

# Midwest Drought Early Warning System

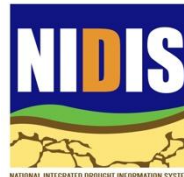
## 2016 Regional Assessment Workshops Report

*Minnesota and Wisconsin Workshop – November 7-8, 2016 (Rochester, Minnesota)*

*Iowa and Missouri Workshop – November 9-10, 2016 (Cedar Rapids, Iowa)*

*Illinois and Indiana Workshop – December 5-6, 2016 (Champaign, Illinois)*

*Ohio and Kentucky Workshop – December 7-8, 2016 (Cincinnati, Ohio)*



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## Introduction

During late 2016, the National Integrated Drought Information System (NIDIS), the National Drought Mitigation Center (NDMC), the Midwestern Regional Climate Center (MRCC), and other regional partners convened four stakeholder meetings in the Midwest Drought Early Warning System (DEWS). Each meeting included a historical drought overview and climate outlook for the region, discussion of critical drought-related needs and challenges, exploration of available tools, local drought planning and management approaches, and strategy development to improve drought early warning and resiliency in the Midwest.



### WHAT IS NIDIS?

The National Oceanic and Atmospheric Administration's (NOAA) National Integrated Drought Information System (NIDIS) was authorized by Congress in 2006 (Public Law 109-430) with an interagency mandate to develop and provide a national drought early warning information system, by coordinating and integrating drought research, and building upon existing federal, tribal, state, and local partnerships.

### WHAT IS A DEWS?

A Drought Early Warning System (DEWS) utilizes new and existing networks of federal, tribal, state, local and academic partners to make climate and drought science accessible and useful for decision makers; and to improve the capacity of stakeholders to monitor, forecast, plan for, and cope with the impacts of drought.

## Objectives

The objectives of the 2016 regional assessment workshops were threefold:

- Build a Midwest DEWS community of federal, tribal, state, and local stakeholders that represent all economic sectors;
- Exchange information and best practices on the status of monitoring, drought planning, use of drought indicators and triggers, challenges and impacts of recent droughts, and drought response mechanisms; and
- Develop actionable strategies to build drought resilience and improve early warning of drought.

The workshop planning team envisioned participants leaving the workshop with:

- Enhanced communication resources and networks;
- Strategies to support drought vulnerability assessments and drought planning at state and local levels; and
- A better understanding of how drought monitoring can be incorporated into drought planning and other hazard mitigation planning efforts.



The workshop planning team also hoped the workshops would help answer:

- How do decision makers currently use available drought and climate tools (e.g., US Drought Monitor)?
- How can stakeholders at the regional or state level create and evaluate consistent drought messaging across sectors and agencies?
- What tools are available to collect drought impacts, what are best management practices associated with building adaptive capacity in the region, and how can these tools and current practices be strengthened?

### Historical Drought Overview and Climate Outlook

Historical records show that modern-day droughts are not as severe or long as the droughts in the early 1900s. Many of the low-flow records for rivers in the Upper Midwest were set in the 1930s. In Illinois, droughts in the 1930s and 1950s were devastating to agriculture and other sectors. In Ohio, the five driest 12-month periods were all in the early 1900s and 1930s-1950s.

In recent decades, many Midwest states have seen a trend toward increased precipitation. As a result, many Midwest states have been more proactive in planning for heavy precipitation and flooding rather than drought. However, drought still occurs in the Midwest and states are noticing a change in how the droughts have been developing. Recently, the onset of drought has occurred very rapidly and conditions have intensified quickly, the region’s 2012 “flash drought” being the most recent example. During that drought, Missouri, Illinois, Indiana, and Kentucky experienced the most severe impacts in the region.

At the peak of the 2012 drought in August, 35% of the Midwest was in extreme drought, with 7% in exceptional drought, the most severe level (Figure 1). Missouri was the state most deeply affected by

the drought. At its peak, almost the entire state of Missouri was in extreme drought (D3) and 36% of the state was in exceptional drought (D4). The drought took a toll on every part of the agriculture industry in Missouri<sup>1</sup>, with estimated financial losses of more than \$547 million to Missouri livestock and poultry operations.

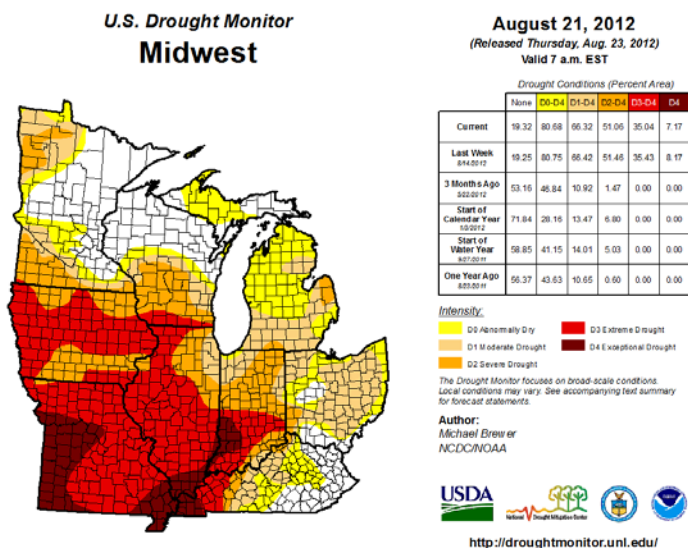


Figure 1: The U.S. Drought Monitor during the peak of the 2012 drought in the Midwest.

