PAYMENTS FOR ENVIRONMENTAL SERVICES IN COSTA RICA: CONSERVATION AND PRODUCTION DECISIONS WITHIN THE SAN JUAN – LA SELVA BIOLOGICAL CORRIDOR

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CHAPTER 2

Social Ecological Structuration: Developing a Linked Human-Environment Model with a Case Example of Costa Rica's Program of Payments for Environmental Services

Abstract

The environment is both a setting for and a product of human interactions. Understanding the dynamic nature of human-environment interactions is critical for mitigating the impacts of human induced environmental change. Current research on environmental change has focused on the reduction in the ability of many ecosystems to provide environmental services and the subsequent impact on human well-being. To frame these interactions, a theoretical model or framework is necessary. This paper presents a model based upon linking structuration theory from the social science with a theory of patch dynamics from landscape ecology. To operationalize the model for empirical analysis, variables from a meta-analysis on tropical deforestation and from the livelihoods framework are then added and discussed in terms of multiple landscape and social scales. This model then guides an agent context analysis using Costa Rica's program of payments for environmental service as a case example. Findings suggest the model has potential for understanding land use change and evaluation of environmental service payment programs.

Introduction

A landscape is both a setting for and a product of human interactions (Scoones, 1999). Understanding the dynamic nature of human-environment interactions is critical for mitigating the impacts of human induced environmental change on the ecological services that that we, as humans, value (Stern, 1993). Research on the causes and consequences of environmental change is necessarily an integrated endeavor and has spawned a cross-fertilization of ideas among numerous disciplines (Grimm, Grove, Pickett, & Redman, 2000; Grove & Burch, 1997; Gunderson & Holling, 2002; Klein, 2004; Millennium Ecosystem Assessment, 2003; Scoones, 1999). A longstanding conceptualization of the reasons for environmental change has focused on deforestation, fragmentation and land use change in the tropics and consequent impact on biodiversity and sustainable livelihoods (such as Angelsen & Kaimowitz, 1999; Brandon, Redford, & Sanderson, 1998; Kramer, Schaik, & Johnson, 1997; Rudel & Roper, 1997). More recently, the focus of research on deforestation and land use change has shifted to environmental services that ecosystems can provide (including biodiversity habitat, carbon sequestration, watershed values, etc.), as well as how those impact human well-being (Lambin, Geist, & Lepers, 2003; Millennium Ecosystem Assessment, 2003; Pagiola, Arcenas, & Platais, 2005; Smith & Scherr, 2003; Wunder, 2007).

Discussion of environmental services has evolved from identification of their importance and value to both human and natural systems (Costanza et al., 1997; Daily, 1997) toward more nuanced efforts of classification and understanding of the ecological processes providing services (de Groot, Wilson, & Boumans, 2002; Farber, Costanza, & Wilson, 2002; Kremen, 2005; Millennium Ecosystem Assessment, 2003; Norberg, 1999). There has also been attempts to define, identify and calculate values of environmental services from ecological, economic and integrated perspectives (Boyd & Banzhaf, 2006; Heal, 2005; National Research Council, 2005; Pagiola, von Ritter, & Bishop, 2004; Turner et al., 2003; Winkler, 2006). Furthermore, a growing body of literature discusses emergent markets and public schemes used to promote/conserve land uses that provide environmental services (Ferraro & Kiss, 2002; Grieg-Gran, Porras, & Wunder, 2005; Landell-Mills & Prorras, 2002; Pagiola, Bishop, & Landell-Mills, 2002; Wunder, 2007). However, making the links between the influences of land use change and the provision of environmental services is not thoroughly developed. To date, this area has relied on integrated studies of land use change.

A recent meta-analysis of land use change case studies of deforestation in the tropics concludes that change is influenced by multiple, multiscale, and synergistic factors such as economic markets, political policies, demographic changes and technological factors among others (Geist & Lambin, 2002). Land use change is rarely driven by single underlying factors such as population or poverty as is commonly perceived (Lambin et al., 2001). In accordance with this more dynamic perspective, a landscape can be viewed as the result of complex adaptive systems where multiple household production decisions resulting in land use allocations are made within a particular social and environmental context over time (Lambin, Geist, & Lepers, 2003). This has led to a shift in analysis to 'people in places', where detailed social and environmental histories are used to provide information about how unique and dynamic social contexts influence land use choices of households (agents) over time (Batterbury & Bebbington, 1999; Leach, Mearns, & Scoones, 1999; Scoones, 1999). However, as indicated in Lambin et al. (2003):

> What has been lacking so far is the development of an integrative framework that would provide a unifying theory for these insights and pathways to land use change and a more process oriented understanding of how multiple macro-structural variables interact to affect micro agency with respect to land. (p. 217)

The need for this type of integrative framework for human-environmental systems has also been identified by others and has led to the development of a number of conceptual models of linked human-environmental systems (such as Alberti et al., 2003; Bebbington, 1999; Grimm, Grove, Pickett, & Redman, 2000; Millennium Ecosystem Assessment, 2003; Pickett et al., 1997). However, none of the models to date explicitly identify variables and relationships or adequately use social and ecological theories that account for both agent – structure interactions of social systems let alone the linked biophysical patterns and processes.

This research was part of a larger interdisciplinary study that explored the consequences of Costa Rica's program of payments for environmental services (PES) on influencing landowners' decisions regarding land use and the subsequent provision of environmental services. As such, a model that could be used to explore policy, landowner decision making and their linkage to the provision of environmental services was postulated. The first part of this paper is dedicated to the presentation of the theoretical model, which

links micro-macro social and ecological process; a Social Ecological Structuration Model (SEStM). The model was developed for investigating the impact of Costa Rica's PES program on land use decisions and how those decisions have influenced the provision of targeted environmental services.

The second part presents a case study using the model to explore the dynamic social context for implementation of Costa Rica's PES program for landowners within the La Selva – San Juan portion of the Mesoamerican Biological Corridor. The objective of this portion of the paper was to identify the social factors that have influenced land use change in the region since 1969. The year 1969 was selected because it was the first formal Forestry Law. Specifically, the following four research questions were asked: 1) What are the social systems that have influenced land use decision since 1969?; 2) How have the identified social systems influenced land use decision since 1969?; 3) What are the Forestry Laws and policies that have influenced land use decision since 1969?; and 4) How have the identified Forestry Laws and policies influenced land use decision since 1969?

Social Ecological Structuration Model (SEStM)

To understand the impacts of Costa Rica's policy on land use decisions, an approach encompassing how structural factors (policy) influence agents' (landowners) decision making was used. Additionally, the framework incorporated aspects of land use choices and their relationships to changes in environmental services. Elements of structuration theory from the social sciences (Giddens, 1984; Stones, 2005) and the theory of patch dynamics from the ecological sciences (Pickett & White, 1985; Wu & Loucks, 1995) were used to provide the heuristic framework for this study. The following sections will present the integrated theoretical components of this social ecological structuration model (SEStM). Next, the use of the model to conduct an actor-context analysis (Stones, 2005) specific to understanding Costa Rica's PES program is described.

Land Use and Land Cover

Land cover is the link between social and ecological systems and the key element for understanding the effect of policy and landowner livelihoods and on the alteration of landscape patterns ultimately resulting in environmental services. Quoting Leach et al. (1999):

> People's actions and practices, preformed within certain institutional contexts, may serve to conserve or reproduce existing ecological features or processes (e.g., maintain a regular cycle of fallow growth or protect the existing state of a watershed and its hydrological functions). But people may also act as agents who transform environments (e.g., shorten the fallow, altering soils and vegetation, or plant trees in a watershed). (p. 239)

Pickett et al. (1997), Grimm et al. (2000) and Redman et al. (2004) have also argued that land use and land cover should be the central focal point of linked human-environmental systems in the study of urban ecosystems...

Two separate theoretical frameworks interact and mirror each other in the model. However, since the mechanisms of ecological and social structuration function differently, they were modeled as opposite sides of the same process. For example, humans act with foresight, intent, reflexivity and can communicate these ideas into the future, which ecological systems do not (Holling, Gunderson, & Peterson, 2002; Walker et al., 2006). Further differences that have been identified are the ability of humans to abstract from a situation in time and space, the ability to be reflexive and evaluative, the ability to generate expectations, the ability to create technology, and the scale of influence that humans have, all of which warrant using a theoretical framework that can differentiate the systems processes (Westley, Carpenter, Brock, Holling, & Gunderson, 2002). The theoretical frameworks mirror each other in that they together represent linked complex adaptive systems that are both the medium and outcome of interactions recursively organized across time and space (Giddens, 1984; Gunderson & Holling, 2002; Scoones, 1999).

Structuration Theory

Structuration theory (Giddens, 1984; Stones, 2005) is a promising social theory for linking social and ecological systems (Bebbington, 1999; Gunderson & Holling, 2002; Leach, Mearns, & Scoones, 1999; Scoones, 1999). Structuration theory combines "the notion of emergent processes with the notion of enduring institutions" (Scheffer, Westley, Brock, & Holmgren, 2002). It postulates "the interaction of structure and agency across scales [that] must be the centerpiece of a dynamic understanding of people-environment interaction" (Scoones, 1999, p. 493). A number of studies have argued that structuration theory can help to: 1) move beyond static structural explanations (Leach, Mearns, & Scoones, 1999); 2)

frame rural livelihoods analysis (Bebbington, 1999); 3) integrate human-environmental systems across scales (Warren, 2005); and 4) provide an explanation of the similarities and differences in social and ecological systems (Scheffer, Westley, Brock, & Holmgren, 2002; Westley, Carpenter, Brock, Holling, & Gunderson, 2002). Giddens' structuration theory as presented by himself and others (Giddens, 1984; Kaspersen, 1995; Kondrat, 2002; Munch, 1994; Ritzer & Goodman, 2004), but particularly as modified by Stones (2005) forms the basis of this study's model.

Social Structuration

Structuration theory avoids an overly objective structural approach and an exaggerated emphasis of subjectivist, agent-based approaches by focusing on their interaction as socially situated practice (Stones, 2005). Human action is viewed as a continuous flow of practice (Giddens, 1984). Based on this procession of human social conduct, Giddens identifies a concept termed duality of structure. It is a duality because agents and structure are not considered independent of one another (Ritzer & Goodman, 2004). Structure is seen as both "the medium and outcome of the conduct it recursively organizes; the structural properties of social systems do not exist outside of action but are chronically implicated in its production and reproduction" (Giddens, 1984, p. 374). Structure enters into the constitution of the agent as a medium (internal structure) and from there into the practices that the agent produces as an outcome (external structure) (Stones, 2005). Structures that are the outcome of one period of practices (actions, activities, praxis) become the medium for the next round of agents' practices (Stones, 2005). Through recursive social practice, structures influence the activity of individuals, who in turn, produce, transform, or otherwise reaffirm those same structures constantly producing and reproducing society (Kaspersen, 1995; Kondrat, 2002). According to Munch (1994),

> This means that structures are not predetermined once and for all, but made in social praxis. All social praxis starts with a given structure that has emerged from previous praxis and provides an instantiation of that structure in social actions, and results in contributing to the continuation or transformation of the structure. (p. 191)

Therefore, the process of structuration can be defined as the "structuring of social relations across time and space" due to the recursive nature of social practice (Giddens, 1984).

Social Systems

Social systems can be thought of as the *patterns* of social relations, or regularized social practices that stretch across time and space produced by the process of structuration (Kaspersen, 1995). They are the "complex, entrenched, and powerful networks of relationships, behaviors, beliefs, interactions, rules, and resources" and are both temporally and spatially contingent (Kondrat, 2002, p. 446). Furthermore, they are integrated with other social systems hierarchically and across space and over time; "all societies both are social systems and at the same time are constituted by the intersection of multiple social systems" (Giddens, 1984, p. 164). However, if one of the social systems involved is based a long way away from the actor spatially (e.g. global markets) or temporary (e.g. the constitution), the more resistant to change the social systems become (Giddens, 1984).

