7-2013

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Abstract: From 1997 to 2007, 9.6 million hectares of grassland were converted to cropland and fifty seven percent of these conversions occurred in the Northern Great Plains (NGP). Since 2007, another 9.5 million U.S. hectares have been converted with the majority located in the NGP. Short-term, positive benefits include increased food production and higher financial returns to farmers. However, there could be unintended consequences through loss of ecosystem services. Consequences may include compromised water quality, wildlife habitat loss/fragmentation, and decreased carbon sequestration. The principal objective of this work is to: 1) identify structural features influencing land use decisions through agricultural stakeholder engagement; and 2) to synthesize results into a causal loop diagram through a group model building process. This information can be used to construct a stock-flow model to quantify implications for land management, forecast potential unintended consequences from major land use changes, and develop strategies to minimize their impacts.

Key words: Grasslands, natural resources, stakeholder engagement, group model building.

Introduction[1]

> *"The beauty of South Dakota's rural acres may be esteemed in the eye of the beholder, but valuation, it seems, is determined by legislation." – Lisa Hare, Yankton Daily Press & Dakotan, July 15, 2009.*

The United States Department of Agriculture's Risk Management Association (USDA-RMA) continues to provide numerous subsidy and insurance options for farmers. This is vitally important for maintaining a successful and stable long-term agricultural industry and one that continues to feed a growing world population. The United States regularly ranks among the most productive agricultural nations (FAO 2005) and with a much smaller population growth rate (.86%, or 137[st] fastest globally, World Bank, 2012). This puts the United States in a unique position as world food providers and brings an enormous economic benefit to United States producers (estimated $91.7 billion agricultural profit for 2012, USDA-ERS 2012a).

[1] We would like to especially thank Michael Goodman (Innovation Associates Organizational Learning) and Corey Peck (Lexidyne) for their continued support throughout this project.

However, this status and privilege come at a high economic and social cost. Annually, the USDA expends between $10-20 billion in subsidy payments (USDA-ERS 2012b) and over $7 billion in insurance premium assistance for producers (due to extremely high cost of commodity insurance, the USDA pays about 60% of a producers premium); (Congressional Research Service 2010). Subsidies and insurance receipts (when needed) composes anywhere from 22 to 72% of farmers net income (USDA-ERS 2012b).

The question then becomes: could these subsidies provide an extra incentive to continue or increase acreage devoted to farming? With the newly established South Dakota state tax policies (highest and best use taxation), recent appeal rejections at the state level, continued support from the USDA Farm Bill Programs, as well as CRP and other conservation land coming out of contracts or rest, Northern Great Plains (NGP) producers making these land use choices are faced with difficult decisions.

USDA programs, primarily crop insurance, marketing loans and disaster assistance continue to rely on current production figures. Under this system, farmers can expand their eligibility to receive payments from such programs by converting grassland to cropland (USDA-ERS 2011). Of the gross shift of U.S. acres from grassland to cropland (23.7 million acres), 57% were located in the NGP (or about 13.5 million acres). Since 2007, another 23.7 million acres have been converted across the country, the majority of which are located in the NGP (Faber et al. 2012). These changes were likely driven by prices, U.S. farm programs (e.g. crop insurance) and policies (e.g. ethanol mandates), technology (e.g. no-till, precision application techniques), or social and cultural (i.e., qualitative) values of land owners and managers.

Immediately, the economic and social benefits have been positive through increased food production and economic returns to farmers. However, there have been some negative unintended consequences. Grasslands provide a wide array of ecological services under light or moderate grazing (Conner et al. 2001). For example, the NGP is a rich region for wildlife habitat and fisheries. Grasslands in the region account for 50% of North American duck production. Compared to cropland, grasslands store substantial amounts of carbon which could be released back into the atmosphere (Eve et al. 2002) if managed incorrectly and tend to produce cleaner water. Despite these benefits, the NGP are considered one of the most endangered ecosystems in North America (Samson et al. 2004, Cully et al. 2003) and have seen greater reduction in native grassland acreage than any other ecosystem (60-70% loss in the eastern Plains, 30% loss in the west; Samson and Knopf 1994, Hartman et al. 2011). Fragmentation of grasslands, overgrazing and the spread of invasive species damage terrestrial and aquatic habitats, and once native grasses are lost through cultivation or invasion, it is extremely difficult to achieve reestablishment.

Land conversion not only affects direct land uses, such as biodiversity and ecosystem services (e.g., carbon storage, water filtering, wild habitat, etc.), there are ‘downstream’ effects as well. Water availability is the most important factor of land use in the NGP and roughly 76 billion liters of water are pumped each day for irrigation and/or urban use (U.S. Global Change Climate Program 2009). This directly impacts near-surface hydrologic processes (Mahmood and Hubbard 2002). Land cover changes can either be net carbon sinks or sources depending on use (Fuhlendorf et al. 2002), and loss of native prairie and wetlands have large impacts on native biodiversity (Samson and Knopf 1994, Higgins et al. 2002).

According to a USDA-ERS report *Grassland to Cropland Conversion in the Northern Plains: The Role of Crop Insurance, Commodity, and Disaster Programs* (Claassen et al. 2011), most high productivity rated land is used for intensive cropping (80%) while most low productivity land is used for grazing (73%). Medium productivity land is spread across all land uses, including cropping (53%), hay and pasture (10%), range (32%), and Conservation Reserve Program (5%). The report concluded that this data "implies that [economic] returns to medium productivity land are similar across land uses, although landowners may differ on the most valuable use" (Claassen et al. 2011). Similarly, the FAO (2011) stated:

> "Ranchers, advisors, and policymakers must not assume that a uniform management approach for all grasslands can be successful in maintaining the unique ecology of each grassland type; such an assumption has been shown to be disastrous in the past, and could be catastrophic in the future. The grassland goods and services valued by society also vary a great deal, as they are influenced by different soils, topographies, climates, and managements, and their interactions."

Together, these reports highlight the role that diversity of life forms plays in maintaining grassland ecosystems as well as the services that grassland ecosystems can provide. Thus, land use in large portions of the NGP depends not only on economics, but on history, culture, and management goals and personal values as well.

Based on this preponderance of evidence from multiple perspectives, this is a complex, dynamic problem with numerous interrelationships. Land use changes depend on responsiveness of land allocation to crop revenues, net returns, and variability of profit over time. Farmer and ranchers alike face constant changes in commodity and input markets, technology advances and political shuffling that are likely to influence land allocation decisions. Cultural and social trends and changes and individual family goals and objectives can influence land decisions as well. A systems or holistic approach that links the socio-economic and political factors with the underlying ecological and biological processes to develop an integrated decision support tool could provide much needed insight and understanding for policy makers, producers, and researchers to better understand and manage agricultural land uses.

Problem Articulation

Conversion of native grassland in favor of row-crop, tillage production agriculture has been a growing concern. However there have been several issues that 'muddy the water' when trying to understand the scale and drivers of land use change.

- First, there is a gap in National Resource Inventory (NRI) reporting. The NRI is a 5-year report created by U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS) detailing land use data over time for row crops, pasture and hay, etc. This essential report had been recognized as one of the most reliable estimates of land use change. However, due to political compromise USDA-NRCS did not release a report for 2012 (K. Forman, personal communication), making the last available data from this source 2007. Estimating most recent and alarming conversion is compromised.

