PERCEPTIONS OF CLIMATE AND ENVIRONMENTAL CHANGE IN NORTHCENTRAL KANSAS

by

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Abstract

Global and regional climates have changed significantly in recent decades. One of the sectors most affected by a changing climate is agriculture. While the scientific consensus is clear that climate has changed, a declining number of Americans believe in the seriousness of “global warming”. Bridging this knowledge gap will require a more in depth understanding of public perceptions of climate change. The research reported here addressed public perceptions of climate and environmental change in north central Kansas and found that farmers are aware that climate has changed over their lifetimes. Local residents were found to be aware on ongoing environmental changes and adopting changes in land management practices that balance improving environmental conditions with the need to make a profit. More information is needed on what information sources and presentation styles would work best for the communication of updated information, both for communicating with farmers and with educators.

Table of Contents

List of Figures

Chapter 1 - Introduction

Global climate has changed significantly in recent decades. According to a recent report by the United States Global Change Research Program (Karl *et al.* 2009), the rate of change is more rapid and the range is greater than anything to which society has had to adapt in the past (Karl *et al.* 2009). Human activities have enhanced Earth's natural greenhouse effect by increasing the amount of longwave radiation absorbing gases in the atmosphere. The human-enhanced greenhouse effect has resulted in a global temperature increase of 0.8°C in the 20th century (Hansen *et al.* 2006). The international Intergovernmental Panel on Climate Change (IPCC 2007) notes that all earth systems are being affected including biological and physical systems. Global changes, such as earlier arrival of spring peak river flows (IPCC 2007) and significant shrinking of portions of the cryosphere, have already been observed.

In the Northern Hemisphere, 2010 was the warmest year on record going back to 1880 according to the 2010 *State of the Climate* by the U.S. National Climate Data Center. The 2010 average planetary surface temperature was 0.73°C above the average for the 20th century (NCDC 2010). Changes related to climate warming–similar to observed global changes–are occurring in the United States. These include changes such as sea level rise, and heavier and more frequent rain events ((Karl *et al.* 2009).

One of the sectors most affected by a changing climate is agriculture; greatly impacting the global food supply. The IPCC's Fourth Assessment Report notes that 40% of Earth's surface is currently being used for food production which underscores the importance of this sector to humankind's well being (IPCC 2007). To further exacerbate the problem, agriculture is sensitive to multiple stressors which all need to be accounted for when planning for adaptation to future climate change. In the Midwest and Great Plains, temperatures have risen more in the winter than in the summer over the last 30 years (Karl *et al.* 2009). Seager *et al.* (2007, 1181) examined 19 climate models for the southwestern United States and found that, "In the multimodel ensemble mean, there is a transition to a sustained drier climate that begins in the late 20th and early 21st centuries." They also found that while precipitation and evapotranspiration both decrease, according to model changes, precipitation decreases more (Seager *et al.* 2007). Future drought events will be worse than droughts of past centuries because the starting point for such dry periods will be drier than any time in human history (Seager *et al.* 2007). According to Karl *et al.* (2009), the American West and Southwest, which include some major grain producing areas, are projected to become drier and experience heat waves that are more frequent and last longer. These extreme events will have an effect on food security and production.

Now is the time to start doing something to curb greenhouse gas emissions (Brown 2009). "Reducing emissions of carbon dioxide would reduce warming over this century and beyond" and will be more effective now than waiting until a later date (Karl *et al.* 2009, 23). In order for decisions to be made effectively at any level, a basic knowledge of climate change causes and impacts is needed (NRC 2010). Information is labeled as 'policy relevant' when it provides policy makers with information specific to a particular sector and enables an informed response to climate change (NRC 2010). More than 20 years since the founding of the IPCC in 1988, an ominous cloud of uncertainty and apathy continues to surround the public's perception of the seriousness and validity of global climate change. Fewer and fewer Americans believe the climate science behind climate change.

A March 2009 Gallup poll showed 41% of Americans believe that the seriousness of global warming is exaggerated (Kerr 2009), while the most recent information from the IPCC shows that changing climate conditions are worse than previously thought. In a 2009 update to the IPCC's Reasons For Concern (RFC) analysis from its Third Assessment Report (TAR), *et al.*it was.found that "[…] the temperature range from which a consensus definition of 'dangerous anthropogenic interference' might be drawn is getting lower" (Smith *et al.* 2009, 4137). It has been noted that the extent to which the public is concerned and involved in the climate change issue has an effect on policy. "The uncertainty and complexity surrounding climate change, its impacts and implications, have long hampered efforts to raise its profile on the national and international agenda" (Lowe *et al.* 2006, 435). Matthew Nisbet, a political communications researcher at American University in Washington, D.C., recently suggested that climate scientists refocus their message to a smaller scale and that they use new pathways for reaching individuals to replace traditional media (Kerr 2009). Instead of talking about global or even national changes, scientists should explain what is happening in individual communities. Narrowing the knowledge gap and raising awareness must first start with a better understanding of public perceptions, including preferred information sources. Ehrlich and Kennedy (2005, 563) called for a global assessment of "public opinions and attitudes" toward climate change.

Understanding climate impacts and local perceptions of climate change requires an understanding of the social norms and environmental knowledge within a community. Middendorf *et al.* (2009) stated that, "the biophysical elements of the environment shape society by providing opportunities, resources, and limitations, all of which are perceived differently depending on the mental models of the humans interacting with those elements." In other words, people are shaped by the history of their environment and their relationships with the landscape.

The ultimate goal of this thesis is to add to the body of knowledge that will allow farmers to continue their rural agrarian lives in a sustainable manner. Flora (1999, 398) recognized what was necessary in order to do this: "We now understand that sustainable systems for prairie grasslands reflect the relationship between the landscape and the people in it."

The research for this thesis addresses an understanding of public perceptions of climate change among farmers, ranchers, and agricultural specialists in seven counties in north central Kansas. In depth conversations with people in the agricultural sector in this local area were undertaken to better understand what farmers perceive about their environment, what they think about climate change, and where they turn for information about weather/climate, the environment, and land management.

In his study of Mitchell and Lincoln counties in the Smoky Hills, Procter (1995) found that engaging locals in conversation about their place is an enabling factor in dealing with threats to a community. "Talking about the local environment heightens a community's sense of place, crystallizes community values, and identifies appropriate forms of action" (Procter 1995, 232). "Citizens believe that if progress is to occur…the effort must come from them. At the same time, this individualism leaves the people and the land vulnerable to neglect and exploitation" (Procter 1999, 232).

Chapter 2 - Literature Review

This chapter reviews salient research on climate change impacts on agriculture in the Great Plains of the United States. North central Kansas was the focus of this study and is a part of the larger Great Plains region. Also addressed are studies of public perception of climate change concentrating on residents of the United States.

History of Agriculture in the Great Plains

While Great Plains land cover has been greatly affected by humans since the time of European settlement, its geographic extent is still defined by climate among other factors (Webb 1931). The area extending east from the Rockies to the Missouri River, including the Dakotas, and north from the Texas Panhandle into the Canadian Prairie Provinces is a region of contrasts. The area is both uniquely homogeneous in terms of strong seasonal temperature variation, a lack of trees, and the spatial extent of droughts as well as strikingly dissimilar with its steep east-west rainfall gradient (Borchert 1950). Droughts generally affect large portions of the region when they occur. Droughts of the 1890s and 1930s impacted the entire Great Plains, while major drought episodes in the 1910s and 1950s were extensive over the southern plains (Borchert 1971).

Dense, fibrous root systems that extend several feet below the surface allow prairie grasses to survive in response to the highly variable climate of the region. Several thousand years of growth cycles of these native prairie grasses have helped create the deep, fertile soils in the area of tallgrass prairie in the eastern part of the region. In an analysis of data from regional climatological stations, Borchert (1950) identified the cause of the geographic extent of this unique grassland biome as due to patterns of atmospheric circulation, the orography of the

Rockies, and the position of the region within the interior of the North American continent. Atmospheric circulation patterns are dominated in summer by the poleward margin of the south-to-north shifting of the tropical Hadley Cell, and in winter by the upper-level jet stream, or Westerlies (Harrington and Harman 1991).

Atmospheric circulation patterns, together with the physical position of the region, are responsible for both the timing and amount of moisture available to plants in the soil, which is withdrawn through plant physiological processes and exits the plants through transpiration. The process of moisture deposits and withdraws associated with the hydroclimatic cycle is important because "agricultural land can only be productive when there is a balance between moisture [supply and moisture withdrawal…]" (Rosenberg 1986, 202). The general rule for rainfed agricultural success, as expressed by Kincer (1923), is between 15 and 20 inches of rainfall. When year-to-year precipitation totals are highly variable, agricultural areas in the region of these long-term average annual isohyets become highly vulnerable unless supplemental sources of water are found.

Possibly due to negative descriptions of the Great Plains by early explorers (e.g., the Great American Desert) as unsuitable for agriculture (Rosenberg 1986), settlement in the region began rather late in the 19th century. Unfortunately the early settlers were rewarded for their hard work in sod busting with a severe drought in the 1890's (Riebsame 1983) with 1894 being especially harsh. Since that time somewhat recurrent drought episodes have plagued the region's farmers. Despite these cycles of drought, dryland farming spread rapidly throughout the region aided in part by "mechanization, government aid programs, and increases in farm size"

(Riebsame 1983, 259). In fact, Riebsame (1983, 268) notes that, "dryland wheat production has become the dominant use of the American Great Plain's."

Drought

Within the Great Plains, the temporal fluctuations and intensity of precipitation and drought are somewhat cyclical and highly variable with a number of scholars attempting to link drought to sun spot cycles (Willett 1974). Harrington and Harman (1991) point out the presence of numerous temporal fluctuations ranging from days to millennia. While the majority of precipitation comes in the form of spring and early summer rain showers, July-August rainfall is highly variable (Borchert 1950). Decade-to-decade variability leads to frequent and severe droughts compared to areas of similar average annual rainfall (Borchert 1950). Borchert (1950) and Namias (1982) point out that periods of drought are compounded by the accompaniment of soaring summer temperatures and a lack of cloud cover. However harsh, it is this pattern of drought and an occasional lack of precipitation that helps give the region is distinctiveness.

The two most severe droughts during the 20th century occurred in the decades of the 1930s, lasting eight years, and the 1950s lasting five years (McGregor 1985). McGregor (1985) described the core area affected by the 1930s drought as extending from the High Plains of Nebraska to the Texas Panhandle. The spatial extent of the 1950s drought began differently, but still encompassed the entire central portion of the region reaching as far east as the Corn Belt state of Illinois by 1954 (McGregor 1985). McGregor (1985, 293) labels the year of 1956 as: "the single most severe dry year this [the 20th] century." Fortunately for the denizens of the Great Plains, it was also the last year of the 1950's drought episode. Borchert (1971) attributed the differences in the geographic extent of these drought events to differences in the meteorology/climatology that existed in those summers. The 1930's drought encompassed the entire Great Plains, had plenty of fronts go through, but very little moist air; whereas the drought of the 1950's had more moist air but not enough frontal boundaries to induce rain events (Borchert 1971).

Opie (1992) highlights the sort-term drought event of 1988 as an example of the relationship between agriculture and drought. Lower-than-average sea surface temperatures in the equatorial Pacific helped push the upper-level jet to extend farther north than normal, causing the seasonal supply of moist tropical air from the Gulf of Mexico to turn sharply east before it had a chance to flow north. This anomaly in the atmospheric circulation caused record stretches of above 90°F temperatures from Montana to Georgia (Opie 1992). The consequences of the high temperatures and low precipitation were the temporary abandonment of 14 million acres of agricultural land, permanent damage from soil erosion due to a lack of vegetation cover, fluctuating commodity prices, and falling farmland values (Opie 1992). The drought and devastation continued into 1989 and farmers who had gambled on the chance of winter snows and spring rains lost out.

Crop Failure

Record crop failure is not unheard of in the Great Plains especially during the mid-20th century. In Nebraska, wheat failure was reported in 1932, 1934, 1937, and 1941 with more than 1 million acres going unharvested in each year (Hewes and Schmieding 1956). Between the years 1931-1952, 88 percent of the counties in Nebraska experienced at least one year where wheat failure was as much as 30 percent of the total seeded acreage and failure of greater than 90 percent in a year was not uncommon for this time period (Hewes and Schmieding 1956). While drought was the major cause of these failures, wind and hail are also major causes of crop loss in the region. Hewes (1965) suggested that the threat of crop failure due to insects ended after the 1930's due to better methods of control.

Climate Variability and Agriculture

The passage of the Homestead Act in 1862 led many opportunists to take a gamble on farming in the Great Plains. Several years of above average precipitation in the last half of the 1880's bringing abundant crop yields encouraged the western expansion of agriculture (Kincer 1923). Reilly *et al.* (2003) analyzed the historical variability of crop yields and movement of cropping in the United States and found that there was substantial westward and northward shifts in the centroid of maize, wheat, and soybean production between the years 1870 and 1990. Centroids for corn and soybeans both started in Indiana. By 1990 corn had moved northwest to Iowa and soybean to western Illinois. The center of wheat production began in Illinois and in 1990 was located in central Nebraska. These geographic shifts in where crops are grown may be due to new technologies, new crop varieties and hybrids, as well as federal farm programs (Reilly *et al.*, 2003). Current extent of United States crop production will be important in future adaptation strategies.

During the 1930s, 1940s, and 1950s, dry years and wet years tended to occur successively (Borchert 1950) causing striking cycles of boom and bust (Riebsame 1983). The record of multi-year drought followed by ample precipitation has prompted farmers to adjust their practices in order to mitigate the effects of drought and insure a more consistent harvest (Riebsame 1983). Some of these technological fixes include irrigating, summer fallowing, and stubble mulching (Riebsame 1983).

