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## Project Title: Sustainable Adaptations to Drought and Climate Variability in Agricultural Production Systems Across Nebraska

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**Final Report Submitted to the NOAA's Human Dimensions of Global Change  
Research (HDGCR) Program**

**Project Title: Sustainable Adaptations to Drought and Climate Variability in Agricultural Production Systems Across Nebraska**

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**I. Preliminary Materials**

**A. Project Abstract**

Drought is a normal part of Nebraska's climate. It is also the leading cause of monetary disaster loss in the United States. FEMA (1995) has estimated that U.S. drought losses average \$6-8 billion dollars per year. A majority of these losses are incurred in the agricultural sector. Nebraska's losses alone topped \$1.2 billion in 2002 (AP 2003).

To enhance viable operations in this variable climate, many Nebraska farmers and ranchers have begun making the transition to agricultural practices that fall into the realm of sustainable agriculture. Sustainability has been increasingly stressed as essential for creating more resilient systems and reducing the effects of natural hazards (Anderson 1994, Mileti et al. 1995, Mehta 1997, United Nations 1997, Mileti 1999). However, little research has been done to understand the linkages between sustainable agriculture and drought management. This type of research is essential for enhancing agricultural adaptations to climate variability in Nebraska and in similar regions around the world.

This study focused on investigating the linkages between sustainable agriculture and drought within the state of Nebraska. Specifically, this research investigated coping mechanisms adopted by sustainable producers to reduce the effects of short and long-term drought, their perceived feasibility and effectiveness, and producer perceptions of drought and forecast products that are needed to increase the resiliency of sustainable agricultural systems to drought. This information was collected through a mail-back survey and in-depth interviews of Nebraska's sustainable

agriculture producers whom have had recent experience dealing with one of the most severe droughts in Nebraska's recorded history.

### **B. Objectives of Research Project:**

This study investigated the linkages between sustainable agriculture and drought within the State of Nebraska. Specifically, this research investigated coping mechanisms adopted by sustainable producers to reduce the effects of short and long-term drought, their perceived feasibility and effectiveness, and producer perceptions of drought and forecast products that are needed to increase the resiliency of sustainable agricultural systems to drought. This information was collected through surveys of Nebraska's sustainable farmers and ranchers.

### **C. Project Approach:**

This project utilized several methodological approaches to investigate drought management among Nebraska's sustainable agricultural producers: a literature review, a focus group, a mail-back survey, ethnographic interviews, and workshops. It is believed that this multi-methodological approach yielded more insights than could have been amassed by utilizing a single method alone.

First, a literature review was conducted to learn about sustainable farming, holistic resource management, and their linkages to drought management. A focus group of sustainable agricultural producers was then assembled to assist in developing a written mail-back survey. The group was presented with a proposed survey instrument that had been pre-approved by the University of Nebraska-Lincoln Institutional Review Board that monitors research involving the use of human subjects. During the focus group, producers were asked to provide feedback and develop additional questions relevant to the research.

A mail-back survey was then sent out to mailing lists of the Nebraska Sustainable Agricultural Society, the Nebraska Crop Improvement Association, and the former Nebraska Branch of Holistic Resource Management. The survey utilized a combination of closed and open-ended questions to elicit responses on the effects of recent drought and related management strategies and the use of climate and forecast information. The mail-back survey utilized Dillman's Total Design Method (Dillman 1978), which included an introductory letter to inform the target producers of the survey followed by the survey and a personalized cover letter a week later. Non-respondents were sent a reminder postcard after one week and another copy of the survey after three weeks. Included in the survey was a postcard asking if the recipient would participate in a more in-depth ethnographic interview. Willing members of the population were then interviewed in face-to-face qualitative interviews to evaluate study findings and fill in additional details to provide a deeper understanding of the sustainable drought management issues.

Survey data were then examined using a combination of SPSS and content analysis approaches where applicable (i.e., for quantitative vs. qualitative responses). Survey data were also geo-referenced utilizing ARCGIS, allowing for a spatial analysis of information in relation to available baseline data such as crop and livestock losses and perceptions identified during the surveys.

Finally, two workshops were held near the conclusion of the project to present drought management information that was highlighted by producers during the surveys, and to provide another opportunity to gather general feedback from stakeholders. Together, the multi-methodological approach yielded valuable information to assist agricultural planners, technical decision makers, and policymakers in more effectively preparing for and responding to drought conditions.