Agency

That said, actors (households owning land) are perceived to always have agency, to be able to 'act otherwise,' 'make a difference' or otherwise intervene in the world (Giddens, 1984). This means that an actor has the power to make things change, and that whenever an actor acts; it is an assertion of that power (Munch, 1994). An actor's agency/capabilities in this regard also emanate from their ability to harness elements of structure (Bebbington, 1999; Stones, 2005). Structures are considered to be both enabling and constraining of agents actions (Giddens, 1984). Structure can be further broken down into 'rules and resources' that are recursively involved in the reproduction of social systems (Giddens, 1984). Rules are "techniques or generalizable procedures applied in the enactment/reproduction of social practices" (Giddens, 1984, p. 21). These are the formula or procedures to action that tell us 'how to get on' in the world (Kaspersen, 1995). Rules can be codified and formal, such as laws and regulations or informal such as how close one should stand when talking (Kondrat, 2002). The term *rules* is considered by some to be an overly rigid interpretation of social structure, so the term *cultural schemas* (or schemas) has been offered as a replacement (Sewell, 1992; Stones, 2005). Resources, on the other hand, refer to the 'structures of domination' and include both allocative and authoritative resources (Giddens, 1984). Allocative resources are the "material resources involved in the generation of power, including the natural environment and physical artifacts" (Giddens, 1984, p. 373). Authoritative resources involve domination or control over people and their activities (Giddens, 1984). Having control over either of these types of resources can increase an

agent's power and transformative capabilities (Sewell, 1992). However, all actors are not situated equally in their capabilities, or knowledge of schemas and access to resources as indicated by Kondrat (2002):

> Actors may be located at varying positions along structuring dimensions of social life such as class, status, gender, and cultural or religious marginality. An individual's social location influences access to resources (including technological resources), power, opportunity, and information, all of which enter into the determination of what one knows, does not know, or is prevented from knowing (Giddens, 1984, Kondrat, 1999). (p. 441)

Additionally, an actors knowledge of and access to structural resources is likely to be geographically and historically contingent (Kondrat, 2002). Agency can also be limited by other actors who have sanctioning power. Therefore agency should be seen on a continuum where all actors have some degree of agency, but no actor has completely unconstrained agency (Ritzer & Goodman, 2004). Power, then, is the medium through which agency operates and can be "defined pragmatically in terms of the allocation of rules and resources in a given situation" (Kondrat, 2002, p. 438).

Giddens views actors as both powerful and knowledgeable; "all social actors know a great deal about the conditions and consequences of what they do in their day to day lives" (Giddens, 1984, p. 281). A key to understanding the capability of actors to use structural resources is the conception of the agent in structuration including: 1) motivation to action; 2) knowledgability and the rationalization of action; and 3) reflexive monitoring of action (Giddens, 1984). Motivation to action includes the wants and desires that prompt individuals to engage in social practice. Motivations can be intense and directed but are usually mundane with no motivation identifiable for most daily actions (Stones, 2005). Rationalization of action includes knowledgability of social structures and how to do things best to obtain one's goals (Munch, 1994). Reflexive monitoring of action includes the intentional and purposive part of action (Kaspersen, 1995). While agents are seen as knowledgeable it is not a perfect knowledge, "the agent's knowledgability is always limited by the unacknowledged conditions of and the unintended consequences of action" (Kaspersen, 1995, p. 40).

Visualizing Social Structuration

Building on this framework and the critiques of numerous authors (Archer, 1995; Mouzelis, 2000; Sewell, 1992 and others as cited in Stones, 2005), Stones (2005) outlined a quadripartite formulation of structuration. As the four stages are outlined, they will be represented on a diagram (Figure 1). To maintain the mutually constitutive formulation of the duality of structure and to heed cautions about using too simplistic and sequential pattern of causality (Stones, 2005, p. 20), we have adopted a cyclic model to present the four stages of structuration as a process. The model is similar to and adopted from Gunderson and Holling's (2002) adaptive cycles used to represent their "heuristic theory of change" (Holling & Gunderson, 2002, p. 49). However, for the purposes of this paper, the model depicts the process of structuration specifically and does not apply it to the four phase cycle representing exploitation, conservation, release and reorganization of social and ecological systems of Panarchy theory (though the sequence of these phases is entirely possible within the structuration framework as presented herein).

Stones (2005) presents the duality of structure in four separate but dependent components. The diagram presents the process of structuration as a linked figure eight showing structure as both the medium and the outcome of actors' actions (Figure 1). The arrows represent the flow of time, but also to demonstrate the continual interaction of the structure and agency. The three aspects describing the process of agency happen instantaneously through action and the outcomes (both internal and external) are created for the next period. This flow of structuration is outlined with a hypothetical example of a landowner's (the actor) decision to change land use (Figure 1). The larger and thicker circle representing external structures is to be indicative of the time space distanciation of social structures, they are generally slower to change and last longer than agents (Giddens, 1984).

External social structure (1S- Figure 1).

The first (though there is no correct order as the process is cyclic) aspect is external structures as conditions of action. This is the in situ 'action horizon' structural context faced by the landowner at time 1 (T1) (Stones, 2005) and is diagramed as the top of the structure circle flowing into the landowner. External structures feature existing social systems such as the economic markets for goods and services, the politics and policies regulating trade, and the cultural norms related to marketing a product that are present at time one and currently exogenous to the landowner.

Internal structure (2S).

External structures or social systems are diagramed to flow into the internal structures of landowner livelihood strategies. Examples of a landowner's internal structures include their worldview and general understanding of the norms and procedures of how a market system operates (schemas) and their specific understanding of their place within those systems. Internal structures would include landowner's knowledge of the resources at their disposal and how to apply those resources to accomplish their goals. A landowner can look at price trends and supply and demand and consider their own costs and benefits and make a decision about whether to clear land or to plant a crop. They can also make use of their social assets and talk to their neighbors and extension agents to learn about what they have to say about the market conditions.

Unacknowledged conditions (dashed line).

The dashed line above the internal structures represents the unacknowledged conditions at time one (T1). This aspect of the model recognizes that knowledge of the external structures such as markets and policies is often incomplete, such that actors lack perfect information at any given time. Current investment in the same crop in another country is an example of a possible unacknowledged condition that might affect price at harvest time.

Action (3S).

The third aspect of the duality of structure is that of active agency where the landowner uses the internal structures for action. This is the moment of structuration. This is where a landowner makes a decision applying their knowledge of the social systems and their capabilities and control over resources such as financial assets for investment and their farm conditions and takes an action that impacts land cover. For example, a landowner may clear a patch of forest or change a pasture into a crop. This is the 'proximate' cause outlined in the land use change literature and is the result of the landowners action.

Outcomes (4S & 5S).

The final phase is that of outcomes as "external and internal structures and as events" (Stones, 2005, p. 85). In this way there are multiple simultaneous outcomes of the action, internal and external outcomes. Results of the action may have pleased or frustrated the landowner changing or reinforcing internal structure as part of the whole structuration

process (Stones, 2005). The planting of a crop may have been more difficult or costly than expected or the labor may have been unreliable all of which the landowner has learned and will consider in any subsequent land use decision as part of their internal structure. Additionally, the external social structure could be elaborated, reproduced or preserved by the outcome of the event. In the action of planting a crop, the landowner bought seeds from a local distributor and hired employees from local labor force, reinforcing or contributing to the social systems that support the industry surrounding that crop.

Unintended consequence (dashed line).

The dashed line below the internal structures as outcomes represents the unintended consequences of the action that is both an input to external structures and internal structures for the next period. A landowner may not have expected that their own land use decision to influence migration patterns, but the hiring of employees may have contributed to local demand for labor and immigration to the area.

Theory of Patch Dynamics

Patch dynamics theory is used in this model to present the ecological 'side' of the complex adaptive systems (Pickett & White, 1985). Additionally, hierarchical patch dynamics (Wu & David, 2002; Wu & Loucks, 1995) is incorporated because it focuses on both the structural and functional properties of patches. This theory was selected because of its prevalence in landscape ecology and conservation biology (Franklin, 2005). Patch dynamics are also effectively and commonly applied to land use change studies with remote sensing and GIS technologies because of its landscape, or horizontal perspective (Turner, Gardner, & O'Neill, 2001). Because of these properties, the framework also lends itself to framing ecological processes across a variety of scales useful for assessing environmental services. Using a human ecosystem model, both patch dynamics and hierarchical patch dynamics have been used to explain ecological and social processes in urban ecosystems (Grimm, Grove, Pickett, & Redman, 2000; Grove & Burch, 1997; Machlis, Force, & Burch, 1997; Pickett et al., 1997; Wu & David, 2002).

Ecological Structuration

Modern ecological understanding of environments is that they are non-linear, hierarchically organized, have multiple equilibrium, and function as complex adaptive systems (Gunderson & Holling, 2002; Levin, 1999; Peterson, 2000; Scoones, 1999; Wu &

David, 2002). Quoting Levin (1999) (as cited in Gunderson and Holling 2002, p. 89), "The combined weight of multiple small scale processes can accumulate to help shape other patterns of interaction, and hence the structure and function of ecosystems, from small scales to the biosphere." This concept of dynamic interaction of small and fast variables with large and slow variables is also a fundamental concept for the adaptive cycle in Panarchy (Gunderson & Holling, 2002). Along this same line, Scoones (1999) describes ecological processes using the key notion of recursiveness as used in structuration theory; "environments are dynamically and recursively created in a nonlinear, nondeterministic, and contingent fashion" (Scoones, 1999, p. 492). When this recursive process of ecological 'structuration' is viewed with the explicit interaction of linked social and ecological systems, it has been termed "structuration of the environment" (Leach, Mearns, & Scoones, 1999, p. 238). For this model, we use patch dynamics as an ecological theoretical framework within a recursive structuration process that structures ecological relations across time and space.

Patches

Patches are defined as a discrete spatial pattern or homogeneous unit relative to an ecological system that can be characterized by their size, shape, content, structure, function or complexity (Wu & Loucks, 1995). Patches are scale independent and the research question of interest drives patch definition (Pickett, Wu, & Cadenasso, 1999). Hierarchy theory was integrated with patch dynamics to extend the ability of the theory to address multi-scale issues with a 'vertical' perspective (Wu & Loucks, 1995). Controlling for complexity by using the idea of 'enveloping' from hierarchy theory, or the exploration of the scale below the focal scale to understand mechanism while examining the scale above to understand context, provides a practical framework for analyzing patch dynamics (Allen & Hoekstra, 1992; O'Niell & King, 1998; Wu & David, 2002). As described in this model, the focal level is the patch with the impacts of disturbance on the patch's internal dynamics as the scale below and the impact of those changes on the larger patch mosaic as the scale above. In this way, it is possible to consider hierarchies of nested patch mosaics where at each level a patch is composed of its own dynamic patch mosaic (Wu & Loucks, 1995). This is an important feature for use in this model because it recognizes the internal structure of an individual patch. As with the internal structure of the actors in structuration theory who have various

livelihood assets, the individual patch will have its own unique heterogeneity, function, and relationship to the external patch mosaic.

Patch Dynamics

The theory of patch dynamics defines ecological systems as dynamic patch mosaics and "studies the structure, function and dynamics of patchy systems with an emphasis on their emergent properties that arise from interactions at the patch level" (Wu & David, 2002, p. 11). It emphasizes change and heterogeneity which are driven by natural variation and disturbance (Turner, Gardner, & O'Neill, 2001). Disturbances are discrete events that change patches and are classified by size, shape, frequency, and intensity (Turner, Gardner, & O'Neill, 2001). Disturbances can be either naturally occurring such as a lightning fire or due to human intervention such as land use change. Multiple patches form a landscape or patch mosaic. A dynamic patch mosaic refers to the change in the mosaic over time including changes in structure and function (Pickett, Wu, & Cadenasso, 1999). We can therefore view a duality of patch dynamics where the external structure of the patch mosaic is both the medium and the outcome of recursive disturbances at the patch level. Disturbance corresponds to the actors' actions in structuration theory. Action and disturbance become synonymous when the action is one of land use change.

Visualizing Ecological Structuration

Figure 2 presents the process of ecological structuration as a linked figure eight designed to show how structure (both internal patch and external patch mosaics) is both the medium and the outcome of disturbance events. The flow is meant to show the progress of time, but also to demonstrate the continual interaction of the patch with the patch mosaic. It is suggested that this model represents the hierarchical patch dynamics model in terms of flows; "Thus, the dynamics of ecological systems are composed of the dynamics and interactions of constituent patches on different scales; this is an emergent property in that it is not simply the sum of the individual patch dynamics." (Wu & Loucks, 1995, p. 451). The three aspects describing the process at the patch level happen instantaneously as the outcomes (both internal and external) are created for the next period. The larger and thicker circle representing structures is to be indicative of the time/space distanciation of ecological structures; they are generally slower to change and last longer than individual patches.

External structure (1E - Figure 3).

The first (though there is no correct order as the process is cyclic) aspect is the patch mosaic as the existing condition at time one (T1) (external structure) and is diagramed as the top of the patch mosaic circle and flowing into the internal patch structure. This is the initial condition or template "for the subsequent structural development and dynamic interactions of the system" (White & Brown, 2005, p. 31). A landscape composed of a patch mosaic of forest and agricultural lands with all the attendant ecological functions and processes such as soil erosion rates into streams is an example of the external structure at time one.

Internal patch structure (2E).

