An Assessment of Decadal Drought Information Needs of Stakeholders and Policymakers in the Missouri River Basin for Decision Support

Part I: Water and Agriculture Sectors in the MINK Region (Missouri, Iowa, Nebraska, and Kansas)

Vikram M. Mehta[1], Cody L. Knutson[2], Norman J. Rosenberg[1], J. Rolf Olsen[3], Nicole A. Wall[2], Tonya K. Bernadt[2], and Michael J. Hayes[2]

1 Center for Research on the Changing Earth System (CRCES), Maryland
2 National Drought Mitigation Center (NDMC), University of Nebraska – Lincoln, Nebraska
3 US Army Corps of Engineers (USACE) – Institute for Water Resources (IWR), Virginia

A Report Provided to
the NOAA-Climate Program Office-Sectoral Applications Research Program
Under Grant NA080AR431067

The Center for Research on the Changing Earth System CRCES | National Drought Mitigation Center | US Army Corps of Engineers®

Summary

The Missouri River Basin (the Basin hereafter) is the largest river basin in the U.S. The Basin produces approximately 46% of wheat, 22% of grain corn, and 34% of cattle in the United States; and is thus a major "bread basket" not only of the U.S., but also of the world. Three decadal climate variability (DCV) phenomena -- the Pacific Decadal oscillation, the tropical Atlantic sea-surface temperature (SST) gradient oscillation, and the west Pacific Warm Pool SST variability -- significantly impact the hydro-meteorology of the Basin. Records available from 1950 to 2000 show that decadal droughts and wet periods in the Basin are correlated with various combinations of these three DCV phenomena in their respective positive and negative phases.

We have undertaken a project, titled "*An Assessment of Decadal Drought Information Needs of Stakeholders and Policymakers in the Missouri River Basin for Decision Support"* and funded by the NOAA-Climate Program Office-Sectoral Applications Research Program, to (1) conduct workshops involving stakeholders and policymakers in the Basin; (2) develop retrospective drought and wet period scenarios using statistical modeling of DCV indices and their associations with hydro-meteorological variables in the Basin; and (3) develop sectoral impact evaluations through use of the Hydrologic Unit Model of the United States (HUMUS) and the Erosion Productivity Impact Calculator (EPIC) driven by the retrospective scenarios. Approximately 25 stakeholders and policy-makers from Missouri, Iowa, Nebraska, and Kansas participated in the first Workshop in this project, held in Kansas City, Missouri on April 27-28. The purpose of this Workshop was threefold: (1) to show that climatic events on the decadal scale have major effects in the Basin, including major droughts and wet periods; (2) to gather information about the effects of droughts in the 1980s and the most recent drought period in this decade; as well as the prolonged wet period of the 1990s; and (3) to explore the potential for developing future decadal climate outlooks and potential management options that would be useful in preparing for and coping with droughts and wet periods.

This Report describes major conclusions, potential barriers to using decadal climate outlooks, and recommendations from the Workshop.

Table of Contents

1. Introduction

The Missouri River Basin (the Basin hereafter) covers more than 500,000 square miles and a part or all of 10 states (Montana, Wyoming, Colorado, North Dakota, South Dakota, Minnesota, Iowa, Nebraska, Kansas, and Missouri), numerous Native American reservations, and parts of the Canadian provinces of Alberta and Saskatchewan. People living in the Basin depend on the Missouri River for drinking water, irrigation and industrial needs, hydro-electricity, recreation, navigation, and fish and wildlife habitat. The Basin contains some of the country's most sparsely-populated agrarian counties as well as a number of large metropolitan areas such as Omaha and Kansas City on the Missouri River and Denver at the foothills of the Rocky Mountains. Grain crops for food and feed provide much of the Basin region's agricultural income. About 117 million acres are in cropland in the aforementioned states. Of that total, about 12 million acres are irrigated. The Basin produces approximately 46% of wheat, 22% of grain corn, and 34% of cattle in the U. S.; and is thus a major "bread basket" not only of the U.S. but also of the world. Of the 18 Major Water Resource Regions of the U.S., shown in Figure 1, freshwater withdrawals for irrigation are greatest in California, the Pacific Northwest and the Basin.