#### **D. Description of any matching funds used for this project:**

The Center for Rural Affairs (CfRA) shared the costs associated with hosting two wrap-up workshops. This resulted in a cost-savings to our project and allowed the CfRA to more efficiently combine two drought-related projects that were underway.

## **II. Interactions:**

### **A. Interactions with decision-makers**

This project has resulted in a wide variety of interactions with local, state, and federal decision-makers, and the media. First, the project's focus group and surveys allowed feedback to be gathered from approximately 150 Nebraska farmers and ranchers. Second, 130 stakeholders from Nebraska, Colorado, and South Dakota attended the workshops held at the end of the project. Third, several newspaper and radio interviews have been given in order to promote the workshops and present study results (two additional presentations are scheduled for the fall of 2006). Fourth, a compact disk was made of the workshop presentations and mailed to approximately 600 farmers, ranchers, and educators from the University of Nebraska-Lincoln Cooperative Extension Service, which has resulted in requests for additional copies for local clientele. Fifth, the workshop presentations have also been placed on the website of the National Drought Mitigation Center [[http://www.drought.unl.edu/mitigate/workshop\\_presentations.htm](http://www.drought.unl.edu/mitigate/workshop_presentations.htm)], which has also been advertised in the Center for Rural Affairs newsletter.

### **B. Interactions with the climate forecasting community**

Cody Knutson also presented results from the study at the North American Thorpex Societal and Economic Research and Applications Workshop, sponsored by the National Center for Atmospheric Research in Boulder, Colorado. This workshop brought in forecasters and social scientists from across the United States to discuss what is needed to enhance the use of 1-14 day weather forecasts in decision-making. The Nebraska study provided an example of the use and non-use of weather forecast information by agricultural producers, which helped to guide discussion during the Thorpex workshop.

### **C. Coordination with other projects of the NOAA Climate and Societal Interactions Division**

Not applicable

## **III. Accomplishments**

### **A. Research Tasks Accomplished**

A mail-back survey instrument was initially designed by the research team. After receiving UNL Institutional Review Board approval, the team conducted a focus group with sustainable farmers and ranchers in Hartington, Nebraska, to finalize development of the mail-back survey instrument. During the spring of 2005, the survey was then mailed to 630 sustainable farmers

and ranchers across Nebraska. Out of this number, 122 responses were received with 103 surveys meeting the selection criteria<sup>1</sup> and being filled out adequately enough to be analyzed. This resulted in a return rate of over 16%, however, an accurate response rate was difficult to quantify because some of the people on the mailing lists were retired or only urban financial contributors to the organizations. Therefore, the actual effective response rate was larger than shown by a direct comparison. The surveys were analyzed using SPSS 8.0 with assistance from a graduate student and a temporary employee: Tucker Handley from the Sociology Department and Lawren Graf, a recent M.S. graduate of the UNL School of Natural Resources.

Along with the survey, producers were asked to return an enclosed postcard if they would be willing to participate in a face-to-face interview. Fifty-seven respondents agree to such an interview. Of these, 47 farmers and ranchers across Nebraska were interviewed between June and August of 2005. The majority of the interviews were carried out by two graduate students, Melissa Melvin and Jeff Nothwehr, from the School of Natural Resources at the University of Nebraska-Lincoln. Project investigators from the National Drought Mitigation Center and the Center for Rural Affairs also conducted or contributed to a portion of the interviews. During these interviews, producers were asked to expound on ideas mentioned in the previous mail-back survey to provide a deeper understanding of drought management issues. These interviews were tape recorded, transcribed, and analyzed utilizing a content analysis approach.

Two workshops were then developed based on important themes highlighted by producers in the survey and ethnographic interviews. To help defray the cost of the workshops, the Center for Rural Affairs agreed to pay for a portion of them through another drought planning project that had been funded by the USDA Risk Management Agency. This combined approach resulted in a cost-savings to both projects and allowed for more effective project management. The first workshop was held in North Platte, NE, on June 5<sup>th</sup> and focused primarily on livestock production. This location was held because of its history of recent drought, its central location in relation to many survey participants, and it is an area heavily reliant on livestock production. In addition to project investigators, several individual ranchers, University of Nebraska-Lincoln Cooperative Extension faculty, and federal agencies presented lectures on climate issues and effective drought management. The second workshop was held in Chadron, NE, on June 6. This workshop targeted a broader audience of livestock and crop producers to meet the needs of the local area. Again, a range of speakers presented information on climate and drought management issues to approximately 130 stakeholders.