<sup>1</sup> <https://dnr.mo.gov/pubs/TheDroughtOf2012.pdf>



## Workshop Discussion Summaries

### Challenges of Drought and Future Ideas

On the first day of each workshop, attendees brainstormed major drought issues with the Midwest region, projects that could address these issues, and resources or stakeholders that could be leveraged to increase effectiveness. There were some common themes shared among the attendees across all four workshops.

#### **Observations and Monitoring**

The lack of spatial resolution, or an inadequate number of observing stations across the country, for environmental monitoring (e.g., soil moisture, evapotranspiration, groundwater levels) was mentioned at all four workshops. In addition, attendees mentioned the lack of sustained political and financial support for observation networks that provide this critical environmental monitoring (i.e., mesonets).

Attendees identified potential solutions to the issues described above, which include utilizing existing network sites and adding more parameter sensors, developing a marketing program to build awareness for the value of monitoring networks to drought early warning, and establishing relationships with private sector entities that have proprietary data networks.

Several attendees called for improvements to the accuracy of drought index products. There were a number of projects that were identified to address this, including: a study to integrate multiple drought indices to give the most accurate representation of current drought conditions; additional investments into existing indices like the Evaporative Demand Drought Index (EDDI) and the Evaporative Stress Index (ESI); and a study to develop a flash drought index.

#### **Interdisciplinary Research and Applications**

Workshop participants discussed the need to better understand surface and subsurface water resources and the vulnerabilities that these resources face. A project that studies the sub-surface geology, groundwater availability, and surface water availability could help address this need. Identifying susceptible systems and studying the impact of agricultural practices, like irrigation and tilling, were also mentioned at multiple workshops.

#### **Planning and Preparedness**

All four workshops revealed that to improve drought planning and response, there is a need for more drought impact information for many sectors and topics, including agriculture, energy, navigation, public health, water quality, water quantity, economics, habitats, and recreation and tourism. Better understanding the drought impacts and needs from the energy sector was brought up multiple times. Attendees suggested that the Midwest DEWS develop a relationship with energy stakeholders in the region, such as the [Great Plains Institute](#), as well as state departments of energy.

#### **Communication and Outreach**

Complacency is one of the biggest challenges for effective drought preparedness and communication. In the Midwest states, the infrequency of drought has led to a heavier focus on the management of precipitation and flooding at the expense of drought mitigation and response planning. In order to address the complacency issue, workshop participants identified that existing groups like the



Communication Organizations Active in Disaster (COAD) and the Extension Disaster Education Network (EDEN) should be invited to be more active in the Midwest DEWS to increase communication to decision-makers and the public. In addition, social media was noted as a potential medium for communicating relevant drought information to the public.

### Existing Activities to Improve Drought Early Warning and Resiliency

Before the workshops, attendees were asked to compile existing drought projects underway in the Midwest region. Projects presented at the workshops are summarized below. A comprehensive list of all identified drought projects is in Appendix A.

#### ***System Wide Low Flow Management Plan for the Mississippi River above St. Paul, Minnesota***

*Presenter: Greg Kruse, Minnesota Department of Natural Resources (DNR)*

- During the 1988-90 drought, the Mississippi River above St. Paul experienced significant fluctuations in water levels due to a lack of communication between water users along the river. Major users included hydropower facilities, municipalities, and power plants.
- To prevent this from happening in the future, Minnesota DNR led the effort to develop this plan in 1995 to minimize the impact to public water supplies and power generation users during low-flow conditions.
- [The plan includes](#) monitoring and reporting requirements during low-flow conditions, limited reservoir fluctuations, ramping rates for normal and low-flow conditions, and increased communication among water users. During the 2012 drought, water use issues were once again an issue as in the past. However, the plan helped increase communication among water users along the river, avoiding the significant river fluctuation issues felt during the 1988-90 drought.

#### ***Island Lake Reservoir Technical Committee***

*Presenter: Craig Schmidt, NWS Chanhassen*

- Minnesota Power manages the Island Lake Reservoir in northern Minnesota. To involve the Island Lake landowners in reservoir management decisions, Minnesota Power established the Island Lake Reservoir Technical Committee.
- The [committee typically meets three times per year](#) (during early winter, mid-winter, and spring) to look at the current and forecasted conditions of the lake reservoir levels to decide if regular operations can continue, or if they need to implement low-flow operations.
- The Chanhassen NWS Office provides the forecasted outlook for the reservoir and is a key partner in the technical committee.

#### ***Climate Summary and Outlook Reports and Webinars***

*Presenter: Doug Kluck, NOAA*

- Every month, the National Centers for Environmental Information (NCEI), NIDIS, Regional Climate Centers, American Association of State Climatologists and partners host a [Climate Summary and Outlook Webinar](#) to summarize current climate and drought conditions and provide an outlook for the upcoming months for the Great Plains and Midwest region.
- Every quarter, NOAA and partners produce a two-page [Quarterly Climate Impacts and Outlook report](#) for the Midwest that summarizes significant events and impacts during the past season, as well as an outlook for the upcoming season.