The internal structure of the patch prior to a disturbance is included to represent the internal patch mosaic of any given patch within the hierarchical patch mosaic at time1. The patch in this case might be a forest that a landowner is considering clearing to plant crops. The patch of forest has certain characteristics of its own such as riparian areas and fallen tree gaps signifying its own internal patch mosaic.

Disturbance (3E).

The third aspect of the model represents the disturbance event on the patch. Disturbance (like action in the social system), is the catalyst of structuration of the ecological system, where the disturbance has the potential to transform, reproduce or maintain the structure and function of the patch and the patch mosaic. The disturbance could be caused by a farmer clearing part of the patch to plant a crop or could be a fire that runs through the patch of forest.

Outcomes (4E & 5E).

A disturbance will impact both the internal structure of the patch, but also, and simultaneously, be an input to alter the dynamics in the patch mosaic. A disturbance may have impacts on some aspects of the internal patch mosaic, but not others. For example, clearing a forest for a crop may leave a buffer around riparian areas, or a fire may never reach the crown of a forest. Therefore, *how* the patch has been impacted by the disturbance (disturbance to structure at the internal patch level, or the internal patch mosaic) will impact how it will in turn influence the larger patch mosaic. The structure of the patch mosaic could be changed, reproduced or preserved by the outcome of the disturbance. The example of forest clearing may significantly alter landscape connectivity and impact biodiversity at the

landscape level, however, a ground fire may reinforce the patterns of vegetation that are dependent on fire.

Social Knowledge of Ecological Systems

The combination of the two models requires further explanation (Figure 3). In structuration theory there is a distinction made between actions and intentions (Ritzer & Goodman, 2004). The distinction is made because of the limited nature of human knowledgability and the likelihood of unacknowledged conditions and unintended consequences of human action (Giddens, 1984). These conditions have already been addressed in relation to social structures, however, when combined with ecological systems; two new instances need to be added to the model.

Actor's knowledge of ecosystems (1SE).

This process is labeled with the social element first, because it represents an interaction element of the social and ecological systems. This is the landowner's knowledge of 'ecology in general' of the larger patch mosaic (Figure 3). It includes a landowner's general knowledge of the larger environment, about conditions, processes, feedbacks, and thresholds. For example, a landowner may have a general understanding about greenhouse gases and global warming and how carbon from the atmosphere could be sequestered in their forest.

Actor's knowledge regarding knowledge about their land (2SE).

This is the specific knowledge that a landowner has about the ecological conditions specific to the action they are considering such as land use change on their farm. This 'local knowledge' may be different than their general ecological knowledge due to direct interaction and feedbacks that they may have experienced and learned on their land. A landowner may be aware of variations of soil types across their land and how crops have fared in the past.

Actor's unacknowledged conditions of ecosystems (dashed line).

As noted regarding ecosystems, "knowledge of the system we deal with is always incomplete. Surprise is inevitable. Not only is the science incomplete, the system itself is a moving target" (Holling, 1993, p. 553 as cited in Scoones, 1999). There may be unacknowledged conditions about both general ecosystems and the landowners own land. Both of these unacknowledged conditions are indicated by the dashed line beginning in the

patch mosaic at time one (T1) and entering into land use and cover change action/disturbance of the agent.

Unintended consequences (dashed line).

The land use decision by a landowner results in an action/disturbance that may be either intended or unintended. Either way, the physical result is represented in 4E as the internal patch outcome. The remaining dashed line under 4E is to indicate unintended ecological consequences of the landowner's action. An example of this is if the crop the landowner planted had led to the spread of a disease across the landscape.

Open systems.

The final elements on Figure 3 are the flows to and from other social and ecological systems. These are done in recognition that both social and ecological systems are open systems (Gunderson & Holling, 2002). Both systems represented are hierarchical across both space and time and therefore require acknowledgement of flows to and from other systems (Giddens, 1984).

Methodological Bracketing

The SEStM depicts the multiple scales of analysis that are necessary to analyze land use change at the regional level. It frames the individual decisions farmers make on their land in terms of agency, and the contextual external structures in terms of social structures. Methodological bracketing is a method designed to focus the researcher on certain aspects or dimensions of the structuration process (Giddens, 1984). Stones (2005) reformulated Giddens' brackets to include agents' conduct analysis and agent context analysis. The conduct analysis is focused on the knowledgability, motivations, reflexive monitoring, and desires of the agent (Stones, 2005). Context analysis is intended to be "used to analyze the terrain that faces an actor, the terrain that constitutes the range of possibilities and limits the possible" by focusing on social systems (Stones, 2005, p. 122). The two bracketed methods are intended to provide an outside-looking-in and inside-looking-out analysis of the process of structuration in social systems. A similar type of bracketing that helps reduce complexity can be found in the use of hierarchy theory for ecological systems (O'Neill, Johnson, & King, 1989).

Empirical Analysis

For empirical analysis, however, the model needs additional specificity and identifiable variables. As recommended by Stones (2005) and McKee et al. (2000), combining research frameworks with insight into a particular issue can "produce more powerful critical frameworks" (Stones, 2005, p. 119). Therefore, a meta-analysis of the proximate and underlying causes of tropical deforestation (Geist & Lambin, 2001; Lambin, Geist, & Lepers, 2003) was used to provide variables for the social systems for a context analysis. Variables identified for analysis of livelihood strategies were added to specify the actors' capabilities to exert power for the agent conduct analysis (Bebbington, 1999). A summary of the two frameworks follows.

Agency to Livelihood Strategies

Livelihood strategies are the activities and choices that actors (in this case, landowners) make about the different ways of combining their livelihood assets to meet their own goals and objectives that can vary within geographic areas, across sectors, and even within households over time (Chambers & Conway, 1992). Livelihood assets include: 1) human; 2) social; 3) financial; 4) physical; and 5) natural capital (DFID, 2003). Individual farm households are different in terms of livelihood assets in that they have varied production goals, skills and knowledge, resource endowments, and incorporate different combinations of factors of production in their livelihood strategy (Leach, Mearns, & Scoones, 1999). As indicated in the discussion of agency, power is associated with proximate control over, or the capability to access and use rules and resources (Giddens, 1984). Because different actors begin with different initial endowments of livelihood assets, agent capabilities may be measured in terms of livelihood assets as detailed in Bebbington (1999). We will follow their insights for this model, and use the five livelihood assets as a measure of an agent's capability to exert power (DFID, 2003). Both social and human assets were used to identify authoritative resources to measure access to and integration of social structures into agents' internal structures. The livelihood assets identified as financial, physical, and natural were used to assess the allocative resources and the 'material levers' that landowners can combine with their social and human assets to perform an action and exert power. However, landowners are also nested within a regional and global context where socio-cultural, economic, and policy forces are constantly changing. The context of these social systems that an individual faces influences decisions regarding different livelihood strategies.

Structure to Social Systems

A meta-analysis of case studies of tropical deforestation provided a detailed account of the social systems associated with deforestation and land use change (Geist & Lambin, 2002; Lambin, Geist, & Lepers, 2003). In their analysis (Lambin, Geist & Lepers 2003), land use change can be seen as a process akin to structuration:

> Human-environmental systems are complex adaptive systems in which properties, such as land use, emerge from the interactions among various components of the entire system, which themselves feed back to influence the subsequent development of interactions. (p. 227)

Drivers of land use have been framed as proximate and underlying causes (Geist & Lambin, 2002). Proximate factors are the human actions that have directly led to land use change while the underlying factors are described as the indirect social factors causing the proximate changes. "Underlying causes are formed by a complex of ….variables that constitute initial conditions in the human-environment relations and are structural (or systemic) in nature" (Lambin, Geist, & Lepers, 2003, p. 203). The underlying factors identified in Geist & Lambin (2002) include: 1) demographic factors; 2) economic factors; 3) technological factors; 4) policy and institutional factors; and 5) cultural factors while predisposing environmental factors (e.g. soil quality); biophysical drivers (e.g. drought) and social trigger events (e.g. war) were lumped into an 'other' category within their framework. Two modifications to the model they presented were made including the inclusion of: 6) natural factors; and 7) infrastructure as a main bins or categories of social systems. As a key focus of this model is land use change, it was determined that the environmental factors (natural factors) were a critical element for evaluation. Additionally, although the category 'infrastructure' is presented as a proximate cause of land use change (a road takes up space) in the Geist and Lambin (2002) model, it made more sense to include infrastructure as a social system within this model where the proximate causes are directly resultant from landowner actions. Therefore, infrastructure in this model is presented as a social system that enables or constrains landowner decisions. Similar variables reported to drive land use change were found in frameworks for long term ecological research programs (Redman, Grove, & Kuby, 2004) and for the evaluation of the impact of loss of environmental services on human well being (Millennium Ecosystem Assessment, 2003). Table 1 and Figure 4

present how variables from the two frameworks were combined within the SEStM for empirical analysis.

Methodology

This research was part of a larger interdisciplinary study that explored the consequences of Costa Rica's program of payments for environmental services. This portion of the study explores the influence of social systems on conservation and production decisions about land use in the La Selva – San Juan portion of the Mesoamerican Biological Corridor in Costa Rica from 1969 until 2003. The conceptual model previously explained guided the data collection and analysis. The agent context analysis is presented in this paper as an example application of that component of the model.

Agent Context Analysis

To conduct the agent context analysis a single case study approach was used (Yin, 1994). A case is a phenomenon bounded in time and space (Miles & Huberman, 1994). The case presented here is the influence of social systems on farmer conservation and production decisions. The spatial boundary of the case is the San Juan-La Selva portion of the Mesoamerican Biological Corridor where Costa Rica heavily targets its PES payments. The temporal boundary of the case was selected on the basis of the signing of Costa Rica's first forestry law in 1969 with emphasis on land use changes since the mid-1980s until 2004 and used for the interdisciplinary study. Two sources of evidence were used: expert interviews and document evidence. These provided both a form of data triangulation and methodological triangulation "aimed at corroborating the same fact or phenomenon" (Yin, 1994, p. 92).

Data Collection and Participant Selection

Qualitative data were collected through semi-structured interviews with local land use experts (Table 2). Qualitative data were collected to provide richness and to explore the meaning, or salience, people place on the events and structures in their lives (Miles and Huberman 1994). Experts were defined as individuals that had influenced or had special regional insights to landowner land use decisions. The experts lived and/or worked in the region at local offices on a daily basis often working directly with landowners. These experts were members of conservation and production NGOs, government agencies, local companies, tourism operators or non-affiliated individuals. Eighteen semi-structured

interviews were conducted in the fall of 2003. Interviews lasted approximately 1 ½ hour and were led by the lead author and one assistant. Four interviews were conducted with individuals and the rest with small groups. Small groups were interviewed to allow for discussion and synergistic effects that can develop in group interviews. After each interview, names of other 'experts' in the region who could provide insight into the study were solicited. This was a form of snowball sampling and used to identify additional participants to interview (Tashakkori & Teddlie, 1998). These groups of experts were important for both their intimate knowledge of the land use in the region and for their ability to provide access to local farmers in the region. Interviews were conducted until the amount of new information obtained at each interview declined dramatically and the suggestions for additional 'experts' no longer provided new contacts.

Expert Interviews

The small group semi-structured interviews with land use experts had two main components: 1) a land use – social system analysis using a matrix to guide the interview and 2) a land use transition tree. The expert group interview was used to explore how the regional social systems influenced landowner conservation and production decisions about land use. This grounded but regional perspective was considered key to understanding the local influence of social systems and provides a narrative perspective (Butterfield, 1994).

The first section of the interview allowed the experts to generate lists of current and historical local land uses (e.g. pineapple, forestry, pasture) that have existed in the region. They were instructed to discuss each land use from the perspective of each social system variable from the conceptual model (Figure 4). Data from this discussion was used to develop a historical timeline of influences on land use change for the study area (Figure 5). The second part of the interview had the experts develop a land use transition tree to identify and restrictions or land use legacy issues or restrictions. Participants were asked to describe the process of land use change from forest to the land uses that they identified in the previous part of the interview. For example, if they identified a change from forest to pasture this would be drawn as the first branch on a tree. If pasture was reported to change to perennial crops or reforestation, these were drawn as a second branch coming from pasture (Figure 6).

Data Analysis

Interviews were transcribed and entered into NVIVO (N6) textual analysis software (QSR, 2002) to organize the textual data for analysis through coding and data display. Coding is part of data reduction and conclusion drawing (Miles and Huberman 1994). Data analysis was ongoing throughout the interview process in batches with 3-4 interviews conducted before each analytical phase. This was done to allow time for transcribing the interviews. The analysis of qualitative data used descriptive coding which utilizes basic categorical codes as descriptive devices to categorize data. In the case of this research the codes included the categories from the decision model developed in the SEStM model; economics and technology, politics, infrastructure, culture, demographics, and nature (Figure 4). Organizing interview data under these codes formed the first layer of data reduction and analysis (Miles and Huberman 1994). Matrix displays with land uses on one axis (pasture, forest, pineapple, etc.) and social systems on the other (economics, politics, etc.) were then developed from the coded data. In this way it was possible to compare land uses by each social system attributed to be a factor in the selection of that land use.