- Second, because NRCS-NRI reporting has been delayed, most recent attempts to link land use changes to potential drivers have relied on 2007 estimates. However, 2007 precedes several factors believed to be highly influential on grassland (e.g. ethanol mandates and the associated rise in crop prices, particularly corn; insurance premium subsidies upwards to 60%; removing wetland compliance in the Farm Program).
- Third, is that the most current land use investigations rely on satellite imagery and geographic information system (GIS) techniques. Although powerful for aggregating across a huge spatial scale like the NGP, these images do not capture the management decisions or considerations which led to particular land uses.
- Lastly, many land use prediction efforts (e.g. Stephens et al. 2008, Sohl et al. 2012) rely primarily on models that treat variables (e.g. soil organic carbon, precipitation, elevation, soil capability class, slope, percent grass cover, type of ownership, etc.) exogenously and linearly. This assumes that these variables directly influence land management decisions, which is likely not the case, and that there is no feedback between variables across time. Land managers could be said to be influenced or informed by such variables, but ultimately it is a management choice to decide on one alternative land use or another.

These reasons have led to an extremely linear (due to lack of feedback approaches) and yet blurred view of landscape change (due to lack of recent data). Therefore, problem articulation favored increased involvement from land managers and stakeholders across the region. Triangulation of known data with the personal stakeholders involved in land management was the primary method employed.

Methodology: Triangulation using System Dynamics

This project follows a qualitative-quantitative method of triangulation. Triangulation is defined as "a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study" (Creswell and Miller 2000) and can be used as a strategy to improve validity and reliability of research findings (Golafshani 2003). The three spokes of this proposed project will be: 1) qualitative information gathering through semi-structured interviews of key stakeholders across the Northern Great Plains; 2) the system dynamics methodology proposed by Forrester (1992) and Sterman (2000) in a Group Model Building (Andersen et al. 1997; Vennix 1999) team to model land use decisions; and 3) incorporating data from established and reputable sources to quantify key variables and their historic behavior and to forecast potential scenario consequences around established parameters.

The primary investigator completed data gathering and individual coding using methods recommended by Kim and Anderson (2012). Each step preceded that of the model building group's activities. With the completion of the first two steps (gathering interview data and open coding) a group model building meeting was held in Brookings, SD on January 22, 2013. The primary data summaries by the primary investigator acted as a comparison as well as guide during group discussions. Upon completion of the second series of steps (axial coding, word-and-arrow-diagrams (e.g. CLD), and generalized structural representations), a second group meeting was held in Brookings, SD, on February 26, 2013.

This meeting was facilitated by the use of Albin's (1997) System Dynamics Model Conceptualization worksheets as well as the coding summaries of the primary investigator. Using a combination of these methods and tools the eventual model was expected to be more representative and well-rounded for testing, simulation, and communicating implications. The results of this process are summarized in the Group Model Building sections below rather than in the Individual Coding sections, even though results were combined during the both steps.

Research Questions

The project investigated the following research questions to develop a better, clearer understanding of the complex issue of decision making and land use changes:

1) What personal values influence producer decisions about land use?
2) What factors influence a producer's land use choices?
    a. Individual/personal factors;
    b. Economic factors;
    c. Environmental factors;
    d. Political factors?
3) What are long-term, unintended consequences of grassland conversion to row-crop production?

The dynamic between personal values and objectives with landscape function through land-use choices was explored to gather needed insights about what is driving the loss of grasslands. The contemporary nature of this problem makes this work a valuable contribution to help direct policy makers, future research, and raise producer and public awareness.

Qualitative Data Collection

> *"There is equal need to understand the social processes that determine rangeland use and management as there is to understand biophysical processes." (Sayre 2004)*

The first spoke of triangulation will be qualitative information gathering through semi-structured interviews. This allows for producers and stakeholders across the region to be directly or actively involved in the research process (Gibbon 2002) and to describe their experiences in, about and around land use decision making in the NGP. In a semi-structured (or focused) interview, the investigator goes into the interview with a preset number of questions for the participant. However the conversation can vary based off questions stemming from previous responses to go into more detail (Hancock et al. 2007). This should follow an informal, conversational-type discussion rather than a formal question and answer.

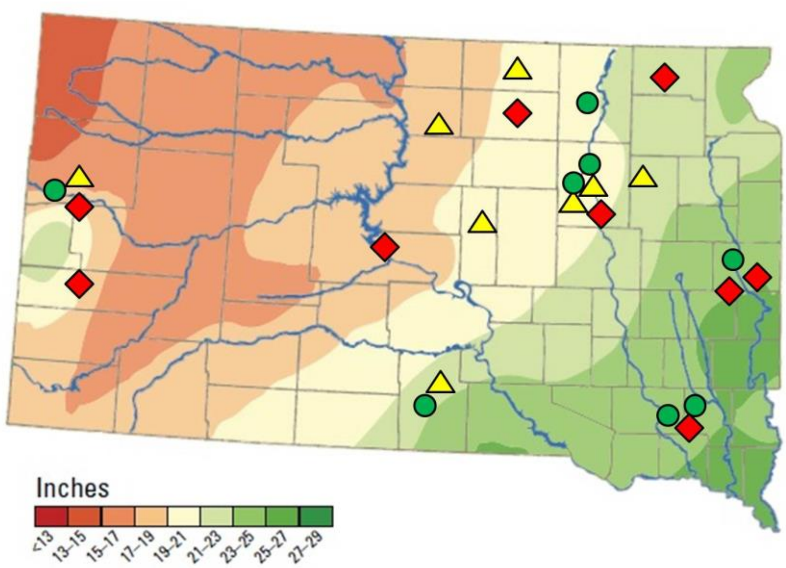
The aim of these interviews was to describe as closely as possible the mental models of systems participants. Mental models articulation is crucial for understanding the complexity and perceptions existing in dynamic systems. These documented descriptions of active mental models will be one of, if not the most, valuable resource the group model building team will need to complete the early stages of the system dynamics research process. By understanding these mental models, system conceptualization, objectives and structure will be more reflective of the actual system behaviors and processes.

Sites and Samples of Interviews

Due to the numerous stakeholders involved across the NGP and the complexity of the issue, interviews were sought from three categories of system participants: 1) those participants inclined to rangeland use; 2) those inclined for farming use; and 3) policy makers and influencers (i.e. highly knowledgeable persons not inclined to rangeland vs. farmland use but whose opinion is valued across stakeholder groups). These interviews are continually conducted until the most recent interviewee per category yields no new information (Didier and Brunson 2004) or until a total of 10 interviews per category are reached.

Farmer and ranchers were the primary voices contributing to this study and were supplemented by third-party stakeholders. Third party stakeholders were defined as those individuals who were knowledgeable and aware of land use changes, were direct influencers of land managers, and were directly influenced by land use changes. In total, 25 system participants were interviewed (8 farmers, 8 ranchers, and 9 stakeholders) from the state of South Dakota (Figure 1).

Figure 1. Map of South Dakota indicating interviewee (Green dots = farmer; Yellow triangle = rancher; Red diamond = stakeholder). Color gradient indicates annual rainfall.



Subjects were initially contacted via cold-call through an in-state directory which stemmed from a continuing education program. For those who did participate, the researcher sought participant’s friends and neighbors nearby to further explore land use in that geographic area. Of those contacted through the directory or by reference from participants, only one declined to participate. Respondents ranged from highly engaged in the land use debate (e.g. on a committee or elected board member of a commodity group; publicly elected officials) to those who preferred not to publicly engage, focusing strictly on their own operation.

