, the ability to change these systems can be seen as the result of governance systems well matched to characteristics of users. Governance systems reinforce shared norms, as pointed out by Gibson & Koontz (1998) in an earlier study of two of these communities. However governance systems also create shared norms by regulating membership, as occurred in all of the communities, by facilitating information exchange, as happened, for example, in Tulip Poplar after tree cutting led to erosion on one of the lakes, and by communicating shared expectations to new members or visitors, as at Tulip Poplar and Box Elder.

The literature on robustness of socio-ecological systems (Anderies, Janssen et al. 2004) has emphasized the importance of tradeoffs between different system goals. We have seen in the cases of Box Elder and Oak how attempts to increase community capacity have led to problems with new members who do not share values, while Twin Oaks's decision to stay small and avoid the problems with new members threatens its long-term robustness. It is also apparent that some tradeoffs can be managed through improved institutional arrangements – for example, while land privatization at Oak led to increased heterogeneity and conflict, Maple developed institutions to protect community values and control membership while effectively privatizing land.

Communities with limited capacity, such as Twin Oaks and Oak, are less able to design institutions that facilitate adaptive responses. At Twin Oaks, persistence is related to the lack of severe disturbances, while at Oak, responses have been maladaptive and have required appeals to higher authority. While these two communities have persisted, their inability to design adaptive institutions indicates that they may not be robust to future disturbances.

Ostrom's (2007) ontological framework is a new tool that has not yet been widely applied. While our analysis has illustrated its utility, it also points to conceptual problems which may require future revision. First, the variable U6 – norms/social capital has been applied here to describe a broad array of phenomena relating to shared cultural values. While norms are one way in which such values are expressed, it is not clear if the concept of norms fully captures this phenomenon. Second, RU4 – economic value, may require respecification to capture values, such as spiritual values, which do not easily fit into the framework of economic values. Since these values are, properly speaking, characteristics of the users, and not characteristics of the resource itself, it may be that such a respecification might be related to the problem with U6.

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Table 1: Factors that contribute to community response to disturbance based on Ostrom (2007)

Social, Economic, and Political Settings (S)	
* S1- Economic development	S4- Government settlement policies
* S2- Demographic trends	S5- Market incentives
* S3- Political stability	S6- Media organization
Resource System (RS)	**Governance System (GS)**
* RS1- Sector (e.g., water, forests, pasture, fish)	GS1- Government organizations
* RS2- Clarity of system boundaries	GS2- Non-government organizations
* RS3- Size of resource system	* GS3- Network structure
RS4- Human-constructed facilities	* GS4- Property-rights systems
RS5- Productivity of system	* GS5- Operational rules
RS6- Equilibrium properties	* GS6- Collective-choice rules
RS7- Predictability of system dynamics	* GS7- Constitutional rules
RS8- Storage characteristics	* GS8- Monitoring & sanctioning processes
RS9- Location	
Resource Units (RU)	**Users (U)**
RU1- Resource unit mobility	* U1- Number of users
RU2- Growth or replacement rate	U2- Socioeconomic attributes of users
* RU3- Interaction among resource units	* U3- History of use
* RU4- Economic value	* U4- Location
RU5- Size	* U5- Leadership/entrepreneurship
RU6- Distinctive markings	* U6- Norms/social capital
RU7- Spatial & temporal distribution	* U7- Knowledge of SES/mental models
	U8- Dependence on resource
	U9- Technology used
Interactions (I) → Outcomes (O)	
I1- Harvesting levels of diverse users	O1- Social performance measures
I2- Information sharing among users	(e.g., efficiency, equity, accountability)
I3- Deliberation processes	O2- Ecological performance measures
I4- Conflicts among users	(e.g., overharvested, resilience, diversity)
I5- Investment activities	O3- Externalities to other SESs
I6- Lobbying activities	
Related Ecosystems (ECO)	
ECO1- Climate patterns	
ECO2- Pollution patterns	
ECO3- Flows into and out of focal SES	