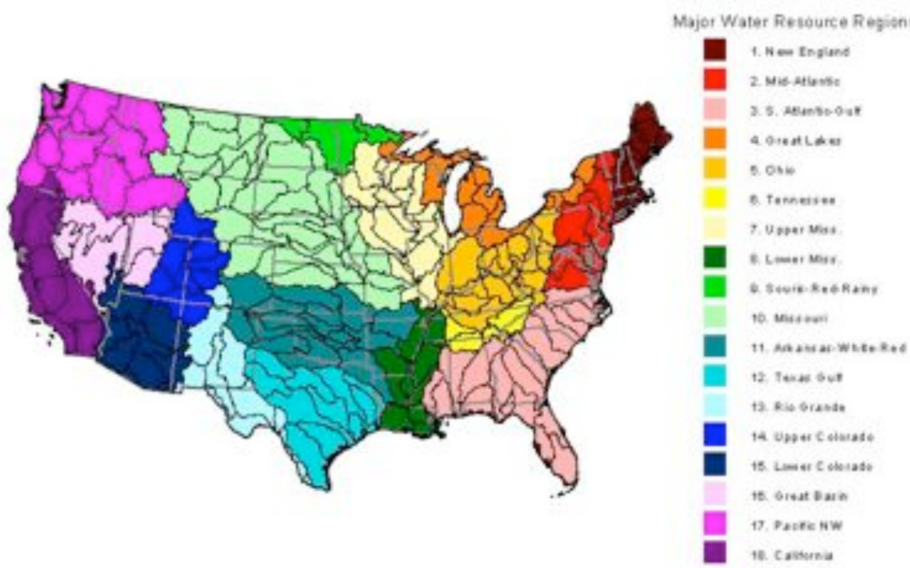

Figure 1: The 18 MWRRs of the Conterminous USA showing, as well, the ("4-digit") Hydrologic Unit Areas as Defined by the US Geological Survey.

The vulnerability of the Basin changes, of course, with precipitation variability forced by large-scale climate variability, especially at interannual and decadal timescales. These explain 60-70% of the total variance of annual-average precipitation. For example, during a major multiyear-to-decadal (hereafter referred to as decadal) drought, such as that in the late 1980s and the drought of 2000-01 to 2008, inflows in the Basin were insufficient to fully support reservoir-based recreation and Missouri River navigation. Conversely, too much water in the Basin reservoir system during above-average precipitation years of the 1990s resulted in greater than normal water releases from the reservoirs, which threatened farms and homes in the Basin's floodplains. Decadal droughts in the Basin deplete the stored water leading to the tensions over competing water uses between upstream and downstream states.

2. SARP I

In our previous project funded by NOAA-Climate Program Office-SARP, referred to as SARP I here, we used century-long precipitation time series over the Basin and found that interannual El Niño-Southern Oscillation (ENSO) variability explains less than 20% and that decadal (>7 years) timescale variability explains approximately 40-50% of the total variance in precipitation. The interannual and decadal precipitation variability thus accounts for 60-70% of the total precipitation variance in the Basin. These precipitation (and snow accumulation and stream discharge) estimates are also reflected in the percentage area of the Basin under severe to extreme drought conditions. As shown in Figure 2, the fraction of the Basin experiencing severe to extreme drought in the 20th century has ranged from 20% to 60% or more at interannual to decadal timescales. From 2000-01 to 2008 much of the Basin experienced such a drought.