Efforts were made to obtain input from as many types of land-based operations and stakeholders as possible (e.g. farms or ranches ranging from a few hundred acres up to 15,000; legislators, CPA's, industry middlemen; industry, academic, and state natural resource agency researchers, etc.). Tables 1 and 2 shows the type of operations and stakeholder role represented in the sampling. Interview data were strengthened due to overlap among producers and their respective enterprises (many operated more than one), making most of the interviewees extremely knowledgeable about land use influences and consequences.

Table 1. Type and number of agricultural enterprises represented in farmer and rancher sample.

Type of enterprise	**Number in sample**
Row crop	14
Cow-calf	13
Feedlot	3
Wildlife hunting/recreation	3
Hay/pasture	3
Stocker/custom grazing	2
Swine	1

Table 2. Stakeholder role and representation in the third party interview sample.

Stakeholder role	**Number in sample**
Grain marketer	2
Cattle order-buyer	1
Certified public accountant	1
Agency wildlife researcher	1
Farm researcher	1
Legislator	1
Water district manager	1
State Department. of Agriculture representative.	1

The author's degree of involvement differed among participants. Although each interview was kept within one hour, more or less time was spent with each person due to logistics and individual schedules. For example, some interviewees insisted meeting over dinner at their home or spending the night if they knew the author had lengthy travel, while others insisted meeting in an office or at another location due to time and travel limitations, so that interaction occurred strictly during the interview. The first author's relationship with other respondents was somewhere between these examples.

The physical presentation and background of the researcher may influence responses. The author's background includes agricultural experience in rural Texas. It was common to wear blue jeans, boots, a western hat or baseball cap to an interview, likely giving interviewees comfort that the researcher was knowledgeable about agriculture and did not feel the need to 'dumb-down' their responses. Most interviewees also inquired about the author's background out of curiosity. Not being from the state or region, the participants realized the researcher did not have an 'agenda' or was attempting to expose producer's responses for a specific cause.

Interview methods

The qualitative method used in this study was semi-structured interviews. As stated earlier, this was to obtain in-depth information from participants from predetermined questions but also allowing the conversation to vary based on previous responses in an effort to garner more detail. Interviews were conducted face-to-face, usually at the home, home-office or office building in which the participant chose to meet. Only one interviewee was not met in person due to time limitations of traveling; that interview was conducted over the phone.

The interview guide consisted of two lists of 20 open-ended questions (Table 3; Appendix Ia and Ib) divided into sections related to:

a. Description and history of operation/what role and in what industry
b. Personal values and management goals/how one contributes the industry
c. Up-coming challenges to production and management for agriculture
d. Land conversion history
e. Views toward public policy
f. Views toward ecosystem goods and services
g. Views toward solutions/strategies to conserve remaining grassland.

Not all questions were asked of every participant but all were asked at least one from each topic area in the question lists.

Interviews were audio recorded and transcribed usually within 24 hours. Due to some interviews taking place back to back or due to travel demands, some were transcribed later. None were transcribed later than three days after the interview took place. Handwritten field notes were taken during each interview were used for reference during transcription to reference specific concepts or terms used by the interviewee whenever words or phrases did not sound clear in the recording.

Individual Data Analysis via Coding

The aim of the data analysis portion of the project was to summarize interviews into key themes and prepare for the group model building process. Similar to other system dynamics research, this project draws from grounded theory, focusing on theory generation rather than testing (Charmaz 2006), which has been shown to be congruent with system dynamic model conceptualization. The coding process was intended to identify major factors and themes in the data. These factors and themes were then used in the group model building process (described below).

The coding procedure used here primarily followed recommendations of Kim and Anderson (2012) for applying grounded theory to system dynamics. This procedure included open coding and axial coding. The purpose of open coding has been described as identifying and defining the problem, setting the system boundary and identifying key variables and their causal arguments that reflect mental models in the system. During axial coding, segmented data are aggregated by finding relationships among categories of codes.

Table 3. Interview sections with example questions.

Interview sections	Sample question(s)
Description of enterprise/role	• Can you describe the nature and scope of your operation? • How does your organization help agricultural producers? Land managers?
Personal values/nature of contribution	• What motivated you into the agricultural business? • What are the primary tools you use to help land managers make decisions?
Challenges/issues coming for agriculture	• What challenges or issues do you foresee in the near- and long-term future for your industry?
Conversion history	• Have you converted acres from prairie to cropland? Why or why not? • Have you witnessed prairie being converted to cropland?
Views toward public policy	• How has public policy, like subsidies or insurance, influenced your decisions?
Views toward ecosystem good and services	• What value do you place on ecosystem goods and services? • If any of these goods and services are lost, are they worth trying to restore/recover?
View about potential conservation strategies	• What, if any, solutions do you see in the struggle to conserve native rangeland while still being able to produce field crops that are so highly demanded?

For the first stage of analysis (open coding), each transcription was read and color coded based on factors or clues about the land use issue. For example, ecological, agricultural production, or land use characteristics were coded green. Comments related to public policy, government, and politics were coded blue. Economics, marketing and technology were coded in yellow. Lastly, personal values, extracted mental models and family and community related thoughts were coded in gray. Memoing was also used widely throughout open coding. These included comments about implicit structure, sub-factors within a given color code (e.g. commodity prices or input costs within economics), general observations or sometimes simple questions to be reflected upon later.

During the second stage, the color code for each interview group (i.e. farmer, rancher, and stakeholder) were aggregated together for further analysis in axial coding. These single arguments were arranged by theme within stakeholder group and ranged from as little as one or two sentences to an entire page. Coding charts were created for each argument that revealed an insight into the system’s dynamic behavior. These were given a Conversation Identification Number (CIN) based on type of interviewee, producer number, and paragraph number. Information sources were recorded where applicable. Also, themes were recorded based on the color coded area from which the argument came as well as notes that described any memos that provided additional information. Over 160 coding charts were created from over 150 pages of interviews. An example coding chart and the original argument are shown here:

> *"First of all, look at the incredible advances that have occurred over time on the agronomy side of the ledger - better seed varieties, more cold tolerant seed varieties, more drought tolerant varieties, with GMO technology - have set the stage towards being physically possible to get a more economically viable corn or soybean crop. Second would be those commodity support and crop insurance programs where that sort of safety net is not afforded to people running cow-calf pairs or yearlings. Commodity prices we're experiencing right now feeds into that also that will be the third one. Fourth, I hear it over and over and over again from folks that still have a stock cow herd in eastern South Dakota, when they look at those first three trends, they look at the hard, year-round work that it takes to maintain a cow herd, the low profit margins that often occur with selling these calves, and the lack of a safety net. It makes those land-use decisions difficult to keep that grass there." (S7-P11)*

ID:	Stakeholder 7			*CIN:*	S7-P11		
Main argument:	Agronomy technology, crop insurance support, commodity prices and potential returns to lifestyle all contribute to grassland loss.						
Causal Structures	*Cause variable:*	Agronomy technology	Subsidy level (%)	Grain (price)	Age of producer	Crop feasibility	Willingness to farm
	Effect variable:	Crop feasibility	Willingness to farm	Grain margins	Willingness to farm	Grass (acres)	Grass (acres)
	Relationship type:	Positive	Positive	Positive	Positive	Negative	Negative
Variable behavior	*Cause variable:*	More enhanced genetics	Greater % coverage	Escalating grain prices	Older producer base	Improved feasibility	More willing to farm
	Effect variable:	Improved feasibility	More willing to farm	Improved profitability	More willing to farm	Reduction in grass acres	Reduction in grass acres
Information sources:	Comments about primary drivers of land use change.						
Theme:	Technology, subsidies, commodity prices, producer age.						
Note:	Drivers identified: 1) agronomy technology, 2) support programs tilted in favor of cropping, 3) commodity prices surging, and 4) amount of work for cattle and less support and dwindling margins for a producer getting older.						