Impacts of Climate Variability on Agriculture

Researchers generally follow a procedure of assessing climate impacts on agriculture by looking at a community's or a region's vulnerability to climate change. Polsky *et al.* (2003) define vulnerability as being a function of exposure, sensitivity, and adaptive capacity. Agriculture is exposed to multiple stressors. Intrinsically complex and disparate factors such as extreme weather events, climate variability, and market fluctuations increase sensitivity. This section will look at sensitivity and exposure by reviewing literature on extremes, variability, and plant threshold responses.

Sensitivity to multiple stressors such as extreme weather events, increased climate variability, and the physiologic function of plants combine to influence the vulnerability of the agricultural sector. Considerable effort has been made in recent years to describe the effect of multiple stressors. In a simulation of future winter wheat yields, Southworth *et al.* (2002) found that the largest decreases in winter wheat yields came from increased climate variability. Longer periods between rain events and the timing of rain events have been shown to increase the frequency distribution of winter wheat yields (Porter and Semenov 2005). Long periods between rain events puts plants under considerable moisture stress. The timing of rain events at critical stages in plant growth in necessary for successful growth, grain filling, and yield. An increase in the frequency distribution of yield increases the risk for producers who grow winter wheat.

Rosenzwieg *et al.* (2002) focused specifically on damage to maize crops by extreme precipitation events. They found that, when compared to current climate conditions, excess moisture could cause 90% more damage to maize crops due to and increased occurance of extreme precipitation events (Rosenzweig *et al.* 2002). The study also showed that individual extreme events could cause damage equal to or greater than the midwestern floods of 1993

(Rosenzweig *et al.* 2002). Changes in the variability of both daily and interannual temperature and precipitation have the greatest impact on soils where moisture storage is limited (Mearns, *et al.* 1996). This means that yield changes are closely tied to specific characteristics of a given location, such as soil texture.

The physiology of many widely grown crop species makes them particularly sensitive to extreme temperatures. Simulated yields of both corn and winter wheat drop considerably the longer the crops are exposed to above average temperatures (Brown and Rosenberg 1995). This simulated negative influence was true even when positive impacts such as CO_2 fertilization and decreased cold stress days were taken into consideration. In fact, the top three most extensively grown US crops were all shown to have relatively low threshold temperatures above which yield dropped precipitously. Schlenker and Roberts (2009) examined the link between weather and yields for corn, soybeans, and cotton and found that all three demonstrated a nonlinear relationship. Yields increased up to the critical temperatures of 29°C, 30°C, and 32°C respectively (Schlenker and Roberts 2009). The greater the duration that each crop is exposed to temperatures above these thresholds, the greater the decrease in yield.

The IPCC defines adaptation as "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2007, 79). The extent to which the agricultural sector can adapt to changes in climate can lessen vulnerability. Since the beginning of agriculture in the Great Plains producers have continuously implemented measures to adapt to the environment and market demands as each operator sees fit. Often referred to as autonomous adaptations, some examples of these independent adaptations include irrigating in areas with too little rainfall, including a fallow year in rotation, adding fertilizer, and supplementing farming income with off-farm jobs. While autonomous adaptations have made agriculture economically viable on otherwise marginal land, it is believed that the benefits of adaptation will decrease as average daily maximum temperature (Tmax) increases (Howden and Crimp 2005).

Many farming communities are sucessfully farming today under highly variable climate conditions. Polsky and Easterling (2001) examined climate sensitivities of farmers in response to social factors and the characteristics of the larger community within which they live. They found that communities that routinely deal with variable conditions benefit from increases in Tmax during crucial crop growth periods more than communities that have not had to operate under variable climate conditions because they have had prior experience adapting to climate conditions (Polsky and Easterling 2001).

Adaptation will have to continue at an increased pace in order to adeptly adjust to the 21st century impacts of climate change on agriculture. This means policy makers should plan for the changing climate conditions that are likely to happen in the coming decades. Howden *et al.* (2007) recommend linking climate change adaptive policies with existing climate risk policies. For cropping systems practices such as altering crop varieties, wider use of water conservation, and the use of climate forecasting are recommended as examples of management level adaptations (Howden *et al.* 2007). For livestock, it is beneficial to adjust pasture stocking rates and the dates that cattle are put to pasture (Howden *et al.* 2007).

Successful implementation of adaptation related policy is dependent on the framework in which decisions are made. One important suggested change to decision making practices is to adopt a particitatory approach where farmers are directly involved in the process (Howden *et al.*

2007). Stakeholder involvement serves to inform adjustment to climate change impacts while simultaneously preserving cultural values that are meaningful to stakeholders (Howden *et al.* 2007). Howden *et al.* (2007) stress that involving farmers, agribusiness, and policy makers equally is crucial for adaptations to be effective. This makes sense given that, while influenced by their social and political surroundings, ultimate decision-making authority concerning individual operations is retained by the farmer (Polsky and Easterling 2001).

Projected Impacts

Keeping in focus the uncertainty inherent in the complex nature of agriculture's vulnerability to climate change, specific impacts are likely for the Great Plains. This section is a review of the current state of scientific knowledge on likely impacts. In order to provide a concise, yet balanced overview of the large body of literature on the subject, I have chosen to highlight climate change impacts on crop yield, livestock, and rangelands.

Winter wheat used for bread making is primarily and extensively grown in the southern and central Great Plains (Weiss *et al.* 2003). Weiss *et al.* (2003) simulated yields of winter wheat for three climate zones across the central Plains using future climate scenarios/projections. Results suggest a decrease in yields and end-use quality at the most western, semi-arid locations. Other simulations of future wheat yields show similar results. Porter and Semenov (2005, 2028) found that "increased annual variability in weather causes increased variation in yield," even when mean temperature was held at the current value.

This increased inter-annual yield variation, and thereby an increased risk to farmers, is echoed by results from Tubiello *et al.* (2002). Under the drier of two climate change scenarios used, simulated winter wheat yields dropped 10-50% in the first 30 years of this century

(Tubiello *et al.* 2002). An increase in inter-annual yield variation means that the frequency of below average harvests increases, posing a great risk for farmers to plant that particular crop (Easterling *et al.* 1993). Easterling *et al.* (1993) attribute the decrease in yields to higher average daily temperatures, which cause crops to reach the end of their growth cycle before the grain heads adequately fill out, and also to increased water stress.

Similar simulations for corn show that increases in growing season rainfall were only beneficial in hot, dry years and that yield actually decreased in wet, cool years (Chagnon and Hollinger 2003). This suggests that in agricultural areas predicted to receive increased rainfall, more precipitation may not necessarily result in yield increases for corn. The CERES-Maize based crop model used by Rosenzweig *et al.* (2002) and modified to simulate crop damage due to excess moisture, resulted in crop losses by 2030 that are double today's values. Further compounding losses, variations in the percent of damage to yield in the future were predicted to be skewed toward greater loss with each event (Rosenzweig *et al.* 2002).

Characteristics of the highly variable climate of the Great Plains make cattle especially vulnerable (Mader *et al.* 2003). Extreme high summer temperatures decrease both voluntary feed intake (Mader *et al.* 2009) and conception and fertility rates in cattle (Tubiello *et al.* 2007). To compensate for predicted climate changes, beef producers would need to feed cattle between 4 percent and 16 percent longer in order to see similar animal weight gains and in the worst case temperatures may increase to levels higher than cattle can naturally adapt (Mader *et al.* 2003) resulting in animal losses.

Under moderate warming conditions as are predicted for the first half of the 21st century, pasture yields may benefit in temperate regions, but decline in semiarid regions (Tubiello *et al.*

2007). Yield decline in semiarid regions is linked to increased water demand related to the increased temperatures (Tubiello *et al.* 2007). This is significant because rangeland is almost entirely dependent on snow and rain fall to provide the needed soil moisture (Tubiello *et al.* 2007). Even in areas where precipitation is expected to increase, higher temperatures will increase evaporation of soil moisture to the point where drought frequency will increase (Morgan *et al.* 2008).

Public Perceptions of Climate Change

Studying perceptions of climate change is difficult because climate is not a concept that people have generally thought about at length. According to Hulme (2008, 2-3):

> Climate cannot be experienced directly through our senses. Unlike the wind which we feel on our face or a raindrop that wets our hair, climate is a constructed idea that takes these sensory encounters and builds them into something more abstract.

In order to circumvent this conceptual problem, Kempton (1997) studied how people process information. This is not easy to study because people take in new information by building onto what they already know (Kempton 1997). Kempton found that people form opinions about environmental issues by applying what they learn to concepts that they already know; he called these concepts "cultural models" and noted that they are often erroneously applied (Kempton 1997). Nisbet (2009) identified the importance of a qualitative approach saying that research methods such as interviews were needed to address cultural beliefs. The advantage of qualitative approaches to research are that they allow for exploration of the human understanding of certain problems in society (Creswell 2009).

Interviews and Participant Observation

Attempts have been made to determine the roles that the media play in shaping the public perception of environmental issues including climate change. This type of research is important because journalism has a large consumer audience (Moser and Dilling 2007). Stories are chosen based on their ability to draw new consumers and retain current consumers, not necessarily on their importance to environmental issues.

In an essay published in *Environmental Communication* in 2009, Kevin DeLuca interviewed Greenpeace International (GI) senior media analyst, Soenke Lorenzen, about his organizations choices to successfully communicate their message. GI is an organization that advocates for more attention to be paid to environmental issues. One of the significant comments from Lorenzen is his belief that climate change and related sustainable energy issues are “the most pressing environmental issues that the world faces” (DeLuca 2009, 264). Lorenzen is also surprisingly optimistic about the future of climate change policy. He says:

> Personally, I am more energized than ever from the fact that the voices of environmental NGOs, and the critical equitable sustainability issues that they champion, have gone from being heard in the back rooms to the board rooms of major multinationals and the seats of governmental power from Bejing to Brussels (DeLuca 2009, 269).

In a qualitative study of the non-response of a town in Norway to the issue of climate change, a participant observer method was used. From June 2000 to May 2001, Katie Norgaard lived in Bygdaby, a rural town of 14,000 inhabitants. She attended various local political and volunteer meetings and conducted 46 in-depth, semi-structured interviews with community members using a non-biased sampling strategy (Norgaard 2006). Norgaard (2006, 356) found that,

> People were aware that climate change could radically alter life in the coming decades, yet they did not go about their days wondering what life would be like for their children, whether farming practices would change in Bygdaby, or whether their grandchildren would be able to ski on real snow.

The community was well informed about climate change science and nearly 100% believed it to be true, yet they choose to put the issue out of their minds when living their daily lives (Norgaard 2006).

The participant observer method of research led Norgaard from an initial research objective of examining how this community experienced information on climate change to a revised objective of determining how and why well-informed residents chose to ignore the problem in their daily lives. Norgaard paints an interesting, yet disturbing, picture of rural attitudes in the oil-wealthy nation of Norway. By immersing herself in the day-to-day activities of her subjects, Norgaard discovered a phenomenon about the community that was previously unknown to her; they were turning a blind eye to a future problem.

Surveys and Interviews

Interviews and surveys are often used as a way to gather qualitative information because they reveal personal aspects such as opinions and experiences that are otherwise difficult to gather (Dunn 2005). Raphael *et al.* (2009) applied quantitative methods to qualitative data in order to make generalizations from a sample of 2004 residents in the state of New South Wales, Australia. The purpose of the study was to ascertain the level of risk perception associated with drought in rural Australian communities. The New South Wales Public Health Survey is an ongoing telephone survey conducted throughout the state. Between April and June 2007, drought questions were added to the survey.

Survey questions were coded on a 5-point Lickert scale and weighted for probability of selection in order to get a random sample. Based on the responses of the participants and their demographic information, a multivariate analysis could be performed. Using the SURVEYFREQ procedure in the statistical analysis software SAS 9.2, researchers weighted the data "to adjust for probability of selection and for differing non-response rates among men and women and different age groups" (Raphael *et al.* 2009, 331). With a 95.5 Confidence Interval, Raphael *et al.* (2009) found that women and people with children were generally more concerned about the risk of continuing drought. It was determined that people who lived in more remote areas were 3.2 times more likely to think that continued drought was a likely possibility (Raphael *et al.* 2009).

Harrington (2001) assessed the attitudes of major emitters of greenhouse gases in six counties in southwest Kansas. The assessment used interviews and surveys to produce numerical data. Survey responses to specific questions were analyzed to give a percentage of the total and presented in tables throughout the paper. Two tables presented further quantitative data by giving the Chi-square, degrees of freedom, and significance values for the varying answers to each question. Along with the numerical data, qualitative data in the form of direct quotes were also presented and conclusions were drawn by taking into account both the quantitative and qualitative data. Harrington (2001, 116) drew the conclusion that "climate change was not a major concern in the study area." When asked to rank a list of personal concerns, household respondents put 'slowing the rate of global warming' as least important (Harrington 2001). Respondents did not see climate change as a problem in the next 50 to 100 years, in the lives of their children, or in the lives of their grandchildren (Harrington 2001).

Relying on participants to be open and honest introduces a certain level of bias to the data, however, Harrington (2001) points out that the ample amount of responses expressing doubt regarding climate change suggests that the respondents were truthful and not overly influenced to answer in any certain way. The methods used here were highly effective and were able to shed light on the intra-regional variation within the United States in answers related to climate change and thus a need for more research.

Mixed Methods

Both qualitative and quantitative data have distinct advantages and disadvantages. Using both methods concurrently means the results will have strengths associated with both types and disadvantages will be minimized by building on the convergence of both data types together.