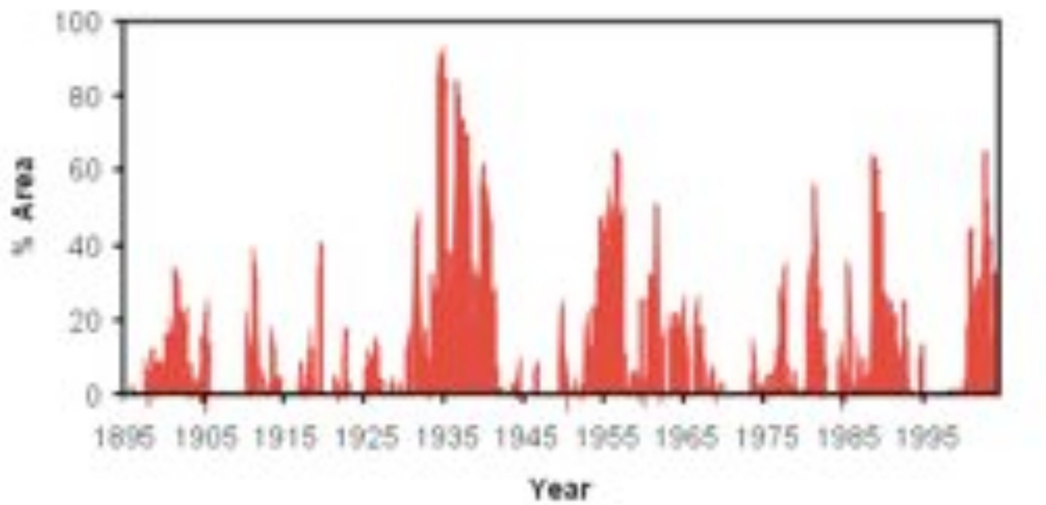

Figure 2: Percent of total Missouri River Basin area experiencing severe to extreme drought between January 1895 and March 2004. Based on data provided by the National Climatic Data Center, NOAA; Copyright 2004 National Drought Mitigation Center.

The climate of the continents is sensitive to what happens over the oceans; unusual warming and cooling of vast oceanic areas creates such phenomena as the Pacific Decadal oscillation (PDO), the tropical Atlantic sea-surface temperature (SST) gradient (TAG for brevity) oscillation, and the west Pacific Warm Pool (WPWP). In SARP I we found that these three decadal climate variability (DCV) phenomena significantly impact the hydro-meteorology of the Missouri River Basin. Records available from 1950 to 2000 show that decadal droughts and wet periods in the Basin are correlated with various combinations of these three DCV phenomena in their positive and negative phases.

In December 2006, a representative cross-section of Nebraska stakeholders and policymakers was interviewed by the project researchers to gather information about perceived needs for climate information. Discussions were held with over 30 local and regional water managers, policymakers, farmers, and researchers in Nebraska and western Iowa. Some of the major organizations represented in this study were Central Nebraska Public Power and Irrigation

District, Bureau of Reclamation, Army Corps of Engineers, Nebraska Farm Bureau, Tri-Basin Natural Resource District, National Park Service, and various departments and centers within the University of Nebraska–Lincoln system. These stakeholders', policymakers', and academic researchers' very positive and articulate responses to our questions led to the following major conclusions: (1) impacts of persistent, decadal, hydro-meteorological anomalies are qualitatively different compared to impacts of year-to-year anomalies; (2) agriculture, water resources for municipalities, power plants, and navigation in the MRB are much more vulnerable to decadal drought events than to year-to-year events; (3) there is an evident need for decadal drought outlooks; (4) any particular DCV-related drought/flood event can have differing sectoral and economic impacts in the various geographical portions of the MRB (e.g., recreation in Montana and the Dakotas, irrigation in Nebraska and Kansas, and navigation in the downstream States); (5) municipalities and industry, particularly power generation, are sensitive to drought/flood-related changes in water supply everywhere in the MRB; (6) farms along the Missouri River are much more vulnerable to persistent floods than to persistent droughts; (7) while crops are, of course, sensitive to changes in weather associated with year-to-year hydro-meteorological anomalies, modern crop breeding is increasing their resilience to short-term climate variations; (8) the addition of new dimensions to research are necessary, such as the need to include groundwater in total impacts of droughts/floods on water availability and very important impacts on unmanaged ecosystems, and in land-use, such as areas being driven at this time by the Conservation Reserve Program and the introduction of biomass cropping; and (9) a much more detailed study, with questions focused on individual groups and a wider range of economic sectors, is needed for the entire MRB.

Thus, SARP II was born as a result of the results of SARP I.

3. SARP II

The primary purpose of the SARP II project is to widen our understanding of drought information needs from that gathered in the earlier phase. This is to be done by soliciting, evaluating, and documenting stakeholder knowledge of DCV phenomena across the entire Basin. In order to achieve this purpose, we are undertaking systematic assessments of the DCV-related perceptions and drought information needs of various types of stakeholders (such as local/regional water managers, farmers and cattle producers, researchers, and local/regional business people) and policymakers in the Basin for decision support by means of a series of workshops, surveys, and web-based communication methods.

To help demonstrate the relationships between DCV and associated impacts in the Basin, we also developed retrospective scenarios for three DCV-related hydrologic events in the Basin; the multiyear-to-decadal drought event in the mid-to-late 1980s and the recent drought (2000-01 to 2008) and the multiyear-to-decadal wet period event in the 1990s; and are assessing their possible impacts on hydro-meteorology, water and crop yields, and regional economy. This work is essential to help provide credibility of the DCV-societal impacts relationships to stakeholders, be useful in fostering discussions on the effects of DCV, and provide a starting point for discussion on the information needed to better understand and effectively adapt to and cope with DCV-related droughts and excessive wetness.

