Abstract

This paper presents a unique application of dynamic systems modelling (using* STELLA Research 7 for Windows*) to address land fragmentation due to recreational, agricultural and urban pressures on rural lands in Texas (USA). An innovative aspect of the modelling undertaken here is factoring social and cultural impacts into decision-making, such as the cultural relationships of farmers and ranchers with the land (the agricultural land ethic). This approach offers planners and policy-makers a powerful tool for visualising, understanding and managing development and recreational pressures on the cultural heritage and sustainability of rural Texas.

It provides a rich avenue of research for tourism scholars interested in bringing human dimensions to natural systems. Implications of the role and importance of the 'family farm' in individual, state and national heritage and identity are presented in the form of research questions.

A Systems Tool For Sustainability-Based Planning:

Modelling socio-cultural impacts in rural Texas

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Introduction

Globalization, declining soil productivity and competition from larger producers are contributing to a major crisis in rural agriculture within the US. In Texas, many of the small to medium rural producers who have occupied the land through generations of frontier traditions now struggle to hang on to their livelihoods. The pressure on their land is manifold. With over 90% of its population urban (and growing), agricultural lands, particularly those close to urban centres, are increasingly subject to demands for commercial development and recreational access (Engle, 2002; Nelson, 1994; Skadberg, Jamal & Skadberg, 2004). Land characteristics are consequently changing rapidly, with 74% of Texas counties experiencing reduction in mean rural ownership sizes between 1992 and 1997 (USDA-NASS, 1998). Land values are transitioning from traditional agriculture to aesthetic and amenity values.

These changes are also resulting in habitat fragmentation in some instances (James, 2000). Fragmentation in areas adjacent to national parks is an especially serious problem, as the existing farm or ranchlands provides a valuable buffer zone against encroaching

development (Smith, 2000). The *Governor's Task Force on Conservation* (2000) summarised the potential impacts of this trend in the following sobering statement:

> *The fragmentation of large family-owned farms and ranches poses perhaps the greatest threat to our wildlife habitat and to the long-term viability of agriculture in Texas.*

While economies of scale are considered vital to agricultural sustainability, very little research has been conducted to show the impacts of parcelisation (a synonym for land fragmentation in this paper) on human-social and ecosystem health. Engle (2002) offers a preliminary study in this direction, which suggests that these relationships are complex; habitat and biodiversity impacts are not necessarily clear or causally related to parcelisation, and subsequent land use plays an important role. Developing mechanisms for understanding the socio-economic and biodiversity-related impacts of rapidly changing land values, land fragmentation and the loss of rural agriculture is a crucial, emerging need of public agencies and policy makers. These concerns frame the main research question that guided the study below:

Research Question 1 (RQ1): How do agricultural and recreational pressures on private lands affect land use and values in rural Texas?

The question is more broadly centred on private lands in order to include other privately owned parcels that are not agriculturally productive. While economic or ecological impact assessments are commonly applied to this problem, a sustainability perspective suggests that more is required than weighing the trade-offs between economy and the environment. Integral to sustainability is taking into consideration (i) the societal and cultural values that influence ecological preservation and conservation, and (ii) the well-being of the rural communities and local people who live on the land or are sustained by it, directly or indirectly (Machlis & Field, 2000). Tools that use a systems approach have been argued to be effective for studying and managing the diverse, interrelated factors in the sustainable planning domain (Innes & Booher, 1999). The main purpose of this research was, therefore, to conduct an exploratory methodological inquiry to:

- Identify relevant economic, social and cultural influences that impact the rural agricultural setting in Texas and develop a sustainability-based conceptual model that addresses all these dimensions.
- Examine systems-based modelling as a tool for addressing the impacts of recreation and leisure-related pressures in the rural agricultural domain in Texas.
- Explore the benefits and limitations of this modelling approach for integrative planning, communication and policy setting.

In the next section, the theoretical background and rationale for a systems approach to dynamically model the rural agricultural and nature-based recreational domains are outlined. This is followed by a methodological discussion of model development, and of social and cultural variables involved in the human-ecological domain of rural Texas. The general conceptual model resulting from this research project is presented, as well as a discussion of the benefits and limitations of the modelling approach. The paper closes with several insights on the application of this tool for sustainability-based planning at a regional level. Research questions emerging from the modelling research and analysis are also presented.

Systems modelling in complex planning domains

General Systems Theory was forwarded by the biologist von Bertalanffy (1968, 1972) to distinguish open systems such as biological ecosystems which have close interactions and interdependencies with the environment versus closed systems typified by those in the physical sciences. A system under this theory is defined as *a set of elements standing in interrelation among themselves and with the environments* (von Bertalanffy, 1968, 1972). Managing eco-systems and social systems using general systems theory provides a philosophical base for melding the human-ecologic domains, as 'soft systems' theorists and ecosystems modelers have discovered. Social theorists like Luhmann (1989) have also drawn upon general systems theory to develop a view of ecological communications where society is comprises as a set of six 'function systems' (economy, law, science, politics, religion and education) that actively constitute relationships with the environment through internally driven responses. Peterson (1997) has applied Luhmann's system theory to sustainable development, while Grant, Peterson and Peterson (2002) apply Luhmann's social theory to develop a quantitative model for simulating societal constraints on environmental action.

The importance of a systems-based view to learning and decision-making at the organi-sation or inter-organisational level is a central point in the study of system dynamics. With its foundations on Jay Forrester's *Industrial Dynamics* (1961), systems dynamic works with feedback theory of information based on the assumption that a system is composed of positive and negative feedback loops,

which, when linked together, build more complex systems. Feedback loops, or causal loops, supply elements for the mapping and building of archetypes of systems using diagrams, equations and programming language for the development of computational simulation and analysis (MIT - System Dynamics in Education Project, 1997), helping to overcome the limitations of language (Senge, 1990). System dynamics also makes use of behavioral theory to describe, define and identify empirical processes of decision-making (Sterman, 1987, 1989).