Sterman and Sweeny's (2002) analysis of participant's performance on simple logistical tasks, with relevance to understanding climate change, represents a mixed methods approach to data collection and interpretation. Methods were tested on a subsample prior to the actual test in order to refine the data coding techniques. Researchers administered two versions of one task and a third task that contained more information than the other two at two geographically distant sites. Results of each task were tested against each other for significant differences in answers; none were found. Tasks were administered at both the MIT Sloan School of Management and the School of Business at the University of Chicago. Included in the participants were students with undergraduate degrees in the sciences, some with graduate and doctoral degrees. The students were given a graph depicting a hypothetical scenario of anthropogenic emissions of CO_2 which were immediately reduced to zero in the year 2000. The students were asked to graph the results to atmospheric CO_2 and global average temperature. Figures 1, 2, and 3 (below) provides a sample of the graph they were asked to complete, a typical response from the students, and what would actually happen in the given scenario. Students did not understand the lag time of CO_2 concentrations and related temperature change in response to actual emissions (Sterman and Sweeny 2002, 230).

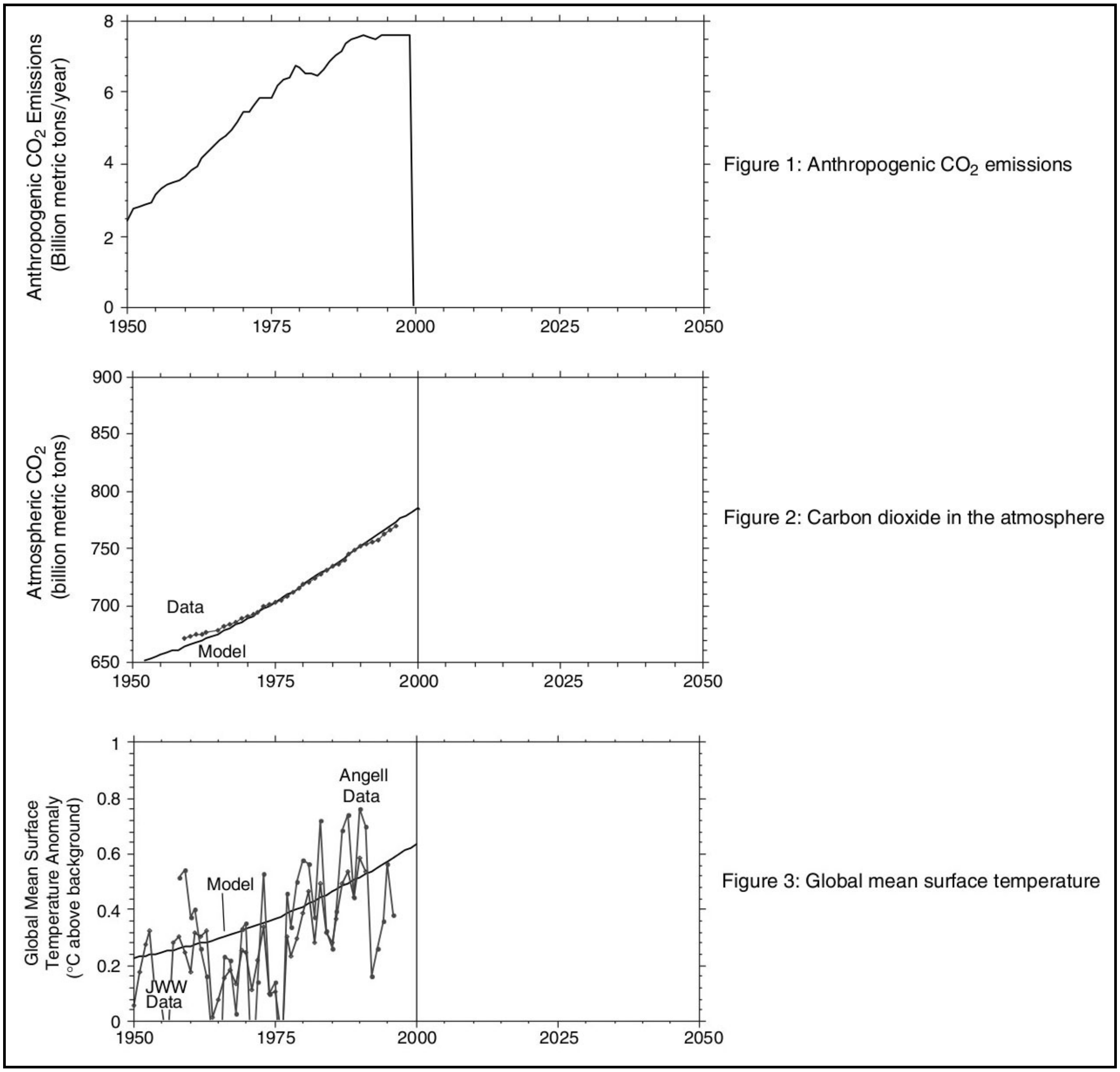

Figure 2.1 - The Zero Emissions task (showing the CO2 graph treatment) from Sterman and Sweeny (2004, 216)

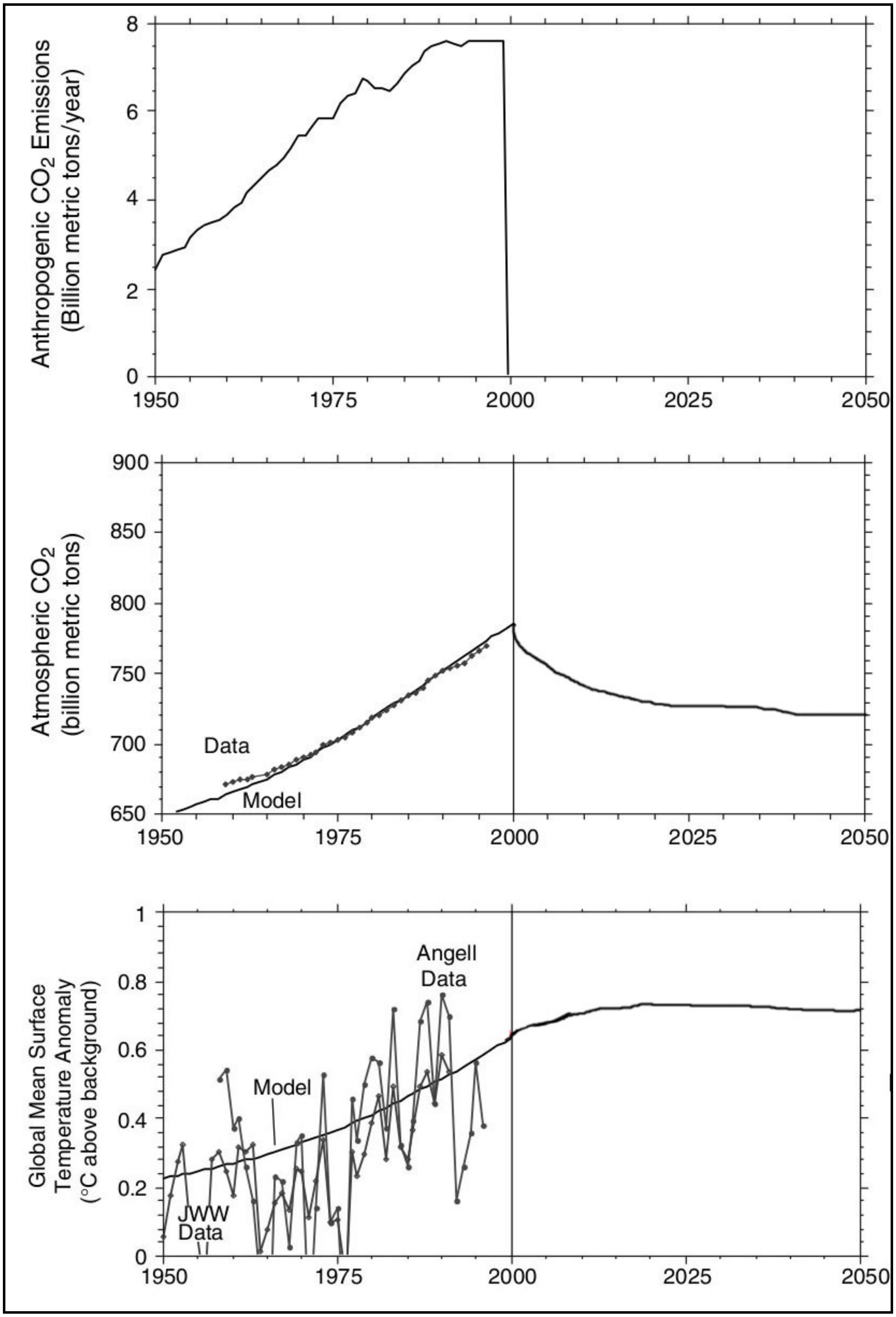

Figure 2.2 - Simulation of Zero Emissions Task. Adapted from Sterman and Sweeny (2004, 218)

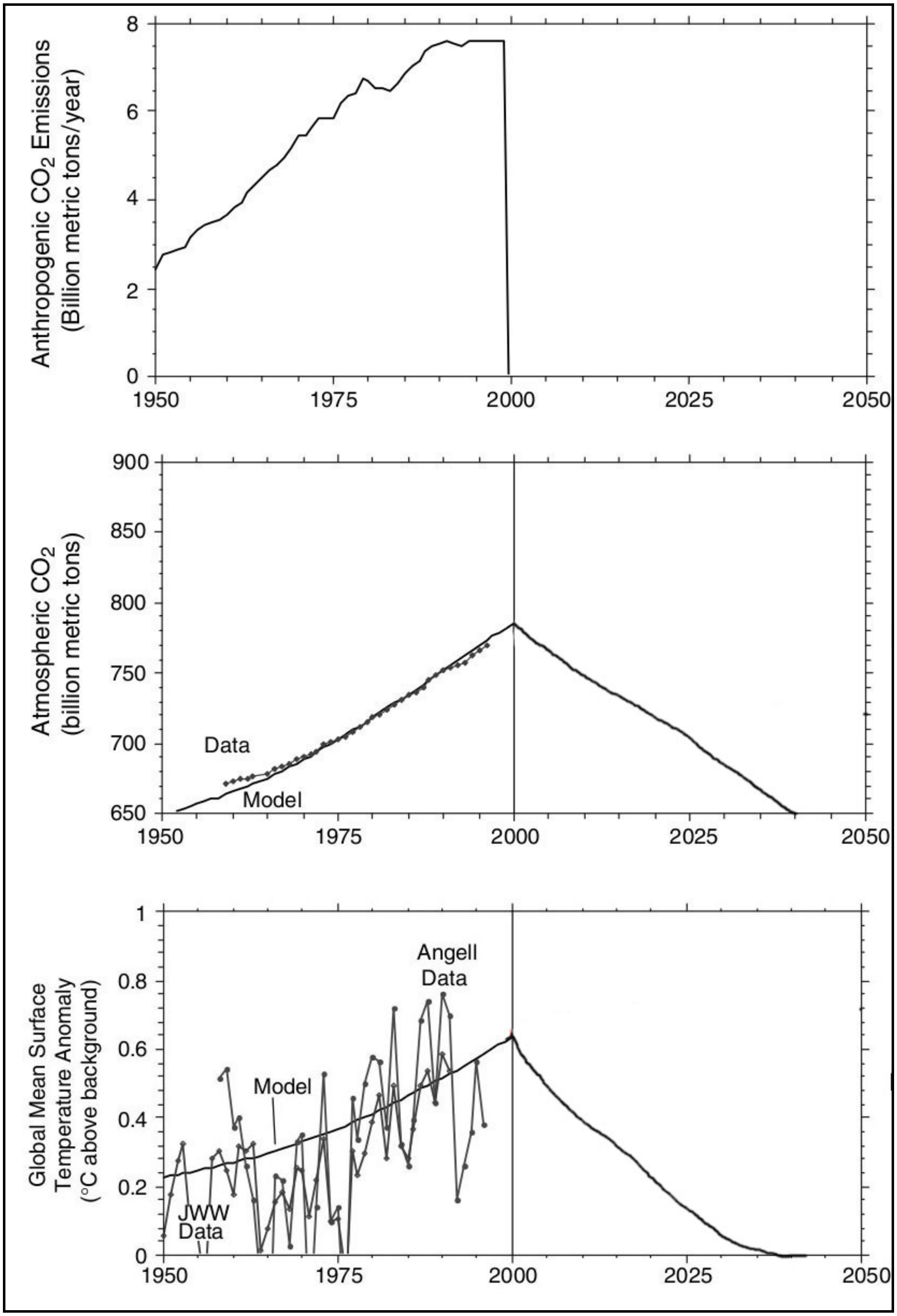

Figure 2.3 - Typical erroneous response to the global warming task. Adapted from Sterman and Sweeny (2004, 221).

Sterman and Sweeny (2002, 234) noted that even highly educated people lack an adequate understanding of the science behind the study of climate change related to carbon dioxide emissions and that this translates to a poor handling of climate change policy:

> As long as people's common sense tells them that stabilizing emissions is sufficient there can be little political will or public pressure for policies that could stabilize climate and prevent further warming. As long as people believe the delays in the response of the system are short, they will conclude it is best to ''wait and see'' if warming will occur and how much more harmful it will be before taking action.

The researchers acknowledge a few limitations to their methods such as the role that the length of time students had to complete the tasks may influence answers, or whether or not the students gave serious effort to completing the tasks. Other possible issues with the research design are left unaddressed. For instance, Sterman and Sweeny make generalizations of all highly educated people without ever giving their definition of what "highly educated" means. They do not mention why business schools were chosen as opposed to a traditional 4-year university. One final criticism is that they do not acknowledge that education level is not necessarily a good indication of a person's intelligence or the amount of knowledge he or she may possess on a particular subject.