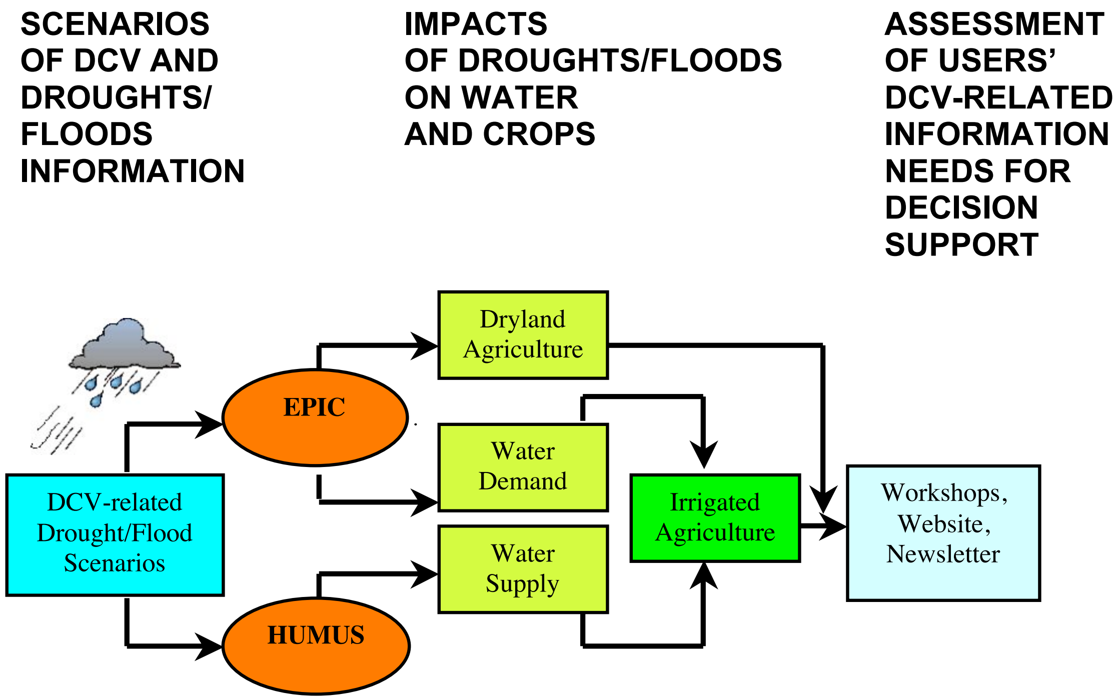

Figure 3: From scenarios of DCV-related droughts/floods to assessment of users' drought information needs.

This project, titled "*An Assessment of Decadal Drought Information Needs of Stakeholders and Policymakers in the Missouri River Basin for Decision Support*" and funded by the NOAA-Climate Program Office-Sectoral Applications Research Program, consists of several interconnected components as shown in Figure 3. The project is being conducted via workshops involving stakeholders and policymakers in the Basin; development of retrospective drought and flood scenarios using statistical modeling of DCV indices and their associations with hydro-meteorological variables in the Basin; and development of sectoral impact evaluations through use of the Hydrologic Unit Model of the United States (HUMUS) and the Erosion Productivity Impact Calculator (EPIC) driven by the retrospective scenarios. Retrospective scenarios of hydro-meteorological variables, crop yields, and water flows are being compared with records of actual hydro-meteorological variables, crop yields, and water flow; and observations and model results are a part of the DCV-related drought information provided to users in workshops. The first workshop in this project was held in Kansas City, MO on April 27-28 and this is a Report based on workshop proceedings.

The purposes of this first workshop (the second of the series was held in Helena, MT on 24-25 June 2009) were threefold: (1) to show that climatic events on the decadal scale have major effects in the MRB, including major droughts and wet periods; (2) to gather information about the effects of droughts in the 1980s and the most recent drought period in this decade; as well as the prolonged wet period of the 1990s; and (3) to explore the potential for developing future decadal climate outlooks and potential management options that would be useful in preparing for and coping with droughts and wet periods.

Approximately 25 stakeholders and policymakers representing a variety of sectors in the Basin participated in the Workshop. Their names and affiliations are listed in Appendix 1.