Presentations from the workshops were re-produced on compact disks and sent to approximately 500 farmers and ranchers from our original mailing lists, as well as about 100 UNL extension educators across the state. The publicity surrounding the workshops resulted in many interviews with local newspaper, television, and radio outlets across the state. Information has also been included on the website of the National Drought Mitigation Center and several publications and presentations are pending.

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<sup>1</sup> The Nebraska Agricultural Statistics Service requires farmers and ranchers to produce over \$1,000 worth of commodities per year to be classified as an agricultural producer.

## B. Key Research Results

### Perceptions of Sustainability

Eighty-seven percent of respondents to the mail-back survey provided a definition of sustainable agriculture. There were a variety of definitions but most of the responses revolved around six main components: 1) implementing practices that are environmentally friendly, 2) a management system that maintains long-term viability, 3) an operation that is holistically managed, 4) a production system that requires few inputs, 5) financially sound management, and 6) activities that are socially and personally acceptable. Together, these themes represent the philosophical outlook of the majority of respondents that participated in our study, which are often reflected in their methods of dealing with drought in a sustainable manner.

### Agricultural Practices Implemented to Reduce the Effects of Drought

From 1999-2005, drought affected many Nebraska farmers and ranchers, particularly in the western and central portions of the state where conditions were most severe. In both mail-back surveys and during ethnographic interviews, farmers and ranchers reported on a range of drought effects, including: cattle culling and reduced stocking rates, reduced grass and hay production, crop losses, surface water/ground water quantity and quality problems, increased supplemental feed costs, emotional stress, increased pests such as grasshoppers, wind erosion, increased irrigation, reduced cattle pregnancy rates, increased weed pressures, tree losses, hindered pasture burns, and increased disease problems.

To reduce these effects, many producers reported implementing a range of drought mitigation and response actions (Table 1). Some of these are best management practices implemented as part of their normal operating procedures while others were implemented specifically to deal with impending drought conditions. The most cited practice among livestock producers was reducing the number of cattle on their land by selling them earlier, selling off more or buying

Rank	Practice	Respondents
1	Reduce cattle numbers (e.g., culling, early weaning, heifers, feedlots)	35
2	Grazing management (e.g., rotational and modified grazing, leasing additional land)	30
3	Forage production and supplemental feed (e.g., hay, inter-seeding, crop grazing, distillers grain)	28
4	Develop new water sources/irrigation (e.g., springs, ponds, pipeline, more/less irrigation)	20
5	Build soil organics and nutrients (e.g., cover crops, composts, biodynamic preps)	19
6	Minimize tillage and ground disturbance (e.g., no-till, ridge till, zone till, blade plow)	15
7	Crop rotation, alternative crops, inter-planting (e.g., drought-tolerant corn, soybeans, wheat, sunflowers, popcorn, alfalfa, and millet)	14
8	Financial and management strategies (e.g., reduced inputs, record keeping, supplemental income)	10
9	Prepared a drought plan	8

Table 1. Practices respondents implemented to reduce the effects of drought. Practices are ranked by number of producers who listed each (far right column).

fewer calves and yearlings, and keeping fewer replacements. Developing an appropriate grazing management system, including pasture rotation and cross fencing was also mentioned. This allows pastures to rest and reduces the potential for erosion. While many livestock producers also suggested changing haying and grazing practices, they stressed different types of changes. Several mentioned reducing their need for hay by allowing cattle to forage on stubble fields and the range during the winter. On the other hand, others stressed the use of additional hay and supplement feed to survive the winter and allow pastures to rest. Some livestock producers also mentioned converting marginal cropland to pasture provide more grazing land for the cattle. Finally, many livestock producers stressed the need for pipelines, windmills, and wells in order maintain herds and implement desired grazing plans.

Farmers also cited several practices that involve reducing inputs such as herbicides, pesticides, insecticides, and water. Most favored maintaining soil quality and moisture through methods such as biodynamic preps (natural animal products put on or in the fields), crop rotation, and minimizing tillage. In addition, many producers mentioned raising alternative crops and livestock such as drought-resistant corn, sorghum, soybeans, sunflowers, alfalfa, millet, and organic cattle and bison. It was felt that these practices helped enhance soil nutrients, soil moisture, and farm diversity, which helped to withstand the effects of drought.