## Iowa Water Summary Update Report

Presenter: Mike Anderson, Iowa DNR

- Since spring 2012, Iowa DNR and other partners have produced a [Water Summary Update](#) report (Figure 2). The report is produced bi-weekly during the early spring to early fall, and monthly during late fall through winter.
- The report graphically summarizes water conditions by county in Iowa and includes information about precipitation (percent of normal), streamflow, shallow groundwater levels, and the U.S. Drought Monitor, as well as a point of contact for all pieces of information presented in the report.

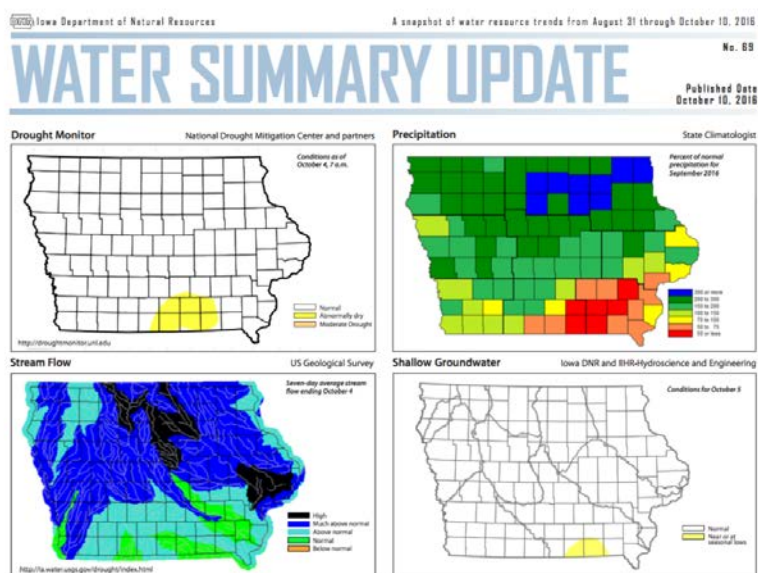


Figure 2: A snapshot of the October 10, 2016 Iowa Water Summary.

## Osceola County Rural Water District Water Sustainability and Induced Recharge Study

Presenter: Mike Gannon, Iowa Geological Survey

- In Osceola County (Iowa), 95% of groundwater is used for large-scale livestock production. Livestock producers become concerned during drought that conditions will jeopardize the livestock and cause fatalities.
- To better understand the groundwater supply in Osceola County and how to manage groundwater during drought, the Iowa Geological Survey [conducted a study](#) that included significant data collection, as well as modeling, to identify strategies that this area can utilize as drought management options.



### **Expanding the Role of Extension Professionals in National Drought Monitoring**

*Presenter: Hans Schmitz, Purdue Extension*

- Extension professionals are in a unique position to collect on-the-ground information from colleagues and clientele. Extension can serve as information providers to the authors who create the U.S. Drought Monitor map each week.
- This [project](#) will form a North Central Region Climate Team, to use team members to offer expert input to the Drought Monitor. The goal of the project is to have Extension professionals actively participate in drought detection and reporting. [Update: As of December 2017, two team meetings have taken place; one in December 2016 and another in April 2017 at the U.S. Drought Monitor Forum].

### **State and Regional Water Supply Planning in Illinois**

*Presenter: Jason Zhang, Illinois State Water Survey*

- To ensure there is adequate, reliable, clean, and affordable water for Illinois residents, the Illinois DNR funds the Illinois State Water Survey (ISWS) to conduct regional water supply planning for the state.
- The ISWS studies water supply, availability, and demand and recommends how to best accommodate future water demands from a regional point of view. Illinois DNR uses this information to help municipalities that may be at risk to identify options for reducing demand and additional water supply opportunities.

### **Useful to Usable Decision Support Tools**

*Presenter: Jim Angel, Illinois State Water Survey*

- [Useful to Usable \(U2U\)](#) is a USDA-funded research and extension project designed to improve the resilience and profitability of U.S. farms in the Corn Belt amid a changing climate.
- U2U has developed several decision support tools on their Decision Dashboard, including the [Irrigation Investment DST](#), which is most applicable to the Midwest DEWS work. It combines historical weather data and crop simulation model data with customizable yield, cost, tax and loan information to help the user evaluate whether an investment in irrigation equipment may be profitable.

### **Kentucky Efforts to Coordinate Drought Preparedness and Response**

*Presenter: Stuart Foster, Kentucky State Climatologist*

- A proactive approach to address water resource challenges critical to agriculture and rural communities in Kentucky has been developed through the coordinated efforts of the [Kentucky Farm Bureau Water Management Working Group](#), the [Kentucky Agriculture Science and Monitoring Committee](#), and the [Kentucky Water Resources Board](#).
- Collectively, these groups seek to address challenges related to both water quality and quantity by developing science-based policy recommendations, investing in appropriate technology, and promoting best management practices.