Since its foundations in 1961, several relevant studies have reported the use of system dynamics, including Forrester's *Urban Dynamics* (1969) and *World Dynamics* (Forrester, 1973) and Meadows' *Limits to Growth* (Meadows, Meadows, Randers & Behrens, 1971), often referred as the basis for the concept of sustainable development, and *Beyond the Limits* (Meadows, Meadows & Randers, 1992). Because system dynamics is based on model building and simulation, its use was limited by the low access to computers and software. A crucial turning point occurred in the 1990's with the advent of the PC and user-friendly software. Today, system dynamics is being applied by several fields of study such as ecological economics (Portela & Rademacher, 2001), ecology (Pérez-Maqueo, Equihua, Hernandez & Benitez, 2001), and more recently, in tourism to facilitate forecasting and scenario-based planning (Lee, 2001; Walker, Greiner, McDonald & Lyne, 1998). Our concern here is addressing socio-economic and cultural factors in a modelling tool for managing complex sustainability domains.

Complex domains are characterised by multiple stakeholders, numerous regulatory and administrative structures, ill-defined public interests, interrelated impacts and often less than clear problem definition (Gray, 1989; Innes & Booher, 1999). Obtaining agreement in such settings is difficult because stakeholders base their assumptions and positioning on mental models, which are fuzzy, incomplete, imprecisely stated and change even in a short time span (e.g., a discussion). Participants in a debate may employ different mental models to interpret the same subject, may not reveal fundamental assumptions or desired goals, or may draw vastly different implications about future outcomes (Forrester, 1971). A well-laid out procedure (see below) combined with carefully identifying, including and assisting participants to jointly develop and use the model can result in a powerful tool for planning and problem-solving in complex ecological-social domains (being sensitive, of course, to the power dynamics involved - see Gray & Hay, 1989; Wearing & McDonald, 2002).

Modelling the impact of changing agricultural land values in rural Texas

With approximately 97% of Texas under private land ownership, a significant portion of which is used for agricultural production, rural Texas is suffering from the same agricultural crisis facing rural America. The Census of Agriculture recorded that there were 194,301 farms in Texas in 1997. The draft Texas Parks and Wildlife Department's *Land and Water Resources Conservation Plan* (2002) reported that 33% of large landowners in the state were interested in opening their land to provide more outdoor recreational opportunities, while an additional 39% percent stated that they would be inclined to provide public access if they had liability protection. Since the state of Texas does provide liability protection, the potential for tourism and recreational development on private lands in Texas is high. A growing trend towards parcelisation (fragmentation) of land continues, particularly in the urban-rural interface in Texas which is under pressure from rising recreational demand, both for outdoor recreational pursuits, and for country-style living (ranchettes).

The resulting transformation of land values to commercial and recreational use is of particular concern in Texas, where economic profitability factors lag behind social and cultural factors in decision making related to the land. Huett's (1999) extensive survey of agricultural landowners in Texas showed that being able to pass on the family-owned estate as an inheritance to their children, and having a working lifestyle comprised over 50% of the owners' long-term strategic goals. Conservation came third and income fourth (around 10% of the goals). Huett's study reinforces the importance of adopting a sustainability-oriented approach to the study of rural land fragmentation in Texas. Cultural and social impacts have to be factored into the picture, because the ongoing rapid fragmentation of land is also impacting individual and collective heritage and identity. Research Question 2 (along with specific sub-questions RQ2a-d) and Research Question 3 emerged as a result of this early probing into the factors and motivations that exacerbate rural and fragmentation in Texas, and frame the study conducted below:

Research Question 2 (RQ2): What social factors and cultural values influence ownership and land use decisions of agricultural landowners and producers (farmers and ranchers) in rural Texas? [e.g., to sell, consolidate or maintain ownership of their land parcels and related property, or to employ alternative strategies such as diversifying into nature-based tourism]

RQ2a: What micro and macro-level social and socio-political factors influence seller motivations? [e.g., owner's age,

Figure 1: Monetary factors affecting landowners' motivations to sell or h

uncertainty about future conservation policies, societal pressure for recreational access to natural areas within private lands]

RQ2b: What cultural values influence seller motivations? [e.g., What is the owner's relationship to the land? How does this influence seller motivations, and what if the producer is a tenant farmer, but not an owner, or if the owner does not live on the land?]

RQ2c: What (inter)related economic and social-cultural variables influence seller motivations? [e.g., role of inheritance tax and parcel size to family succession, importance of land as heritage in decision making relative to declining agricultural income or attractive market value]

RQ2d: What are the (inter)related social-cultural impacts of changes in ownership, parcel size and land use? [e.g., impacts on cultural heritage and associated land relationship, and therefore long-term environmental impacts]

A major challenge then follows with respect to effectively incorporating social and cultural dimensions into the decision making, for this is often left out of sustainability planning and few precedents exist on doing this well (Robinson, 1999). Research Question 3 arises from this and is closely related to Research Question 2. While RQ2 focuses on the substantive (content) aspects of the issue, RQ3 addresses the process-related question in this planning domain:

Research Question 3 (RQ3): In light of the complex (inter)relationships among the ecological, economic, political and social-cultural systems, what tools or processes can be used to facilitate effective communication, planning and decision-making for sustainability in the rural agricultural domain?

Research Questions 2 and 3 call for new ways of understanding, and new tools for integrative planning (see Getz & Page, 1997; Sharpley & Sharpley, 1997) in complex domains like the transitioning rural agricultural system. Systems-based modelling is commonly used in ecological and economic studies, but few precedents exist for the innovation demanded when human dimensions (especially social and cultural) have to be considered as integrated aspects of ecological and economic systems. A systems-based approach has been advocated to address interdependencies between ecological, social and tourism sub-systems (Lee, 2001; Murphy, 1985; Walker *et al.*, 1998). Yet the socio-economic and cultural dimensions have only received perfunctory treatment in these approaches. We take up this challenge by applying a user-friendly software based on systems dynamics, *STELLA Research 7 for Windows*, to develop an integrated regional model. The model approaches the sustainability of the rural agricultural domain by attempting to incorporate social, cultural and heritage-related values related to the land and its inhabitants.