Many producers also listed financial and management practices such as reducing capital inputs on unnecessary machinery, keeping better records for cost-benefit analyses of various practices, and devising strategies for earning supplement income to offset hard times. Having a drought plan in place prior to the drought was also a management approach some producers had implemented in order to coordinate drought preparedness and response actions.

### **Barriers to More Effective Drought Preparedness**

Approximately 89% of respondents to the mail-back survey felt the practices they employ helped to reduce the negative effects of drought, while 7% felt they had not and 5% felt they had both positive and negative effects. For producers whose drought impacts were not reduced by their practices, they said that implementing the practices were too expensive to offset the gains and that income was reduced by drought even though there was improvement to the land. Even though most respondents felt that their strategies helped reduce the effects of drought, they noted several barriers that restrict them from fully preparing for drought (Table 2). The primary limitations noted were a lack of capital to modify their operation and the need to maximize their current production system to meet expenditures. To address these issues, producers proposed expanded or more effective assistance and insurance programs, more education on agricultural sustainability, and fostering individual and collaborative drought planning.

### **How Drought Information Has Been Incorporated into Agricultural Management**

Survey respondents listed a variety of sources for weather and climate information. Similar to other studies, the large majority of producers cited radio as the principal source of information followed by television, internet, The Weather Channel (TV and internet), and the National Oceanic and Atmospheric Administration. Respondents also listed a variety of activities for which they use current weather and forecast information.

According to survey results (Table 3), agricultural producers appear to rely on current and recent

<b>Barriers to Drought Preparedness</b>	<b>N</b>	<b>Mean</b>
Lack of capital to modify operation	84	3.1*
Market need to maximize crop production	64	2.9*
Lack of drought planning knowledge	76	2.3
Federal farm programs	62	2.2
Landlord control over your operation	49	2.2
Unreliability of weather data and forecasts	78	2.2
Feel that nothing can be done about drought	72	2.1
Bank control over your operation	53	2.0
Peer pressure	49	1.6
Lack of access to weather and forecast products	66	1.4*

\* Statistically significant to .01%

Table 2. Barriers survey respondents noted that limit their ability to prepare for drought. Responses are on a scale from 1 (no barrier) to 5 (great barrier).

<b>INFLUENCED THIS DECISION IN 2004:</b>	<b>Current and Recent Past Conditions</b>		<b>Short-Term Forecasts</b>		<b>Long-Term Forecasts</b>	
	<b>N</b>	<b>Mean</b>	<b>N</b>	<b>Mean</b>	<b>N</b>	<b>Mean</b>
Summer livestock decisions (e.g., stocking, culling)	76	3.6 <sup>b</sup>	76	2.4 <sup>a</sup>	76	2.9 <sup>a</sup>
Summer cropping decisions (e.g., pesticides, fertilizer, water applied, cutting hay)	64	3.3 <sup>b</sup>	67	3.2 <sup>b</sup>	65	2.1 <sup>a</sup>
Crop/livestock marketing	75	3.3 <sup>b</sup>	70	2.4 <sup>a</sup>	70	2.6 <sup>a</sup>
Fall livestock decisions like stocking and feeding	74	3.2 <sup>b</sup>	68	2.3 <sup>a</sup>	69	2.6 <sup>a</sup>
Spring livestock decisions such as stocking options	77	3.2 <sup>c</sup>	74	2.0 <sup>a</sup>	77	2.5 <sup>b</sup>
Harvest and post-harvest decisions like fall tillage	39	2.9 <sup>b</sup>	41	2.6 <sup>ab</sup>	40	2.1 <sup>a</sup>
Spring cropping decisions (e.g., crop type, seed variety, tillage, and date)	50	2.7 <sup>b</sup>	48	2.2 <sup>a</sup>	50	2.4 <sup>ab</sup>
Purchasing crop insurance	49	2.9 <sup>b</sup>	45	1.6 <sup>a</sup>	47	2.3 <sup>b</sup>

Table 3. Averages of responses to influence of weather forecasts on the specific decisions listed. Responses are on a scale from 1 (no influence) to 5 (greatly influenced). Letters indicate homogenous subsets using paired t-tests and the  $p < .01$  significance level.

past conditions the most in making their farming and ranching decisions. Whether or not the short-term forecasts (up to 14 days) or long-term forecasts are used is dependent upon what kind of decision is being made. The largest use of current and forecast information was cited to be summer livestock and cropping decisions such as stocking, culling, and moving cattle; when to apply crop chemicals or water; and cutting and baling hay. Livestock producers primarily used recent/current weather information and long-term forecasts for their summer decisions, while farmers reporting using recent/current conditions and short-term forecasts. The next highest use of weather and forecast information was for crop and livestock marketing. Producers utilized all information available in making these decisions, with recent/current conditions and long-term forecasts being used somewhat more in their decision-making. The second-highest use of short-term forecasts were reported for harvest and post-harvest decisions like fall tillage.