During the third (transforming text into word-and-arrow diagrams) and fourth stages (generalizing structural representations) we departed somewhat from the suggested methodology of creating stock-flow diagram tables for each argument. This was primarily due to the time requirements for creating stocks and links in Vensim® and integrating them into tabulated tables. Instead, the coding charts were used to create a rough draft causal loop diagram. To achieve this, each stakeholder group was analyzed individually by drawing the identified links from interview coding charts. As new variables arose the causal loop diagram expanded and as variables or like-variables were repeated in the coding charts, these links were identified in the developing diagram. These diagrams were done by hand on notebook paper. Once each group was complete, these diagrams were overlaid to find similar variable and feedback loops across the interviews. These structures were then drawn using causal loop tools in Vensim®.

Group Data Analysis for Group Model Building

Much of group model building has been largely focused on management teams or organizational change (e.g. see Vennix et al. 1996). Due to the nature of the grassland conversion problem, it was first thought that group model building could be achieved by bringing together willing participants from farming, ranching and other invested professions within the region. However, due to the controversy surrounding land use incentives and benefits (e.g. subsidized crop insurance), it was decided that group model building may be more effectively achieved after the interview process within the research team rather than the primary investigator alone with a group of stakeholders.

Andersen et al. (1997) described three goals of group model building as:

1) Mental model alignment;
2) Creating agreement (consensus) about a policy or decision;
3) Generating commitment with a decision.

Since this is a departure from common group model building efforts, the goals of the group model building process were altered to better reflect the purpose of the work as well as the respective backgrounds of the team members. The research team is not directly involved in large scale land management or policy decisions directly. The goals then became:

1) Alignment of key factors, themes and variables; consensus on extracted mental models of systems actors;
2) Creating agreement about the underlying structure of the system in question;
3) Generating consensus about model focus, testing and communicating results.

These were accomplished over two group model building meetings. Prior to the first meeting, three unique, color coded interviews (one farmer, one rancher, one stakeholder) were sent to each of the co-investigators. Each co-investigator read these transcripts and made additional notes and memos. The primary investigator acted as facilitator during the meeting, which lasted 150 minutes, and represented the remaining interviews that were not shared. Each investigator shared key insights and clues about what they extracted from the stakeholder interviews they had read. As consensus built about key factors, themes were then crafted, followed by discussion. Once there was general consensus about key themes, a dynamic hypothesis was drafted and what-if questions and scenarios were raised as potential focusing questions for the model.

Alignment of key factors, themes and variables; extracted mental models of systems actors.

As previously stated, each co-investigator received three unique interviews with color coded texts. Each investigator shared their insights and how those insights reinforced ideas that were coded or were different which necessitated a unique code or note. Group discussion continued until it became evident that key factors were just as evident or relevant across the full range of interviews. Findings are described as key factors that emerged from the interviews related to grassland conversion in the NGP: economic, community, land base, land ethic, ownership, technology, ecology, soil health, and public policy (Table 4). Each factor is accompanied with a sample quote from one of the interviews. Further evidence about each of these factors is presented (Appendix 2) along with descriptions of extracted mental models of the interviewees. Many of the interviewee responses overlapped among multiple factors, highlighting the highly linked and complex nature of the problem.

Table 4. Identified system factors accompanied with a response. Each factor is accompanied with a sample response. Each sample response is followed by the stakeholder identification number. For example, F7 is Farmer #7. R=Rancher, S=Stakeholder.

Factors:	Sample Response:
Economic	"The drivers are the economics; it's not good. The technology advances have aided it, but the fact is they have to make money- it's sheer economics" (F7)
Community	"The thought about the community, I don't think we can restore the community any more than we can restore the range. I don't think that we can restore the dynamics of the communities in this state any more than we can restore the grasslands." (R6)
Land base	"The other thing is that we're to have more and more pressure put on us as producers to produce more and more on fewer and fewer acres and at the same time be faced with the regulatory and environmental regulations that will impact our ability to do what we need to do." (R1)
Land ethic	"Conservation would have a very very high value to me. I would not consider exposing or risking the resources that are entrusted to me, be it erosion or degradation, in the name of profit. It has to be a sustainable …it's got to be good for the land, safe for the land, or I won't do it."(R7)
Ownership	"I'm probably less willing to take some wild risk on something really wild out there than someone who didn't have the roots that we have" (F4)
Technology	"As our farming practices have changed we're seeing more sophisticated agronomy, seeing a lot higher use of fertilizer with guys using variable-rate, using global positioning for tillage." (S4)
Ecology	"One of the statements that I make is that if we degrade our ecosystem in an attempt to feed 9 billion people then we will end up starving ourselves- that's the long-term view. We shouldn't be doing anything to degrade our own ecosystem." (S5)
Soil health	"Healthy land has to have high organic matter, and it has to have residue out there to protect it from wind and water erosion Healthy land has high organic matter and high levels of macro- and micro-nutrients. But to me healthy land has residue to protect it." (F3)
Public policy	"You know the cattle people don't get government payments. They may get a cost share on a fencing project and there is the futures market to protect yourself somewhat, and there is some Band-Aid grass insurance out there. But there isn't anything out there that's going to guarantee you $800 an acre whether it rains, hails, whatever. So the livestock industry is at a disadvantage right away." (R6)

Key Themes and Mental Models

Four themes emerged across the range of interviews and factors. These themes combine multiple factors and/or combinations of responses that most clearly explain the dynamic behavior of land use. The key themes that emerged are accompanied with a brief description (Table 5).

Table 5. Identified themes with a brief description.

Major Theme	Description
"We are putting all our eggs in one (or a few) baskets."	Government support for a few crops influence the varieties planted, which locks in technology adoption and future planting decisions.
"Touchdowns are easier running downhill."	Mental model of farming is to work the referees while ranching builds a goal-line wall.
"There isn't enough 'stick' to go with the carrots."	We should enforce the rules we have rather than trying to pay someone else to make them to go away
"Ignorance (or just looking the other way) is bliss."	Most people don't understand the complexity of the problem, education is essential.

The first theme, *We are putting all our eggs in one (or a few) baskets*, represents a reinforcing loop comprised of elements from public policy, land base, technological and ecological factors. Public policy in the U.S. Farm Program has continually shifted to support only a few crops (e.g., corn, soybeans and wheat). This support incentivizes producers to plant such crops, and thereby adopt or invest in specialized technology. This not only locks a producer into future crops to fully utilize the investment, but also signals to agronomy and equipment companies that these are the commodities that need development emphasis (e.g., improving genetics, increasing combine size, etc.). As producers now have to scale this technology over more of the same highly supported crops, the number of species in the ecosystem decreases as more land is added to production. This trend leads towards a more monoculture based ecosystem which relies on only a few key commoditized species.