Methodology

From a process and planning perspective, model development followed Steps 1-4 below. A general conceptual model was developed by our cross-disciplinary research team, using STELLA. Team members consisted of an ecological scientist (wildlife specialist), a communications scholar with experience in the cultural dynamics of rural agricultural systems, an economist with modelling expertise, and two social scientists experienced in sustainable tourism and strategic planning. Using an iterative process of dialogue, study, modelling, a number of interrelationships between human, ecological, socio-cultural and economic factors were explicated. A four-step process was developed based on the literature review presented above and prior experience with STELLA modelling (Grant *et al.*, 2002; Jamal, Borges & Figueiredo, 2004; Lee, 2001).

Step 1 – Develop a general conceptual framework based on literature review, expert knowledge and assistance of modelling experts and input this into a STELLA model.

Step 2 – Modify the model based on expert input within the research team and academic/ Extension community. Develop mathematical relationships and quantify relevant components and variables (i.e., develop quantitative measures and qualitative relationships that can be entered as data inputs).

Step 3 – Obtain historical and current data on case study location of interest. Enter into model and do trial run. Revise model based on results.

Step 4 – Continue Steps 1-3 in an iterative process, involving relevant experts and stakeholders as required. Continue this procedure for the next case study location when satisfied with results from the first case study.

Extensive examination of research and policy-related documents, as well as consultation with experts such as Extension agents and other scientists, provided a series of inputs and general hypotheses that guided the development of the conceptual model shown in Figures 1-3. This modelling research is being conducted in two phases, where Phase 1 represents the detailed background analysis and extensive concept modelling. This paper focuses on Step 1 (Phase 1) in order to show the importance of developing not only the general conceptual model, but also the social and cultural factors that are often omitted for such research domains. The rest

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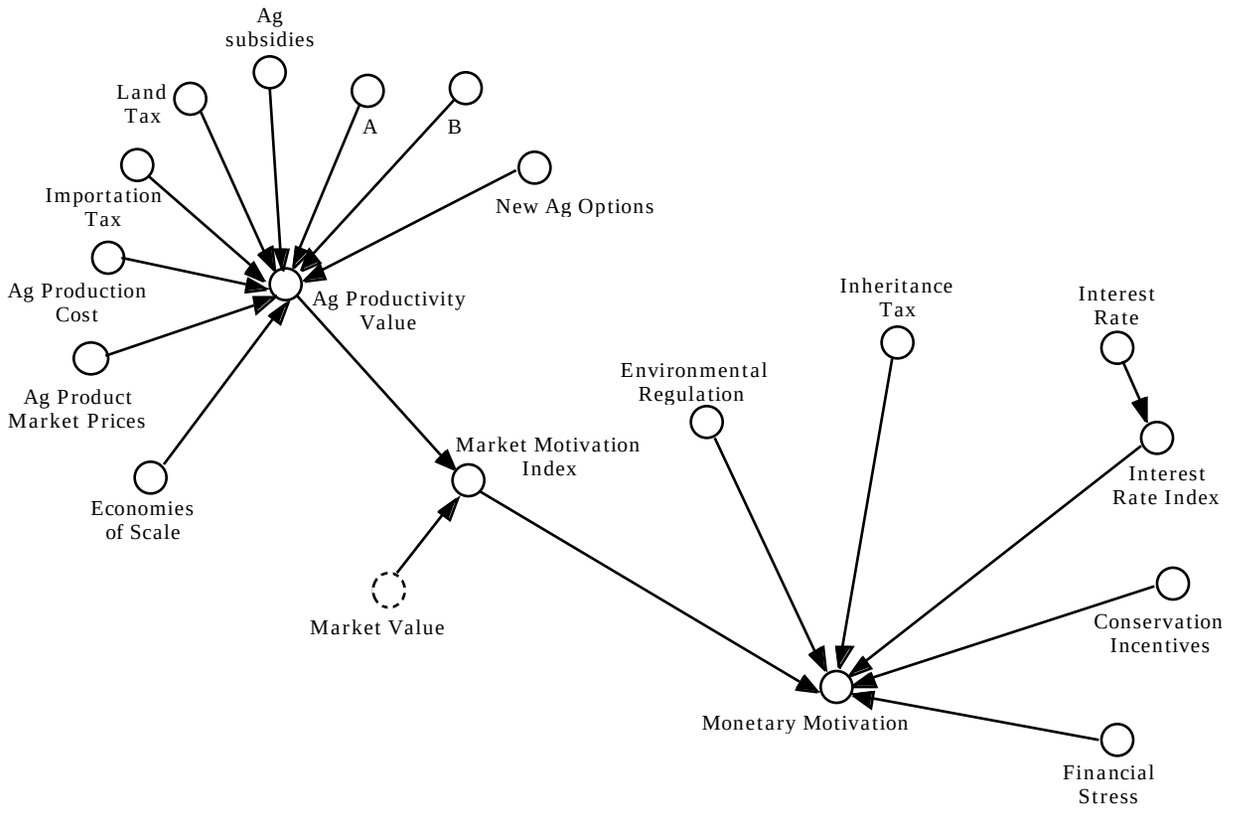

Figure 1: Monetary factors affecting landowners' motivations to sell or hold land

of the paper therefore addresses methodological issues and the modelling process, including identification of key social and cultural variables for inclusion in the model, benefits and limitations of this approach and future research directions.

Key concepts and variables

State and accessory variables

An important aspect of the problem lies in understanding the population and recreational demand-related pressures on agricultural land ownership in the urban-rural interfaces around the growing urban cities of Austin, Houston and San Antonio, Texas. Population (number of people) and land parcels (number and size by hectares of land) as well as land-use (current types of use of the land) become important STATE variables, also known in modelling jargon as stock variables. The stock represents the type and amount of material that are being transferred through the system. One example of stock variables could be different categories of parcel size, e.g., <500 acres, 500-2000 acres. An example of material transfer would be parcels moving from the latter to the former size due to parcelisation.