4. Stakeholder Interaction Techniques

The project team used a variety of techniques to interact with stakeholders. Initial information about the project was provided via a quarterly newsletter, "*The Missouri Basin Climateer*", started as a part of this project. To provide information to Workshop participants and others, a Web site (www.DecVar.org/MRB_project.php) is also set up as a part of this project, to be maintained after the project ends, and information was also provided via this Web site. A preliminary description of the Workshop's purposes and a questionnaire were provided to the participants a few days prior to the event. Project team members delivered a series of presentations, as shown in Figures 4 and 5, during the Workshop and sufficient time was allowed for interactions with participants. Between and after the presentations participants were asked for their opinions on the quality and information content of the presentations. Many sessions were arranged in which participants were divided into small discussion groups as shown in Figure 6. Each group then presented major conclusions of their discussions to the entire group of participants and the project team. At the end of the Workshop, participants were asked to respond to a final questionnaire about the Workshop content and offer suggestions for improvement.

Figure 4: A Presentation Introducing Various Decadal Climate Variability Phenomena.

5. Information Provided to Stakeholders

In the main presentation by the project team, stakeholders were introduced to various definitions of DCVs and then to the three major DCV phenomena – the PDO, the TAG, and the WPWP variability. Spatial patterns and time histories of evolution of these phenomena were shown and major hypotheses for their causes were briefly described. Statistical associations between each of the DCV phenomena and hydro-meteorological variables such as rainfall and surface air temperature were used to show how each contributes to hydro-meteorological variability in the Basin at decadal timescales. Rainfall and temperature patterns associated with two recent, multiyear to decadal timescale hydrological events – droughts in the 1980s and a prolonged wet period in the 1990s –reconstructed from the aforementioned statistical associations were shown to Workshop participants.

The Erosion Productivity Impacts Calculator (EPIC) model was used to simulate crop yields in the Basin under idealized but realistic hydro-meteorological scenarios characteristic of the three DCV phenomena.

Figure 5: A Presentation From the U.S. Army Corps of Engineers About Management of Missouri River Reservoirs.

The crops modeled were corn, winter and spring wheat, and soybean. The results of these experiments with EPIC were also shown to Workshop participants.

The aforementioned information imparted to participants was discussed in several sessions. Participant recollections of these events were elicited. The question of future evolution of the DCV phenomena and their possible impacts on the Basin was taken up. The project team initiated this series of discussions by reviewing the current status of efforts to produce decadal climate outlooks by several major, climate modeling groups around the world. The difficulties of producing such outlooks were also described and discussed.

6. Workshop Results

6.1 Participant Recollections

6.1.1 The 1980s Drought

Low-flow conditions in the Missouri River in 1988 impacted river flows and reservoir levels, with the run-off into the reservoirs reduced by as much as 50%. The low-flow condition adversely affected intakes for municipal and power plant water supply. Low reservoir levels impacted recreation and flow support for navigation uses. Similarly, low-flow conditions in the Kansas River also affected various uses such as municipal water supply and reservoir levels. In some cases, as in Lincoln, Nebraska and several Kansas municipalities in 1988, the low-flow conditions led to restrictions on water-use in cities, Kansas and other states were prompted to hold a series of drought workshops and to establish 'thresholds' for assembling the State governor's response team to cope with the droughts. Dust storms, provoked by the droughts brought back memories of the "dirty thirties" in Kansas. The low-flow conditions also resulted in a shortening of the navigation season on the Missouri River and in increased fish kills in many rivers and streams in the Basin.

This prolonged drought being the first real stress on the Missouri River reservoir system since it became fully operational in the 1960s, the overall impact of this decadal drought period led the states to compete and lobby for water stored in reservoirs, Also, perhaps for the first time, states and stakeholders began to question the reservoir system's purposes.

Agricultural impacts included reductions in crop yields; for example, corn yields decreased 30% in the widespread drought in 1988. Livestock sell-offs increased, reduced water supplies lead to increased use of ground and surface water for irrigation. This, in turn, worsened water shortages.

6.1.2 The 1990s Wet Period

During the 1990s wet period, floods occurred in 1993, 1995, and 1997, lingering onto October 1998 in some areas. Saturated soils carried over from 1992 exacerbated and accelerated the floods in 1993.

Figure 6: A Group Discussion Led By Two Project Team Members.