* are assigned to variables which are identified with explanatory power in our case study analysis

Table 2: Characteristics of five Forest Communities in Southern Indiana

	Maple	Oak	Box Elder	Twin Oaks	Tulip Poplar
Origin	1976	Late 1960s to early 70s	1983	1971	1969
Whole area in acre/ha:	304/123	450/182	109/44	140/57	1100/445
Forested in acre/ha	200/81 (66 % of area)	110/44,5 (25 % of area)	90/36 (83 % of area)	120/49 (86 % of area)	590/239 (54 % of area)
Timber harvest	No	Yes	No	No	Yes
Founding members:	About 10	2	About 20	2	2
Group size change	Slowly increasing up to 40 people, after fire in 1980 decline, today 23 members	First increasing up to 40 people, after conflicts decreasing, today about 10 people	Members: stable, Festival visitors: increasing (hundreds)	2 friends were included very early, now only 1 member left	Selling of 1 acre lots to private individuals, today 527 permanent adult residents
Group heterogeneity	Low	First high, today low	Among members low	Low	High
Motive	Community life, Back-to-the-land	Community life, Securing a gathering space	Spiritual refuge, Securing a gathering space	Privacy in nature	Privacy, Resident-ial development, Recreation,
Governance:	All members & Council	All members	Elder Council	All members	Board of 9 directors
Decision making	First consensus, later majority rule	Majority rule	First consensus , later majority rule	Consensus rule	Majority rule
Internal social disturbances	Tree cutting, Change of generations	Tree cutting, Leadership/Membership	Tree cutting, Leadership	Moving away and death of members	Tree cutting, Change of generations
External social disturbances	Poaching, Hostility from neighbors	Poaching, Trespassing, Conflict with neighbors	Trespassing, Hostility from neighbors	Trespassing, Poaching	Trespassing, Poaching
Natural disturbances	Fire in 1980	None	None	None	Lake-level differences, Flood in 2008, Erosion at lakes/in forests

Table 3: Tree cutting disturbances

	Maple	Oak	Box Elder	Twin Oaks	Tulip Poplar
Disturbance	Tree cutting on private home site	Tree cutting on privatized lots	Tree cutting on common land	None	Tree cutting on privatized lots > led to erosion
Factors leading to Disturbance or lack of if no disturbance.	Violation of formal rules, i.e. ineffective monitoring & sanctioning (GS8)	Lack of formal rules (GS5), Created privatization in order to increase members (U1), New landowners didn't share informal norms (U6)	Lack of formal rules (GS5), Volunteers (U1) did not share informal norms (U6)	Community is small and has homogenous values/norms (U6)	Lack of formal rules (GS5), Lack of awareness of externality from tree cutting (U7)
Response	None	Appealed (unsuccessfully) to external authorities, did not create new rules, recurrence of clear cut (2004) had no response	Created new formal rules to formalize informal rule/norms	NA	Created new formal rules, building on existing institutions
Factors leading to response	Norms of maintaining community relationships (U6)	Lack of shared values (U6), Went to court taking advantage of collective choice rules of a nested system (GS6)	Strong shared norms against tree cutting because of shared spiritual values ("sacred grove") (U6)	NA	Shared values about the lake use (U6, RU3), Already had a governance system in place for land mgmt. (GS6)
Adaptiveness of response	Neutral	maladaptive	adaptive	NA	Mostly adaptive
Tradeoffs	None	Invited outsiders in but unable to regulate them, Didn't have to struggle for creation, so didn't develop collective institutions	None	Small community facilitates similar norms, but incorporates weak survival capability	None