### Ohio River Forecast Center Resources

Presenter: Jim Noel, NWS Ohio River Forecast Center

- The Ohio River Forecast Center (RFC) through the National Weather Service (NWS) offers situational awareness and support for the Ohio River Valley region. The Ohio RFC offers a [Water Resources Outlook](#) page, as well as a [Drought Briefing](#) page.
- The Water Resources Outlook page provides an average mean daily streamflow outlook for the current month, and is a partnership between the NWS, U.S. Geological Survey (USGS), and the U.S. Army Corps of Engineers.

### EnviroHealthLink: Kentucky's Environmental Public Health Tracking Network

Presenter: Colleen Kaelin, Kentucky Department for Public Health

- The Kentucky Department for Public Health (DPH) produced [EnviroHealthLink](#) to provide information and data about how the environment affects human health, including information and answers to questions about air quality, drinking water, cancer, and other topics.

### Use of Existing Drought and Climate Tools

Workshop attendees completed a pre-workshop survey that included questions on existing drought resources and tools and whether or not they use them.

For *Current Monitoring Tools* (Appendix B, Figure i), most respondents use the U.S. Drought Monitor and USGS streamflow data. Respondents were least familiar with the High-Resolution Drought Trigger Tool and the Vegetation Drought Response Index (VegDRI) (Figure 3).

### 2012 Vegetation Drought Response Index (VegDRI)

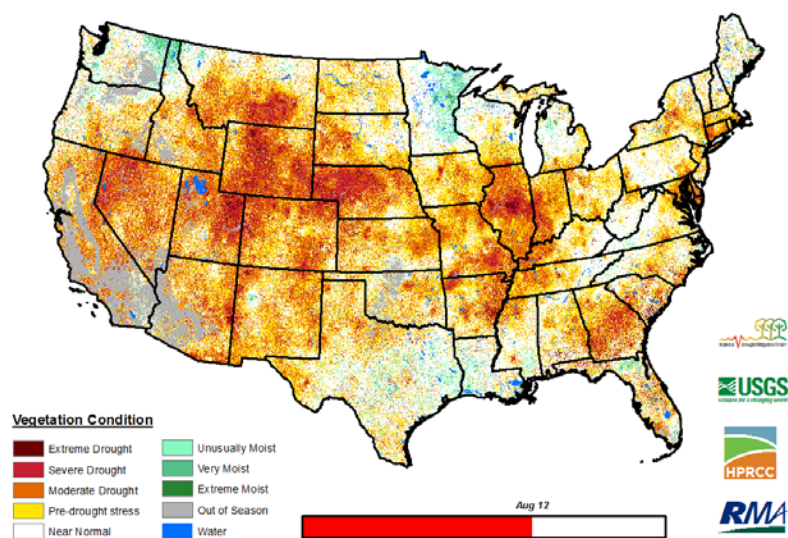


Figure 3: The VegDRI map from August 22, 2012.



For *Drought Outlook Information* (Appendix B, Figure ii), most respondents use the NWS 3-7 or 6-10 Day Outlooks and other monthly or seasonal outlooks from NOAA's Climate Prediction Center (CPC). Respondents were familiar with many of the tools in this category, but were least familiar with the CPC Soil Moisture Forecast and teleconnections like the El Niño Southern Oscillation (ENSO).

For *Drought Impacts, Historical Occurrence, or Managing Drought Tools* (Appendix B, Figure iii), most respondents use the U.S. Drought Monitor Archive and Regional Climate Center (RCC) online databases. Respondents were least familiar with the Drought Risk Atlas from the NDMC.

During the workshops attendees provided feedback on certain tools, suggested additional tools or data they need, and brainstormed what an "ideal" tool or resource would be for drought preparedness and management.

Key suggestions and ideas from the discussion were:

- Identify or create a "one-stop shop" for drought tools and resources, organized by topic, with a clear description of what the user will see and receive as output when using this tool.
- Create a GIS interface that users can use to overlay key drought monitoring information such as streamflow, precipitation, and groundwater levels.
- Develop an "alert system" through which users register to receive notifications (via text or email) when a station or climate division reaches user-identified thresholds (e.g., levels of drought).
- Distribute drought information in a mobile app.
- Gather more information on the impacts of drought (e.g., economic, health, social, agricultural) and connect information from the drought observation and monitoring tools to the potential impacts.

Although there is much data available, workshop attendees suggested additional types of data are either limited or do not exist yet:

- Potential evapotranspiration and evapotranspiration
- Soil moisture deeper than 4 inches
- Frozen ground/frost deeper than 4 inches
- Lake level data for local lakes

Appendix C provides a comprehensive list of existing drought tools. The list was developed collectively by workshop planners and participants.

### Drought Planning, Triggers, and Response - by State and USACE District

Each of the meetings included panels on drought planning, triggers, and response. Participants of these panels included drought planning and coordination leaders from each state and local U.S. Army Corps of Engineers (USACE) representatives. Panelists discussed the development and status of state drought plans, successes and challenges with recent droughts, drought response processes, and drought indicators and triggers. Highlights from each Midwest DEWS state and USACE district:



### Wisconsin

- Wisconsin's drought plan is an annex to the state's Emergency Response Plan, which is led by Wisconsin Emergency Management (WEM). The drought annex was first developed after the 2012 drought, and now is reviewed and updated every two years.
- WEM is the lead coordinator of the drought plan, but they rely on expertise in other state agencies to carry out various pieces of the plan.
- The drought annex identifies severity levels based on the U.S. Drought Monitor, and has a set of actions associated with those severity levels.
- During the drought in 2012, the state established a drought task force. Their biggest success was communication – the task force was able to connect their stakeholders with the resources needed during the drought. For instance, they provided weekly reports to Growers Associations, and developed a “farmer to farmer” website, where farmers with extra hay could sell to others in need throughout the state.
- The biggest challenge for the state has been to encourage partners continue planning for drought when there is no drought occurring.