Navigation closed on the Missouri River for several months in 1993 and 1995. Additionally, there were floods on the Kansas River and various streams (including the Salt Creek in Lincoln, Nebraska), damaging property, farms, homes, crops, and spillway around dams. Degradation of the Missouri River bed in Kansas City, Missouri was accelerated by the 1993 flood. Some metropolitan areas in the Missouri River Basin suffered major damage and have yet to recover from the effects of these floods. Cities and towns that had never before experienced floods were inundated. Weather and climate forecasts were uncertain and the causes of uncertainty were not explained to the public, resulting in confused and fragmented responses. The fact that rainfall in the MRB was below average from October 1993 to the end of 1994, delayed public recognition that the region was facing a multiyear wet period. As a result of the 1990s wet period, crop and flood insurances expanded by a factor of 100 or so.

6.1.3. The Droughts in the 2000s

The droughts of the first decade of the 21st century caused wide-spread water shortages that led to the exercise of water rights, and a curtailment of some users such as irrigators in order to protect senior rights and minimum stream flows. The navigation season on the Missouri River was shortened. Not only the Missouri and its tributaries experienced low-flow conditions, but long-term and intermittent springs as well as lakes and ponds also went dry. It was actually possible to plant crops on dry lake beds for the first time since the mid-1970s. The long-term droughts also exposed submerged cultural remains.

Communities and industries drawing water from rivers and streams had to install pumps at water intakes to continue to meet municipal and industrial water demands. In some cases, e.g. a meat-packing plant in north-central Missouri, industries had to reduce production due to a reduction in available water. There were serious crop losses over wide areas, including a shortage of hay, during this drought period. During 2000-2006, the imposition of restrictions on lawn watering was under consideration and water requirements for several endangered fish and wildlife species within the MRB became important.

As during the 1990s wet period when floods were interspersed with droughts, the 20-ought decade droughts were interspersed with floods (2003-04 and 2009); and forecasts of this mixture of droughts and floods were uncertain and the causes of the forecast uncertainty were not explained to the public, making the responses confused and fragmented. However, in order to monitor river and stream flows, these droughts encouraged the State of Missouri to fund more stream gauges in the state. The Governor of Kansas adopted the State Drought Plan as a result of these wide-spread droughts. These droughts also encouraged the affected states to participate more effectively in the Missouri River Recovery Implementation Committee (MRRIC; http://missouririver.ecr.gov). MRRIC was established following the enactment of the Water Resources Development Act (WRDA) of 2007. MRRIC's purpose is to help guide the prioritization, implementation, monitoring, evaluation and adaptation of recovery actions and to ensure that public values are incorporated into the study and the recovery and mitigation plans; and its primary duties are: (1) With respect to the study to be conducted (Missouri River Ecosystem Restoration Plan), provide guidance to the Corps and any affected Federal agency, State agency, or Indian tribe; and (2) Provide guidance to the Corps with respect to the Missouri River Recovery and Mitigation Plan in existence on the date of enactment of WRDA 2007.

6.2 Usefulness of Decadal Climate Outlooks

6.2.1 Multiyear to Decade-long Droughts

Workshop participants were presented observations on climate and impacts from the 1980s and the 2000s drought periods as if they were 100% accurate climate forecasts with multiyear to a decade lead times. They were asked to describe how they would have used these decadal climate outlooks (DCO) had they been available just before the onset of the 1980s and the 2000s drought periods. The ensuing discussions resulted in reasonably specific ideas about how DCOs would be used provided that the DCOs were 100% accurate.

Planning in all sectors would benefit greatly from such outlooks, even from some reliable information about the current state of each DCV phenomenon relevant to the MRB. It was also felt that impacts on many societal sectors occur via weather events and variability, so DCOs should include some information about weather statistics over the DCO period. In agriculture, the DCOs would be used as a tool for guidance about which crops and particular varieties to plant, the correct mixture of crops to plant, irrigation planning and number of intakes to provide water to irrigation systems, and when fertilizer should be applied. Some guidance on how transportation systems would be affected can also be used to decide whether crops will be transported to market by truck, train, or barge. In reservoir operations, DCOs would be used as a tool to plan water level, and water release times and amounts in spring. Purchases of the types and quantities of fire-fighting equipment for wildfires, the required number of fire-fighters, and timing of controlled burns would also be guided by DCOs. Municipal water supply and drainage systems would benefit in decision-making about water conservation measures. The DCOs would also be very useful in management of fisheries and wildlife hatcheries, and waterfowl.