Document Evidence

Contextual analysis of documents was used to understand the evolution of social systems influencing land use change at the national and regional level for this specific case. The documents used included government agency reports, company/NGO reports, theses, and peer reviewed literature that directly addressed the case (Yin, 1994). Data from the expert interviews was used to target documents for the purpose of corroboration and augmentation of information revealed during the interviews (Yin, 1994). Over 100 documents specific to this case were identified and analyzed. Special emphasis was given to forest policy in the evaluation of land use change because the context of the environmental service payment program was the focus of the study. Document analysis provided a systemic perspective of the underlying factors or social systems associated with land use change (Lambin, Geist, & Lepers, 2003). This information provided the opportunity to track trends over time and ‘fill in’ the temporal aspect of a historical timeline in detail (Yin, 1994). The results of this contextual analysis are presented in the form of a historical timeline of major policy and other social systems that were documented to influence land use in the region (Figure 5).

Quality Assurance

Multiple sources of evidence including expert interviews and secondary data in the form of documents specifically relevant to the case were used to triangulate data and thus improve inference quality (Yin 1994). The interview data provided a local 'story' of which social systems were thought to be important to landowners from their grounded perspective. Documents were used to augment and corroborate the findings of the interviews (Yin, 1994). Another consideration in quality design of a study is the potential for researcher effects which occur when participants change, target, or otherwise behave differently then they normally would because they know they are being studied (Miles and Huberman 1994). To minimize this potential problem the purposes of the research, researcher affiliation, and how the research would be used were made clear to participants (Miles and Huberman 1994).

Two additional methods were used to ensure interpretative rigor, including member checks, and peer debriefing. A member check involves having a participant in the study check the categories, conclusions and interpretations made by the researcher. Four formal member checks were conducted with expert representatives at the end of the expert interview phase. The expert 'story' was reviewed with each expert to identify missing or misinterpreted information. Peer debriefing on coding was conducted to probe the analysis for any potential biases (Tashakkori and Teddlie 1998).

Study Site

This research was conducted in the San Juan - La Selva portion of the Mesoamerican Biological Corridor (MBC). The MBC is a multinational project designed to integrate the conservation of ecosystems and biodiversity with sustainable cultural, social, and economic development (Miller et al. 2001). The MBC is a network of core protected areas and buffer zones linked together by proposed corridors throughout Central America. The San Juan-La Selva portion of the corridor connects the central volcanic mountain range of Costa Rica and the Indio Maiz protected area of southeastern Nicaragua. Costa Rica has established this area as a priority area for targeting PES payments.

Costa Rica's development policies have adjusted and been transformed by both national and global economic and political processes. Additionally, forest policy in Costa Rica has been evolving and adapting to changes in national forest conditions within the country and with the evolving understanding of conservation and the environment at the national and global level. It is therefore necessary to understand the historical contingencies

and dynamic nature of these social processes if we desire to understand land-use and land-cover trends and to manage them toward desired ends. What follows is a historical timeline of the evolving forest policy and social context of the San Juan-La Selva corridor region in Costa Rica beginning with the passage of the first forestry law (Figure 6).

Results from Document Evidence Data Analysis

Social Context

1969-1979: Colonization and cattle expansion under policies of import substitution.

Two main factors influenced land use change in the region during this period including the expansion of banana plantations and colonization linked to several government policies. The government of Costa Rica offered incentives to banana companies in the mid-1960s to induce local companies to establish plantations (Montagnini, 1994). Moving up from the Atlantic lowlands, Standard Fruit Company established banana plantations in the region in 1967 (Pierce, 1992). In doing so they improved the road infrastructure and generated numerous employment opportunities drawing people to the region (Butterfield, 1994).

The study area is characterized by its relatively recent forest frontier status and colonization history (largely since the 60s) and for the large proportion of both spontaneous and government colonization projects (McDade, 1994; Montagnini, 1994). Government colonization was promoted and organized by the agrarian development institute (IDA, see Appendix 1 for a list of acronyms) which was formed in 1962 to take advantage of on unused public lands (Butterfield, 1994). IDA was created in response to problems with increasing landless individuals due to concentration of lands into fewer large landholdings in other areas of the country (Cruz, Meyer, Repetto, & Woodward, 1992), combined with increasing national population (Brockett, 1998), and difficult times for producers in the central valley in the mid 1960s (Bouman, Jansen, Schipper, Hengsdijk, & Nieuwenhuyse, 2000) which were pushing people to the frontiers in search of land.

In addition to government colonization, spontaneous colonization of the region was reportedly driven by a number of other factors including land titling laws, credit policies and an international boom in the cattle industry (Brockett & Gottfried, 2002; Butterfield, 1994). Legalized in 1941, land tenancy laws allowed individuals to develop rights to land through ‘improving’ forest land by converting it to pasture and agriculture (Brockett & Gottfried,

2002). At this time hard work was equated with how much land one cleared (Brockett & Gottfried, 2002). These titling policies combined with a cattle export boom throughout Central America to pull migrants to the region (Butterfield, 1994). During this period the government followed a program of import substitution with heavy government involvement in the economy (Bouman, Jansen, Schipper, Hengsdijk, & Nieuwenhuyse, 2000). Under this model, cattle production became a large part of Costa Rica's approach to generate foreign exchange (Sanchez-Azofeifa, 2000) into which the government pumped heavily subsidized federal and international credit (Schelhas, 1991) which greatly encouraged conversion of forest to pasture (Cruz, Meyer, Repetto, & Woodward, 1992; Lehmann, 1992; Lutz & Daly, 1991). The easy access and terms for credit meant that by 1974, 58% of all agricultural credits went for cattle (Watson et al., 1998). This combination of factors also led to substantial land speculation on the frontier where land was cheap. Squatters were reported to even start 'businesses' where they would clear lands not for their own colonization, but to sell them to larger ranchers who could then gain title to the land (Butterfield, 1994; Schelhas, 1996). Both farmers and policy makers had long considered forest areas as sites for future agricultural expansion and of rural development as synonymous with forest clearing (Roebeling & Ruben, 2001). Deforestation in Costa Rica had been reported to have some of the highest deforestation in the world during this period (Peuker, 1992; Sader & Joyce, 1988) and was due in part to the forest's status as an "open-access resource" (Harrison, 1991).

1979-1982: Economic crisis.

A history of foreign borrowing to support government programs when combined with oil price increases and a sharp decline in coffee prices caused a national economic crisis (Cattaneo, Hinojosa-Ojeda, & Robinson, 1999; Hansen-Kuhn, 1993). The government tried to borrow its way out (Montanye, Vargas, & Hall, 2000) and by the early 1980s had one of the world's highest levels of debt per capita (Hansen-Kuhn, 1993). With inflation exceeding 100% many invested in land as a hedge against declining monetary value (Watson et al., 1998) increasing land speculation in the region. With an external debt approaching US $3 billion in 1982, Costa Rica had no choice but to ask the World Bank, International Monetary Fund, and U. S. Agency for International Development for assistance (Montanye, Vargas, & Hall, 2000). This aid was tied to a series of structural adjustment loans which were to have

direct and indirect ramifications for agricultural development and forest cover over the next few decades.

1982-1989: Non-traditional agriculture export production.

This period was dominated by government policies influenced greatly by international lending agencies primarily through non-traditional agriculture export promotion, weaning of support for the cattle industry, and U.S. geopolitical concerns. Funding for the recovery was tied to geopolitical concerns of the Reagan administration in the 1980s (Watson et al., 1998). Largely funded by USAID, "Costa Rica's programs to consolidate territorial and political control over the northern lowlands, border, and communities involved putting in roads, people and cattle leading to continued growth and deforestation well into the late 1980s" (Girot & Nietschmann, 1992, p. 58). Additionally, in 1986 the road was completed between San Jose and Limon which facilitated settlement and stimulated livestock production in the region (Ibrahim, Abarca, & Flores, 2000). Much of the regional development in the late 1980s was influenced by these governmental infrastructure and colonization initiatives and support of the non-traditional agricultural sector (Hall, Hall, & Aguilar, 2000).

Structural Adjustment Loans (SAL) were designed to lower inflation and help balance fiscal and external accounts by reforming state and fiscal sectors and stimulating exports with market liberalization policies (Bouman, Jansen, Schipper, Hengsdijk, & Nieuwenhuyse, 2000). Three SALs were introduced over the next decade and progressively required Costa Rica to reduce the size of government, lower tariffs, eliminate subsidized prices for agricultural products (corn, rice, beans), remove subsidized production credits (including for cattle), shift to non-traditional agricultural exports, and devalue their currency (Cattaneo, Hinojosa-Ojeda, & Robinson, 1999). Under a policy of 'Agriculture for Change' the resulting study area landscape included a shift from national food production crops such as beans and corn to non-traditional export crops such as heart of palm and pineapple and an increase in banana plantations (Kaimowitz & Segura, 1996; Lehmann, 1992).

Pasture continued to grow throughout the region into the mid 1980s even after the international beef price and subsequent exports levels dropped drastically (Read, Denslow, & Guzman, 2001). The distortions continued in part due to cattle subsidies (with real interest loans as low as -10%) and a debt forgiveness scheme that mostly benefited large cattle

ranchers and stressed the banking system (de Camino, Segura, Arias, & Perez, 2000; Montanye, Vargas, & Hall, 2000; Watson et al., 1998). However, with subsidies eliminated in 1985, Costa Rican cattle herds reached their peak around 1988 (Ibrahim, Abarca, & Flores, 2000). National cattle loans dropped and both regionally and nationally abandoned pasture land increased as the cattle herd decreased in many parts of the country (Arroyo-Mora, Sanchez-Azofeifa, Rivard, Calvo, & Janzen, 2004; Ibrahim, Abarca, & Flores, 2000), but not in this region. However, cattle continued to be managed extensively with low stocking rates while the potential for greater returns were available from most other crops (Ibrahim, Abarca, & Flores, 2000). The logic of cattle of low labor, low input, proof of land utilization against squatters, and easy marketability meant that cattle remained a dominant use in the landscape and many landowners were investing in land and not trying to establish highly profitable farms (Schelhas, 1996). Using cattle production to show active use of the land remained important for the region as land invasions continued throughout the 1980s (Schelhas & Sanchez-Azofeifa, 2006).

1989-2002: Mixed development.

During this period Costa Rica continued with the structural adjustment program furthering trade liberalization, slowly downsizing the government, and diversifying agricultural exports while promoting both tourism and conservation. In 1989, the government developed a national strategy of sustainable development (ECODES) designed to negotiate the mix between agricultural development and strict conservation (Watson et al., 1998). By 1996, the administration declared its intent to turn the country into a laboratory for sustainable development (Brockett, 1998) by promoting environmental concerns along with social investment and a more participatory democracy (de Camino, Segura, Arias, & Perez, 2000).

As a region that has been heavily influenced by government policy, this era was no exception. These policies and a favorable market for bananas resulted in forest being cleared for bananas in the region in the early 1990s (Bouman, Jansen, Schipper, Hengsdijk, & Nieuwenhuyse, 2000). This led to an increase in population, employment, and business in the region, but displaced a number of farmers' whose lands were bought out even further into frontier regions (Bouman, Jansen, Schipper, Hengsdijk, & Nieuwenhuyse, 2000). With relatively low prices for cattle in 1994-6 the regional trend of pasture abandonment continued

(Bouman, Jansen, Schipper, Hengsdijk, & Nieuwenhuyse, 2000). Reforestation, plantations of pineapple, heart of palm, ornamental plants, and bananas, have all made the study region is one of the major contributors to the new agriculture export economy (Read, Denslow, & Guzman, 2001). Pineapple became the second leading agricultural export in 2002 passing coffee in earnings (FAO, 2006). There was increased growth and migration to the urban road corridor during this period as the region shifted toward a more wage and service oriented economy (Schelhas & Sanchez-Azofeifa, 2006).

Forest Policy

1969-1979: Park establishment.

Costa Rica's first Forestry Law of 1969 set the stage for many future land use trends in Costa Rica (Figure 5). The most important aspect of this law was that it established categories of national parks, the methods to create them and an administrative body to govern and manage them. The first parks were designed at protecting scenic, historic and cultural values, but soon shifted toward selections based on biological and scientific reasons (Watson et al., 1998). By the end of the 1970s, 13 National Parks had been established including those in the study area; Tortugero in 1975 and Brauilio Carrillo in 1978, and the private reserve La Selva biological research station by the OTS (Organization for Tropical Studies) in 1968 (Sanchez-Azofeifa, Daily, Pfaff, & Busch, 2003). The 1969 Forestry Law also prohibited squatting on public forest land, however, this was seldom enforced (Brockett & Gottfried, 2002).