### Minnesota

- The statewide drought plan for Minnesota was first developed after the 1988 drought and has been updated, but is due for another update.
- Minnesota DNR leads the plan, but it relies on the involvement from several state agencies, as well as outside partners like the USACE.
- The Minnesota drought plan distinguishes each drought “phase” using the U.S. Drought Monitor and average daily streamflow from USGS.
- The statewide drought plan has improved management and communication during times of low flow. However, a recent challenge is conflict between water users since many people need the water.

### Iowa

- In Iowa, drought planning occurs at the local level, and varies from short- to long-term planning. State agencies, primarily the Iowa DNR, assist local governments with their drought planning.
- There are four triggers for drought declaration in Iowa: public petition, “D3” or extreme drought on the U.S. Drought Monitor, the governor's declaration of the drought task force, and/or a committee request from three state agencies.
- When Iowa is in drought, Iowa Homeland Security and Emergency Management takes the lead in mitigation activities, but the Iowa DNR and other agencies assist as well.

### Missouri

- Following the 1988-89 drought, the Missouri state legislature called for a water resources law, which states that Missouri DNR is responsible for protecting the state's water resources. This law also led to the development of a statewide plan for drought.
- The Missouri statewide drought plan is organized into four phases of drought response, which are activated based on various thresholds of the Palmer Drought Severity Index (PDSI). In each phase, a set of actions is defined, which include items such as establishing the Drought Assessment Committee and determining when to activate mandated water conservation.



### Illinois

- In 2011, the state drought plan was developed by the State of Illinois' water and drought task force, which is made up of state agencies and outside partners.
- The state is addressing drought risk through the regional water supply planning partnership between the Illinois DNR and the Illinois State Water Survey. The partnership is conducting a vulnerability assessment to identify communities that would be most at risk during drought. Once they identify drought "at-risk" communities, the DNR works with them to find ways to reduce their risk, such as establishing a backup water source.
- When drought conditions occur or intensify, Illinois DNR calls the drought task force together on a weekly or bi-weekly basis to assess current conditions and outlooks, and to coordinate on drought response across the affected areas.

### Indiana

- The Indiana Drought Response Plan was originally written in 1991, mandated by the legislature after the 1988 drought.
- Indiana DNR monitors potential drought conditions throughout the year, but if there are indicators of drought, they collaborate with other agencies in the state. If drought has been declared, Indiana Department of Homeland Security leads the effort for state coordination.
- For drought indicators, Indiana DNR uses the U.S. Drought Monitor, stream gages, and/or observation wells for groundwater. The response plan has a phased approach (i.e., watch, warning, and emergency), and each phase has various actions for state agencies to put in place (e.g., water conservation tips or mandates, bringing in the National Guard).

### Kentucky

- Although state agency coordination to address drought began in the 1980s and 1990s, Kentucky's statewide drought plan wasn't officially created until 2008. The 2012 flash drought was the first time the state had the opportunity to implement the plan.
- The Kentucky Drought Mitigation Team was established in the 2008 drought plan. As a result, coordination has improved, particularly at the beginning of a drought. The state tries to focus on increasing messaging as the drought worsens in hope that this information will help stakeholders make decisions.
- Based on accurate representation of past drought, in 2016, Kentucky officially made the U.S. Drought Monitor its only drought indicator in the state's plan.

### Ohio

- Ohio developed a statewide drought plan before 2004. The drought indicators in Ohio are the U.S. Drought Monitor and the Standardized Precipitation Index. For the outlook information, the plan uses information from NOAA's Climate Prediction Center.
- In the plan, state agencies work together on the drought assessment committee when conditions get to the "D1" or "D2" level (moderate to severe drought) on the U.S. Drought Monitor.
- In the future, Ohio would like to add more cooperation with surrounding states into their drought plan.



**USACE St. Paul District**

- After the 1988 drought, the USACE and Minnesota DNR developed the “System Wide Low Flow Management Plan – Mississippi River above St. Paul, MN.” In 1992, the USACE St. Paul District developed draft drought contingency plans, which were never officially finalized, but which they still consult during drought.
- The USACE St. Paul District uses low-flow thresholds for various waterway locks throughout the state as their drought triggers. If locks reach these low-flow thresholds, their office publishes this information on the public website.
- During the 2012 drought, successes included better communication with other agencies and improved ability to forecast during drought.

**USACE Rock Island District**

- The USACE Rock Island District’s drought plans are written into the individual reservoir plans.
- The drought index levels in the drought plans have to do with the inflows and pool levels of the various reservoirs. There are specific actions defined for the different index levels, which may include steps like activating the drought committee, reducing release to the base, and allocating water for emergency needs.
- In the plan, states can request additional water from the USACE. In 2012, Iowa tested the request process. The test release was run for eight days to see what effect it would have on the Des Moines River and surrounding areas. Overall, the test run was successful.