The second theme, *Touchdowns are easier running downhill*, expresses a feedback between external stakeholders and policy makers with producers (both farming and ranching) based on their extracted mental models and expressed land ethics. Land (i.e., the playing field) is a finite resource with boundaries. Producers (i.e., the teams) operate on land in an effort to be successful producers. However, farming interacts more opportunistically with other system actors (e.g. stakeholders, policy makers), in effect: working the referees to their advantage. This has tilted the playing field in favor of farming enterprises, giving that land use the advantage. Ranchers, who are much more independent by nature, dig further into their defense. Working the system outside of their immediate control is viewed negatively or greedily in their eyes. This does not help the playing field, however, as the system continues to reward the side that voices their interests. The playing field continues to 'slide the other way', putting more pressure on the land base.

Third, *There isn't enough 'stick' to go with the 'carrots'*, expresses a restraint on the corrective forcing functions of the system. A forcing function is an effect or impact being imposed on the system from an exogenous variable. A corrective forcing function would correct or balance the system within some acceptable or sustainable bounds. For example, government subsidies might be considered a positive or reinforcing function to a system whose corrective function is a limit, constraint, or condition under which subsidy benefits can no longer be received. Corrective functions (i.e., the 'sticks') that have traditionally existed such as wetland compliance are no longer in effect to curtail current behavior of decreasing grassland in favor of crop production.

The last theme, *Ignorance (or just looking the other way) is bliss*, deals with the lack of knowledge and responsibility about the complex nature of ecosystem functions, goods, and services, and how these are altered due to major disturbances such as land use changes. Few people are aware of the scale and scope of land use change and even fewer understand the complex nature of the ecosystem and what it provides (e.g., water cycling, nutrient cycling, food production, wildlife habitat, recreation, carbon sequestration) to society. Knowledge of the issue makes one equally responsible for it (i.e. the more you know, the more you are responsible for). Therefore education about the alarming land use changes is essential for informing, challenging and improving mental models about the system and system behavior.

Mental models of system actors were also quite different due to different land use histories, experiences, roles, and values all of which help describe the current system behavior. Farmers thought of connections much more independently and this was observed in the coding process, as farmer interview data revealed that those producers had a more difficult time 'closing the loop'. Ranchers tended to close loops better and valued diversity of the undisturbed landscape. Stakeholders tended to view the system much more objectively than either of the producer groups. However, they usually supported the group in which they had greater associate. They also cherished their role, that of helping producers within the system (Table 6).

Table 6. Brief mental model characteristics identified for each interview group.

Farming	Ranching	Third Party
Efficiency oriented Enterprise accountants Interactive with external actors Land ethic = maintenance of production	Synergy oriented Whole-farm accountants Independent of external actors Land ethic = integrity of ecosystem	Objective observers Supportive of producers Understand system, cherish the role Valued long-term success for all

Dynamic hypothesis and model focus

With consensus built by the model team around these factors and themes, a dynamic hypothesis was constructed. The group noted that this was one of the most difficult and fragile steps that needed to be completed in the process- that lack of detail would lead to too broad a model focus and results not very applicable or that too much detail would lead to unneeded complexity in determining model parts. With debate and some revision, the working dynamic hypothesis is as follows:

- Conversion of grassland for row-crop production has been driven by an aging agricultural producer, the need to scale farm investment costs, and public support programs (e.g. subsidized insurance, tax incentives) to the exclusion of livestock, which are seen as too time and labor intensive. Row-crop profitability has outpaced historic returns to grassland, which put pressure on cattle grazing opportunities and

> wildlife habitat, decreasing populations of both. Despite these forces, a different land ethic exists for some producers who consciously make the choice to retain grassland. However, with increasing farm costs, support programs that favor producing certain commodities and few incentives to support bringing young people back to production agriculture- conversion of grassland for farming is likely to continue to the detriment of alternative landscapes and the rural community.

With the dynamic hypothesis drafted, what-if or focusing questions were developed by brainstorming to construct testable scenarios for the hypothesis. These included, but were not limited to:

- What does South Dakota look like in 20 years if the trends continue (the status quo scenario)?
- What if crop insurance dropped to 25% rather than raised to 75% (the playing field scenario)?
- What if land owners are not operators (the serfdom scenario)?
- What if livestock were re-coupled to farm production (the diversity scenario)?
- What if we enter another drought cycle or re-enter a wet cycle (the climate scenario)?

The second group model building meeting occurred approximately one month after the first. Prior to this meeting, summaries of the secondary interviews were distributed along with a model conceptualization worksheet (Albin 1997). Within this packet the problem area and dynamic hypothesis were filled in. In preparing for the meeting, each co-investigator worked through the packet addressing model purpose, model audience, the model boundary list, endogenous and exogenous variables, and basic feedback structures. Once into the meeting, notes were compared to agree on model purpose and audience.

Model purpose usually falls into three categories: 1) to clarify knowledge and understanding of the system; 2) to discover policies that will improve system behavior; or 3) to capture mental models and serve as a communication and unifying medium (Albin 1997). We prioritized these by order of difficulty and how current progress could meet these purposes. Our team prioritized clarifying knowledge and understanding of the system as the easiest, capturing mental models and serving as communication medium as moderate, and discovering policies that will improve system behavior as the most difficult. With work to date, it is clear that this modeling effort has clarified understanding of the system by exposing feedback processes previously ignored as well as describing mental models of system actors. With these insights, using the model to communicate these feedbacks, consequences and mental models is essential. These were coupled together to define the primary model purpose. A secondary model purpose was established to investigate system intervention strategies.

Next the group defined the model audience. After brainstorming a list of potential model audiences (Table 7), we tried to describe their interest and degree of leverage on this problem as well as potential strategies to communicate or educate them. Even with discussion, it was difficult to narrow down which audiences were more important than others. This was tabled and will be defined more clearly as the project continues to develop.

Underlying causal structures

Identifiable variables were listed to find congruence in model boundaries as well as endogenous vs. exogenous components. A simplified model boundary chart categorized variables as endogenous or exogenous (Table 8).

Table 7. Prioritized model audience list identified in group model building.

Potential Audience	Interest level	Leverage ability
Congressional Ag. Committees	Low	High
Land Grant college personnel	High	Moderate
Conservation organizations	High	Moderate
Produces	Mixed	High

Table 8. Simplified model boundary chart created during group model building.

Endogenous	Exogenous (forcing functions)
Grass (acres)	Rainfall
Grain (acres)	Opportunity cost of capital
Grain production and inventories	Food demand factors
Livestock inventories and production	% or $ level of support, type
Wildlife habitat and returns	Technology or ‘enhancers’
Rural population	Taxes
# of producers	Public demand for grassland
Rent vs. own land	
Rental rates (farm and grass)	
Willingness to farm	
Equipment size and investment	
Farm size	

Lastly, causal loop diagraming was accomplished from variables extracted as part of the interview coding process. Causal loop diagrams were first done by hand. Common variables, links and loops were identified among the three diagrams for consensus about system structure from the stakeholders. Exogenous variables or forcing functions were identified throughout each diagram as well. These were combined with the synthesized causal structures created in Vensim® (Figure

2) and presented to the research team for analysis and discussion. The group was able to verify major feedback loops based on exposure to interview data as well as personal experience.

Numerous feedback loops emerged (Vensim® loop count > 100), with several key loops identified. Grass (acres) and Grain (acres) is a tradeoff constituting the primary balancing loop central to the model. Each land use also has its own set of activity or drivers (grassland: cattle and wildlife; cultivation: grain crops). These activities can be thought of in economic terms of supply (e.g. livestock inventory) and demand (e.g. demand for beef). Although similar in structure (a coupled reinforcing and balancing loop), these two land use and economic chains are drastically different due to the biological delays- e.g. one grain crop cycle is complete in less than one-year while one calf crop can take 18-24 months.