6.2.2 Longer-term Droughts

Were the DCOs to indicate that a drought might last longer than ten years, they could be used as tools in other aspects of decision-making in a variety of sectors besides the measures mentioned in the previous section. In agriculture, this information would be used to plan irrigation, crop and seed types; planting acreage; insurance coverage; timing of fertilizer, herbicide and pesticide application; and disease control. The DCOs would also be used for groundwater quality and protection, more accurate surface water outlooks, irrigation/dry land conservation and development, ecosystem management, fisheries and wildlife management, and generally in land management via controlled burns and timing of environmental habitat restorations. In livestock production, the DCOs would be used in decision-making about holding or selling livestock, range or lot feeding, purchasing water to maintain cattle on range or in lots, environmental stress, and to estimate feed-to-production ratios. Decisions regarding public water supply would also use the DCOs; e.g. construction of new wells or reservoirs, establishing new pipelines, etc.

River navigation and commodity transportation planning and implementation would be substantially influenced by DCOs. The investment decisions of rail and barge companies may be influenced by the DCO for long-term drought. The electricity-generation industry would use DCOs to make decisions regarding the construction of new plants, number of water intakes, wholesale purchase of fuel, and wholesale marketing of electricity. Since thermal power plants must meet very stringent regulations about the temperature of cooling water released into the environment, DCOs would be used in planning operations of such plants and in legalities of effluent water temperature management. Nuclear power plants must meet even more stringent water temperature regulations than coal- or oil-fired power plants. The river- and reservoir-based recreation industry would use DCOs for improved marina planning and dredging, and in decisions about ramp construction and public access at existing marinas.

Were DCOs to indicate the likelihood of floods/wet periods, the information could be used to guide protective measures for critical infrastructure in flood plains, i.e. whether or not to build new levees, encourage flood zone buyouts, install internal drainage infrastructure in flood zones, provide flood insurance, manage spring runoff, and incorporate estimates of possible damage in budgets.

DCOs would also influence state government planning and preparation for droughts/wet periods, and would lead to improved planning of emergency response strategies. Federal government decisions regarding erosion control, international trade regulations, and biofuels production in affected states would also be influenced by DCOs. Personal and business decisions would also be influenced by DCOs.

6.3 Potential Barriers to Using Decadal Climate Outlooks

Workshop participants were also asked to identify potential barriers to the use of DCOs. They felt that the MRB is often accorded a lower priority in improving climate predictions, so forecasters should pay the necessary attention to climate information needs of this region. The reliability of DCOs was considered to be the most important potential barrier to their use. So, climate scientists should build the information users' confidence in the DCV science and DCOs by demonstrating understanding and prediction skill about past DCV phenomena. Climate scientists should also try to bridge the gap between stakeholder-policymaker and lay people's experiences and observations to climate science, as this Workshop tried to do. There was a general consensus that the accuracy of DCOs is very important within probability limits. The overall decision-making process in many sectors is complex and sensitive to risk perception, and a subjective/objective hedging is involved; climate is just one of the variables; it will be a bigger part of the decision-making process as forecast accuracy improves. Also, the consequences of a wrong forecast must be consider in the decision-making process, including the possibility litigation brought on by wrong decisions.

In order to be useful to stakeholders and policymakers, DCOs would have to be produced at the required spatial and temporal resolutions. Requirements can vary within the MRB and among various sectors. For example, farmers may want to know at a few km resolution when it will rain first time during planting period, how much, and when will it rain next; water managers may want to know the frequency and intensity of rainfall in spring in catchment areas; and nuclear and other power plant operators may want to know the temperature of the water drawn from rivers to cool reactors. So, a concerted effort should be made to define user requirements in close partnership with the users.

There are also institutional barriers to the use of DCOs. The National Environmental Policy Act (NEPA) of 1970 established national environmental policy and goals for the protection, maintenance, and enhancement of the environment, and provides a process for implementing these goals within the federal agencies. NEPA requires the federal government to use all practicable means to create and maintain conditions under which man and nature can exist in productive harmony. It also requires federal agencies to incorporate environmental considerations in their planning and decision-making through a systematic interdisciplinary approach. Specifically, all federal agencies have to prepare detailed statements assessing the environmental impact of and alternatives to major federal actions significantly affecting the environment. Under NEPA, water release decisions by the U.S. Army Corps of Engineers are based on actual water in storage and past history of weather and climate variability in the region; weather/climate forecasts are not currently used at all in decision-making. A clear demonstration of climate forecast accuracy and reliability might overcome these institutional barriers by changes to NEPA and the Corps' operating rules. Similarly, there is limited flexibility in changing the amount of reservoir storage space allocated for flood storage due to legislative authority. Some changes in a reservoir's authorized uses may require action by the U.S. Congress. Also, decision-making processes are driven by events, seasons, and availability of funds, so these processes would have to be changed before DCOs can become useful.