Mertz *et al.* (2009) conducted informal interviews, held focus groups, and administered questionnaires to assess which strategies are being used by farmers in the Sahel to combat the impacts of changes related to development trends, and whether or not the impacts are also related to climate change and climate variability. Data were collected from Eastern Saloum, Senegal between October 2006 and March 2007. Observations from local villagers were then compared to actual rainfall records. The results of the comparison of local observations to official records showed that, "Local communities have a very clear memory of the years dominated by extreme climatic conditions and other significant events leading to disturbances of the production" (Mertz *et al.* 2009, 808). This finding as well as results from the focus groups and questionnaires supports the conclusion that "strong narratives on climate exist in the local communities" (Mertz *et al.* 2009, 815). However, the community does not always link adaptive strategies to climate causes, but rather to economic, political, or social issues (Mertz *et al.* 2009).

Many television markets in the United States carry a good deal of science-related programming. One such program, *Discoveries and Breakthroughs Inside Science* (DBIS), is nationally syndicated and receives support from the National Science Foundation (Hwang and Southwell 2009). Stories broadcast by DBIS are intended to change viewer's perceptions and help them recognize that science is understandable and relevant (Hwang and Southwell 2009). In a macro-level study, they investigate impacts of DBIS on public opinion and used social representation theory as a guide to their research. The theory of social representation suggests that a person's social discourse is a factor in their response to broadcast messages (Hwang and Southwell 2009, 734). They developed two main research questions. The first question asks, "Does media market-level exposure to DBIS news stories affect people's beliefs in the accessibility of science?" The second question asks, "Does DBIS science news exposure interact with interpersonal conversation to predict people's science accessibility beliefs?"

Internet surveys collected from 2,187 regular viewers were aggregated into Designated Market Area's by zip code. Survey respondents were asked to rate two questions related to the accessibility and relevancy of math and science. The responses to both questions were averaged together and used as the dependent variable. Independent variables were obtained from responses to questions concerning amount of time and level of participation in conversations about science as well as questions about age, gender, level of education, employment in a science-related job, and reliance on TV news and newspapers for information. Lastly, DBIS exposure was assessed depending on the presence of and number of networks airing DBIS stories. Results showed that males with higher education and science related jobs as well as those who contributed to conversations about science had a greater probability of belief in the accessibility of science (Hwang and Southwell 2009). Exposure to DBIS was also found to be an indicator of the belief in the accessibility of science and the authors conclude that this research offers a way to determine how best to communicate science through mass media outlets (Hwang and Southwell 2009).

Researchers and policy makers need to understand what the public knows in order to make better decisions for the well being of our planet and its citizens. Polsky *et al.* (2003) propose a common methodology for this type of research which recognizes a varied knowledge base in which local concerns are studied in depth. They also advocate that research be place-based using small study areas (Polsky *et al.* 2003), which will help fulfill this need for a varied knowledge base at the local scale. Small scale studies are just one part of a larger effort that is being undertaken in the scientific community to better inform policy makers of local needs while still taking into account the needs of the environment and the world as a whole. Wilbanks and Kates (1999) note that policies related to global change rely on local scale information especially since global and local change do not operate independently of each other. The north-central Kansas study area chosen for this thesis research is primarily an agricultural area; findings from the Kansas stakeholders will be a small yet important part of global change research.

Chapter 3 - Study Area

As part of a larger, ongoing effort by the scientific community to understand climate impacts and local perceptions of climate change in the Great Plains region, this thesis seeks to understand relevant aspects of local physical, historical, and social characteristics. In particular the study area chosen encompasses the communities of the northern Flint Hills and the adjacent physiographic region of the Smoky Hills. Both regions are located in north central Kansas and are considered a part of the larger region of the central Great Plains.

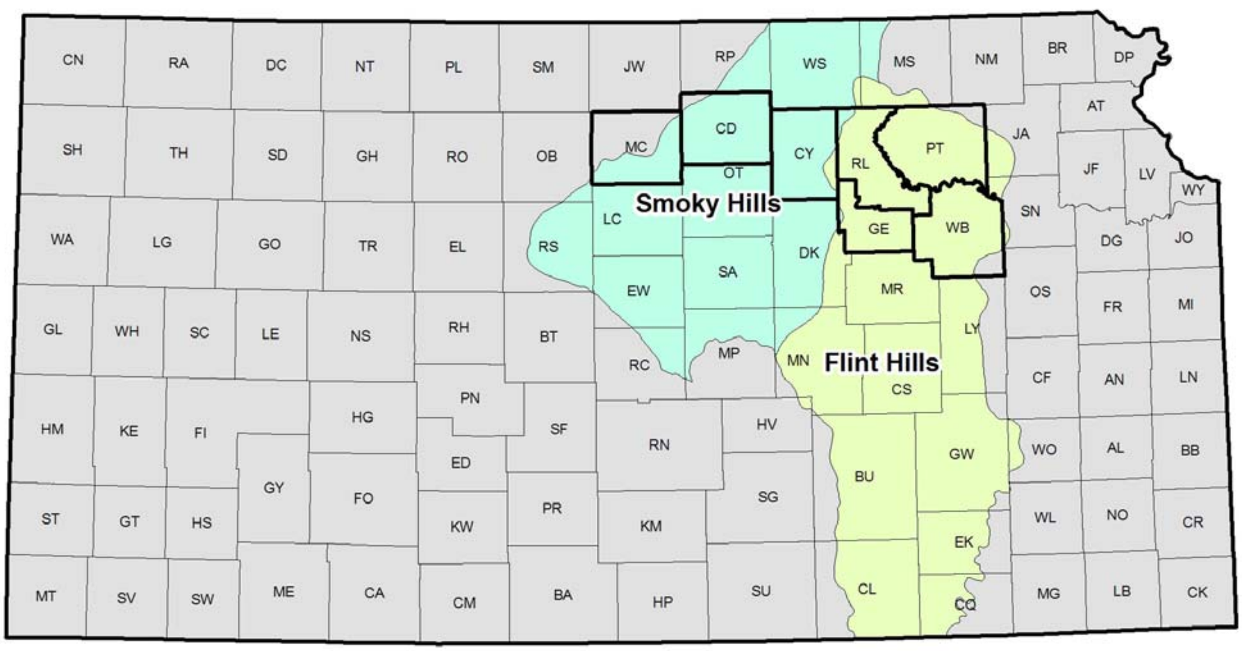

Figure 3.1 – Location of study counties with the Smoky Hill and Flint Hills physiographic regions within Kansas. Source: cartography by the author.

During settlement of Kansas, the Flint Hills region was passed over by crop farmers**,** but came to be greatly utilized by cattle ranchers taking cattle to be shipped east on the ever expanding rail system that was in place during the last half of the 19th century. Land was leased to the cattlemen and this 19th century practice helped establish a transient system of grazing that still goes on today. By the 1920's the number of cattle passing through the Flint Hills alone was more than 400,000 annually (Isern 1985). "For more than a century the Flint Hills have been a stronghold of the livestock industry, an area of Kansas devoted almost exclusively to the feeding and breeding of cattle" (Hickey and Webb 1987, 244). The hardy, drought resistant tall grasses native to the upland region with shallow, rocky soils were excellent for fattening cattle. "One of the last large segments of tall grass prairie that once stretched from Canada to Texas and from Kansas to Indiana, the Flint Hills region covers some five thousand square miles of rolling hills and narrow valleys in east central Kansas" (Hickey and Webb 1987, 244).

The Flint Hills' culture and agriculture developed in such a way as to remain unique compared to surrounding areas (Isern 1985). According to Middendorf *et al.* (2009), the uncommon role of agriculture in the region has developed because of the hardy, drought resistant, native grasses such as the bluestem species. The numbers of cattle grazed in the Flint Hills has risen and fallen with national per capita beef consumption (Middendorf *et al.* 2009).

> The increase in the year-round cattle inventory suggests that the region has developed two primary roles, that of cow-calf operations and herds that sell breeding stock. In both cases, the weight gains on the bluestem pastures are the basic element of the agricultural economy of the region (Middendorf et al. 2009, 17).

Over the years, most consumers have developed a taste for cattle finished on grain. This, together with the higher cost of keeping cattle on grass longer, has changed the function of Flint Hills pastures from a place to finish cattle to a place to get them ready for the feed lot (Isern 1985).

Although few cattle are finished on grass at this time, pastures are still leased to provide an early diet for young steers and heifers before being sent to a feed lot (Isern 1985). Changing climate may require ranchers to adjust their stocking rates so as not to put too much stress on local natural resources. The time cattle are returned to pasture after wintering on hay or crop stubble may change as temperatures begin to rise. Warmer temperatures will mean plants will require more moisture; at the same time evaporation will be increasing as well.

The Smoky Hills is a physiographic region of north central Kansas adjacent to the Flint Hills. It has an agriculture-based economy that will likely be affected by climate change. In Mitchell County**,** 96.5% of the acreage is in some type of agricultural production, mostly cropland (USDA 1977, 2007). Although it can be considered as part of the Great Plains, the Smoky Hills is not a treeless plain. Running along the streams and rivers are assemblages of arboreal species such as cottonwood, elm, and ash (Procter 1995). Native prairie grasses include bluestem, buffalo, and Indian grasses (Procter 1995).

Grasslands have been a prominent biogeographic region in North America for thousands of years, extending from central Canada, through the United States and into Mexico (Reichman 1987). This includes the area known as the Great Plains. At the time of European settlement, vast areas of the Unites States remained grassland; with modern agricultural land conversion only a fraction of the original grassland remains today (Reichman 1987). Mixed prairie grasses dominate in the Smoky Hills whereas native pastures of tallgrass prairie remain in much of the Flint Hills. “The North American tallgrass prairie is special because of the magnitude of big bluestem grass, its dominant variety, which symbolizes the tallgrass prairie” (Reichman 1987, 8).

The short and tall grasses that dominate the Great Plains are a result of the region’s unique climate and relevant plant physiology. “Cut off from ocean moisture on the west by the double rim of mountains, the moisture of this area east of the continental divide is derived from warm, moist air masses moving northward from the Gulf of Mexico to meet cold, dry air masses from the Canadian plain; the whole moves eastward" (Malin 1984, 5). Lack of timely moisture means the frequent occurrence of drought. Native short and tall grasses also became a major food source for animals that adapted to Great Plains climate. Frequent droughts and grazing by large ungulates made it hard for other plant species to survive, but the hardy grasses survived well in spite of these two major oppressive forces (Reichman 1987).

Besides drought and grazing Reichman describes fire as another major force or ecosystem disturbance that was a factor in the development of North American grasslands (Reichman 1987, 59). "Many grasses possess underground stems that can survive fires and that at the same time are protected from drought and grazing" (Reichman 1987). "Furthermore, most of the critical growth tissues (meristems) of grasses are at or below the ground surface, where they are protected from the raves of the aboveground environment" (Reichman 1987, 59).

A steep rainfall gradient exists from east to west here. "The natural vegetation zones correspond in general with the isohyetal lines, and that correspondence extends into the mountains, where both are conditioned by the accidents of altitude" (Webb 1931, 27). According to Webb (1931, 29) "Grass prevails only where conditions are unfavorable to more luxuriant forms of plant life". There is an abundance of rangeland available in the Great Plains.

While the native grasslands of the Smoky Hills were plowed under during agricultural expansion and converted to wheat fields, only the bottom lands of the Flint Hills region could be plowed due to the shallow and rocky soils of the uplands. This left large areas of native grasses that resisted cropland expansion, making Flint Hills uplands unique to the surrounding area.

Breaking prairie sod for growing crops was as unwise deed to undertake in the shallow, rocky soils of the Flint Hills (Reichman 1987).

Human and Agricultural History

Besides drought and grazing by large herbivores, fire was also essential to grassland ecology. Fire was a natural disturbance factor in the prairie area, but the earliest grassland inhabitants learned from nature and began using fire to help them survive in the harsh Great Plains environment. The first known inhabitants of the Flint Hills were the semi-nomadic Kansa Indians who burned the prairie in preparation for hunting bison; bison were attracted to the young grasses that grew after burning (Middendorf *et al.* 2009). According to Middendorf et al. (2009, 9), “bison meat was the most important animal protein in their diet, which they supplemented with elk and deer.”

The fate of the Kansa after European settlement did not end well. “In 1825 the Kansa were placed on a reservation that included Konza Prairie, and they remained there until they were deported to Oklahoma Territory in 1873” (Reichman 1987, 9). Takeover of these grasslands by the United States government was completed in the mid-19th Century. “The United States took legal possession of the mid-latitude grassland of North America (between the forty-ninth parallel and the Rio Grande) during the late 1840’s” (Malin 1984, 10). The final demise of the habitation of the prairie by its native people came at the hands of the military. “Between 1850 and 1880 a series of military posts was constructed in Kansas to control hostile Indians and to protect major east-west trade routes” (Reichman 1987, 27).

Even after the removal of its native people, the Great Plains was slow to become settled by whites. “Prior to the steam railroad, penetration of the interior of the North American continent had followed water-communication systems" (Malin 1984, 11). In Kansas, navigable rivers were few which meant a higher cost to take products to market. "Without railroads, corn at Lawrence, thirty to forty miles from the Missouri River, was worth nothing for sale on the Missouri River markets, because the cost of carriage by animal power equaled the normal market price" (Malin 1984, 11).

Still, agricultural conversion of the prairie inevitably came as a result of the passing by Congress of three bills in 1862. During the Civil War, Congress passed the Homestead Act, the Pacific Railroad Act, and the Morrill Act. Especially important was the Railroad Act, which produced a result that enabled farmers to get their product to market with a relatively low transportation cost. The railroads provided a faster means for transporting large amounts of goods in an area where there were few navigable rivers. After the Civil War ended, farmers began to settle in the bottom lands of the Flint Hills (Isern 1985). The farmers who filled the fertile valleys were often native Midwesterners, but even many European born farmers had already lived in the Midwest for a time before moving further west to the Plains (Isern 1985).