The data also shows that for most decisions, weather information and forecasts would appear to have only a moderate influence on most producers. However, ethnographic interviews did highlight that some producers felt the forecasts were important “psychologically” in deciding what to do. Many financial decisions may not be made based strictly on the forecast but it will be another piece of information that will help them “lean one way or the other” when making a final decision.

#### Limitations in the Use of Weather and Forecast Information

Respondents were asked to comment on the limitations in using weather and climate forecasts in decision-making (Table 4). The accuracy and reliability of weather and forecast information was cited as the primary limitations. For example, one rancher noted that “If they were forecasting that we were going to have another dry year or two years, I couldn’t afford to go out and maybe

The influence of weather information and forecasts on my decisions is limited by:	Current and Recent Past Conditions		Short-term Forecasts		Long-term Forecasts	
	N	Mean	N	Mean	N	Mean
The accuracy of the weather information and forecasts	83	2.69 <sup>a</sup>	80	2.85 <sup>a</sup>	81	3.25
The reliability of the source of weather information and forecasts	80	2.56	78	2.91	78	3.03
My ability to apply the weather information and forecasts	80	1.95 <sup>a</sup>	78	2.08 <sup>ab</sup>	77	2.23 <sup>b</sup>
Availability of weather information and forecasts for this area	81	1.95	79	1.95	78	1.96
My financial situation	83	2.10	79	1.76	80	1.98
Timeliness of weather information and forecasts	78	1.87	76	2.00	75	1.9
My understanding of weather information and forecasts	80	1.91 <sup>b</sup>	76	1.76 <sup>a</sup>	73	1.84 <sup>ab</sup>
Views of others (e.g., banker, friends)	82	1.48	76	1.40	77	1.52
The cost of obtaining weather information and forecasts	81	1.41	79	1.46	78	1.46

**Table 4.** Limiting factors on use of forecast decisions. Responses are on a scale from 1 (no influence) to 5 (greatly influenced). Letters indicate homogenous subsets using paired t-tests and the  $p < .01$  significance level. Factors are in descending order based on the average mean for all three forecast types.

rent more pasture based on that information because it might not be. What if I went out and spent all this money... I wouldn't make decisions like that based on the weather forecasts".

Several other organic producers also noted that they're often limited in the use of forecast information due to the nature of their established long-term rotational system. As stated by one farmer, "With my established rotation (that maintains nutrient flows and provides weed and insect control), I don't want to veer off too much, especially based on the long-term forecast. It's just not accurate enough to risk it."

### **How Drought and Climate Products Could Be Enhanced to Meet the Needs of Producers What Could be Done to Improve Climate Products**

The most common suggestion as to what might be done to make climate products more versatile was increase forecast accuracy at all timescales. Other suggestions were mainly geared toward providing existing information in forums that are more easily accessible such as over the radio, television, and the newspaper. For example, one producer commented that "I use the radio a lot. If information was on there everyday at a certain time, like at 7 o'clock every morning, I would listen. Use of radio would help a lot". Similarly, other producers noted that weather providers could do a better job of making drought information available on a more consistent basis to provide up-to-date information and allow producers to evaluate forecast trends.

Several producers also mentioned that they would like to see new products developed. This information includes detailed humidity forecasts, drought updates and forecasts, current conditions and forecasts of the water table, and detailed wind forecasts. For example, one organic producer "would like to see a short-term diurnal humidity forecast to help decide when to put up alfalfa". Although suggestions were made about the types of additional products producers would like to see, few stated that a lack of information or access to information was a problem in using climate products. Instead, several people proposed that educating producers on regional moisture climatology and the history of droughts will give perspective as to the extremes in our climate. They implied that this heightened perspective could help people make better use of climate information and products.