NA – not applicable

Table 4: Leadership Disturbances

	Maple	Oak	Box Elder	Twin Oaks	Tulip Poplar
Disturbance	None	Two conflictive factions within community over leadership right in the community	One leader (founding member) apparently misused community funds, and was investigated for drug issues	None	None
Factors leading to Disturbance or lack of	No one leader, system of shared power (U5), Clear collective choice rules (GS6), Homogenous values/norms (U6)	No one leader, system of shared power (U5), Lack of clear collective choice rules (GS6), Two different factions with two different mental models of the SES (U7)	Prominent leadership by one person (U5), Operational rules and collective choice rules – one person has too much power and access to capitol (GS5, GS6)	No one leader, system of shared power (U5), Group is so small that leader is not required (U1), Group has similar mental model of SES (U7), and homogenous norms (U6)	No one leader, system of shared power (U5), Clearly established rules regarding governance, including leadership (GS5, GS6, GS7)
Response	NA	Conflict taken to court for external resolution	Removed the leader quickly, Created many new formal collective choice rules building on existing strong institutions	NA	NA
Factors leading to response	NA	Lack of clear internal collective choice rules (GS6), Went to court taking advantage of collective choice rules of a nested system (GS6)	Existence of collective choice rules (GS6) and Constitutional rules (GS7)	NA	NA
Adaptiveness of Response	Anticipatory action is adaptive	maladaptive	adaptive	Anticipatory action is adaptive	Anticipatory action is adaptive
Tradeoffs	None	Costly court fees, Loss of members	None	Small size doesn't require leader but threatens group's persistence.	Bureaucracy complaints such as slow pace of decision making

NA – not applicable

Table 5: Disturbances by neighbors

	Maple	Oak	Box Elder	Twin Oaks	Tulip Poplar
Disturbance	Poaching of gin-seng and morels, Hostility from neighbors	Trespassing to use lake and forest, Poaching of ginseng, Conflict with neighbor over hayfield	Trespassing by ATVs and individuals for hunting and for bathing in the river, Hostility from neighbors	Trespassing by ATVs and for hunt-ing	Trespassing to use lake and for hunting, Poaching of morels
Factors leading to Disturbance or lack of	Economic value of forest products (RU4), Difficult monitor-ing & sanctioning (GS8) Size of resource system (RS3), Clarity of system boundaries (RS2), Lack of formal rules (GS5).	Economic value of forest products (RU4), Difficult monitoring & sanctioning (GS8), Lack of formal rules (GS5),	Economic value of forest products (RU4), Difficult monitoring & sanctioning (GS8), Conflictive local network structure with neighbors and government (GS3),	Disproportion in size of the resource system (RS3) and user group (U1) leads to very difficult monitoring & sanctioning (GS8)	Economic value of forest products (RU4), Clarity of system boundaries (RS2)
Response	Tried to work with police, but was unsuccessful, Confronted one poacher and made him give up money (but then returned it to him)	Tried to work together with external forces like police and professional hunters who would monitor the forest	Erecting signs and putting up fences, Educational activities in public relations, Created new formal rules to reduce noise	Informal attempt to control trespassers but not effective (increased from 1998 to 2007)	Community members confront trespassers directly, Security Commit-tee who would act upon trespassing issues, if needed
Factors leading to response	Network structures – link to larger governance system (GS3)	Different anticipation of the problems among members (U6, U7): only a few members are highly concerned while most members think it could be a problem, thus no internal responses	Property rights systems (erecting signs) (GS4); operational rules (GS5); network structures (with neighbors) (GS3) Strong valuation of/dependence on the forest, and strong community norms (U6)	Monitoring and sanctioning processes (GS8)	Established monitoring system (Security Committee) based on existing governance system for land mgmt. (GS5, GS6)
Adaptiveness of response	maladaptive	maladaptive	mostly adaptive	maladaptive	mostly adaptive
Tradeoffs	Costs of rule creating and/or monitoring of trespassers by community members might exceed benefits	Costs of rule creating and/or monitoring of trespassers by community members might exceed benefits	Increased number of visitors led to rising negative impacts (overuse of fire pits, poaching, trampling, sensitive understory).	Small group size and lack of financial capacity limits the capacity to effectively monitor and enforce against trespassing	None

ATVs – All-terrain vehicles