Just as the early English colonists brought their familiar crops and practices with them, in the same way early Plains immigrants brought their crops and practices with them. English settlers to the New World adopted Indian maize as a stable and brought it with them to the tallgrass prairies in the late 19^{th} century (Malin 1984). Some foreign plants and animals did quite well without any genetic modification when brought to the Plains. British breed Hereford cattle were raised from Canada to Mexico (Malin 1984). Brahman beef and dairy cattle from India prospered in the high temperatures and low rainfall of the Southern plains (Malin 1984). Also important were wheat varieties from Russia, sorghum native to Africa and Asia, and alfalfa originally from Chile (Malin 1984). “Only in the second quarter of the twentieth century did the second, or creative, phase of biological adjustment emerge in effective form, based upon the genetics of mutation and hybridization and the correlation of breeding and agronomic programs with the principles of developmental physiology” (Malin 1984, 111).

The Homestead Act, Morrill Act, and Railroad Act had a combined effect on the population in Kansas. Between 1860 and 1880, population increased by a factor of nine (Mather 1972). The rail system was now in place and prairie grasses were open to all grazers. “During the late 1860’s and early 1870’s drovers from Texas had arrived on their way to Abilene and other railheads” (Isern 1985, 256). As rangeland began to be fenced off in the 1880s, absentee owners made a practice of buying out small farms and leasing the land to Texas cattlemen (Isern 1985). “From the early 1890’s on, every village, every siding in the Flint Hills had a cluster of chutes and pens that each year became a mass of mud when the cattle arrived, in March and April, and a cloud of dust when they were shipped out to commission men in Kansas City, beginning in late July” (Isern 1985, 258). The influence of Texas cattlemen did not stop there. Prairie burning, a practice learned from Native Americans, was seen as beneficial by cattle producers. In fact, cattlemen “demanded early spring burning of pastures to promote quick grass growth and rapid weight gains” (Isern 1985, 259).

At the turn of the century, Americans were enjoying a time of peace and prosperity. During the first two decades of the 20th century, rising demand to feed a growing US population, and export demands from a war-stressed Europe helped drive up the prices of wheat and beef (Middendorf *et al.* 2008). This trend was short lived and had unforseen consequences. In the Smoky Hills and surrounding areas, more native grassland was converted to cropland to meet increased demand (Middendorf *et al.* 2008). When the Great Depression and severe drought of the 1930's hit, crop farmers saw their fields turn to dust and with less pasture acreage available, more cattle were shipped into the wetter Flint Hills where pasture was still available (Middendorf *et al.* 2008).

For a variety of reasons, and particularly "after the 1960's, fewer cattlemen attempted to finish cattle on grass" (Isern 1985, 262). The function of leased pastures changed from one of finishing cattle on grass to providing feeder cattle ready for the large commercial feed lots that had come into existence (Isern 1985). This function still exists in the Flint Hills today.

Technological changes in agricultural production in the 20th century, such as tractors, center pivot irrigation, and hybridization dramatically increased crop yield. Another advance discovered during WWII were new fertilizer products (Flora 1999). New technologies together with a changing world market (Flora 1999), caused prices to drop and by the end of the 20th century commodities were back at their Great Depression low (Stirling 2001). All the while, a farmer's cost of raising crops and livestock continued to grow, thereby narrowing the profit margin (Stirling 2001).

Rural Life

Early settlers to the area were affected by the prairie environment that surrounded them. The land is wide open; often many miles exist between homes and only the dedicated, ingenious immigrants were able to thrive despite hardships brought on by factors such as climate and physical isolation. "The values constructed from the citizens' response to the environment are the values necessary to live and succeed in such an environment" (Procter 1995, 230). Rural inhabitants feel free to live their lives the way they wish. Unfortunately, the same sense of freedom also brings with it a fear of ill-treatment by strangers. In a cultural study of Mitchell and Lincoln Counties in the Smoky Hills, Procter (1995, 229) observed, “county citizens perceive themselves as neglected and exploited by outsiders.”

Pioneer heritage has also shaped cultural views and customs. Sports teams in the region have names like Longhorns, Bison, Buffaloes, and Cowboys. Another factor was the fact that large land holdings were common in the plains even before mechanization allowed farmers to put more and more acres into production (Mather 1972). Perhaps the vastness of the plains has led to a “cultural preoccupation with the grand scale” (Mather 1972, 257). Mather (1972, 257) even went so far as to call them ‘megalophiles’ saying, “this type of enterprise evokes strong regional pride and challenges the Great Plainsman in his next step as a ‘megalophile.’”

Despite adherence to long standing traditions, times have changed. When previously local knowledge of the environment and livestock were of paramount importance, starting “in the 1930’s, additional mechanical skills were required to supplement production skills for farmers and farming community success” (Flora 1999, 402). In addition, today’s farmers must be acquainted with concepts of chemical application and bio-engineering (Stirling 2001). To understand the consumer-driven market for his product, a farmer must have good communications skills, and form new alliances to stay competitive (Flora 1999).

After WWII, “the number of farms declined rapidly, as fewer farmers were needed to produce more” (Flora 1999, 403). “By the 1960’s farms were larger and owners were fewer, increasing the wealth of few and the poverty of many” (Choy and Rounds 1992, 3). Even a farmer’s relationship with his horse isn’t the same anymore. “The average horse of [the early 20th century] was a work animal in a rural environment used by a person of modest education.

Today the typical horse is a pleasure animal living in or adjacent to an urban area, and is a status symbol of the educated and affluent class" (Mather 1972, 251).

Economically and in terms of population density, rural plains communities reached their highest point in the 1920's (Choy and Rounds 1992). Substitutions for farm income are limited in rural areas which caused people to migrate to urban areas (Lonsdale and Archer 1995). "A net outflow of income and a shrinking tax base make it increasingly difficult to provide the range of services typically expected from local government agencies.…the arrival of low-income migrants may actually create the need for additional services not previously provided at the local level" (Vias and Collins 2003, 249).

By the 1980's Great Plains farmers had entered an era of crisis. "Depressed grain prices, lower per capita beef consumption, excessive debt-to-asset ratios, and frequent foreclosures all brought farm and ranch consolidation" (Lonsdale and Archer 1995, 53). The severity of this economic slump was amplified because the region's economy lacks diversity; agriculture is relied on heavily. Employment in the agricultural sector decreased due to the large scale consolidation of farms (Lonsdale and Archer 1995). Employment also went down in the mining and construction industries during the decade of the 1980s (Lonsdale and Archer 1995).

Ironically, the one sector of Great Plains economy that rose may have done more harm than good. Manufacturing jobs went up due to an increase in meatpacking plants needed to service large feedlots (Lonsdale and Archer 1995). Lonsdale and Archer (1995, 57) explain that: "mature industries tend to migrate to ever smaller communities seeking ever-lower wages and non-union labor for more routine manufacturing operations." This trend kept a majority of residents in poor farming counties in poverty or working long hours for relatively low pay.

By the end of the 1990s prices for commodities dropped as a consequence of increased competition. Competition within the US increased as the removal of supply control measures, under the 1996 Farm Bill, brought more land into the production of agricultural commodities" (Flora 1999, 404). "While beneficial for the consumer, large-scale discount merchandising tends to impact nonmetropolitan employment in the same downward direction as does farm and ranch consolidation, through a substitution of capital and machinery for labor" (Lonsdale and Archer 1995, 61).

Residents of the Great Plains have always been a community of people moving goods from place of production to market. Geographers have found that the movement of people in the Great Plains is related to income, but not in the way expected. Vias and Collins (2003) mapped migration and income flows for 381 Great Plains counties and found that for 10 percent of the counties, income decreased when population increased. Part of the explanation for this is that the low cost of living in many rural counties attracts low-income people and employers looking for cheap labor (Vias and Collins 2003).

Climate is changing and agriculture must become more sustainable in order to be able to feed coming generations (Karl *et al.* 2009). Flora (1999, 398) acknowledges, "We now understand that sustainable systems for prairie grassland reflect the relationship between the landscape and the people in it." Agricultural communities interact collectively for support to deal with both environmental and social concerns (Flora 1999). Therefore it is necessary not only to understand environmental processes, but the social interaction of communities of people in order to facilitate change.

In harmony with Kates and Wilbanks (2003), this thesis focuses on the local scale by studying nature-society relationships in the physiographic regions of the Smoky Hills and Flint Hills of north-central Kansas. By understanding the processes that went into building the social and cultural structure of these two regions, a firm foundation can be made for developing tools necessary for effective communication and to foster change. Several things make social change difficult in rural plains communities. As Procter (1995) found in his study of Lincoln and Mitchell counties, rural individualism that was necessary for agricultural success and the self-imposed isolation of the inhabitants means that they do not have collective strength socially or economically.

Chapter 4 - Methods

Climate change will have a direct impact on Great Plains agriculture and the fact that the public as a whole does not perceive climate change creates a great risk (Kart *et al.* 2009). Planned adaptation to a changing climate and mitigation of climate change drivers will only happen if public perception changes. This research looked specifically at the agricultural community's perception of changes in their local environment including changes in weather and climate. As land owners and primary decision makers for their individual enterprises, business and land management practices by agricultural producers are based on many variables including personal values and environmental knowledge. Bridging the gap between scientific climate knowledge and a viable future for agriculture requires that scientists and policy makers take into consideration the local ecological knowledge and values of a community. This research uses interview methods to collect information and evaluate the perceptions of environmental knowledge of producers as well as agricultural specialists as a first step toward bridging the gap.

Data Acquisition

Research design is influenced by many things including other researchers and one's own interests (Bradshaw and Stratford 2005). The design for this study was influenced by the authors previous experience interviewing people in the agricultural region of southwest Kansas; that experience sparked a personal interest in the future of farming under a changing climate. Reading previous studies in qualitative research related to the role of human agency in environmental issues resulted in a desire to address the topic in north central Kansas. Goals for this research included interviewing stakeholders in two different ecoregions, analyzing these interviews to better understand local perceptions of environmental changes, developing an understanding of local word choices related to climate and the environment to enable climate scientists to better communicate relevant findings to the local population, and to provide a policy relevant summary of findings that will enable local producers to maintain values important to them. In designing this research, careful consideration was given to how information on perceptions could be used to help policy makers assist farmers in adapting to a highly variable climate.

A team of two graduate students and four undergraduate students with knowledge of environmental processes spent the summer of 2010 as researchers on this project. The team's first step was to identify the kinds of information we hoped to gain from the interviews of local residents and the best way to acquire the information. In view of the fact that farmers use natural resources as part of their livelihood, guiding interview questions were developed using basic ecosystem goods and services as a framework. As explained by Costanza *et al.* (1997), ecosystem services are the basis for human well being. Ecosystem services include categories such as provisioning services, regulating services, cultural services, and supporting services (MEA 2003). The topics included in the interviews for both farmers and agricultural specialists were based on this conceptual overview of natural resources. Outlines of important topics to be sure to address in the conversations were developed for local agricultural producers and resource managers/specialists.

Both farmers and specialists were asked questions that were intended to open a conversation concerning their knowledge of topics related to soil erosion and fertility, water quality and availability, the effect of weather in day to day operations, invasive species, and land management practices. Two separate interview guidelines were drawn up and tailored to either farmers and ranchers or agricultural specialists. Copies of both interview guidelines can be found in Appendices A and B. As required by Kansas State University, an application for research that involved human subjects was submitted to the University Research Compliance office before any stakeholders were contacted.

Bradshaw and Stratford (2005) mention that both trustworthiness and documentation are needed to ensure rigor. In considering trustworthiness, a sheet discussing confidentiality of answers provided was made available to each person we engaged in conversation. The fact that the students involved were from a land grant university probably helped local residents connect with the motivation/goals of the study.

Weekly meetings with all team members involved in the research were held to discuss progress, distribute the workload, and address any questions or problems. The team also had opportunity to meet with colleagues from other universities to discuss methods, preliminary findings, and receive feedback. With respect to documentation, all completed interviews were logged into a notebook. All handwritten notes were scanned into digital format and all recordings were transcribed as text documents. All interview material was stored in an online data bank separate from individual names and addresses to ensure anonymity. One person was responsible for making sure all notes and transcriptions were complete and accounted for.

Existing knowledge of the environmental education levels and personal opinions of farmers related to environmental change in the seven county study area is largely unknown. Semi-structured interviews were chosen because of their unique ability to simultaneously bridge knowledge gaps, gather opinions, and benefit the people interviewed (Dunn 2005). "One of the major strengths of interviewing is that it allows you to discover what is relevant to the informant" (Dunn 2005, 80). Finding out what matters to farmers is important to the central theme of this study and will be very useful in future efforts related to cognate policy decisions.

Several types of sampling strategies were used during the interview process to increase the total number of interviews. Snowball sampling was useful when previously existing personal relationships between team members and members of local communities existed. Initial and known contacts were able to refer the team to other stakeholders who might be interested in engaging in conversation of the research topics. Purposeful sampling was used in the case of community members whose jobs involve direct contact with local agricultural producers such as specialists employed with the USDA or the County Extension office. Specialist's names were obtained from local directories; appointments for interviews were made by phone, email, or in person. Convenience sampling was also used in an effort to obtain as great a sample size as possible. Several farmers were initially contacted by approaching individuals at gas stations or in local coffee shops. No farmers or ranchers were contacted at their homes without a prior recommendation or personal invitation.