**USACE Huntington District**

- The USACE Huntington District drought plans were developed between the 1990s and early 2000s.
- For drought indicators, USACE Huntington uses precipitation totals, the Palmer Drought Severity Index, stream flow, and/or reservoir levels to assess conditions. The action steps within the drought plan tie to specific reservoir and lake levels.
- To respond to drought, the USACE Huntington provides minimum flows to projects downstream, and they have the authority to fill reservoirs early if drought is in the outlook.

**Mesonets in the Midwest Region**

Dr. Stuart Foster, State Climatologist for Kentucky, presented a seminar about mesonets in the Midwest region. He discussed how mesonets fit into the Midwest DEWS and shared lessons learned from building the Kentucky Mesonet and how several partners in the region are working together to increase the use of the mesonet data.

For the Midwest DEWS, mesonets can provide additional and valuable data (e.g., soil moisture, potential evapotranspiration) for researchers to better understand the region’s hydrologic and climatic processes and to better monitor drought status with higher resolution.



Over the last few years, the MRCC and key partners have developed the [Regional Mesonet Program \(RMP\)](#). The RMP is a collaboration of multiple states and mesonet groups, and it offers the opportunity to see the regional value of mesonet data when various networks are brought together. The MRCC creates and hosts online operational product maps from [various mesonet groups](#) around the region, which are updated daily. The RMP has monthly phone calls and annual in-person meetings to improve coordination efforts and develop RMP products.

## WHAT IS A MESONET?

A mesonet is a regional network of observing stations (usually surface stations) designed to diagnose mesoscale weather features and their associated processes. The National Mesonet Program (NMP) brings non-federal meteorological data sources to NOAA for use in operations at Weather Forecast Offices (WFO) and numerical modeling at the National Centers for Environmental Prediction (NCEP).

## Small Group Breakout Summaries

Each workshop included two breakout sessions focused on identifying action items for the Midwest DEWS. Six topics were covered:

- Collection and communication of drought impacts
- Collection and communication of adaptive management capacities
- Support of drought vulnerability assessments
- Leveraging existing citizen science monitoring programs
- Consistent drought messaging across sectors
- Improving the transfer of drought and climate information to stakeholders

Breakout groups brainstormed regional needs for each topic and identified one action that can be done to fill that need within the next two years, including stakeholders that should lead or be involved, deliverables, and timeframe.

Some of the proposed action items would help accomplish more than one of the topics above. Those are described here:

- To provide a regular in-person forum for Midwest DEWS stakeholders to examine and discuss best management practices and response coordination for drought, and collect regional drought impacts and vulnerabilities. Participants proposed having larger regional meetings every other year and smaller sectoral or local meetings in the alternating years. This could be modeled after the [Climate Outreach Community of Practice in the Gulf of Mexico](#).
- To help establish a “Climate Assessment Committee” in each state of the Midwest. This committee would provide state agencies and its partners a regular mode of communication and opportunity for coordination on climate topics (e.g., drought, flood, heat wave) currently affecting the state. This would follow the idea of a “drought task force”, however, it would continue year-round and cover a variety of weather and climate topics, so that the momentum and conversation continues throughout the year. Through these committees, drought impacts could be collected and brought to the national level, consistent drought messaging could be provided across sectors, best management practices could be shared, and the transfer of drought and climate information could be improved to stakeholders.



- There was much discussion at the workshops on how to better engage underrepresented sectors in the Midwest DEWS, such as energy, navigation, public health, in order to better discover their drought information needs and impacts. Ideas on how to increase engagement included attending sector-specific meetings, hosting sector-specific drought forums, starting sector-specific working groups, and/or conducting sector-specific interviews. With many ideas presented at the workshops, NIDIS and its Midwest DEWS partners should take these ideas into consideration and develop a sector-specific outreach strategy.

### Collection and Communication of Drought Impacts

This session highlighted the need for regular collection and communication about the impacts of drought and climate in order to better understand how drought affects the region and its various sectors. Networks to collect, aggregate, analyze, and communicate impacts of drought could be better-developed, particularly outside the agricultural sector. Information on real-time impacts would be useful for U.S. Drought Monitor authors and others. Information on historic impacts, including summaries of recent drought impacts, can also be useful for policy and planning.

Action items proposed to improve the collection and communication of drought impacts include:

- Making use of existing citizen science networks such as [CoCoRaHS](#) (which is already connected to the Drought Impact Reporter) and [mPing](#) to collect drought impact information;
- Developing a communication “tree” for each state, which would show the communication chain of how drought impact reports can go from the local level up to the national level. For example, the communication tree would tell a county Extension agent who they should contact (e.g., state agencies, NWS office) with a drought impact report, which would then be reported by that higher entity to the Drought Impact Reporter.
- Determining a way to standardize reporting across states (e.g., developing a drought survey template that state partners could send to stakeholders), regions and the country for meaningful comparisons; and
- Researching the impact of each drought level (e.g., severe, extreme) on specific sectors (e.g., agriculture, transportation, navigation, municipalities, energy, water quantity, public health, tourism), and tie this information to the U.S. Drought Monitor. Ideally, these impacts would include economic impact as well.