These material transfers are influenced by driving and accessory variables which explicate seller and buyer motivations (see Figure 1). In order to understand the social and cultural aspects that influenced decision making, the conceptual model was framed around monetary and non-monetary motivations, particu-larly those that influence the seller. The arrows indicating flows between components in Figure 1 should be interpreting as containing either a positive or negative correlation, i.e., the arrows do not represent a causal relationship.

Buyer motivations

Buyer motivations have been included to illustrate both monetary and non-monetary incentives to buy (e.g., a public agency or conservation organisation purchasing parcels in order to consolidate and conserve or preserve the habitats and ecosystems).[1] Buyer demand is factored into market value, and includes demand for various forms of non-traditional use, including demand for recreational and retirement homes and related commercial services, commuter demand for lower cost housing outside urban centres, as well as commuter demand for rural lifestyle, and a growing demand for 'ranchettes', small land parcels (less than 500 acres) on which model ranch or farm-based lifestyles are engaged in as a form of recreation (part-time and weekends), but sometimes full-time. As Figure 2 shows, buyer demand for recreational properties is influenced strongly by proximity to urban centres, size of parcels (small is better), and landscape value (aesthetic-beauty and amenities-recreational potential contained in hills, rivers and related features on the parcel).

Seller Motivation

The various factors that are seen to affect the market value versus the agricultural value of the land are an important aspect of monetary motivations (there is a potential incentive to sell if market value exceeds agricultural value). However, as the term 'motivations' indicates, cognitive and social variables have to be included, as has been done by developing the major component called 'non-monetary motivations' of the landowners. Seller motivations were carefully partitioned to include physical, material and economic factors, as well as cognitive variables such as perceptions of the farmer and ranchers about the profitability of their enterprise (e.g., their concerns about environmental regulation or other external environmental and economic conditions that create uncertainty). Other non-monetary influences include social aspects such as age considerations (micro-level individual factors) and changes in family succession and lifestyles (macro-level social structures).

Social and cultural aspects

Sellers are motivated to subdivide or fragment larger property sizes to avail themselves of profit from the higher market value of their land, or may parcelise for reasons of financial stress, to pay estate tax, etc. (see Figure 2). Two key factors here relate to passing the land on through family succession, and maintaining a rural agricultural lifestyle (Huett, 1999; White & E. Fox, 2002; Williams, 2000). These two factors are closely related to cultural impacts with respect to heritage and identity at the level of the individual and the collective (social and institutional). These are reflected in an ecological ethic (Callicott, 1989, 1994; Gunter & Oelsschlaeger, 1997; Kohak, 1987; Leopold, 1966), a socio-cultural ethic (Nash, 1982) and, more specifically, an agricultural land ethic at the level of the rural producer and landowner (Hanson, 1996; Thompson, 1995).

A major challenge developed in trying to conceptualise the complex land ethic and cultural values that influence the producers to hang on to the land, despite barely being able to eke a living out of it. The land holds deeply rooted meanings for agriculturalists in rural America (Hanson, 1996; Jamal, Everett, & Dann, 2003; Thompson, 1995; Williams, 2000). It forms part of their identity, both individually and collectively as a state or nation. Embedded in this cultural identity is the deeply-rooted frontier history (conquest of the new world), individual rights and private-property rights, religious principles such as the Protestant Ethic (hence the land must be made to produce in order to obtain rewards from God) discussed by Oelschlaeger (1991). Various frontier and Jeffersonian myths are describe by Peterson (1990); Peterson and Horton (1995); and Browers (1996). Prior research in this area and a close study of the diverse literature enabled identifying some key attitudes, behaviours and relationships with the land/nature. For ease of presentation, we divided this into three types of ethics (Table 1):

- An Ecosystem ethic (human-nature relationships)
- Interaction with the land (a physical and phenomenological ethic of place)
- Social and cultural ethic (societally-based, including political)

It can be argued that the agricultural land ethic of these farmers and ranchers extends beyond that of exploitation of land. Involved in this ethic is the notion of stewardship of the land (taking care of the land and 'nature' on the land), in addition to a productionist (making the land produce) and phenomenological (being-on-the-land) ethic (Jamal, Skadberg, & Williams, in press; Thompson, 1995). This phenomenological dimension is not merely one of lifestyle, routine, and immediate experience with the land. It also involves a sense of place (Berry, 1983; Stegner, 1992) that is spatially rooted in space and place, and temporally grounded

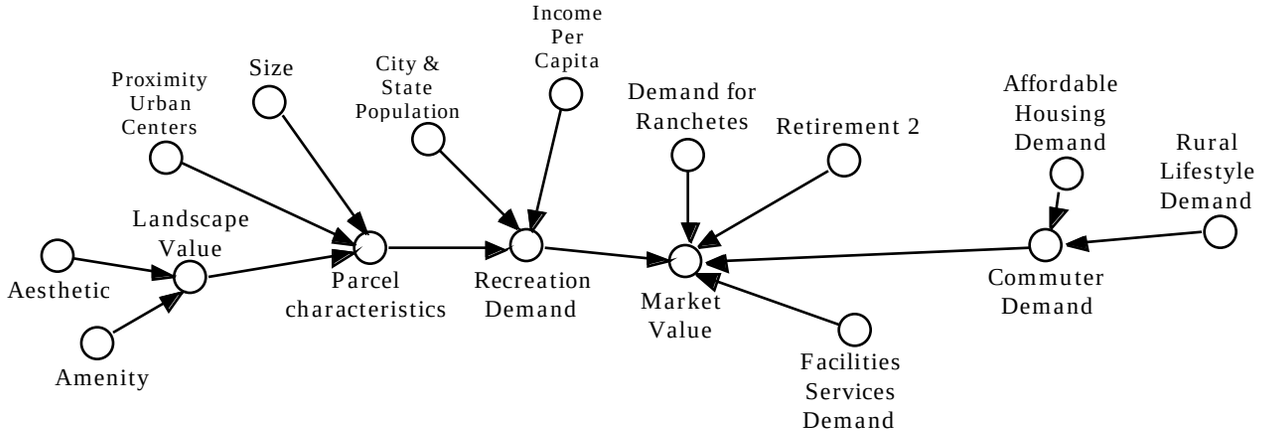

Figure 1: Monetary factors affecting landowners' motivations to sell or hold land

Table 1: Ethical Perspectives Influencing Attitudes, Behaviours and Relationships with Land/Nature.