A positive reinforcing loop was found for grain production through technology. As grain acres increases, the number of crop rotations actually goes down, which is detrimental to overall soil health. This is overcome by no-till or reduced till operations. No-till or reduced till adoption leaves more crop residue on the surface to decompose and increase organic matter. This, along with three other variables, increase farming feasibility: 1) grain genetics have developed new varieties that thrive in warmer, drier climates; 2) agronomy technology with fertilizer placements and harvest efficiency has improved margins; and 3) market access and storage capacity is expanding giving producers more marketing options. Storage is also incentivized by the Farm Service Administration (FSA) subsidy for building on-farm storage units.

Farming feasibility has a positive influence on “Willingness to Farm”. “Willingness to Farm” is also driven by risk preference, tax burden, and land tenure. Of those, tax burden and risk preference are highly influenced by public policy, through both the tax system and subsidized insurance premiums. Land tenure duration, a function of several community factors, decreases as land changes ownership, leasees, or a producer exits production due to age, thereby increasing the likelihood that the next tenant will farm. Willingness to farm then is a function of farming feasibility, taxes, risk preference and land tenure andreinforces the amount of land put into grain production.

From the grassland conservation perspective, willingness to conserve reinforces grassland use. This is positively influenced by livestock profitability as well as CRP and easement value levels. Livestock profit is determined by beef markets and costs (production, grazing and feed costs). Supply of beef is influenced by current grassland acres as well as livestock investments. Costs are also influenced by current grassland acres and land prices as well as grain prices, since grains are the primary inputs to most livestock feeds. Lastly, wildlife habitat influences the potential revenues from hunting. Hunting revenues reinforce willingness to conserve.

From a community standpoint, rural population, producer age, and absentee land ownership influence the grassland and cropland feedbacks described above. As rural populations decline the number of producers declines, but farm size increases. This accelerates the future decline of population inflows. As inflows decline, average producer age increases, which positively reinforces willingness to farm due to favorable labor conditions and negatively reinforces livestock inventory as producers liquidate herds. As the rural population declines, absentee ownership of land increases, increasing the amount of rented land in production. Due to the different financial return requirements of absentee owners, this rented land is under extreme profit pressure, which again positively reinforces willingness to farm.

Lastly, the economic base of rural communities can be aggregated to farming activities, ranching activities, and hunting and tourism activities. The financial returns of each of these activities positively influences the tax base and development potential of the community. These positively reinforce community attractiveness and thereby rural population inflows. Exogenous variables or forcing functions identified were rainfall, which positively influences land production regardless of use, technology advances, and public policy factors, such as ethanol subsidies and mandates, forced low interest rates, and taxation rules. Environmental outputs identified include soil carbon sequestered and volume and quality of water runoff.

Summary and Next Steps

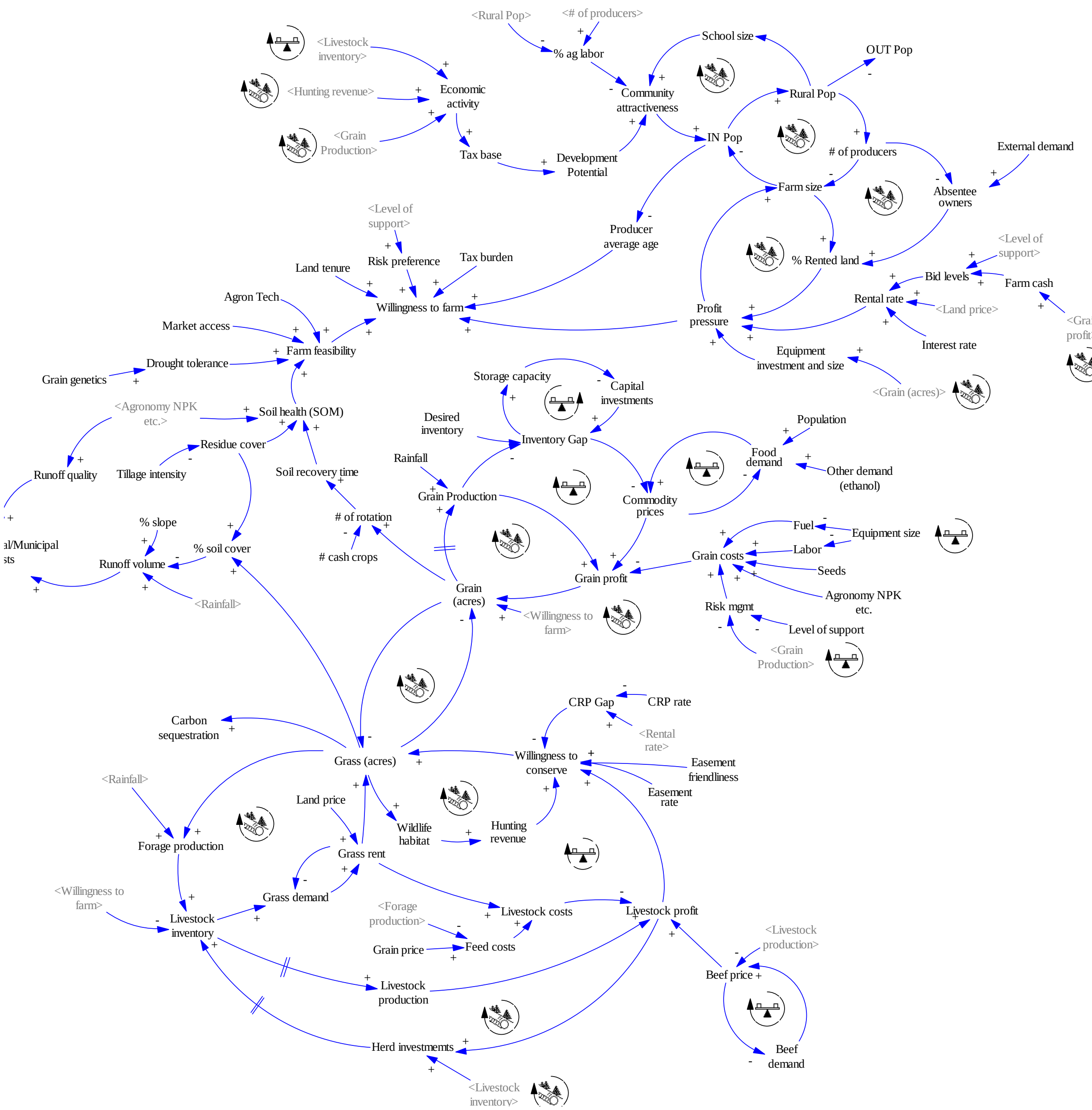
The causal loop diagram developed through variable identification and coding corroborates the anecdotal relationships identified from the interview data, specifically the themes *We are putting all our eggs in one (or a few) baskets* and *Touchdowns are easier downhill*. Potential model testing could mimic the other two themes, *There isn't enough 'stick' to go with the 'carrots'* and *Ignorance (or just looking the other way) is bliss*, by establishing constraints on forcing functions, particularly those that are policy related, and by incorporating education initiatives that might increase willingness to conserve grasslands.