1979-1990: Reforestation promotion and institution building.

Almost no reforestation occurred in Costa Rica before incentives were introduced in 1979 (de Camino, Segura, Arias, & Perez, 2000). Over then next decade an evolving set of incentives were implemented with the focus of meeting wood consumption needs while taking the pressure off of primary forests (Castro, Tattenbach, Gamez, & Olson, 2000). Though based on the Forestry Law of 1969, the first reforestation incentives were implemented in 1979 in the form of tax deductions which targeted the wealthy as poor landowners did not pay income taxes (de Camino, Segura, Arias, & Perez, 2000). In 1983, soft credits for reforestation were offered with low interest (8% compared to 28.5% for agriculture) loans with 10 year grace periods (Rojas & Aylward, 2003). A second Forestry Law in 1986 intended to 'democratize' the incentives and distribute them more evenly

developed the CAF (Certificate of Payment for Forestry) which was a subsidy in the form of a tax-exempt tradable bond for the first five years and up to the cost of establishment (Miranda, Porras, & Moreno, 2004; Sierra & Russman, In press). These programs suffered from a number of problems including low success rates, corruption, and that perception that they benefited mostly wealthy landholders and companies (Brockett & Gottfried, 2002; Thacher, Lee, & Schelhas, 1997; Watson et al., 1998). It was also suggested that some areas were deforested to the plant trees with the subsidies (Brockett & Gottfried, 2002; Morell, 1997). In 1988, the CAFA (Certificate of Advanced Payment for Forestry) was introduced as a subsidy to be paid in advance for the development of forest plantations. It was specifically designed for small landholders who could not afford the up-front costs of establishing a plantation (de Camino, Segura, Arias, & Perez, 2000).

The study area was one of the most advanced regions in terms of the implementation of these programs and a strong civil society of organizations such as CODEFORSA (Forest Development Commission of San Carlos, created in 1983) have gained valuable experience and knowledge of reforestation through these incentives (Camacho Soto, Segura Bonilla, Reyes Garjens, & Miranda Quiros, 2002). While over 100,000 hectares were planted by 1995, a success rate of 50% of plantations reaching harvest is suspected (Arce Benavides & Barrantes Rodriguez, 2004; Watson et al., 1998). However, by the end of the decade there was an increase in private reforestation even without incentives (Watson et al., 1998).

During this same period, no tree was to be cut without a permit from the Forestry Department (DGF). The permit required a technical study of land suitability, a tax payment, and a management plan and was negatively perceived by landowners (Watson et al., 1998). Understaffed and largely unenforceable, this program has little oversight and impact (Brockett & Gottfried, 2002). In 1987, several government institutions were consolidated and MIRENEM (Ministry of Natural Resources, Energy and Mines) was created and to be the main organization responsible for managing natural resources. This same year Costa Rica banned the export of logs and unprocessed timber, and restricted new saw mills protecting the industry, which artificially lowered the value of trees and depressed income for sellers (Brockett & Gottfried, 2002; Kishor, Mani, & Constantino, 2003).

Deforestation rates slowed by the late 1980s and early 1990s (Read, Denslow, & Guzman, 2001; Sanchez-Azofeifa, 2000) and tourism and conservation efforts began to take

hold. A strip between La Selva and Brauillo Carrillo was declared a protected zone in 1982 (enacted in 1986) completing an altitudinal tract from the lowland region up to the central valley (Read, Denslow, & Guzman, 2001). Additionally, in 1985 the Barra del Colorado Wildlife Refuge of 92,000 ha stretching along the Rio San Juan from southern Nicaragua to Tortugero was established (Butterfield, 1994). Strong private sector conservation initiatives were also developed during this period. One of the first Ecolodges in the world, Rara Avis, was initiated in 1986 (Honey, 2003) and several other private reserves including Selva Tica and Selva Verde have added to the base provided by the La Selva Biological Station. Though they offered little in the way of employment in the area (Butterfield, 1994), they were the beginning of an industry on the rise. During this period, Costa Rica at the national level benefited from a boom in tourism in part due to the country's national park system, its reputation as a peaceful nation and President Oscar Arias' winning of the Nobel peace prize in 1987, and to the global explosion of ecotourism (Honey, 2003).

1990-1995: Paradigm shift and institutional reorganization.

The economic benefits from environmental conservation were increasingly being compensated in debt for nature swaps, bioprospecting contracts, and ecotourism based (Lehmann, 1992; Rojas & Aylward, 2003). There was a growing recognition of the economic importance of conservation and a declining dependence on those industries that promoted deforestation (Kaimowitz & Segura, 1996). These trends were augmented with a series of international conferences including the Agenda 21 at the Rio Earth Summit in 1992, Convention on Climate Change, the Biodiversity Convention and the Central American Council for Forests and Protected Areas (Watson et al., 1998) which promoted sustainable development and the value of environmental services beyond what was protected within national parks (Rojas & Aylward, 2003). Beginning in the late 1980s tourism increased significantly and became the top national earner of foreign exchange by 1993 (Watson et al., 1998).

A new forestry law was required in 1990 when the Supreme Court of Costa Rica found the 1986 Forestry Law unconstitutional which initiated the 1990 Forestry Law which began the modern forest incentives era (Brockett & Gottfried, 2002, p. 21; Watson et al., 1998). In 1991, FONAFIFO (National Fund for Forest Financing) was created to distribute subsidies to the forestry sector. Two new incentive programs were initiated during this

period. In 1994 the Certificate of Payment for Natural Forest Management (CAFMA) established credits for the development and implementation of forest management plans, and in 1995 the Certificate of Forest Protection (CPB) was developed as a subsidy to conserve forest on private lands.

Another important reorganization occurred in 1995 with the formation of the National System of Conservation Areas (SINAC) by combining the forestry department with the directorates of wildlife and the national parks. The intention was to consolidate the different agencies for efficiency and to distribute the offices to ten regions in the field to coordinate, democratize, and make the agencies more responsive to local needs and issues (Miranda, Porras, & Moreno, 2004). Costa Rica was an innovator in establishing the Office for Joint Implementation (OCIC) in July 1995 to be able to eventually sell credits in the carbon market as negotiated through the Kyoto Protocol. The process of agency consolidation and independent subsidy programs came to an end in the fall of 1995 when the Structural Adjustment Loan 3 required the elimination of subsidies, including forest subsidies. The current advances in environmental market opportunities and the recently developed payments for reforestation, management and protection combined with the need to eliminate forest subsidies culminated in Costa Rica's Forestry Law of 1996 and their PES system (Rojas & Aylward, 2003).

1996-2002: Institutional strengthening and funding exploration.

The Forestry Law of 1996 instituted a number of changes including the establishment of a legal definition of forest, the prohibition of the conversion of natural forest to other uses on private and public land, and the creation of environmental service payment program (PES). PES is a public incentives system where the government raises funds, sets the payment levels and priorities, and then invites applications from landowners (Snider, Pattanayak, Sills, & Schuler, 2003, p. 20). Under the PES program four services are bundled together: watershed conservation, biodiversity habitat, carbon sequestration and aesthetic beauty (Pagiola, Bishop, & Landell-Mills, 2002). Two of the major changes to the previous subsidy system were the justification of payment for environmental services and a change in the funding mechanism from government subsidies to an earmarked gasoline tax following the polluter pay principal (Pagiola, Bishop, & Landell-Mills, 2002). FONAFIFO was incorporated into the scheme to distribute the funds from RECOPE (the government owned

oil refinery), and the OCIC (Costa Rican Office for Joint Implementation - the organization designed to negotiate carbon sequestration contracts), and to investigate new funding sources (Rojas & Aylward, 2003). Further changes in the 1996 Forestry Law prohibited conversion of forest land to any other system (Snider, Pattanayak, Sills, & Schuler, 2003). Originally, one third of a tax on carbon fuels was earmarked to be used to fund the PES as part of a "polluter pays" principle. There were issues with the Ministry of Hacienda and the total amount of this payment was never paid (Camacho Soto, Segura Bonilla, Reyes Garjens, & Miranda Quiros, 2002), however, in 2001 the issue was resolved through political renegotiation and reduction of the amount dedicated to the PES program.

Within the study region, a number of alternative sources of funding have been found though negotiated contracts with hydroelectric (flow-over and dams) projects and a brewery, who contribute payment for PES programs within their watershed. Several of these agreements have been negotiated through the initiative of the NGO FUNDECOR (Foundation for the Development of the Central Volcanic Mountain Range). Additionally, Cost Rica initiated the Ecomarkets project in 2001 which included a grant and loan from GEF (Global Environmental Fund) and World Bank ($8 and $32 million respectively) to specifically target funding within the Mesoamerican Biological Corridor for protection (Pagiola, Bishop, & Landell-Mills, 2002). Additional funds for the region to support carbon sequestration have come from Germany through the KfW (Ortiz Malavasi, 2003). The PES program has had target areas that have focused on the study area through a focus on poorer provinces and corridor areas linking national parks (Ortiz Malavasi, 2003).

Programmatically, PES payments for sustainable forest management were suspended in 2001 due to arguments from environmentalists that opposed sustainable management in primary forests (Ortiz Malavasi, 2003; Watson et al., 1998). This decision significantly affected the study region as the majority of management projects occurred there (Camacho Soto, Segura Bonilla, Reyes Garjens, & Miranda Quiros, 2002). The forest management program was one of the institutional strengths of local organizations such as CODEFORSA and FUNDECOR, regional organizations that have greatly assisted in the development of PES (Arce Benavides & Barrantes Rodriguez, 2004). FUNDECOR, which began in 1991, has been a catalyst for developing innovative funding opportunities for the PES while

simultaneously administering contracts, providing technical advice, and working with small landholders (Miranda, Porras, & Moreno, 2004).

Several programmatic issues such as transaction costs and land titling that initially plagued small-scale landowner access to the program have been resolved (Pagiola, Arcenas, & Platais, 2005). A significant barrier for entry to the PES contracts of landholders with small farms is transaction costs and scales of economy for all parties involved (Zbinden & Lee, 2005). A system of 'global contracts' was developed where a number of small farmers can join the PES program collectively by working through a local organization, in part alleviating this problem (Pagiola, Arcenas, & Platais, 2005). Locally, the NGOs CODEFORSA and FUNDECOR have provided global contracts. A similar factor affecting landowners with small farms in the study region was that relatively expensive and bureaucratically prohibitive land titles were required to be able to receive payments from the governments; an issue resolved programmatically in 2002 (Ortiz Malavasi, 2003; Pagiola, Arcenas, & Platais, 2005). Finally, a significant development that affected the study region was a conflict between IDA and the PES program. IDA argued that the lands were given to recipients for agricultural use and should not be able to receive payments to keep it in forest as they would be receiving double benefits (Camacho Soto, Segura Bonilla, Reyes Garjens, & Miranda Quiros, 2002). This was negotiated to allow IDA farmers to enter Global contracts (Ortiz Malavasi, 2003).

Results from Expert Interview Data Analysis

Analysis of data from the expert interviews was guided using the social systems from the SEStM as the initial coding categories (Figure 4). This gave a regional but grounded perspective on the key social systems that influenced land use decisions in the case study landscape. All the major land uses throughout the region including pasture (for beef, dairy, dual purpose, breeding), perennial crops (heart of palm, ornamentals, banana) and annual crops (pineapple, yucca, sugarcane) were examined in terms of the six social system components in the model (economics and technology, politics, infrastructure, demographics, culture, and nature) (Figure 4). The remainder of this section focuses on how these components interact during landowner decision making for the spectrum of existing land uses. The purpose is to begin to understand how these influences push and pull landowners toward one land use or another. Highlights of the social system components involved in land

use decisions in the region are presented below to demonstrate how the model can be used to understand the agents' context or 'terrain'. The three land uses selected as examples capture the range of major influences across the region from early settlement to more recent developments; forest, pasture and pineapple.

Natural Forest

Analysis including coding and display of data regarding natural forest revealed multiple social systems involved in the conservation of forest in its predominantly natural state. While most of the land in the region was originally forest, the majority of it was reported to have been selectively harvested since colonization began in the 1950s, or highgraded for the most profitable species. The analysis identified three key social systems involved in the retention of the remaining forest; government policy (politics), economics, and institutions.