### Collection and Communication of Adaptive Capacities

The Midwest DEWS can help coordinate best management practices (BMPs) that exist across the region for managing and responding to drought and other extreme precipitation. Although some sectors and communities have relatively comprehensive response and management plans in place, others may not. Participants brainstormed possible activities that the Midwest DEWS partnerships could undertake to provide a community of resources, expertise, and guidance.

One of the proposed activities was to establish a drought BMP accessible database for the Midwest, which stakeholders from a variety of locations and sectors can refer to when developing or updating their own BMPs for drought. Before collecting BMPs from pre-existing drought plans, a needs



assessment will be necessary to identify things such as: what information sectors/stakeholders need to be more proactive for a drought or heavy precipitation event; who are the trusted advisors on drought management plans; how would more drought awareness and planning be beneficial for their sector; and what are the costs/benefits of having an action plan and revisiting it on a regular basis.

### Support of Drought Vulnerability Assessments

Drought vulnerability assessments are of interest to stakeholders but there are challenges in doing them. Few have been done on a large scale, and those were costly, but also comprehensive. Workshop participants brainstormed ways to start doing more vulnerability assessments in the Midwest DEWS.

Participants want to better understand the use of and dependence on river systems to support public, economic, and environmental interests in the Midwest, and how these are affected by drought. Participants suggested developing vulnerability (including resiliency) assessments focused on the Upper Mississippi River Basin and on the Ohio River Basin.

Participants also supported using vulnerability assessments to better understand the utilization of and dependencies upon aquifers which support diverse population, agricultural, and environmental interests in the Midwest. These assessments would be useful for enhancing coordination and cooperation during drought and would focus on major aquifer systems in the region. Particular focus would be on areas where agricultural and municipal water supplies depend on groundwater, as well as where conflicts currently exist or are anticipated to occur in the future.



Figure 4: A small break-out group during the November 9-10 workshop in Cedar Rapids, Iowa.



Participants suggested the following next steps:

- Engage stakeholders (e.g., water utilities, power plants, manufacturing and processing industries, navigation and transportation companies, USACE, etc.) and others that depend upon river systems, to develop or further enhance channels of communication and understanding of potentially competing needs for water;
- Engage agricultural, municipal, and other stakeholders or their representatives that depend upon aquifers to develop or further enhance channels of communication and understanding of potentially competing needs for water;
- Invest in monitoring systems for precipitation, soil moisture, streamflow, and groundwater to enhance understanding of the capacity and resilience of systems to meet current and future demands during periods of drought; and
- Identify challenges and opportunities for collaborative policy and decision making.

### Leveraging Existing Citizen Science Monitoring Programs

Workshop participants called for a dense spatial network of observations to improve both drought indicators and collection of impacts. Citizen science programs can play a key role in providing such observations as a complement to existing automated and institutional observing networks. These programs can help inform decisions and subsequent actions of drought response and mitigation at the state and local levels. Expanding and enhancing the value of citizen science involves three strategic actions: (1) engagement with members of state drought task forces, (2) development of enhanced tools for querying, analyzing, summarizing, and otherwise utilizing observations, and (3) development of effective marketing programs to expand participation and strengthen commitment of citizen science volunteers.

Participants suggested these actions begin with outreach by NIDIS through its partners, including the NDMC, to state drought task forces in an effort to build relationships and understand current capabilities and needs. Becoming familiar with the needs of task forces will drive the improvement of database query and analysis capabilities, ultimately making the databases more valuable for response and mitigation efforts.

The second action is to engage with operators of citizen science programs, including the [Community Collaborative Rain Hail & Snow Network](#) (CoCoRaHS), [mPING](#) app, the Southern Climate Impacts Planning Program's Field Photo Weekends, and other state-level programs, to develop formal specifications required to enhance the value of databases of drought indicators and impacts.

The actions will help create an independently-managed interstate marketing program. This program should include print, audio, and video presentations as well as templates for press releases and feature news stories highlighting citizen science programs. Marketing efforts should also be leveraging social media. The support and leadership of drought task force members, including representatives of state climate offices and NWS Forecast offices, is expected to enhance the effectiveness of marketing, which will encourage commitment from citizen science volunteers, and add value to citizen science programs.



## Consistent Drought Messaging Across Sectors

Drought information is prepared by and delivered to stakeholders by a number of agencies, and while the basic information is often similar, the messages may vary widely. To better understand the mechanisms for delivering information, what messages are being provided and whether or not they are sufficient, it is important to explore the following questions:

- How do federal, tribal, state or municipal governments communicate to the public about drought severity so they may take appropriate actions?
- Does messaging at all levels of drought severity need to be communicated in the same manner to all sectors (e.g., agriculture, energy, ecosystems, health, industry/manufacturing)?
- Who should make these decisions and are there structures in place at all those levels to do so?