Conversations with interviewees were recorded using handwritten notes and audio recording if permission was obtained. Interviews were conducted by two student researchers whenever possible. In this case, one researcher could guide the conversation while the other took detailed notes. In total, 42 persons were interviewed representing eleven different counties. Twenty-seven interviews took place in the Flint Hills and 15 took place in the Smoky Hills. Twenty of the respondents operated a ranch, raised crops, or both; 22 interviews were with local specialists.

United States Department of Agriculture (USDA) employees with the Natural Resources and Conservation Service (NRCS) and Farm Service Agents (FSA) were interviewed in each county of the study area where possible. Some agents serve more than one county. Also contacted were several seed company employees, Kansas State University Agricultural Extension Agents, a watershed specialist, and a county Noxious Weed employee.

In an attempt to facilitate thoughtful discussion between producers and interviewers, open ended questions concerning the environment and the way landowners manage natural resources were used. Some examples of questions used include, ‘How often do you expect a good yield?’, ‘Are you managing any differently specifically for climate and/or weather events?’, and ‘How do you characterize a drought?’ Specialists were asked similar questions. Examples of questions include: ‘Are you encouraging farmers to manage any differently specifically for climate and/or weather events?’, and ‘What method of information sharing works best?’

Interview Coding

No hypothesis of the expected outcomes were generated prior to conducting interviews. Rather, interviews were coded afterward using ATLAS.ti, which is specialized software for that purpose. The digital record of each interview was loaded into the software and passages of text were coded based on the nature of the conversation/question being asked. For instance comments concerning a farmer or specialist’s opinion on climate change were grouped together under the code ‘climate change’ and could then be viewed as a group. In this way, the ATLAS.ti software facilitates getting a broader understanding of how respondents collectively responded to a particular question or study theme. Figure 4.1 is an example of how one particular document was coded. This section of text was taken from a recorded interview that had been transcribed as a text document.

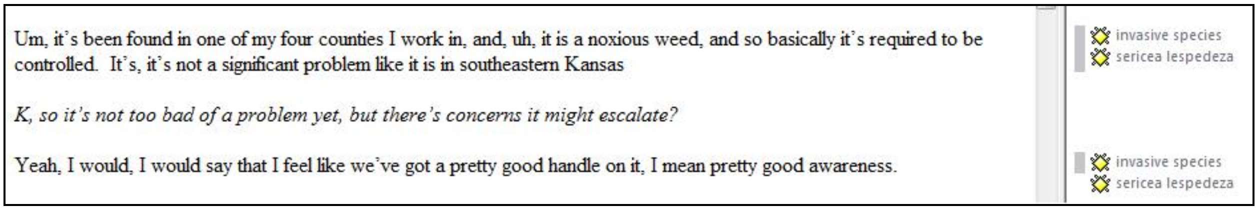

Figure 4.1 – Sample document coding using ATLAS.ti.

ATLAS.ti software also allows for codes to be linked to other codes. This capability was helpful for managing a large amount of data by grouping codes into families as in the example below. Many different types of animals were discussed as answers when interviewees were questioned about changes in local wildlife. Figure 4.2 shows the linked codes as a graphic that allows for easy visual interpretation. The first number under each code shows the number of times the code was used in all documents. The second number corresponds to the number of other codes to which that particular code was linked. For instance, the code *Coyote* was linked both to *Wildlife* and to *Invasive Species.* The linkage diagram provided helpful information for the analysis of how local stakeholders use specific word choices in discussing an environmental change topic. Conclusions as to the outcome of the interviews/conversations could then be drawn by viewing texts and codes in their respective groups.

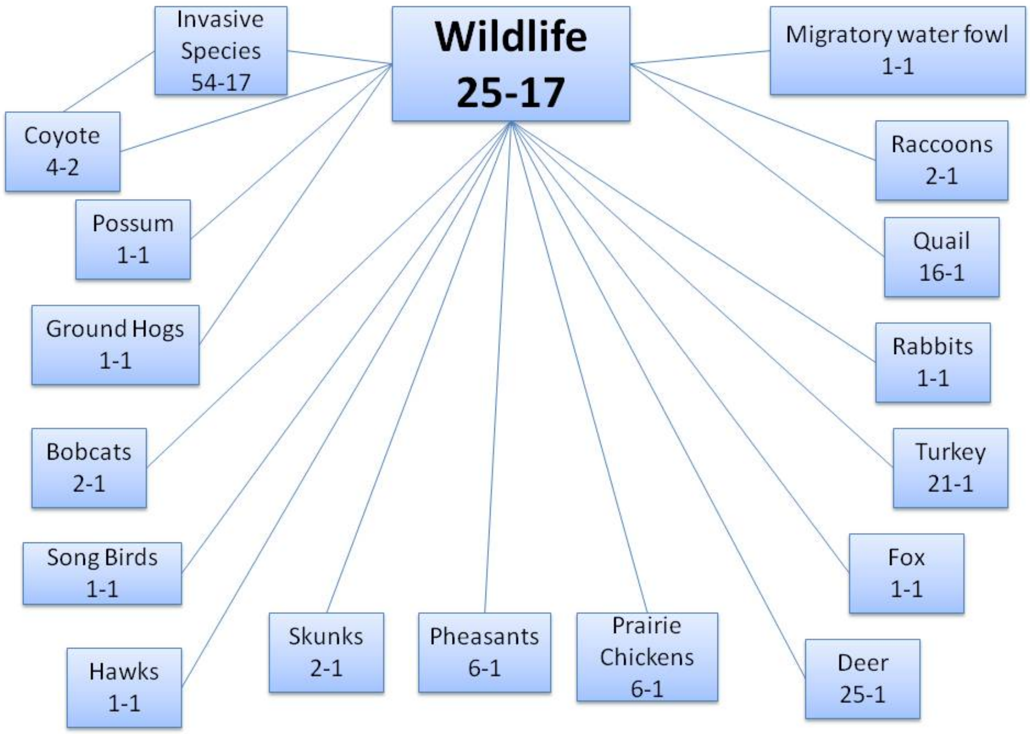

Figure 4.2 – Wildlife ATLAS.ti output. Source: ATLAS.ti graphic modified by author.

Details of the research design emerged as the process of conducting interviews and analyzing the results took place. While the interview guidelines were determined using an ecosystems goods and services approach, the resulting codes and the organization of results presentation in Chapter 5 was driven by the data collected. Appendix C gives a full list of selected codes together with the families into which they were grouped. The research began with an interest in understanding farmers perceptions of climate change in order to broaden scientific knowledge related to a desire to improve the local response to possible climate change (NRC 2010). Previous experience interviewing farmers served as a basis for developing thought-provoking topics for conversation. Each team member contributed their own personal knowledge of the environment and natural resource management to engage the interviewees in conversation. ATLAS.ti was instrumental in drawing conclusions and organizing the volume of qualitative data.

Chapter 5 - Results and Discussion

In order to help local residents adjust to a changes in their environment, it is important to understand farmer and rancher perceptions of climate and environmental change in north central Kansas and this thesis was based on the assumption that there is a gap between what scientists know about the state of the climate and what the general public knows. In order to bridge the knowledge gap, it is necessary to find out what the public currently knows about their environment and the language they use to discuss important changes. Conversations, in the form of semi-structured interviews were held during the summer of 2010. These interviews generally lasted about 45 minutes. While the interview guidelines were based on an ecosystem services approach, this chapter is organized based on the emergent themes in the data (see Appendix C).

Background

Seventeen out of the 19 farmers who were interviewed were male with ages ranging from 87 to 29. Total years each individual has spent farming ranged from 87 years to 7 years. Many considered themselves as having farmed since they were born; many were born on farms. Education levels varied greatly and extended from some who only went to primary school to several who have Master's degrees. Many of the older farmers remarked that classes related to the environment were not available to them during the time they were students.

The responses indicate that all of the farms are family owned and operated. A few hired seasonal or full time help, but most were run within the family. Ten of the interview participants were strictly crop or vegetable farmers, four raised livestock only, and five had both.

Producers and specialists have some information sources in common. Both groups use the internet to access information. Sites mentioned were those with a .edu extension as well as The Weather Channel's website. Other information sources mentioned were:

- K-State Research and Extension
- Print media such as books and newspapers including farm-specific journals like the locally published weekly farm-news paper Grass and Grain
- TV including local news and The Weather Channel
- Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA); used internally by employees and by farmers
- Dow and Mycogen (seed companies)
- Word of mouth and personal experience
- Almanacs
- Radio
- Konza Prairie Biological Station
- Co-ops

Climate and Weather

Both farmers and specialists were engaged in conversations about how often they expected to see above average yields. On irrigated land farmers expect to see above average yields every year. On non-irrigated land they expect yield to be cyclical. Most common answers were that above average yields happen once in every 3 to 5 years. Respondents often talked about yield being dependent on soil moisture and the fact that yields and rainfall have both been higher than normal in the last few years. General answers to the question can be summed up in the words of one specialist:

> This county lately we have been very fortunate, probably the last five or six years, to have good crop yields all the way around. That's probably above normal, um, generally a person probably if they were going in to get a cash - get a loan or a cash flow or something like that from a bank they would probably figure in a disaster year or a disaster on at least one crop a little more often than that. I don't know what it would probably be, once every four years, something like that.

Farmers were asked to describe what weather/climate conditions are like in a year when crop yields are above average. They answered that not having enough rainfall at the right time is the main difference between a good yield year and a bad one. Other conditions mentioned were being able to get into the field at the right time, when the ground is not too wet, to spray for weeds. Also mentioned were 'no hail damage,' and 'the right number of sunshine and growing days.' Figure 5.1 shows the results of the coding process related to climate and weather. Conversations about climate change occurred 39 times and were linked to 7 other codes.

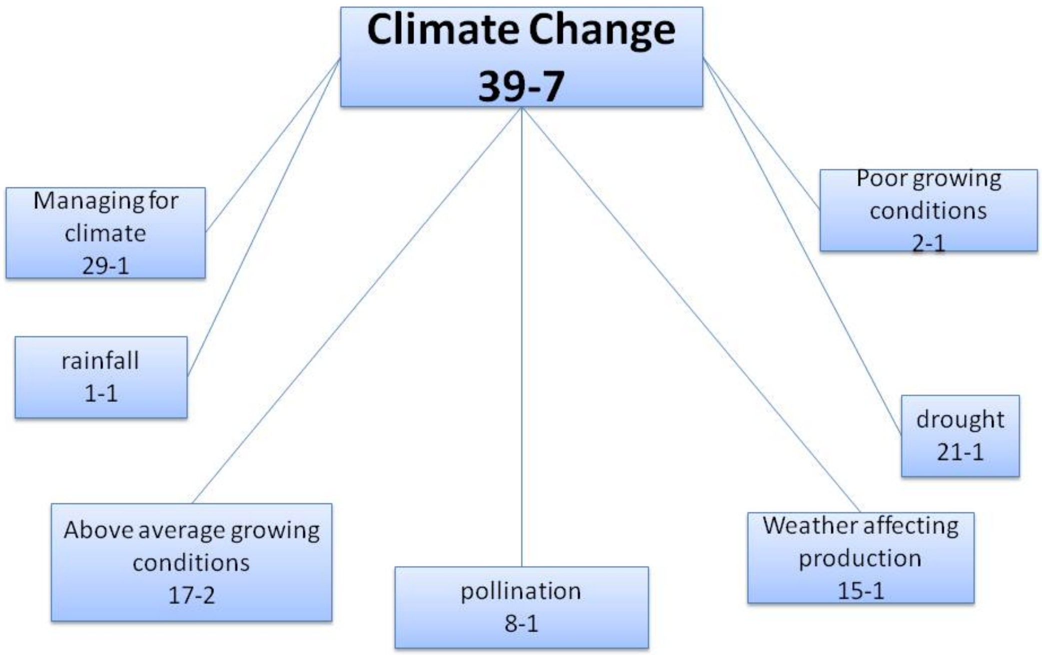

Figure 5.1 – Climate Change ATLAS.ti output. Source: graphic modified by author

No standard answer was given when farmers characterized an agricultural drought. Some said that they call it a drought any time that not enough rain falls at the right time. Some said it was anything less than the yearly average in precipitation. One person answered that a drought was a prolonged dry period or when the weather was dry during critical periods in the growing season.

Out of the 15 farmers who responded to a question about whether they thought climate had changed since they started farming, 12 answered ‘yes.’ Most noted increased rainfall and a greater occurrence of extreme weather events. One farmer said that he has seen longer hot, dry, periods and that they are beginning sooner in the year than they used to. Another farmer answered: “Yes. June is now like July; July is like September, who knows about August.” Generally all participants felt like the past few years had been wetter than usual and that 2010 had actually been too wet.

Specialists were not asked whether they personally believed climate was changing, but rather, what they had heard from farmers. Specialists said that climate change was not a point of discussion among farmers. To quote one specialist: “I would say that climate change discussions in this county are probably laughed at pretty hard.” Farmers talked about what they expected for the future and whether they thought there would be another Dust Bowl. Only one person thought that another Dust Bowl was likely. It was noted that, although similar weather conditions might exist, farmers are using new and better methods for managing the soil than were being used in the 1930’s, such as no-till practices.

Management Practices

Conversation occurred regarding water quality and water availability with both farmers and specialists during the interviews. Specifically, they were asked where their water came from and if the quality or availability had changed over the years they had been farming or ranching. Nitrates, salinity, and sediment loading due to stream bank erosion were common problems identified in the Smoky Hills region, but were not commonly mentioned as a problem in the Flint Hills. Water quality was suggested as having improved over time due to changes in land management such as increased use of no-till. Water availability was not an issue in either region.