One livestock producer thought it may be a good idea to have a network of producers reporting on the progress of storms in remote areas to provide a more accurate picture of what was really going on in the field. Similarly, another producer suggested getting more people to report on rural drought conditions and impacts rather than waiting for someone else to call the alarm that there's a problem. These comments reflected a felt need by many producers to take more personal responsibility in helping to improve the collection and assessment of climate and forecast information.

### **C. List of Presentations and News Releases**

#### **Presentations**

Melvin, M., and J. Nothwehr, *Drought Impacts and Mitigation for Non-Conventional Producers in Nebraska*, Climate and Bio-Atmospheric Sciences Spring Seminar Series, University of Nebraska-Lincoln, Lincoln, Nebraska, February 13, 2006

Knutson C., *Lessons Learned from the 2000-2005 Drought: What Ranchers Said in Recent Surveys*, Surviving the Drought Workshop, National Drought Mitigation Center and Center for Rural Affairs, North Platte, Nebraska, June 5, 2006

Knutson C., *Lessons Learned from the 2000-2005 Drought: What Farmers and Ranchers Said in Recent Surveys*, Surviving the Drought Workshop, National Drought Mitigation Center and Center for Rural Affairs, Chadron, Nebraska, June 6, 2006

Knutson, C., *Predicting Impacts and Communicating Forecast Uncertainty in the Case of Drought*, North American THORPEX Societal and Economic Research and Applications (NAT SERA) Workshop, Boulder, Colorado, August 14, 2006

Knutson, C., *Lessons Learned from the 2000-2005 Drought: What Ranchers Said in Recent Surveys*, Nebraska Section – Society for Range Management, North Platte, Nebraska, October 12, 2006

Knutson, C., *Lessons Learned from the 2000-2005 Drought: What Farmers and Ranchers Said in Recent Surveys*, University of Nebraska-Lincoln Cattlemen's College, Lincoln, Nebraska, November 29, 2006

#### **News Releases**

*Several Years of Drought Shows Farmers, Ranchers Need to be Prepared*, University of Nebraska-Lincoln Institute of Agriculture and Natural Resources Press Release [http://ianrnews.unl.edu/static/0607260.shtml], July 26, 2006

*Farmers, Ranchers Need to be Prepared for Drought*. Porknet Newsletter [http://www.porknet.com/archive/072806.html], July 28, 2006

*Years of Drought Shows Farmers, Ranchers Need to be Prepared*, AgProfessional.com, [http://www.agprofessional.com/show\_story.php?id=42197], July 29, 2006

*Producers Learning to be Prepared*, Grand Island Independent, Grand Island, NE, [http://theindependent.com/login.shtml?orq:http://www.theindependent.com/stories/072906/new\_drought29.shtml], July 29, 2006

Shaffer, S., *National Drought Mitigation Center looks to Preparation*. Radio Iowa, [http://www.radioiowa.com/gestalt/go.cfm?objectid=0DF30DB4-B395-4792-A5EBF73FD09DB60F], August 1, 2006

*Farmers, Ranchers Dealing with Drought*, North Platte Bulletin, North Platte, Nebraska, August 4, 2006

*Drought Tips from Farmers and Ranchers*, September 2006 Center for Rural Affairs Newsletter, [http://www.cfra.org/newsletter/current.htm]

## **D. Significant Deviations from Proposed Work Plan**

There were five deviations from the original work plan:

- 1) The project was delayed several months when gaining final project approval by the UNL Institutional Review Board, which monitors all projects involving human subjects. In 2004, the University of Nebraska modified their IRB procedures and began to require that all project personnel undertake IRB training (instead of only principle investigators). Conforming to these changes delayed project approval and necessitated a no-cost extension.
- 2) The mail-back survey sample size was increased from 300 to 633 because the number of people on mailing lists to sustainable agricultural groups in Nebraska had been underestimated. This benefited the project.
- 3) Instead of including only one graduate student, this study was able to use three part-time graduate students and a temporary employee through a combination of temporary worker and graduate assistantship programs. This helped provide additional opportunities for a greater number of current students and a recent graduate, and assisted financially by providing income for students that were awaiting their assistantship to start or whose assistantship had expired prior to graduation.
- 4) William Waltman withdrew from the study after ending his employment at UNL, and Robert Hitchcock and Jeffrey Peake's level of participation did not require them to use their total available financial resources.
- 5) Because of cost-savings achieved by consolidating workshops with the Center for Rural Affairs, the project team was able to hold two workshops at the conclusion of the project instead of only one that had originally been envisioned.