Legal restrictions in the form of command and control efforts and the more recent environmental service payment (PES) programs were identified to be key elements of forest retention. The long standing protected status of riparian forest on the banks of rivers and around springs has resulted in effective forest conservation. Another policy example is the linking of Braulio Carillo National Park with the La Selva Biological Station in 1986 which closed the frontier and open access to cheap land. The Forestry Law of 1996 with its legal restrictions on forest conversion and program for environmental service payments was also reported as being a key factor for forest protection. However, it was mentioned that the payments are very small for landowners with small forests; "it is a very small amount per hectare…but is profitable for large areas of forest such as 30 and above, but forest areas of 8 or 10 hectares there will be too much paperwork to make it worth their while" (*Interview 1*). Therefore, while the legal restrictions are reported to influence all landowners, those with larger patches of forest were thought to be more interested in the PES due to profitability.

Analysis showed that private reserves for ecotourism were also key factors for forest conservation with a number of them identified in the region such as Rara Avis, Selva Tica, and Laguna del Largato Lodge. Study participants reported that these endeavors often were driven by economic and conservation interests of the owners and financial capital flowed into the area from outside the region since the reserves were often owned by foreigners. Data revealed that generally across the region there were high expectations beginning in the early

1990s about how tourism could contribute to the local economy but these haven't yet been realized: "the people believe that there will be a boom in tourism and all of the world will eat from it" (*Interview 4*), but that "the small farmer and their families haven't been able to take advantage of these economic benefits" (*Interview 5*).

Institutions as a component of the social system were seen to be both critical for conservation and, contrarily, as proponents of deforestation. Both FUNDECOR (Foundation for the Development of the Central Volcanic Mountain Range) and CODEFORSA (Forest Development Commission of San Carlos) were identified as key agencies responsible for promoting forest stewardship and for facilitating the PES. The 1996 Forestry Law was also seen to contribute to potential regeneration of forest by giving a legal definition to forest; "a silvacultural definition about how many trees of a certain diameter exist per hectare" allowing for greater oversight (*Interview 3*). Institutional cooperation was cited with ICE (Costa Rican Institute of Electricity) as another way of promoting forest conservation and working with the NGO FUNDECOR and hydroelectric companies worked collaboratively to raise funds for the PES program. However, institutional competition between conservation organizations and IDA (Institute for Agricultural Development) was also identified. There are large amounts of land under the colonization and redistribution projects administered by IDA which are often given to landowners specifically for agricultural development. Conservation of forest was seen to be outside of IDA's mission. The final key institution mentioned was MINAE (Ministry of Environment and Energy). Data revealed that MINAE was unable to enforce the legal restrictions on forest conversion because they had too few workers for such a large area.

Pasture

The primary land use in the region is pasture. There were four types of cattle production identified including beef cattle, dairy, cattle breeding and dual purpose. The first two are outlined below.

The key political factor involved in the establishment of early pasture in the region was reported to be land titling laws. These laws stated that a landowner had to demonstrate use to obtain title to the land and to protect it from squatters. The most effective way to demonstrate use was to clear the forest land and put in cattle. This factor combined with the adaptability of cattle to be produced under a variety of conditions was reported to have

facilitated their spread. Cattle were reportedly able to be used as a functional production system about anywhere in the region. The analysis showed that cattle are generally raised extensively and for beef production and need very little care and low labor. One expert described this situation as, “the cattle here are extensively raised, that said, nothing more than put the animals in the field and after a number of months go get them and take them to market” (*Interview 1*). This feature facilitated the large absentee land ownership in the region by professionals and city dwellers who were not interested in production systems that necessitated daily attention. Also, over time an infrastructure developed around cattle production in the form of organizations and government agencies offering technical assistance (e.g. pasture, breeding, health) and increased marketing opportunities with the development of subastas (auction houses) throughout the region where previously ranchers had to go to the central valley to market their cattle. Furthermore, many of the migrants to the region knew how to manage cattle because they were from Guanacaste and San Carlos provinces and parts of Nicaragua where cattle ranching was part of their culture.

Another key element of the social system involved with the spread of cattle in the region was economics. Credit was easy to obtain and was offered at very low rates during earlier periods (1960s -1970s). Cattle could also be used as collateral for loans which was useful because if there was a bad year the bank took the cattle, but not the farm. Credit was reported to currently be much harder to obtain for cattle ranching. While marketing is easy, and cattle can be held until small fluctuations in prices pass, larger drops in the market like in the early 1990s were reported to have negatively influenced the decision to work with cattle.

Dairy production decisions were reported to involve slightly different factors. The two key factors identified regarding the production of milk in the region were natural setting, labor and economics. The natural setting of a cooler climate facilitated the production system for the breed of cattle used. Therefore, dairy farms were usually found in the foothills and on the mountainside of the central volcanic range. Because these lands tended to be much more expensive it was necessary for dairy farming to be more intensively managed than beef cattle.

Study participants identified financial capital for investment, a key export company for marketing, and national economic policy as factors of the economic component of the social system. A large investment in farm equipment is required for dairy production

including equipment and stable for milking and milk tanks. Additionally, farm infrastructure including divided pastures for rotation and road access were required. This production system is much more intensive and requires daily labor generally milking twice a day. While a cultural tradition of milk production was identified as an influence, the current systems are much more technical. The main market for dairy is Dos Pinos, a company located in San Carlos but who sells milk products throughout Central America. Tariffs (national economic policy) protecting the milk industry in Costa Rica have allowed Dos Pinos to offer a number of services and pay high amounts to ensure quality. Dos Pinos, as an institution, provides technical and veterinary assistance, has stores throughout the region with equipment and inputs, and provides a secure and lucrative market through membership in it cooperative. While this assistance was reported to be very beneficial, expert participants were concerned about the quota system of membership with Dos Pinos which excludes other producers from entering the dairy market.

For all cattle production systems, there were a number of other factors that were involved that were described as being influential including infrastructure, politics and culture. Those geographic areas with less access to services like schools and electricity were reported as some of the first to be abandoned with price drops in the beef markets. As a related factor, the Contra war was identified as an early (late 70s through mid 1980s) factor for migration away from the frontier with Nicaragua with reports of insecurity and robberies of cattle and equipment.

On the other hand, a cultural affinity for having a cattle ranch was identified as a continued reason for maintaining cattle on a farm, even when it is not a comparatively productive land use. “Yes, because your father and grandfather had cattle and to be a rancher is important, to walk around with your hat….it is a way of life” (*Interview 5*). This cultural affinity and knowledge is further intensified by Nicaraguans immigrants who act as caretakers or laborers on many farms and are knowledgeable about working with cattle.

Due to combinations of the reasons cited above, using cattle as a production system began earlier and has evolved to become part of the structure of the economic, institutional, political and cultural components of the social system. However, trends in 2004 document the buy out of many of the large cattle farms in the region by national and international companies and their conversion to pineapple for export.

Pineapple

Key factors involved in the production of pineapple are primarily economic but with cultural, demographic, and institutional components of the social system also having some impact. Costa Rica has had long history of producing pineapple (20-25 years) but with a limited extent of land under cultivation. Since the late 1990s there has been an explosion of pineapple in the study area with two major types being produced. The Monte Lirio variety is more acidic and is and has been used for a longer period by local companies for making fruit juice. The other variety is the MR2 which is a large yellow sweet pineapple used for export. There has been an explosion of this second variety across the region reportedly due to a drop in international production and a rise in prices. Pineapple that is used for export needs well drained soils and relatively flat land because it is highly mechanized. There are a large number of both national and international companies involved with the national companies collaborate with the international companies for exportation. In particular, Dole and Chiquita were reported to be involved in exportation using the infrastructure and shipping from their banana industries. Regional companies have begun buying up large farms throughout much of the region with a specific focus on the area around Pital, Rio Cuarto and La Virgen where the land tends to be more level and the roads well developed. Due to the explosion of pineapple across the region a number of experts have become concerned about overproduction. However, since it is an annual crop it is easily converted to other land uses, it was not a great concern. As of 2003, pineapple had become the number two exportation crop from Costa Rica earning more than coffee.

Pineapple companies often have their own packing plant right on the plantation and it is a labor intensive process. A large part of the employees are reportedly Nicaraguan though many Costa Ricans with smaller farms are working the plantations as well. The overwhelming majority of the production is from large producers, but with a large number of small landholders also producing pineapple. Small land holders primarily grow the older variety of pineapple for local juice production as obtaining the more expensive MR2 seeds can be expensive and criteria to meet exportation guidelines can be complicated.

A number of institutions have been organized to help landowners with small farms, and government agencies and banks are involved offering credit and technical assistance to help integrate landholders with small farms into the export market. However, it was noted

that the boom in pineapple is very much market driven and managed by large and medium companies instead of through government incentives. This demonstrates how a component of the social system takes on very different roles and functions.

Land Use Transitions

Land use transition patterns identified by expert interviews were used to identify factors (biophysical or social) that may constrain or enable the transition of one land use to another (Figure 6). The tree style graphic started with forest, which essentially covered the region prior to colonization. Phases of land use transitions were sequentially ordered by participants. The ordering did not specifically relate to a time period because the changes were part of an ongoing process. The first transitions from forest in the region were to pasture and subsistence farms by frontier colonizers. Colonizers were reported to clear land for pasture, and not specifically to harvest the timber. There was also a transition directly from forest to banana plantations. This was by large international companies and in response to global markets and national incentives. Bananas were reported to be a terminal land use with few transitions back to pasture as banana companies consolidated their lands. While subsistence agriculture and staple crops of beans and corn and rice were some of the original land uses (see Figure 6), they had reportedly largely disappeared on any significant scale from the landscape due to the elimination of price supports and crop diseases. Both annual crops such as pineapple and yucca and perennials like the heart of palm and ornamentals were reported to have replaced some pasture lands. Pasture was also reported as being converted to banana plantations or as being abandoned or fallowed. Pasture is the primary land use that most all other land uses in the region transition to and/or from. Forest was reported to primarily transition to pasture or bananas and not directly to other land uses. Once lands were in perennial crops, however, transition was physically much more difficult and transitioned primarily with severe reductions in that crop (dashed lines in Figure 6). This was mentioned with regard to heart of palm and ornamental crops. Though these crops had few biophysical requirements (they did well anywhere) they tended to be spatially correlated due to marketing and a Costa Rican aptitude for “watching your neighbor” and learning from their successes and failures. Annual crops were generally reported not to shift except to another annual crop. Results from the data analysis suggest this is because these crops were located on lands that were more productive and therefore more likely to maintain crops

which produce higher returns to the land. Pasture continued to transition to most other land uses including reforestation. Reforestation also was derived from some crop land and reportedly from areas in forest recovery that had formerly been pasture. A small amount of recovery was thought to make it to forest, though a legal restriction on harvesting secondary forest was identified as an influence making that less likely to happen. Forest recovery was reported to be a temporary use and shifting to other productions systems was common.

The land use transition data suggest that some uses are more fluid than others because of the biophysical 'qualities' of the land and/or features of the crops themselves. The land uses that don't transition easily to other crops were banana (due to its high investment in associated drainage systems and infrastructure and large corporate backing), heart of palm and ornamentals (due to difficulties in clearing after planting) and reforestation (due to its long term harvest regimes). Pineapple is currently experiencing explosive growth and yields much higher income than extensive cattle ranching. The high value would indicate that it would be more permanent, but the annual nature of planting and concerns reported about over-production may make it a fairly fluid land use. The most fluid land uses were pasture as the dominant land use in the region and forest recovery which was much smaller but commonly transitioned.

Comparing Contextual Analyses: Systemic and Narrative Approaches

Both expert interview and document sources of data provided insights to land use change in the region. The data sources were triangulated between and within sources. The two types of sources revealed slightly different emphases. All the main social factors identified in the contextual analysis of the expert interview data were corroborated in the analysis of the document data. However, the analysis of document sources offered a much more detailed analysis of the interactions of the social systems and the evolution of the influential factors.

The contextual analysis of the interview data identified the key factors involved in the decision to have pasture for cattle as influenced by land titling, credit availability, market prices, the Contra war and the natural attributes of cattle. There were a variety of ways cattle could be managed including extensively for beef, intensively for dairy, smallholder dual purpose use and for breeding and each with their own unique role. There was an emphasis on the adaptability of cattle and how that production system was widely applicable across the

region. In particular, the low labor aspect of production was reported to be conducive to absentee land ownership. This production factor facilitated the ability of speculators from other regions to be able to maintain land in their possession against squatters. From the local perspective, market prices were noted to vary, but the opportunity to sell remained consistent and marketing was easy as the system was understood and widely available. Pasture was also identified as a very fluid land use indicating that if other cropping opportunities arise such as pineapple, they are easy to implement. Additional insights from the analyses of expert interviews were on the implications of the Contra war on landowner security and subsequent out-migration from the border region.