To maintain involvement with system actors (Wolstenholme 1983), a follow-up correspondence will be conducted to show interested interview participants the progress to date and ask for any additional remarks about the nature of the problem. This will allow for another round of feedback to improve the causal loop framework before model construction begins. Also, an independent working group of producers and stakeholders will be convened to corroborate, refute or clarify/refine the system structure as created after the interviews and group model building steps.

It was recognized that several stakeholder groups not included in the original round of interviews would be of great benefit to enriching the study including absentee landowners and representatives of commercial agricultural companies. Interviews with absentee landowners is in process with commercial agricultural representatives to follow.

Construction of the stock-flow model will be ongoing as causal structures continue to emerge and as reliable data sources are incorporated for calibration. One of the anticipated hurdles to overcome will be how to handle the spatial nature of the problem. There have been some recent developments in this area (see BenDor and Kaza, 2012), but the spatial approach for this project is still under discussion. It is our intent to discover the correct spatial tool or method that best captures the structure of the problem but is also easily communicated to potential model audiences.

Figure 2. Causal loop diagram created by diagramming each set of coding charts from each interview group.



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Appendix 1a. Producer stakeholder questionnaire.

1. Can you describe the nature and scope of your operation?
2. What commodities do you produce?
3. How long have you been in operating the business?
4. What motivated you into the business?
5. What would you describe as short and long term goals for your operation?
6. How would you characterize the economic health of your operation?
7. How would you characterize the ecological health of your operation?
8. What challenges or issues do you foresee in the near and long term future for your industry?
9. Have you converted acres from prairie to crop? Why or why not?
10. Have you converted acres from crop to prairie? Why or why not?
11. How has public policy, like subsidies or insurance, influenced your decisions?
12. Do you foresee any biological or ecological consequences from your management systems?
13. How might you describe your personal values that guide your decisions and management?
14. How would you describe continued land conversion to farming in the NGP?
15. Do you foresee any ecosystem consequences to large amounts of land conversion?
16. What value do you place in ecosystem goods and services?
17. What to you is an appropriate time scale for evaluating the integrity of ecosystem goods and services?
18. If any of these goods and services is lost, are they worth trying to recover/restore?
19. If so, which ones? And at what cost (social or economic) should they be evaluated against?
20. What, if any, solutions do you see in the struggle to conserve native rangeland while still being able to produce field crops that are so highly demanded?

Appendix 1b. Third party stakeholder questionnaire.

1. What organization do you currently work for?
2. How does this organization help agricultural producers or land managers?
3. What is your current role in the organization?
4. What are the primary tools you use to help land managers make decisions?
5. What are some to the short- and long-term challenges do you see for land owners you help?
6. How has land use changes influenced your organization? Your Role?
7. Have you seen acres converted from prairie to cropland? How much?
8. If so, why do you think that these conversions have taken place?
9. Have you seen cases of prairie re-establishment? If so, how much?
10. How do you think public policy influences producer land management decisions?
11. Do you foresee any biological or ecological consequences from the current trends in land management decisions?
12. How might you describe the decision making process of the land managers you serve?
13. How would you describe continued land conversion to farming in the NGP?
14. What do you identify as the key drivers of this trend?
15. Do you foresee any ecosystem consequences to larger amounts of land conversion?
16. What value does you and your organization place on ecosystem goods and services?
17. What do you see as an appropriate time scale for evaluating the integrity of ecosystem goods and services?
18. If any of these good and services is lost, are they worth trying to recover/restore?
19. If so, which ones? And at what cost (social or economic) should they be evaluated against?
20. What, if any, solutions do you see in the struggle to conserve native rangeland while still being able to produce field crops that are so highly demanded?

Appendix 2. Brief description of each factor identified through interview analysis.

Economic factors: *You can't escape the economics of it (F2)*

All three stakeholder groups overwhelmingly recognized the role that economics has in grassland to cropland conversion. Although there were some very different personal viewpoints expressed depending on what role the interviewee had, many of the basic economic factors identified converged. For example, producers (farmers and ranchers) expressed the pressure they feel to economically scale production over a large spatial area to justify their equipment costs. Producers also highlighted the profit potential existing for row crop operations due to exceptional prices and increasing technological advances helping control costs.

However, producers expressed a clear divergence when asked about grassland conservation and management. Ranchers expressed their awareness that they continually make non-economic choices to keep grassland as the primarily land use. On the other hand, farmers that have plowed up grassland tended to express the economic benefits of doing so.

Other major responses dealt with topics such as livestock profitability. That is, the more profitable cattle operations are, the more economical it is to maintain and protect grasslands.

Economics obviously plays a huge role in the conversion vs. conservation decision process of producers land use choices. Farm investment costs, commodity prices and profitability, livestock sustainability and a growing food demand were major responses across all of the interviews.

Community factors: *The challenges I see- there's getting to be less of us that farm. (F4)*

The second element that clearly emerged through the interviews was the role and impact that land use choices, particularly conversion, has on the rural community. All three interviewee types highlighted trends in declining rural populations and the challenges of an aging agricultural producer with fewer young people returning to agricultural production careers. All of these issues were found to impact the plow or not plow decision.

Primary concern was about the size of the rural community, particularly how its influenced by farm size. As farm size increases neighboring families are forced off the landscape and the community size declines.

An even more complex problem than a declining rural community is that of an aging agricultural producer and how young producers and livestock operations influence it. As producers age, farming becomes a more lucrative business because it is less labor intensive. As they liquidate cattle operations and expand farming, labor demand goes down and farm size limits neighboring farmers ability to remain on the rural landscape.

These remarks highlight a major feedback process between agricultural land uses and enterprise size with the rural community that has received less attention than other causative factors (e.g. economics). The shifts identified within community factors included declining rural community size, increasing farm size, increasing average age of producers, and a changing preference from livestock to row crops.

Land base: *If we are going to continue to feed the world I think it's got to happen (F5)*

The third factor described here has to do with the land base. Here, external pressures on both farmers and ranchers have led to an array of pressure on the landscape. External pressures include growing food and energy demands, political pressures to meet growing compliance requirments, and profit and expansion pressures to reach long-term goals (e.g. transfer operations to the next generation).

All of these pressures put land health in an ever stressful situation. For example, the pressure to scale production, fulfill demand and remain profitable could lead to 'mining' of natural resources (i.e. inherent soil health). These remarks, considered in context particularly with the economic factors, highlights the tremendous opportunity in farming, but also the tremendous pressure being applied to the landscape.

Land ethic: *We are just tenets here (R1)*

The land ethic concept is widely attributed to Aldo Leopold (see A Sand County Almanac, 1949). Each producer groups expressed a clear land ethic, however the way in which they defined it differed dramatically. Ranchers expressed views of holism and emphasized the long-term in decision making compared to farmers, who characterized maintenance of productivity as a personal value.

Stakeholder responses of farming and ranching offer further characterization of these differing views of land ethic: The stakeholder comment below is likely the most concise way to summarize the different land ethic definitions of various producers:

> Its farming is a business [row crops] versus farming is a lifestyle and I am a steward [ranching] (S8)

These differing views of land use provide insights about a given operator's preference to disturb the landscape through intensive cultivation. Cultivation is less a concern for the business oriented producer versus those who view themselves as tenants and stewards first.

Ownership: *I'm probably less willing to take some wild risk on something really wild out there than someone who didn't have the roots that we have (F4)*

Ownership changes in the Northern Great Plains have influenced land use as well. Ownership change influences land tenure, which directly impacts the cultural and historical ties someone feels to the land and whether or not it should be cultivated for crops. As absentee ownership continues to rise, pressure is put on the landscape to meet not just production goals, but external financial obligations based on the landowners alternative investment returns as well as financial goals of tenants.