## **IV. Relevance to the Field of Human-Environmental Relations**

### *A. Enhancing the Use of Climate Information in Decision-Making*

Similar to previous studies, this research helps to verify some of the problems agricultural producers experience in utilizing drought and climate-related information. It also provides user-based input on methods to enhance the use of this information. Similarly, the presentation of these issues to farmers, ranchers, and policymakers provides an education opportunity to increase the use of climate information in agricultural decision-making. However, in terms of the climate research and outreach community, the greatest contribution may be in the identification of high impact forecasts for specific agricultural activities.

To date, most previous studies have only analyzed the general use of climate and forecast information in agricultural decision-making. As shown in Table 4, this study analyzed the use of climate and forecast information for specific agricultural activities. This approach allows climate researchers to identify information that is deemed most important for specific tasks. As discussed and highlighted at the North American THORPEX Societal and Economic Research and Applications Workshop (focused on increased the use of climate forecasts), this understanding will allow researchers to focus on producing climate and forecast information that will have the highest impact on local decision-making.

### *B. Impacts/Contributions of Project Results*

Through this study, Nebraska farmers and ranchers commented on their use and non-use of drought and climate information in decision-making during the last several years of drought, cited barriers to utilizing this type of information, and provided recommendations to address these barriers. In addition, they commented on new adaptations that have been implemented in order to better withstand the effects of drought and general climate variability. These issues are very important in several areas of study including: adaptations to long-term climate change, natural hazards mitigation, the development of tools for end users, enhancing the sustainability of vulnerable areas and people, and the use of local knowledge in developing new scientific information.

### *C. Suggestions for Future Research*

Similar research could be conducted in other geographic regions of the United States to ascertain whether the same limitations and opportunities exist in the application of drought and climate information. It is recommended that this type of research be conducted during or soon after drought conditions while events are fresh in the minds of agricultural producers, and news outlet and policy-makers are interested in results from the project. A great deal of interest has been expressed for this type of information from university cooperative extension personnel; state and federal agricultural agencies such as the USDA Risk Management Agency and USDA Natural Resources Conservation Service; and non-profit agencies such as the National Center for Atmospheric Research. These agencies could serve as potential collaborators on future projects.

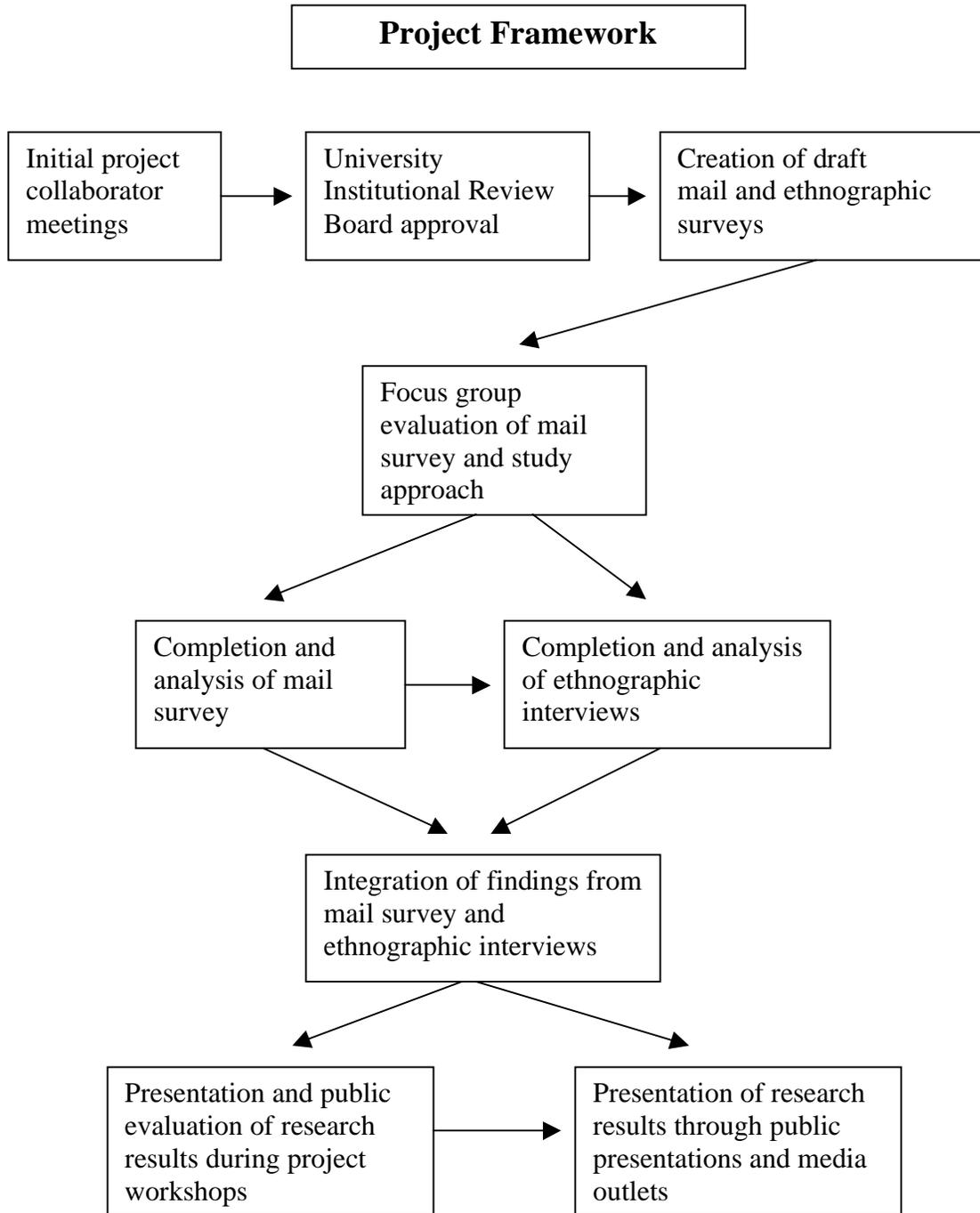
Specifically related to the use of climate and forecast information, future research should continue to focus on identifying what types of related information are most important for specific decisions by agricultural and other user groups. This will assist climate researchers in targeting the development of products to better meet the needs of user groups.