A specialist from the Smoky Hills region said: “Well, I think in the last thirty years there has been a gradual increase in nitrates in ground water.” A specialist from the Flint Hills felt differently:

> We've had a high rate of adoption of no-till in this county. I would say we're probably over 50% no-till. Which I think has a lot of benefits for water quality. Reduce sedimentation in streams and lakes. And so that's something I'd point to as a water quality improvement.

As shown in Figure 5.2, water quality was coded 37 times and linked to 8 other codes such as nitrates and sediment loading.

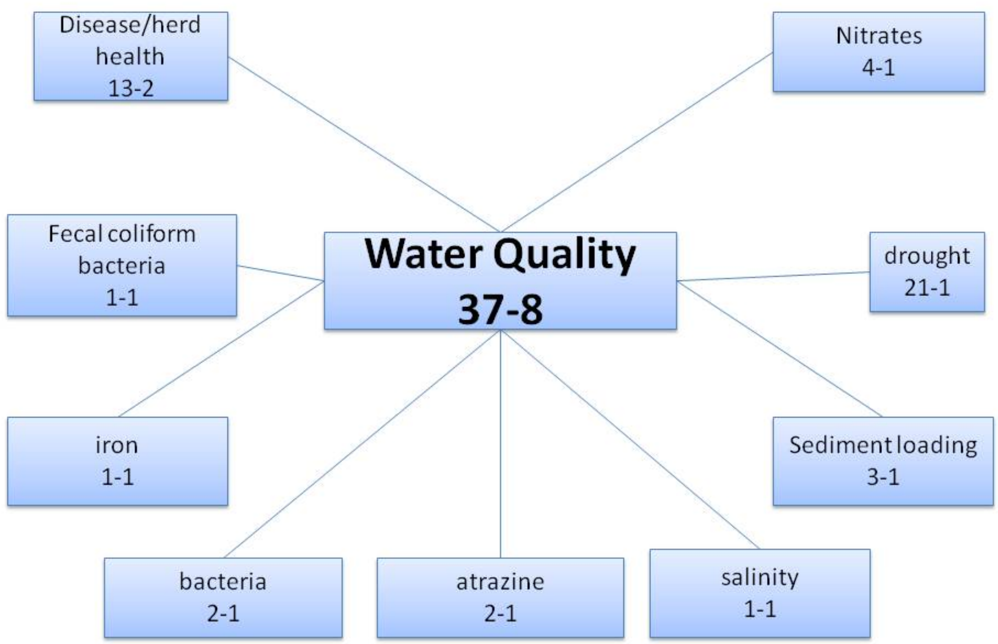

Figure 5.2 – Water Quality ATLAS.ti output. Source: graphic modified by author.

Soil fertility was not an issue for farmers or ranchers in the study area. They discussed that either there had been no change or that fertility had improved due to an increased adoption of no-till farming. Prevention of soil erosion was also thought to have improved. Some of the reasons noted for the improvement were changes in land management practices such as terraces, grass water ways, and no-till farming. Typical answers were similar to one specialist who said: "There is a continual movement towards no-till. I would say fairly dramatic actually, and that does help from a soil erosion standpoint."

The increasing trend to no-till was repeated again when participants were questioned about land management practices. Notes taken during interviews had comments like:

- Every year there's a few more people switching to no-till
- 70 percent minimum till in Cloud County
- Increase in no-till over the last 10 years; over half the county's acres are no-till, only 10 percent were before
- No-till and low till are the norm in the last two to five years
- We've learned that tilling is not good for the soil

Burning is not a common land management practice in the predominantly crop agricultural area. Some comments from participants in the Smoky Hills were:

- There's probably not as much burning as there was
- There is not a lot of pasture burning
- Very limited; less than before

Reasons given for minimal utilization of burning include an issue of liability and a fear the fire getting out of control. It was noted that this lack of burning has led to the encroachment of red cedar and a decline in the quality of pastureland.

The story is quite different in the Flint Hills. One specialist said: "I'd say the majority of the grass in the county gets burned at least three out of four years." Often neighbors get together to help each other with burns. Specialists encourage the farmers to burn: "I would say if you're in the Flint Hills, they're encouraging them to burn under a proper rotation system; once every three years."

Another land management practice, pasture management, was mentioned less than crop management practices, especially in the Smoky Hills. Some pasture management practices mentioned included spraying for weeds, mechanical removal of cedars, and less often - burning and pasture rotation. Lack of knowledge of native rangeland ecology and the fact that many farmers have more of a vested interest in cropland as opposed to rangeland are possible reason for less emphasis on pastures in the Smoky Hills.

> I don't know if it's specific to Mitchell County, but largely in western Kansas most of them are farmers first and then they have cattle as a side thing. So range management has taken a back seat in most of their production as compared to the Flint Hills where I think there are more people that are strictly ranchers; so they have more of an invested interest in the grass itself.

Poor rangeland and pasture management including over stocking generate problems such as overgrazing and encroachment of invasive plant species. It was noted that the size of steers has increased from 1000 lbs to between 1200 lbs and 1400 lbs, so there is a need to adjust the stocking rate. Specialists are also encouraging rotational grazing. One farmer commented, "I don't have really enough land to rotate 'em on. I'm not set up for a rotational graze sorta thing, even though we're getting closer to doing that." Other farmers have adopted rotational grazing as part of their regular pasture management. "On our regular pastures we do try to do somewhat of an intensive grazing program where the cattle are given a limited area where they utilize all the grass and then they move into another paddock and back-and-forth and vice-versa; it gives the grass a chance to rest and rejuvenate."

As a part of land management, specialists were asked if they were encouraging farmers to manage differently specifically for climate change. There were a lot of specialists who simply answered "no." More explicit answers were:

- “If I start telling producers my thoughts or theories on what they should do then I would get blamed for something that didn’t financially work for them.”
- “No, not me personally, but I think that those guys take weather events into account.”
- Not really; farmers now-a-days are quite educated and self-reliant

Of the specialists who responded positively, some of them said things like: No-till “plans for drought ‘cause you have better water conservation.” Another one said he encourages producers to plant flex and semi-flex hybrids of corn because of their ability to put out good yields even in drought years.

Biodiversity

Other topics related to ecosystem provisioning services included biofuels and biodiversity. Most interviewees voiced support for biofuels, but don’t feel it is a long term solution to our energy supply problems. When talking about biofuels, most referred to ethanol or biodiesel. Not many mentioned the possible effects on seed or market prices. One specialist gave his take on the topic by saying,

> The prices are another variable and as far as people planting corn or soybeans specifically for biofuel production most farmers aren’t. They don’t know where their crop goes after they sell it. It’s just based on the market. It may be indirectly affecting what’s being planted because it can increase the price, so therefore there’s more corn or soybeans planted.

Participants talked about changes they had seen in the amount or type of wildlife, an aspect of biodiversity. Their answers suggest that they have seen an overall increase in the amount of wildlife and that there is generally more diversity than there was 30 years ago. In all, 16 different species of wildlife were mentioned. Specific species mentioned as having increased were turkey and deer. Quail and pheasants were often noted as decreasing in population size. An increase of deer and turkey was mentioned by some as causing problems related to the animals disturbing cropland.

Although turkey and deer were mentioned as being a nuisance a few times, generally when participants talked about changes related to invasive species they mentioned plants. Several farmers and specialists mentioned the forb, Sericea lespedeza, as a huge problem in both pastures and cropland. “We’re right on the edge of a serious Sericea lespedeza problem,” said one specialist from the Flint Hills. Another from the Flint Hills said, “Yeah we are finding some resistance, especially bindweed and here lately there is some Sericea that we’ve been having trouble with spraying repeatedly and three years in a row nothing’s happened - so there are some concerns.”

Discussion

Farmers, ranchers, and specialists are much attuned to the weather and its annual and seasonal rhythms . They know good yields are dependent on moisture and expect a good yield whenever rains are abundant and timely. Participants were less sure when asked to describe a drought. This could be due to the fact that rains have been plentiful in the last several years so drought has not been a recent concern. Interviewees said that the last few years had seen above average precipitation. Figures 5.3 to 5.5 confirm what farmers felt to be true (HPRCC 2011). Maps showing the deviation from normal warm season precipitation (June through August) for the summers of 2010 to 2008 all show above average precipitation for the study area (outlined in red).

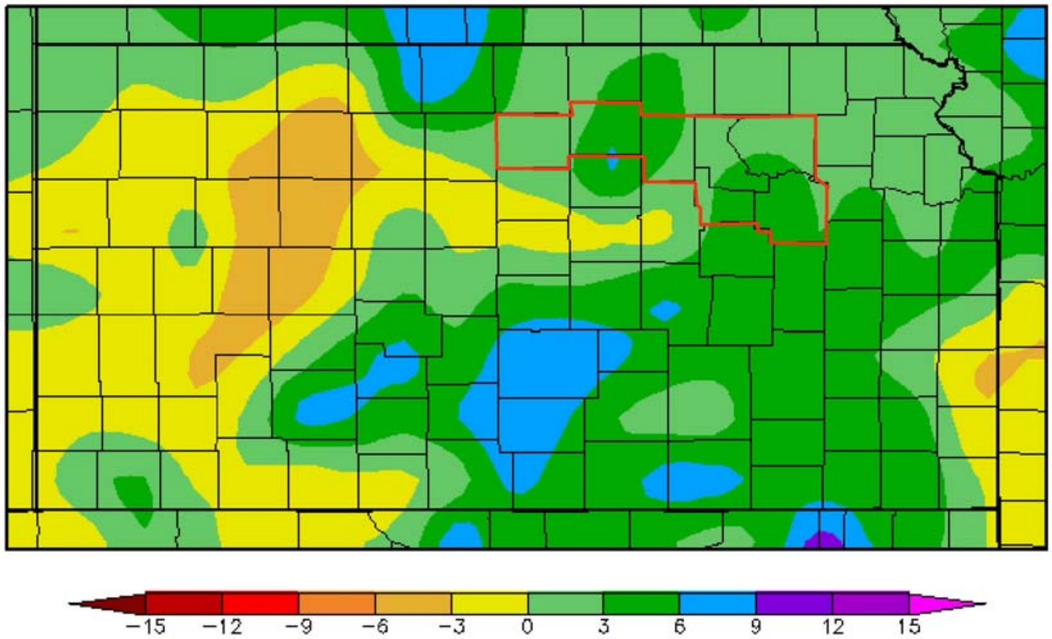

Figure 5.3 – Departure from Normal Precipitation (inches) 6/1/2010 – 8/31/2010. Source: Adapted from High Plains Regional Climate Center.

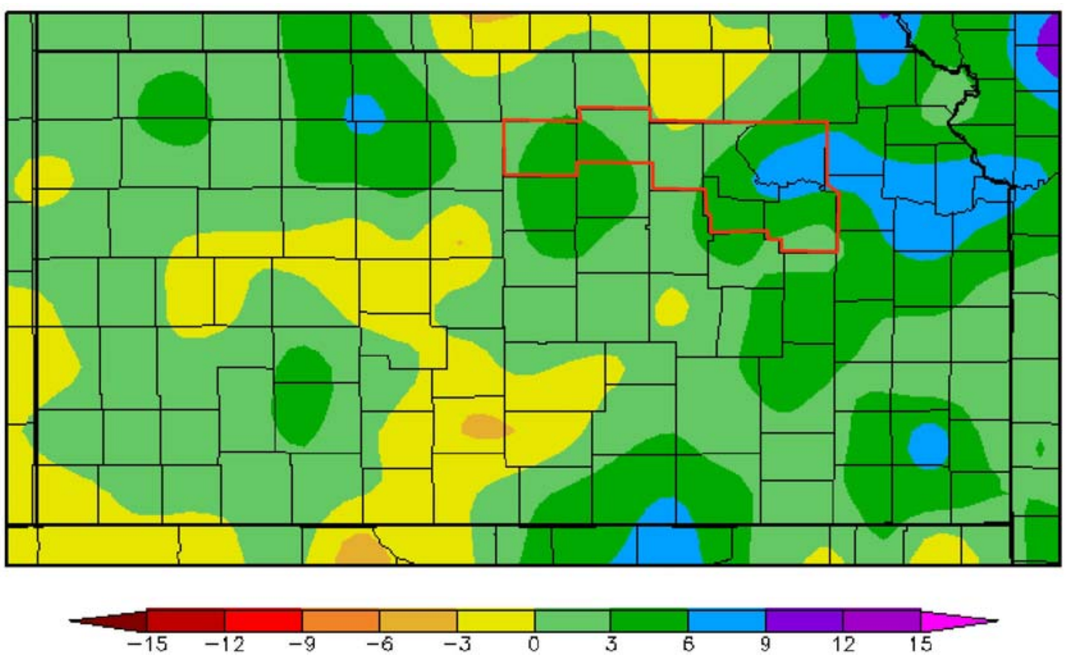

Figure 5.4 - Departure from Normal Precipitation (inches) 6/1/2009 – 8/31/2009. Source: Adapted from High Plains Regional Climate Center.