As land ownership continues to change and land prices continue to rise, decisions tend to be made based on risk of financial loss over potential losses of the landscape (e.g. soil, wildlife, water requirements). However, ownership change may have some positive impact on conservation goals as many landowners invest due to hunting and recreation uses. As land ownership continues to trend toward more absentee owners and more land in production being rented rather than owned, conservation of grasslands will likely be influenced by ownership preferences and rental values that drive production costs of both farming and ranching.

Technology: *They think science is going to be an answer to everything (S8)*

Technology advances have had a tremendous impact on the way food is now produced- from both crop (e.g. drought tolerance, agronomy enhancements) and livestock (e.g. genetic potential, cow efficiency) perspectives. However, farmers and ranchers tended to view technology in distinct ways.

Farmers tended to view technology as a tool to overcome the next production hurdle by increasing precision (e.g. fertilizer placement, tillage advancements). Livestock producers tended to view technology as a supplement to production but not one to overcome inherent constraints of either the environment (e.g. arid climate where drought is common) or their own personal constraints (e.g. farming is to risky).

Technology has also influenced the community through reduced labor demands. Interestingly, advancements in technology were also perceived to provide potential advances in conservation. Operators are able to maximize current acres as well as identify trouble or sensitive areas and manage around them.

Each stakeholder group recognized technology as a critical component of land use decision making, however each viewed it differently. Those in farming viewed technology as a tool to get over the next production hurdle and make their operation more precise. Those in ranching tended to view technology as efficiency enhancing but placed more emphasis in Mother Nature- the inherent environmental constraints. Stakeholders tended to view technology along or between these two lines as well. The one common view towards to technology between the producer groups was a ‘fear of falling behind.’

Ecology: *I don’t think anyone realizes how many species will be lost in all this (R2)*

Grassland ecosystems provide an array of ecological benefits (i.e. ecosystem goods and services) that could potentially be jeopardized. This value of grasslands was recognized across all the stakeholder groups. However, cultivation may impact ecologic integrity, preserving that integrity and maintaining productivity becomes a challenge and usually requires an individual sacrifice (e.g. having to farm around conservation areas; ecologically sound practices have no direct economic incentive). Ranchers face a similar challenges with livestock, and usually have to give up some production to maintain ecosystem integrity (e.g. residual forage management; rotational grazing is more labor intensive). Stakeholders expressed concerns similar to those of farmers and ranchers in that grasslands provide essential goods and services, but were usually sympathetic to whichever producer group they are more closely tied to.

Ecological actions have usually been technological or political in nature, each with their own pros (e.g. risk management tools; no-till technology) and cons (e.g. highly subsidized industry; reliance on chemical applications). Pressure to produce and make a living will continue to exert pressure on the ecosystem. However, the production systems employed may have to become more efficient, diverse, and/or have less environmental impact, and will likely have to include grassland systems (due to lower investment costs, increased flexibility, ecosystem buffer capacity, community benefits).

Ecological consequences were clearly recognized among all the interviews. However, there are continual pressures either externally (e.g. production demands) or internally (e.g. need to make living), on the ecological integrity and benefits of the system. Solutions typically viewed as effective are not without consequence, adding to the complex nature of land use priorities.

Soil Health: *I'm afraid what's going to happen down the road we are going to mine more of the soil and their going to try to get as much out of it before you're done (F3)*

Soil is vitally important for ecosystem health. Healthy soil is not simply a medium for growing plants, but also storage unit for carbon and a filter for water cycling. All three interview groups valued the role of soil in the ecosystem, but j they defined their management considerations quite differently.

Farmers tended to view soil productivity as the primary measure of land health (e.g. soil fertility tests). Farmers tended to view erosion as the primary risk to soil/land health and crop residue management as the primary practice to work against it.

Ranchers tended to view soil much in the same way they viewed the ecosystem- health being defined as similarity to its native state and soil as a component of that integrity. Stakeholders provided some unique insights to these two very different mindsets of producers:

> I would say most ranchers are very conservation minded and I would also say that most farmers are conservation minded. But farmers have a different mindset because they depend on putting seed in the soil every year and doing whatever it takes to grow crop whereas the rancher I guess it's more natural process. They harvest what Mother Nature gives them every year, they don't go out and plant seeds so that the cows or steers or calves have a place to graze (S1)

All groups recognized the role of time in the development of soil, its management, and consequences to the system, but defined the necessary time scale for evaluation differently. Farmers held a shorter term, ranchers a moderate term, and stakeholders a very long term view:

> You're not necessarily going to have the yields, that's going to be a little longer time…if you converted back to a grassland, that takes time. That could be 10 years before you get a decent stand so you can't even judge the practice for 10 years, it's very complex and site-specific (F4)

> Long long-term probably 100 years or 200 years…it's taken 40 years do it [degrade the soil] but it takes 40 years to recover so I think you have to monitor it for a long, long time, it's a long-term process (R4)

> I don't know, but if you say 600 years it just shocks them and so then it's easier to get them to think about 20 years or 30 years. Think about if Teddy Roosevelt didn't think about us 100 years ago we wouldn't have Glacier Mountain or Yellowstone or Yosemite, so having a long view on things is sometimes helps you better understand (S5)

Soils obviously play a crucial role, from an ecosystem integrity viewpoint or from strictly a production standpoint. But the mental models expressed offer clear departures about how the landscape is viewed and evaluated.

Public Policy:

> *I would like to see some of the policies be more flexible (F2)*

> *Level the playing field economically and you solve the problems (R8)*

> *It's all tied to public policy in a sense and that all of those programs and funds…are drivers of land-use change one way or the other (S7)*

The final factor identified pertains to the influence of public policy, which was best described as forcing functions on the structure of agricultural production systems. Responses from producers ranged from very little concern about public policy influences on an operation to extreme concerned. Responses also varied in their focus on incentives or disincentives to undergo some activity. On the whole, interviewees were all concerned that the amount of meddling from public entities into their respective enterprises and that additional regulations or compliance issues would hamper management intuition and flexibility.

Public policy has conservation and ecosystem diversity consequences (e.g. CRP, EQUIP, CSP, FSA premium subsidy). Public policy was also said to push operations towards larger and larger farm sizes and reliance on technology adoption, which also influences the rural community. Subsidized crop insurance for select commodities had mixed reviews depending on which side of the issue the interviewee was on (e.g. farmer for; rancher against; stakeholder mixed).

Policies that set protocols, established production requirements or imposed management restrictions were seen as unnecessary, detrimental to management, or simply too inflexible to be used beneficially (e.g. CRP inflexibility, ethanol requirements, environmental oversight).

Regardless of how effective certain farm programs and policies were viewed by the interviewees, many recognized that if market-driven solutions are to emerge, government programs need to take a back seat economically and ecologically. Several stakeholders expressed insights about producer mental models and ecosystem diversity as seen through public policy:

> I think historically the crop guys, whether it be peanuts, corn, sugar beets, sweet corn, I think they've been more successful on that [establishing favorable policies] than cattle [guys] have. Cattle [guys] seem to be a little late to the party and I think that stems from the mentality of the ranchers, they typically didn't see themselves to want to be beholden or dependent on the government, farmers didn't seem to hold that reservation (S4)

These findings clearly highlight that land use trends in the NGP are highly influenced by a multitude of factors.