## **V. References**

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**A. Graphic of Project Framework/Approach**

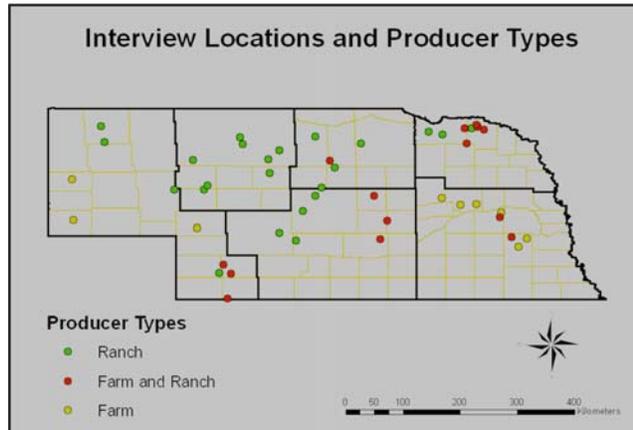


## B. Map of Ethnographic Interviews and Study Area



### Face-to-Face Interviews (Summer 2005)

- 47 producers interviewed (23 ranchers; 9 farmers; 15 mixed)
- 17 produce organic products
- 29 counties represented



### C. Photographs from Field Work



Photograph 1. Flows in the North Platte and other Nebraska rivers have been reduced by drought since 2000. Many irrigators who have relied on river and ground water resources have been forced re-think their agricultural practices. (Melissa Melvin, NDMC, 2006)



Photograph 2. Lake McConaughy in western Nebraska, a primary irrigation and recreational water source, has experienced record lows during recent drought. Note that the reservoir level is typically at the top of the water line shown on these structures. (Melissa Melvin, NDMC, 2006)



Photograph 3. The above picture show a rotary hoe. This rotary hoe is used by an organic farmer to minimize soil disturbance and control weeds in his fields without the use of pesticides. (Melissa Melvin and Jeff Nothwehr, NDMC, 2005)



Photograph 4. The blade plow gets under the top layer of residue, but leaves it on top of the soil. This farmer uses the blade plow to control weeds and provide a better cover in his fallow rotation to conserve moisture. (Melissa Melvin and Jeff Nothwehr, NDMC, 2005)



Photograph 5. The blade plow was used in this field during the fallow rotation to control weeds and conserve soil moisture. (Melissa Melvin and Jeff Nothwehr, NDMC, 2005)