The systems perspective (Lambin, Geist, & Lepers, 2003) from the document analysis insured a much wider perspective was examined and allowed the linkage between the social factors influencing cattle production to emerge. For example, the governments desire to earn foreign exchange and the support and advice of international institutions resulted in cheap and easy access to credit to develop the cattle industry during the colonization period. This is an example of linkages that are unlikely to be identified at the local level, but are critical for understanding land use change. Easy credit and tax breaks were first offered for cattle and bananas during the colonization period, and then later for non-traditional crops like heart of palm and pineapple during the 1980s. The numerous incentives were identified as key factors for transitioning from pasture to the non-traditional crops. Both sources of data identified speculation as a factor of land use change in the region, but the systemic approach was able to associate speculation with high interest rates which were influenced by the economic crisis of the early 1980s.

In the analysis of the text from the expert interviews three key influences of forest protection in the region resulted including legal restrictions and incentives, economic benefits from ecotourism, and institutions. Specific nuances of these factors such as the local expectations for economic development from ecotourism are difficult to identify at the national or systemic level. Additionally, insights about inter-institutional collaboration and confrontation and/or ineffectiveness are important at the local level where the implementation of the national policies is carried out.

Systems focused data analysis enabled the tracing of the origins of the different forestry laws and policies that are implemented at the local level. By understanding the

context of world conferences and treaties that were attended and signed by the Costa Rican government it is possible to see the global influences on the local landscape. In particular, world values for biodiversity and carbon sequestration have been used to justify payments from the World Bank to local landholders for forest maintenance. Additionally, international conservation organizations and other countries throughout Central America have accepted the Mesoamerican Biological Corridor as target areas for sustainable development.

A benefit of using the systems perspective (Lambin, Geist, & Lepers, 2003) is that it guided or provided a structure for exploring synergistic effects of different land uses. In other words, there are social factors that are involved in the production of one land use that were described as having impacts on other land uses in the region. For example, the banana company that established plantations in the late 1960s opened the area to colonization with new infrastructure and a demand for labor drawing people to the region. The roads facilitated access to an otherwise closed area and created opportunities for colonists to enter the region and establish pastures. However, establishing context in time is critical as well. These same opportunities for wage labor in bananas in the region in the early 1990s (and more currently pineapple) have had the effect of drawing landowners from the frontier region to more urban corridors. In the process they sometimes abandon or reforest their pasture. Another temporal shift has occurred with regard to absentee landholders. In the early colonization period, speculators were investing in land to avoid high interest rates and as a financial investment by making improvements (clearing forest), establishing title, and then selling the land. Landowner attitudes, at the time, considered forest as an impediment to development. More recently, however, many absentee landholders of large forest are enrolled in the PES program or have established ecotourism operations or are otherwise actively maintaining their forest. Attitudes regarding the value of forest have changed among landholders in the region.

Additionally, historical legacies of past land uses have structured the current context. Identification of land use transitions helped identify physical restrictions on land use change and indicated what transitions may be blocked due to other factors. For example, the historical legacy of cattle production due in part to local knowledge of how to manage cattle, land tenure policies, and adaptability of cattle production have led to significant physical infrastructure including subastas (cattle auction houses) and social structures such as the desire to have a cattle farm. Similarly, the physical and social structures developed long ago

for banana production (from roads to ports to marketing to local knowledge producing pineapple) facilitated entry into widespread pineapple production. Land colonization projects and Nicaraguan immigration led to cheap labor for industrial production. And though road building associated with the support for the Contras extended the road network, security issues related to the war led to out-migration from the border region. While the contextual analysis of interview data afforded us insights into the major trends in the region from a local perspective, elaboration on how those trends evolved and were connected was provided in the systems perspective as identified using documents as a source of data.

Conclusion and Implications

This paper began with the presentation of a model that frames human-environment interactions as recursively structured systems that include social and biophysical systems. The conceptualization of land use and land cover change as both a medium and outcome of social and ecological structures recursively organized was used to provide a link between the systems. The social and ecological systems were visualized as separate but mirrored systems to illustrate both the similar and different mechanisms by which they operate. This model was then applied to analyze the historical context where Costa Rica's forestry laws and PES program dynamically competed with and/or reinforced other social systems to impact land use decisions within the San Juan – La Selva portion of the Mesoamerican Biological Corridor. Three main conclusions or implications for the model and the case are presented: 1) the model was successful for identifying the key social systems influencing landowners land use decisions for this case; 2) some refinements to the model at the empirical level of analysis have been identified; and 3) implications for the future use of the model are given.

Successful Identification of Key Social Systems

The contextual analysis of documents provided a detailed account of the components of the social system that have influenced land use in the region. Through the development of a historical timeline, documents provided an image of the dynamic and interacting social systems (Lambin, Geist, & Lepers, 2003). Interviews with local experts provided additional insight or a grounded/narrative to how these systems influenced landowner decisions. We found that the variables identified in the model from the land use change meta-analysis on tropical deforestation did serve as valuable indicators of the important social factors driving land use change in the region. Analysis of data from both sources of data and methods

(documents analysis and expert interviews) provided converging lines of evidence corroborating the history of land use change over the study period as presented in this chapter. Each data source provided supplemental information to the other, but neither identified additional social systems that would have been missed.

Model Refinements at the Empirical Level

However, while applying the social system variables to this model a few adjustments needed to be made. The original adjustment of the model to include infrastructure at the social system or underlying structural level of analysis was determined to be appropriate as infrastructure was commonly referenced in its role for enabling or constraining landowner decisions. For example, access to basic resources such as electricity and schools was reportedly related to absentee land ownership and road access to the capital and important factor in the decision to maintain a ranch in the region as a second home. Additionally, the decision to include natural factors as a key social system or structure facilitated discussion on the key environmental factors important to land use decisions. For example, natural factors were critical for the site specific production of dairy cattle and crops. However, the adaptive ability of cattle (their natural attributes) to be used as a production system almost anywhere in the landscape was suitable to speculators and to others wishing to show use of the land without providing local labor were also key natural factors impacting land use decisions. In other words, natural qualities of the land, the product (cattle or crops), and the production system were combined with the landowner's livelihood strategy to determine which aspects of the natural factor was critical.

An adjustment to the social system variables that could be included in future analyses was the use of technology as a primary social system for analysis. In this study technology was mentioned primarily as a modifier of other systems and largely in combination with or as a subset of economic decisions. For example, the technology used for pineapple production was seen to be associated with market prices and production systems and not as a separate entity. We also found that it was useful to analyze a range of land uses in the region when conducting an agent context analysis. This is because we found that the key social components influences differ across land uses, and they are often synergistic effect across land uses. For example, policies favoring cattle influenced forest cover and policies favoring pineapple influenced cattle markets. Therefore, it is suggested here that analyses of land use

change identify drivers for all land uses in the region instead of focusing primarily on those that change one particular land use (e.g. a focus solely on the factors influencing forest cover).

Finally, due to the fact that this model includes actors, we found it useful to refer to the social factors as influences on land use decisions instead of 'drivers' or 'causes' which reflects too direct a structural influence for this model. It also recognizes that actors can be differentially situated in terms of capabilities and motivations and what may be a 'cause' for one landowner may be a constraint on another.

Future Uses of the Model

This model incorporates the concepts that others have identified as critical for understanding linked human-environmental systems. Lambin and others (2003) suggest that agent-based systems and narrative perspectives all need to be combined to effectively understand land use change. By explicitly outlining the process of structuration, this model represents one way to overcome the proximate/underlying divide "so as to allow for more complex interplays of human agency and structure in processes of land use change" (Geist & Lambin, 2001, p. 99). Additionally, it is suggested that this model can incorporate spatial heterogeneity in both social and ecological systems through the incorporation on hierarchical patch dynamics, which others have identified as critical for linked human environmental systems (Pickett et al., 1997; Wu & Loucks, 1995). Furthermore, that this model meets the requisites outlined in Grove (1997) for understanding social and ecological systems (Grove & Burch, 1997, p. 264) and goes further to present a framework for unacknowledged conditions and unintended consequences for both social and of ecological systems.

In sum, it is suggested here that both the model and its application to the study of Costa Rica's PES program were robust. Finally, it is hoped that the SEStM model will be the subject of further elaboration in both design and application.

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Tables

Table 1: Structuration with integrated empirical research frameworks.
Integrating structuration theory (Giddens, 1984; Stones, 2005) with empirical models of land use change (Geist & Lambin, 2001) and landowner decision making (DFID, 2003)

Structuration Theory		**Variables for empirical study**
Structure	Schemas/Rules	**Underlying causes** • Economic • Political • Technological • Infrastructure • Demographic • Cultural • Natural
	Resources	
	Unacknowledged conditions and Unintended consequences	Unacknowledged conditions and Unintended consequences
Agency/power	Allocative	**Livelihood assets** • Financial • Physical • Natural • Human • Social
	Authoritative	

Table 2: Sources of evidence and data collection methods.

Source of Evidence	**Data Collection Methods**	**Sampling**	**Purpose**
Expert: NGO/Agency Field Staff (18 expert interviews)	Small group semi-structured interviews (individual agency)	Snowball sampling: Politically important/ expert, knowledgeable	Explore land uses, social systems, and their possible connections. Explore history of area. Identify farm types. Identify land use transitions.
Expert: Member check (4 expert interviews)	Multiple agency group presentation with feedback	Representatives who participated in individual agency interviews; representative from same agencies but from different locations	To check conclusions and interpretations made by the researcher.
Document analysis (>100 documents)	Academic journals and institutional reports	Census relevant material	Background and review of social forces identified.

Figures

Figure 1: Social structuration: Quadripartite nature of structuration.

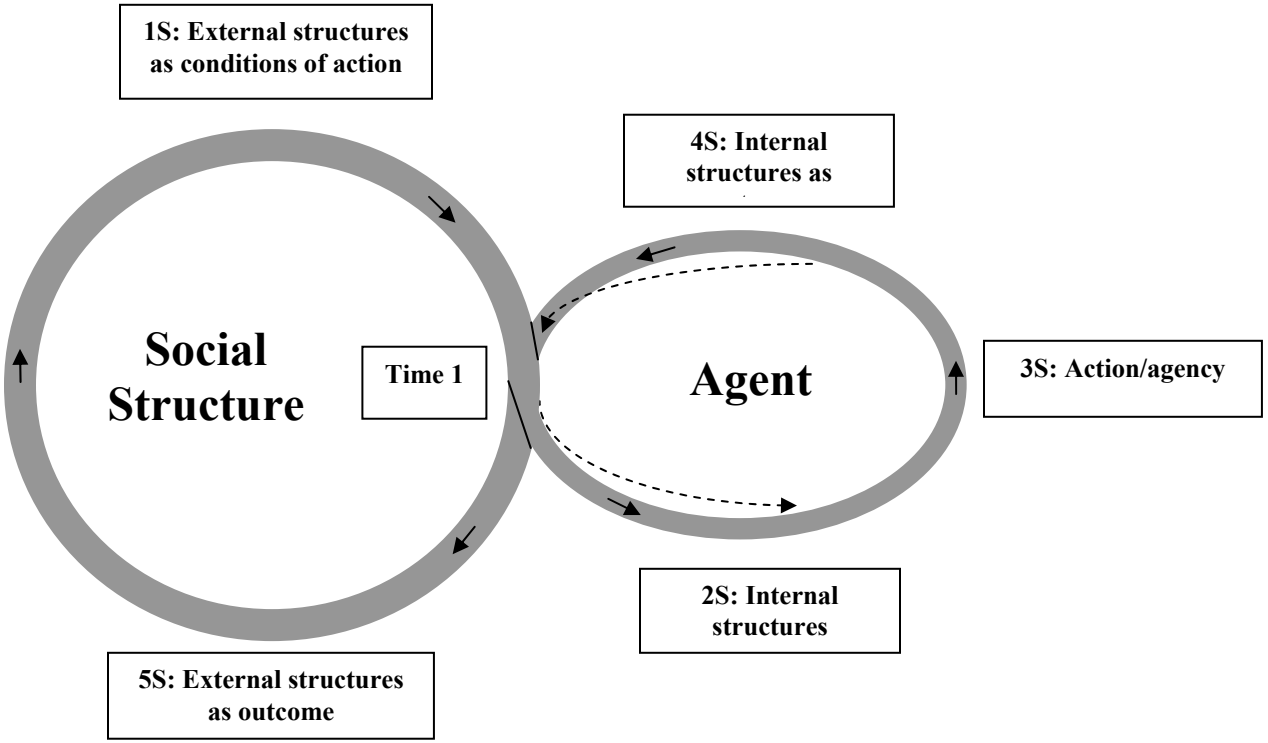

Figure 2: Ecological structuration: Hierarchical patch dynamics.