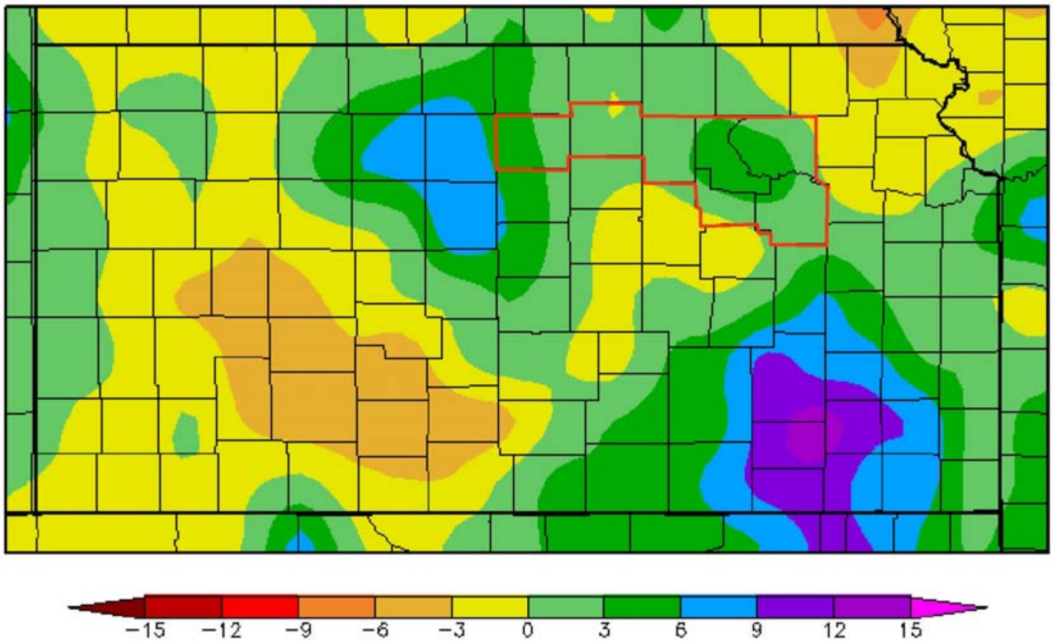

Figure 5.5 - Departure from Normal Precipitation (inches) 6/1/2008 – 8/31/2008. Source: Adapted from High Plains Regional Climate Center.

One thing is certain: farmers and ranchers do know climate is changing despite their reluctance to talk about it. Specialists seemed the most reluctant and doubtful. This may be based on personal views or the perceived views of others they come into contact with in a business capacity. Most farmers and specialists do not believe that a Dust Bowl of the magnitude experienced in the 1930's is likely to happen again. They believe that current land management practices will save them from that type of catastrophe. This may be due to the fact that the Dust Bowl is a distant memory for some and not part of the memory at all for many. Television weather stations and internet weather pages were the most common information sources for farmers. If these news outlets are not talking about future climate conditions then farmers are not going to talk about them either.

Water quality has been a problem in the Smoky Hills in the past. There are conflicting views about whether it is still a problem. Some say no-till has made the quality of water better while another say nitrates have gotten worse. Water quality testing is done in this area, but perhaps it is not tested often enough. Water quantity is plentiful and no change over time was noted. This local observation comes even though there have been droughts within the last several decades (e.g., 1988-89); recent enough for even young farmers to remember. The last few years have been relatively wet which may account for the discrepancy.

Changes in biodiversity provide good indicators regarding the relative health of an ecosystem. Farmers, ranchers, and agri-business specialists who work closely with producers are observant about the changes going on around them. The overall increase in wildlife is a signal that something in the local environment is changing. This is the kind of important semi-empirical evidence of which scientists and policy makers need to be aware.

Producers and specialists recognize the importance of being good stewards of the environment. They readily acknowledge the benefits that no-till practices have had over the years on soil erosion and fertility. While they may initially be reluctant to try new methods, once they see firsthand benefits they are likely to change. Some land management practices still have not been widely adopted due to a lack of land owner knowledge either about process or outcomes. This is the case with burning in the Smoky Hills. This example emphasizes the necessity of education that will have to take place between producers and specialists, and specialists and policy makers.

Chapter 6 - Summary

This qualitative research addressed agricultural stakeholder perceptions of climate and environmental change in north central Kansas. Significant findings includea recognition among agricultural producers that climate is changing. Farmers are noticing increasing rainfall, more extreme weather events, severe hot and cold temperatures, longer hot, dry periods, and the spring season starting earlier in the year. The idea of an agricultural drought brought out many varied descriptions from interviewees. Conditions similar to the Dust Bowl of the 1930's are not expected to occur again due to better land management.

Both old and new species of plants are invading crop and pasture land. Some, like Sericia lespedeza, are showing resistance to burning and chemicals. Woody plant species, such as Eastern Red Cedar, are expanding in the study area. Coyotes, deer, and turkey were also considered a nuisance to crops due to an increase in numbers. Wildlife in general has been increasing, both in the extent and overall numbers being seen.

Farmers are not doing anything specifically to manage for climate or climate change. Cattle turnout dates and stocking rates have stayed about the same despite the recognition that spring warm up is occurring earlier in the season. Farmers generally have a strong educational background and continue to educate themselves through KSU extension programs.

More information is needed on what information sources would work best for information delivery both for communicating with farmers and with educators. Some questions that could be addressed in the future include: What is the best venue for disseminating farmers and ranchers concerns to policy makers? Also, what types of information outlets will be the most productive for educating farmers and getting feedback from them concerning climate change policy.

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Appendix A - Sample Interview Sheet for Farmers and Ranchers

Local Ecological Knowledge Interview Short Sheet – Farmers and Ranchers

Interview Code:___________________________________

I. What is the exact nature of your operation?

   A. Employees?

II. Family owned?

III. Climate/weather

   A. How often do you expect a good yield?

   B. What are weather conditions like in a good yield year? What about a not so good year?

   C. How do you characterize a drought?

   D. Do you think the weather has been changing?

   E. Change in occurrence/type of pests and/or disease?

   F. What do you expect for the future? Do you think there will be another Dust Bowl?

      1. What sources do you use for information concerning weather? What about climate?

         a. Friends//media//government (county, state, federal, university)//other

IV. Provisioning Services

   A. Water

      1. Availability

         a. Has there been a change in availability?

         b. Source (river, groundwater, rain)

      2. Quality

a. Has there been a change in quality? If so, do you have an idea why?

b. Irrigation type (CPI, rainfed)

B. Biofuels – Thoughts, concerns

C. Biodiversity

1. Are you seeing about the same amount of wildlife? If not, what's changing?

2. Invasive species

a. Plant

i Woody invasion (i.e. red cedar)

ii Sericea lespedeza

b. Animal

D. Pasture

1. Do you run cattle?

2. What are your stocking practices?

3. What do you do to help maintain your grass in good condition?

V. Regulating Services

A. Soil

1. Erosion

a. Where do you get information?

b. Have you changed practices?

2. Fertility

a. Better or worse than in the past

b. Fertilizer practices

c. Information sources

3. Management

    a. Tillage practices

        iii No-till//low till//conservation//conventional Have your practices changed?

    b. Burning if yes, how often?

    c. Crop rotation

    d. Information sources?

    e. Has the number of days it takes to grow swine changed since you started?* Hog farmers only

    f. Has the time of year cattle are turned out changed?

    g. Are you managing any differently specifically for climate and/or weather events?

    h. Do you notice more flies, or have you changed how you approach fly control?

    i. Weight gain of animals

    j. Disease/herd health

B. Pollination (corn?)

C. Disturbances

    1. Flood occurance//extreme temp or precip//hail//drought//frost

VI. Background/demographics

A. Age Estimate:

B. Gender: Male Female

C. Educational Background: some high school//high school diploma//some college//college degree

    1. Have you had classes in environmental science, ecology, agronomy?

    2. What is your best source for new info about the environment?

D. Length of time individual has been in farming/ranching

1. Total length of time family has been in farming/ranching

Appendix B - Sample Interview Sheet for Specialists

SPECIALISTS

Interview Code:__________________________

Interested in publications? Yes No

I. Background

A. Geographic extent of office:

B. Purpose of job:

II. Climate/Weather

A. How often are farmers getting a good yield?

B. What comments have you been hearing about weather/climate affecting crops/livestock?

III. Provisioning Services

A. Water

1. Availability

a. Has there been a change in availability?

2. Quality

a. Has there been a change in quality? If so, do you have an idea why?

B. Biofuels – Thoughts, concerns

IV. Biodiversity

1. Are you seeing about the same amount of wildlife? If not, what's changing?

2. Invasive species

a. Plant

i Woody invasion (i.e. red cedar)

ii Sericea lespedeza

b. Animal

V. Regulating Services

A. Soil

1. Erosion

a. Have you changed practices?

2. Fertility

a. Better or worse than in the past

b. Fertilizer practices

3. Management

a. Tillage practices

iii No-till//low till//conservation//conventional Have your practices changed?

b. Burning if yes, how often?

c. Crop rotation

d. Has the number of days it takes to grow swine changed since you started?* Hog farmers only

e. Has the time of year cattle are turned out changed?

f. Are you encouraging farmers to manage any differently specifically for climate and/or weather events?

g. Disease/herd health

B. Pollination (corn?)

C. Disturbances

1. Flood occurance//extreme temp or precip//hail//drought//frost

VI. Information Sources

A. What types: own agency other agencies___________ Interest groups

Internet sources:______________ Trade publications:______________

Other:_______________________

VII. Sharing Information

A. How much of the work is: outreach Contacted as a resource

B. Methods of sharing info:

1. What works best?

2. What doesn't?

Appendix C - Code List

Note – *Code Names* are the codes used in content analysis. *Grounded* refers to the number of times each code was used. *Families* is the name of the category into which each code was grouped.

Code Name	Grounded	Families
1985 Farm Bill	2	Management Practices
above average growing conditions	18	Climate/weather
Age	11	Background
Alfalfa	7	Management Practices
Aphids	1	Plant and Animal
Atrazine	2	Management Practices
Bacteria	2	Management Practices
bind weed	5	Plant and Animal
Biofuels	38	Management Practices
Bison	4	Management Practices
black swallow	2	Plant and Animal
Bobcats	2	Plant and Animal
Brome	2	Management Practices
buck brush	1	Plant and Animal
buffer strips	1	Management Practices
Burning	43	Management Practices
Cattle	6	Management Practices
cattle turnout	28	Management Practices
Cedar	15	Plant and Animal
change in animal weight gain	6	Management Practices
climate change	39	Climate/weather
cold stress	3	Climate/weather
Conservation Reserve	8	Management Practices
control plots	1	Management Practices
Corn	2	Management Practices
cost sharing	2	Management Practices
Coyotes	4	Plant and Animal
Crabgrass	1	Plant and Animal
crop rotation	28	Management Practices
crop types	2	Management Practices
Deer	25	Plant and Animal

disaster programs	2	Climate/weather
disease/herd health	14	Management Practices
Drought	21	Climate/weather
dust bowl	9	Climate/weather
Eagles	1	Plant and Animal
Education	18	Background
Employees	11	Background
expected frequency of above ave yield	33	Climate/weather
extreme weather	22	Climate/weather
family owned	12	Background
fecal coliform bacteria	2	Management Practices
Fertilizer	14	Management Practices
Flooding	3	Climate/weather
Fly control	10	Management Practices
Fox	1	Plant and Animal
Future	12	Climate/weather
Gender	9	Background
Geographic Area	18	Background
Goats	5	Management Practices
Grasshoppers	1	Plant and Animal
Greensnap	2	Climate/weather
ground hogs	1	Plant and Animal
Hail	1	Climate/weather
Hawks	1	Plant and Animal
Haying	2	Management Practices
hog farming	7	Management Practices
Horses	1	Management Practices
Individual time farming	14	Background
information sharing	39	Background
information sources	56	Background
invasive species	56	Plant and Animal
Iron	1	Management Practices
Irrigation	3	Management Practices
Johnson grass	1	Plant and Animal
Kudzu	1	Plant and Animal
land management	21	Management Practices
Leaching	1	Management Practices
leafy spurge	2	Plant and Animal
Lime	1	Management Practices
loss of cattle	1	Climate/weather
low till	6	Management Practices

managing for climate	31	Climate/weather
mares tail	3	Plant and Animal
migratory water fowl	1	Plant and Animal
Milo	4	Management Practices
Mosquitoes	1	Plant and Animal
native grass	5	Management Practices
Nitrates	5	Management Practices
nitrogen loss	1	Management Practices
no-till	12	Management Practices
osage orange	2	Plant and Animal
Overgrazing	3	Management Practices
partridge pine	2	Plant and Animal
Pasture	19	Management Practices
pests/disease	17	Plant and Animal
Pheasants	6	Plant and Animal
plant breeding	1	Climate/weather
Pollination	8	Climate/weather
poor growing conditions	8	Climate/weather
Possums	1	Plant and Animal
prairie chickens	6	Plant and Animal
prairie dogs	1	Plant and Animal
Purpose of job	24	Background
Quail	17	Plant and Animal
Rabbits	1	Plant and Animal
Raccoons	2	Plant and Animal
Rain	58	Climate/weather
Replant	1	Climate/weather
rotational grazing	6	Management Practices
Salinity	3	Management Practices
scarab beetles	1	Plant and Animal
Sediment	4	Management Practices
seed price	5	Management Practices
Sericea lespedeza	28	Plant and Animal
Sheep	2	Management Practices
size of cows	1	Management Practices
Skunks	2	Plant and Animal
soil erosion	52	Management Practices
soil fertility	39	Management Practices
soil moisture	2	Management Practices
song birds	1	Plant and Animal
soy beans	3	Management Practices

Spraying	5	Management Practices
stocking rate	15	Management Practices
Sumac	1	Plant and Animal
Terracing	4	Management Practices
test plots	3	Management Practices
The weather channel	1	Background
Thistle	8	Plant and Animal
Ticks	1	Plant and Animal
tillage practices	34	Management Practices
Total length of time family has farmed	1	Background
Turkey	22	Plant and Animal
type of operation	14	Background
water availability	41	Management Practices
water quality	41	Management Practices
Water Source	22	Management Practices
weather affecting production	15	Climate/weather
Weevil	1	Plant and Animal
Wheat	3	Management Practices
wild cane	1	Plant and Animal
Wildlife	27	Plant and Animal
wind farms	1	Management Practices
Windstorm	1	Climate/weather
woody plants	6	Plant and Animal
zebra mussels	1	Plant and Animal