1. Ecosystem Ethic

A. Types

- Egalitarianism
- Ecocentrism
- Biocentric (e.g. deep ecology)
- Utilitarian
- Anthropocentric
- Ecofeminist (brings biocentric and andropocentric together to some extent?)
- "The Conservation Aesthetic" (Leopold, last article in Sand County Almanac)

B. Religious/Spiritual/Moral

- Judeo-Christian influences (e.g. 'Protestant Ethic')
- Buddhism
- Islam
- Confucius/Taoism
- Hinduism
- Indigenous relationships with the land/'nature'
- Syncretic practices
- Greek philosophy

2. Interacting with the land ethic (physical and phenomenological)

- Evolution Biology
- Living on the land (e.g. tenure: how long on the land)
- Making a living off the land (note survival/economic/political ramifications)
- Leisure and recreation on the land
- Consider issues of commodification of nature experiences (market capitalism), types of recreation (golf? power-based vs. contemplative experiences <= Sax, (1980) *Mountains without Handrails*)

3. Social (societal) ethic–correct (appropriate?) relationship among members of society)

- Property rights and self-interest (Political Philosophy)
- Capitalism/democracy/communitarianism/rugged individualism (Olwig & Olwig, 1979)
- Romantic Philosophy (e.g. Wordsworth and the Lake District, England)
- Moral
- Identity (cultural and heritage; individual, regional, national…)
- Status and cultural capital (my suburban lawn, my travel to the Amazonia)

in the past. It is one of historical inheritance - a heritage that many Texan landowners trace back through several generations. Unless there are no family members to inherit the land, or if estate taxes create enough financial hardship to require parcelising and selling all or part of the land, the lifestyle, heritage and cultural values symbolised by the land means that the owner will attempt to endure financial and other hardships (e.g., take on additional work in order to be able to hold on to the land). These intangible values influence their decision making, their motivations to produce, sell, consolidate, parcelise or diversify into other enterprises on the land.

Our analysis indicates that both individual and collective (state/national) heritage, history and time (involved in conducting everyday activities) play an important role here as well. The notion of Jeffersonian democracy and his concept of a land ethic, the Protestant ethic described by Max Weber, and the frontier ethic all hold important implications for individual and collective identity, heritage and landowner decision making (Browers, 1996; Oelschlaeger, 1994; Peterson, 1990; Weber, 1958). Much further work needs to be done in Step 2, to theoretically and empirically develop the agricultural land ethic and the relationship of agricultural producers to 'Nature', but the cultural values related to land, heritage and personal as well as collective identity are included in Figure 3 and represents a starting point for further research and development.

Based on the above literature as well as through discussions among the research team and with Extension experts (all of which was facilitated by the iterative, dialogic model building process itself), a number of social variables were also identified (see Research Question 2a) and included in the model (Figure 3), such as age, family succession (children to inherit the land), lifestyle and livelihood changes (e.g., with mechanisation or encroaching urbanisation).

The next task was to identify specific variables and items to be operationalised at a later date with the help of data gathered. If the variable is not used, it can be ascribed a value of "zero" which means that the variable is inactive, i.e., it does not influence outcomes. A number of specific social variables were discerned from the available literature and discussion with experts. "Hassle factors" (Figure 3) attempt to capture non-monetary social variables and aspects such as failing health or need/desire for retirement, lack of family or others to inherit the property, concern and uncertainty about the future due to declining