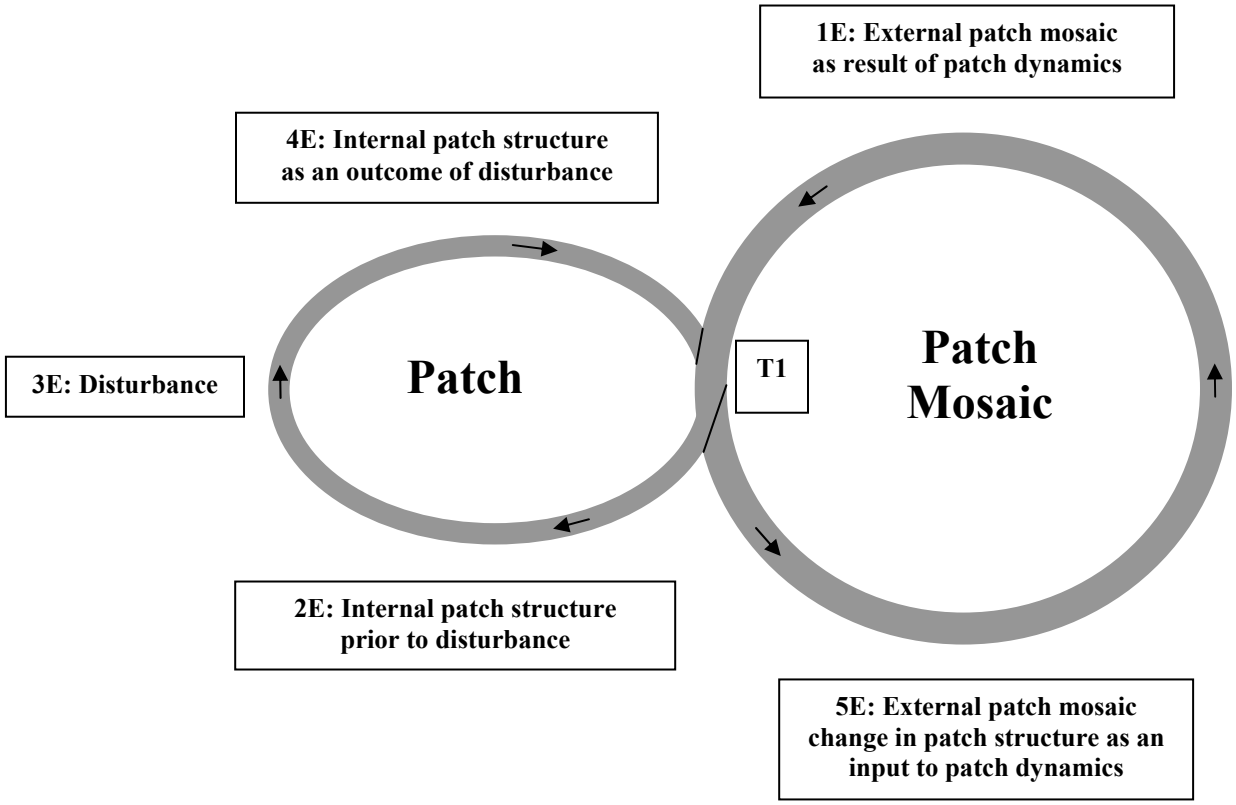

Figure 3: Social Ecological Structuration Model (SEStM).

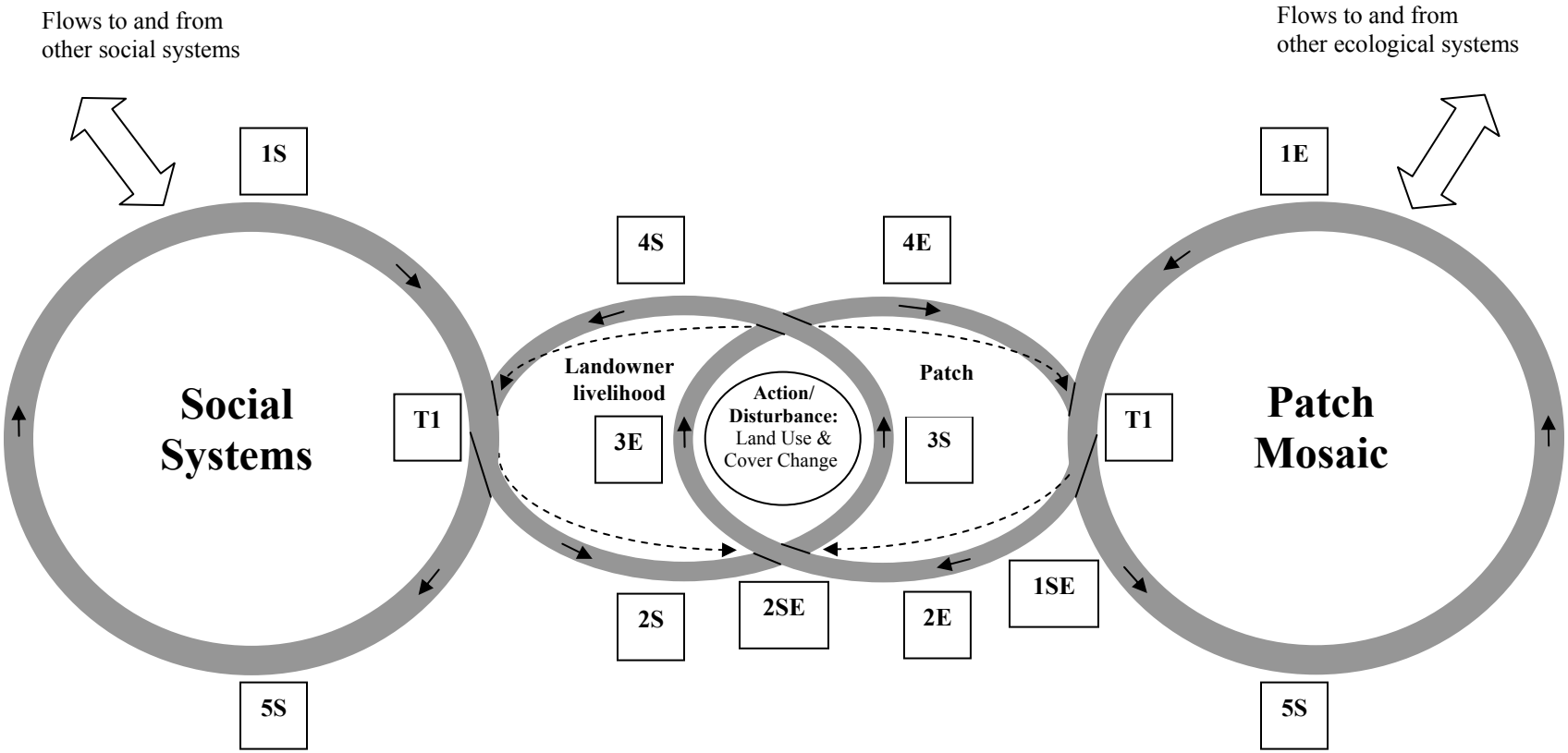

Figure 4: Integrated structuration model with research variables.

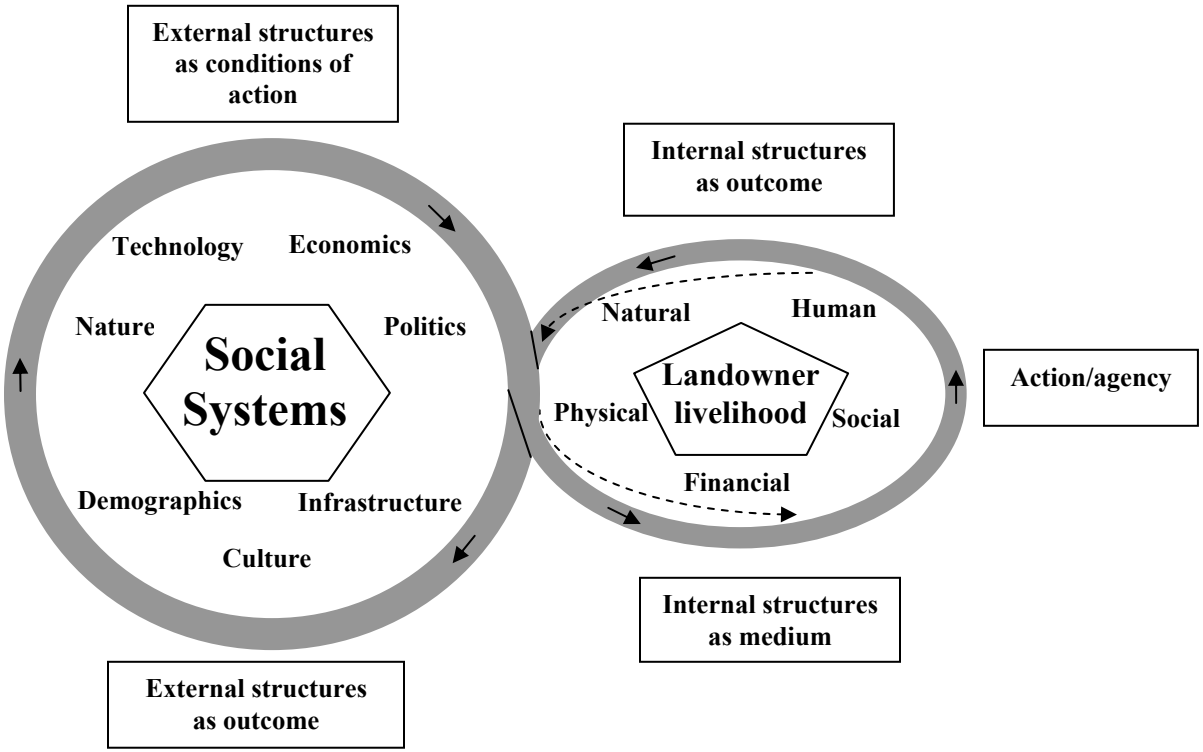

Figure 5: Historical timeline for agent context analysis.

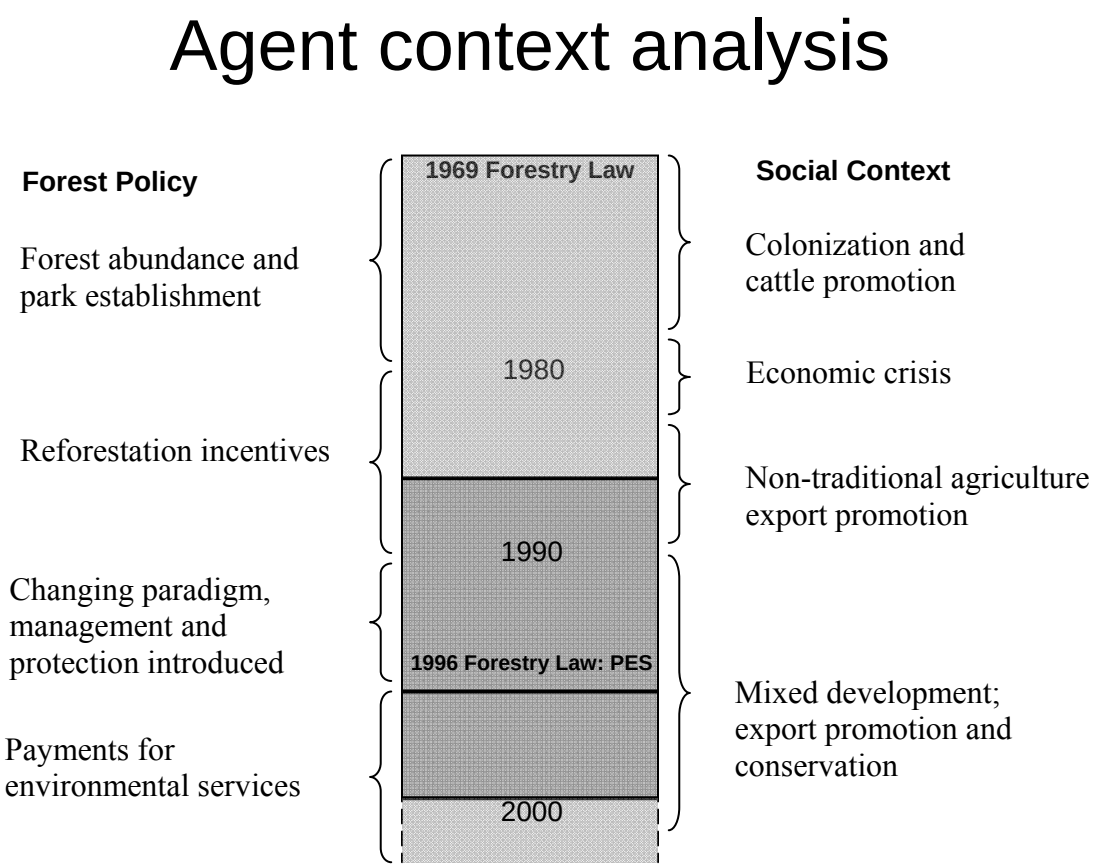

Figure 6: Progress of land cover transition by land use type