The Workshop participants also highlighted the acute need for climate scientists and stakeholders-policymakers to educate one another, first by developing a mutual understanding of the idiom that each group uses. They felt that clarity in information-delivery is very important, including explanations of sources of potential predictability, and limits of predictions. However, the general consensus was that DCOs would be useful, even if of limited accuracy, if they are clearly defined within levels of uncertainty and provide the kind of information needed by stakeholders and policymakers. Finally, it was felt that scenario-planning exercises are lacking among the user communities and climate scientists should become involved in designing such exercises.

6.4 Specific Recommendations for Providing Decadal Climate Outlooks

The Workshop participants recommended that:

1. The existing Missouri River Basin Website, developed for this project, should be enhanced with links to relevant sites; and user-friendly DCV information needed by stakeholders such as probabilities of occurrence, user-definable preferences (including resolutions), GIS capabilities, and explanations of data and information in terms that lay persons can understand; the

information should be in watershed scales pertaining to streams and rivers in the MRB and it should be downloadable in presentation formats developed in collaboration with users.

2. Climate scientists and climate information should be readily accessible to stakeholders-policymakers at the right time for decision-making. Communications between climate scientists and stakeholders-policymakers need to be improved, including a clear explanation of differences between scenarios and forecasts.

3. Existing user networks should be engaged to channel climate information, and there should be more coverage of climate-related matters on TV and other regional/local news media.

4. Social impacts of DCV should be considered a part of the totality of DCV impacts and social scientists should be engaged in assessment and prediction of DCV impacts.

5. Climate scientists should select a few promising sectors and work with stakeholders-policymakers in those sectors to convey the usefulness of DCV information to their general user communities.

7. Next Steps

As the next steps in this process of interactions with users, it was recommended by the Workshop participants that experimental, decadal climate and impacts information for the MRB should be provided to users; this network of stakeholders and policymakers in the MRB should be further developed via the newsletter "*Missouri Basin Climateer*", the already-existing Web site, and through e-mail. The participants also expressed a keen interest in assessing the usefulness of experimental DCOs.

Appendix 1: List of Participants in the Kansas City Workshop

Name	Occupation Title	Organization Name
Steve Adams	Natural Resources Coordinator	Kansas Dept. of Wildlife and Parks
Jimmy Adegoke	Assoc. Prof. of Geosciences	Univ. of Missouri-Kansas City
Chris Anderson	Assistant Director Climate Science Initiative	Iowa State University
Bill Beacom	Transportation	Navcon Service
Dale Blevins	Subdistrict Chief/Supervisory Hydrologist	Missouri Water Science Center
Patrick Cassidy	Director of Environmental Services	Kansas City Board of Public Utilities
Shripad Deo	Research Associate III	Cooperative Institute for Research in the Atmosphere
Patrick Guinan	State Climatologist	University of Missouri-Columbia
Bethany Hale	Collaboration Program Manager	National Weather Service, Kansas City, MO
Denise Jensen	Water Quality Specialist	Winnebago Tribe of Nebraska
Doug Kluck	Climate Services Program Manager	National Weather Service-KC, MO
Kevin Low	Senior Hydrologist	Missouri Basin River Forecast Center
Tom Lowe	Water Resources Planner	Kansas Water Office
Tony Lupo	Professor, Dept. of Atmospheric Science	University of Missouri-Columbia
Steve McIntosh	Environmental Manager	Missouri Department of Natural Resources
Larry Murphy	Team Leader Reservoir Regulation	US Army Corps of Engineers Missouri River Reservoir Control Center
David Pope	Executive Director	Missouri River Association of Tribes and States (MoRAST)
Steven Predmore	Service Hydrologist	NWS Missouri River Basin River Forecast Center, Pleasant Hill, MO
Lori Schultz	Hydrologist	NWS Missouri River Basin River Forecast Center, Pleasant Hill, MO
David Sieck	Producer	Glenwood, IA
Jason Skold	Missouri River Program Manager	Nature Conservancy
Curtis Hoagland	Biologist	Missouri River Ecosystem Restoration Plan (MRERP) and Corps of Engineers Kansas City, MO
Eugene Tackle	Director, Climate Science Initiative	Iowa State University
Elwynn Taylor	Extension Climatologist	Iowa State University
John Drew	State Hydrologist	Missouri Dept. of Natural Resources