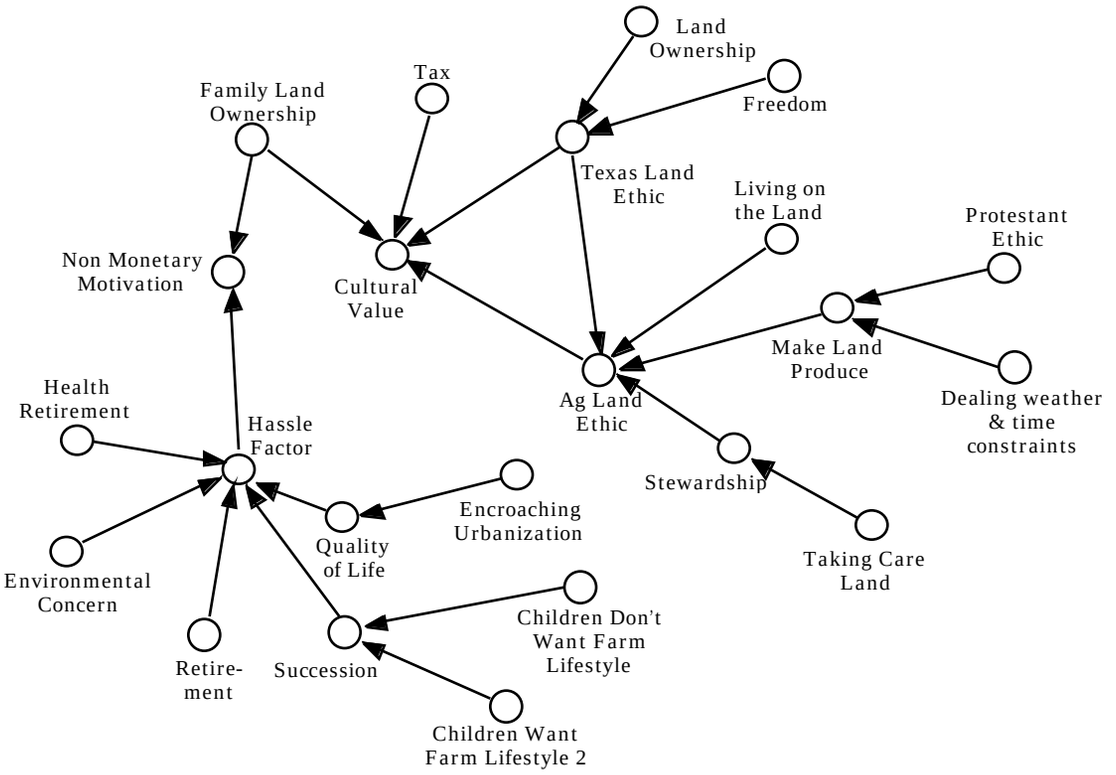

Figure 3: Non-monetary factors affecting landowners' motivations to sell or hold land

agricultural incomes or changes in subsidies, etc.

Model validation

The cultural and social variable shown in Figure 3 of the conceptual model reflect our attempt to address the intrinsic value of the land to these agricultural providers, their cultural, existential and historical relationships to the land and how this relates to individual, state and national identity. Even if they are not operationalised, including the intangible societal and cultural factors at least make them more visible to planners and policy-makers using the model as a decision making aid. This suggests that the process of model development and use, at some stage, *has to include the key stakeholders - those who stand to impact or be impacted by the decision making.* In this study of rural Texas, the landowners are a primary stakeholders to involve. However, beyond the producers, planners, policy makers and rural communities, lies the wider society/public that is being impacted by the changing landscape of rural Texas. Who represents the interests of these secondary stakeholders? Who decides, not merely whether they wish to consume GMO foods, but whether the family farm embodies heritage, social and cultural values important to the well-being of natural and human communities?

Model development and testing is therefore closely related to the issue of model validation, and the overall credibility of the modelling process. The interpretive nature of the modelling exercise means that the ability of the model to aid decision making, depends not only on how the model is operationalised (especially with respect to the qualitatively inclined social and cultural variables), and the accuracy of empirical data used to test the model, but more importantly on the involvement and approval of relevant stakeholders. Documentation is a crucial aspect of this process, particularly when a diverse group of participants are involved. The variables, inputs and changes need to be documented and defined as soon as possible, for the model can become complicated very quickly. What variables were entered for what purpose may not be well-remembered later when it comes to attempting to quantify the variables and gather relevant data. An example of documentation, for instance, of the component "Market Value", is as follows: "Market Value is based on the fair market price of a property on the open real estate market". Model validation is therefore facilitated by including:

- Feedback from experts possessing scientific knowledge of the problem domain as well as modelling experts.

- Feedback from experts and other stakeholders not directly on the team. The approval of stakeholders who stand to be impacted by the problem or issues being modelled is integral to the validation of the model developed.

- Careful documentation of the process, parameters, variables and relationships, so that these

can also be evaluated by interested parties.

- Extensive technical tests using empirical data.

General hypotheses can be developed from the background research to guide the model development, and new hypotheses are generated as the model continues to be refined. A number of relationships and hypotheses started to emerge from the modelling research and development process, several of which are listed in Table 2 to show how these inform or are informed by the conceptual model shown in Figures 1 to 3.

Table 2: Hypotheses on Parcelisation, Fragmentation and Ownership.

Hypotheses on Landowners and Parcel Size, Type and Location

1. Small ownerships are more like to be subdivided than larger ones.
2. Small ownerships are more likely to result in loss of biodiversity and habitat than larger ones.
3. Parcelisation into ranchettes is higher on land with aesthetic appeal (aesthetic value, e.g. beautiful landscapes).
4. Parcelisation due to recreational demand is greater with proximity to urban centres.
5. Growing urban populations are creating increasing demand for rural agricultural lands (for non-traditional use).
6. Parcelisation of mid-size farms (500-2000 acres) is influenced by lack of economies of scale, absentee ownership, financial stress, plus "hassle factors".
7. Ranchettes are more likely to contribute to biodiversity loss and habitat fragmentation than mid-size ranches.
8. Small agricultural parcels (<500 acres) are more likely to be sold for non-traditional uses, due to lack of economies of scale, proximity to urban centres, absentee owner, lack of family succession (having children interested or able to in take over the land ownership – the children may not be able to maintain the land or may not be interested).
9. New owners with less than 5 or 10 yrs land tenure (ownership) will tend to have purchased small parcels (<500 acres) for non-traditional uses.
10. Mid-size farms/ranches will tend to have older owners with longer land tenure (longer period of ownership) than small farms/ranches.
11. Landowners are motivated to sell when market value exceed agricultural productive value.

Hypotheses on Land Ethic and Socio-Cultural Values

12. Effective conservation policies are a function of the non-monetary (e.g. land ethic) and monetary values of the landowners, plus the recreational, leisure and conservation values of 'society' (urban centres located in the agricultural region').
13. Agricultural landowners will tend to stay with the land despite financial hardship or declining profitability, due to both an agricultural ethic and a Texas land ethic.

Hypotheses on Recreation and Tourism

14. Rural recreational demand (for recreational properties, e.g. ranchettes, for second homes, and for general recreational opportunities and related services) is influenced by proximity to urban centre as well as by landscape characteristics (aesthetic value - proximity to rolling hills, water, trees; and amenity value - proximity to service centres, good access roads...).
15. Non-traditional use demand (retirement homes, recreational demand, commercial services), i.e. buyer demand, contributes to increasing market value and hence parcelisation.
16. Diversification by the producer into non-traditional activities like hunting, nature tourism, and agritourism (e.g. B&B on working ranch) is motivated primarily by desire to supplement declining agricultural income (Secondary motives may be present - see Nickerson, Black, & McCool, 2001).

Benefits and limitations of systems-based modelling

While still in the early stages of research and a long ways to go, our experience with systems modelling in rural Texas corroborates other research using systems-based approaches (e.g., Innes & Booher, 1999; Walker *et al.*, 1998) with respect to the potential benefits of applying this modelling tool to planning and policy-making in rural agricultural domains. Benefits indicated by our research so far are summarised below, and relate both to process and content of the systems-based modelling employed here:

- This systems-based modelling provides a collaborative tool for interdisciplinary team-work where thoughts and ideas can be jointly discussed and developed through the modelling process. It helps to objectively lay out the mental models of various team members and other stake-holders involved in developing the model.

- The ability to include and manage the interrelationships between a large number of variables means that tourism system modelling can now be advanced to the level of including social, cultural and political dimensions in addition to the economic and ecological modelling that has typically dominated systems modelling in this domain. This modelling approach thus offers potential for being able to examine micro-macro and local-global impacts in the destination domain.

- Both the exercise and the conceptual model itself also help participants to under-stand relationships and interdependencies between various dimensions and aspects within the overall

system. Modelling complex systems like the one described in this paper helps overcome cognitive limitations by allowing participants to comprehend and manage a large amount of information (in this sense, the modelling is akin to a cognitive mapping exercise).

- In addition to the inter-relationships noted above, the model helps to understand potential long-term effects and impacts, and a number of different time-steps for different aspects can be used (e.g., population change can be modelled in 10 year cycles, while visitation could be structured along a daily, monthly or annual basis).

- Combined with other spatial-explicit modelling and tools like GIS, a systems-based modelling approach as followed here offers great potential for understanding changing land-use and ownership patterns in rural-urban interfaces, e.g., changing land values and linkages between tourism and recreational pressures, rural communities and agricultural enterprises, and the resulting impacts on landscape and natural habitats.

- The modelling exercise and software enables efficient documentation of information and decision making that goes into developing and defining the various, often complex interrelated components and flows in the systems being modelled. As such, the tangible outcomes of this exercise become a source of visible and accountable documentation for others wishing to trace the decision-making process and products.

- A key benefit of this modelling approach is the joint development of the problem domain in the model, and the collaborative learning that occurs in the process, which contribute to the development of a common knowledge-base and participatory skills among the team members.

But this modelling approach also presents several challenges and limitations, as we learned. This type of model can become extremely complex very quickly and setting parameters and restraints on the goals and objectives of the modelling effort, as well as careful documentation of parameters, definitions and procedures is essential. It requires that team members are able to work together, willing to compromise and include others' viewpoints in the model development process. This is important to recognise, that not only does this type of model development require an inter-disciplinary base of knowledge and skills, but that the process is also highly 'political'. Similar to the challenge observed in collaborative planning processes, anyone not able to exert their views or desires risk getting left out of the decision making process (Jamal & Getz, 1995). Not including relevant stake-holders in the model development process means the final product is the outcome of a select group of people, reflecting that group's knowledge, interests and (hidden) agendas (see Gray & Hay, 1989). This potentially jeopardises the legitimacy and acceptability of the model to other stakeholders in the domain.

The participation and input from all stake-holders is essential if the model is to represent the complexity of the decision making process.

The gathering and utilisation of the data also has to be done with careful attention to process and legitimacy issues (e.g., do the stakeholders perceive the data as legitimate, are there conflicts of

interest in the data sources and applications), in addition to the accuracy and quality of data. Both these are crucial factors, for the former will impact the credibility of the outcomes and results, while the latter will impact the outcomes and results themselves. In order to be useful as a decision making tool for policy makers and stakeholders not involved in the design, it is therefore important to keep in mind the uses for which it is being developed. In order to address this and the other challenges outlined above (like the political challenges), two aspects of the research and model development have to be clearly identified early in the process: the process (experts and other stakeholder participation, how development and documentation will be done, etc.) and the *content* (e.g., information, data, variables). Adequate allocation of resources and funds, as well as a realistic time-table for model development help to ensure a useful product.

Furthermore, the complete mathematical model should still be viewed as an interpretive model that represents the information inputs and mental models of the participants, i.e., it is not necessarily an accurate representation of 'reality', but it may be the best we can do to represent reality as close as possibility through a dialogic process incorporating qualitative and quantitative variables. This is particularly so with models that include social-psychological and cultural variables in addition to physical and material variables. Relying on this model as a tool for prediction and generalisation has to be done with caution and sensitivity to the study location and contextual influences. However, as a visualisation model, i.e., for visualising and seeing how variables are affected in the system due to a change in another part of the system, the model offers strong potential for aiding planning and decision making.

A sustainability and systems-based approach to planning

As the above study of rural Texas shows, the urban-modern system, the recreational-tourism system, the agricultural system, the ecosystem and the global-economic system constitute a complex planning domain. Marcouiller and Green (2000) and Tribe, Font, Griffiths, Vickery & Yale (2000) note that the economic sustainability of rural areas relies on the development of community-based strategies that draw upon local productive resources. Land-based recre-ational opportunities, for instance, draw upon natural amenities and resources of the region but, as these authors point out, the relationships between such local resources, recreational use and tourism are not well understood and better assessment of linkages is needed to inform decision-making and community development. The modelling project undertaken in this study suggests that STELLA based modelling merits further study as an innovative tool for integrative approaches to managing urban-recreation and economic impacts in rural agricultural domains. While keeping in the mind the challenges and limitations outlined in the previous section, the systems-based modelling conducted here suggests that this approach is particularly valuable for the following purposes in rural agricultural settings facing development and recreational pressures:

- For mapping out and incorporating a large number of variables through a

As a visualisation model, the approach offers strong potential for assisting planning and decision making.

computerised approach that would be very difficult to accomplish by hand, and at the same time provides a methodology that addresses process and content aspects in planning and decision making. This challenge is magnified in complex domains where stakeholders are multiple and diverse in interests and background, issues and impacts may be interrelated and poorly defined, and a large number of public and private sector organisations influence policies and regulation-setting.

- It can help conceptualise and integrate the mental maps of various stakeholders into a computerised decision-making framework of the various pressures and forces contributing to land fragmentation (parcelisation) and habitat fragmentation in the complex urban-rural agricultural domain. Of particular importance here is the ability to model the dynamic interrelatedness of various types of impacts, and include non-monetary components such as the aesthetic and amenities value of the land, and the cultural values associated with owning and living on the land.

- Based on systems-based thinking and learning theory, this is a valuable tool for collaborative learning (Daniels & Walker, 1996), management and visualisation of a complex recreational and agricultural domain. It allows for improved participation in decision-making together with effective inter-group communication of issues, values, and technical information such as natural resource management policies and techniques. Participants in policy dialogue may include, for example, groups such as private citizens, technical experts, representatives from varying academic disciplines, non-governmental organisations (NGOs) and other special interest groups, as well as different socioeconomic and ethnic groups.

- In addition to (or instead of) being a decision making tool, it can act as a collaborative teaching tool (Jamal *et al.*, 2004) to show viewers the interrelationships among various components and flows within and between the sub-systems and the overall system. The ability to illustrate the dynamic feedback loops between various impact types (including social and cultural), and hence the potential outcomes associated with various options or actions in the decision-making process, makes this a useful sustainability-based tool for generating dialogue and joint understanding of the more intangible cultural and societal trade-offs that need to be made in the interest of 'sustainable development.'

It can thus be argued that even if the socio-cultural variables are not operationalised or operationalisable (as some may claim), depicting these as neutral or inactive components in the model is a valuable exercise. The dialogue involved in building these into the decision making model, and being aware of their presence while using the model, facilitates a sustainability-oriented consciousness to planning and policy making in two ways: (1) the interrelated and sometimes interdependent nature of impacts becomes more evident, and (2) the social and cultural trade-offs that need to be weighed against the outcomes desired by the individual landowner, dweller, the rural communities and wider society (the public) also become more evident. At the very least, it imposes an accountability on those involved to consider stakeholders not present, and impacts not easily tangible.

The rural agricultural domain of Texas thus shows intricate economic, social, cultural and ecological interrelationships that are interwoven through two common denominators, the land and its inhabitants. Our analysis above identified cultural variables (e.g., heritage related) that directly impact decision-making and are, in turn, impacted by long-term decisions to sell or stay with the land. Providing effective conservation incentives and habitat protection measures depends on understanding these complex relationships between the various sub-systems in the domain: the urban-rural system, the agricultural system, the recreational-tourism system and the ecological-political systems that transcend private land boundaries in Texas. Direct gains to human-environmental relationships may possibly be gained through activities such as agritourism and nature-based tourism on the 'family farm', as identified in Research Question 4:

Research Question 4 (RQ4): What role can nature tourism / agritourism play in conservation, with respect to increasing public awareness (through interpretation and education) and providing nature-based experiences that enhance ecological consciousness at the societal level and conservation / preservation at the farm level?

The economic-social system raises a number of additional societal issues related to the 'family farm' and conservation in the state, shown in Research Question 5 below. Is it worth saving the family farm simply because it adds diversity to the economic system (which otherwise will be dominated by factory farms and large-scale producers)? Or is it important to save these family farms because they can be stewards of diminishing natural spaces for a rapidly urbanising population, who may value these intrinsically (as a societal good) or for leisure and recreation purposes? The continued growth of urban centres and loss of adjacent rural spaces through parcelisation (James, 2000) raises

important social justice issues, such as making available nature-based amenities and experiences to those who cannot afford to buy a piece of Texas (e.g., through farm-stays, access to nature-based tourism, and recreation on private lands, agritourism). Research Question 5 captures some of the issues most relevant to tourism and recreation (also see Nickerson, Black & McCool, 2001):

Research Question 5 (RQ5): What are the most effective strategies for sustaining the family farm in order to gain interrelated heritage, ecological and socio-economic benefits and minimise adverse impacts?
RQ5a: What role does nature tourism/agritourism play in diversifying and supplementing farm income?

RQ5b: What are the social and cultural impacts of diversifying into nature tourism/agritourism, and how does this impact long-term agricultural and ecological sustainability (e.g., impacts on working farm/ranch lifestyle, cultural heritage and the agricultural land ethic)?

RQ5c: What is the relationship between sustainable agricultural practices and nature-tourism/ farm tourism at the level of the agricultural enterprise? [e.g., does sustainability accreditation of farms providing nature tourism experiences or agritourism require sustainable farming practices? How does the tourist experience of (un)sus-tainable agricultural practices relate to the concept of sustainable or responsible tourism?]

While still in the early phase of research and test, the modelling approach examined in this research exhibits strong potential to facilitate integrated planning in complex ecological-social domains like that of rural Texas. Further research and refinement will be needed to address the challenges of integrating the various level and types of impacts, systems and sub-systems. A fruitful area for future exploration, for instance, lies in understanding the system and sub-systems of the model through inter-locking cycles that are spatio-temporally bound, rather than through further debates on open and closed systems (Westley & Vredenburg, 1996). Further research will also be need to identify and attempt to operationalise the less visible and hard to quantify, but nonetheless, influential (and often inter-related) social and cultural impacts of development and recreational pressures on the rural agricultural domain.

A sustainability-oriented systems approach brings a social-ecological ethic into the planning and management of human-natural environments. Of this integrated approach, Aldo Leopold's land ethic, as described in *A Sand County Almanac* (1966, p. 239) goes thus:

> *All ethics so far evolved rest upon a single premise: that the individual is a member of a community of independent parts...The land ethic simply enlarges the boundaries of the community to include soils, waters, plants, the animals or collectively, the land.*

Notes

[1] Note that consolidation can also occur either through buyer activities (e.g., a buyer purchasing and consolidating in order to develop a larger area for recreational hunting), or by an existing producer who may consolidate parcels in order to obtain economies of scale.

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