Workshop participants shared ideas and projects to help answer these questions:

- The Midwest DEWS would identify appropriate drought task forces and/or communication managers, and would provide a messaging platform for them share successful practices. Recommendations for creating state drought communication plans for cross-sector messaging could be provided.
- The Midwest DEWS could work closely with state entities and/or drought task forces on building a state-centric and sector-specific web page for drought information (e.g., policy, monitoring, aid, briefings with predictions). Examples include the [Iowa Water Summary Update](#) or [Wyoming's water resource briefings](#). Sector-specific information would require engagement with the sectors, as well as the state.
- The Midwest DEWS could work with journalists and news reporters to understand their needs for drought messaging, and suggest ways to most accurately message drought, its impacts, and related predictions. One way to accomplish this would be to engage through the NWS-hosted "Integrated Warning Team" meetings around the country, which gathers the media, storm spotters, and emergency managers on weather-related topics.

## Improving Transfer of Drought Information to Stakeholders

How does the Midwest DEWS improve stakeholder access to drought information? Workshop participants called for a drought information needs assessment across many sectors (e.g., navigation, energy, public health, agriculture). This sector-based assessment would determine what data is needed to better plan for and mitigate the impacts of drought, what lead time each sector needs to make decisions regarding drought, and whether sector-specific information is important for decision-making. This could be done through surveys, interviews, focus groups, or utilizing existing surveying efforts through the USDA Midwest Climate Hub. Once the needs assessment is completed, NIDIS would use this information to inform an update to the Midwest DEWS page on drought.gov, based on the stakeholder needs.

Workshop participants also discussed developing an option that would allow stakeholders to directly receive drought information. The user could customize information preferences (e.g., "when my region goes into D2") and platform (e.g., text message, e-mail). Some regional partners, like the MRCC and the State Climate Office of Ohio (SCOO), are interested in developing such an alert system. Collaborating with key partners like MRCC and the SCOO, this system could be tested in a pilot region and then expanded to all Midwest states.



Finally, another action is to develop a drought watershed decision support tool platform, which would be modeled off the Iowa Watershed Decision Support System (IoWaDSS) that was used during the [Cedar Rapids Multi-Hazard Tournament](#). Associated activities include: defining the audience, assembling a tool creation team, defining an appropriate host for the tool, and identifying the appropriate data sources for the tool. Stakeholder input would be essential throughout the process. After implementation, the creation team would arrange usability studies to test its effectiveness. The workshop participants thought that the MRCC and NIDIS could co-lead this effort, with integral participation from other partners like the National Water Center, USACE, NWS, etc.



## Appendix A: Midwest Drought Project Matrix

Region-Wide Drought-Related Projects				
Project	Agencies/Entities Involved	Funding Source	Project Dates (or Ongoing)	Contact Affiliation
Midwest Quarterly Climate Impacts and Outlook Report	NOAA, MRCC, American Association of State Climatologists (AASC), NIDIS, USDA, and others	NOAA	Ongoing	Doug Kluck (NOAA)
Central Region Monthly Climate Summary and Outlook Webinars	NOAA, AASC, MRCC/High Plains RCC, USDA, NDMC	NOAA	Ongoing	Doug Kluck (NOAA)
Animal Agriculture in a Changing Climate	Livestock and Poultry Environmental Learning Center, Univ. of MN, Univ. of Georgia, Cornell, WA State Univ., Texas A & M, Univ. of Nebraska	USDA NIFA	6-year project; ended Feb. 2017	David Schmidt (Univ. of Minnesota)
Ag-Climate Decision Support Tools Suite from . <a href="#">Available here.</a>	Useful 2 Usable (U2U) partners (numerous Midwest universities), MRCC, ISWS	USDA	Ended April 2016	Melissa Widhalm (Purdue)
Expanding the Role of Extension Professionals in National Drought Monitoring	Land Grant Universities and North Central Region Water Network	NCRWN	Ongoing	Hans Schmitz (Purdue)
Incorporating Climate Science into Local Planning Efforts	American Planning Association, Chicago Metropolitan Agency for Planning, ISWS, MRCC	NOAA-SARP	Ends June 2018	Jim Angel (ISWS)
OH River Forecast Center Water Resources 1-3 Month Outlook for Droughts and Floods	NOAA, NWS, OHRFC	NOAA, NWS, OHRFC	Ongoing	Jim Noel (OHRFC)
Monthly and Seasonal Climate Summaries – Drought Impact Statement when D2 or worse	NWS, NOAA	NWS, NOAA	Ongoing	Sam Lashley; Ashley Novak (NWS)



<b>Minnesota and Wisconsin Drought-Related Projects</b>				
<b>Project</b>	<b>Agencies/Entities Involved</b>	<b>Funding Source</b>	<b>Project Dates (or Ongoing)</b>	<b>Contact Affiliation</b>
System Wide Low Flow Management Plan, Mississippi River above St. Paul, MN	MN DNR, USGS, USACE, NWS, hydropower and reservoir facility owners, power companies, local units of government, tribal government		Ongoing	Greg Kruse Judy Boudreau (MN DNR)
Minnesota Statewide Drought Plan	MN DNR, Metropolitan Council, USACE, Bureau of Indian Affairs, MN Chippewa Tribal Government, Governor's Office, MN Pollution Control Agency, NWS, USGS, MN Dept. of Ag, MN Dept. of Health, MN Board of Water and Soil Resources		Ongoing	Jason Moeckel Greg Kruse (MN DNR)
Minnesota State Drought Task Force	Various federal, state, and local government		Ongoing	Jason Moeckel Greg Kruse (MN DNR)
Report to the Legislature: Definitions and thresholds for negative impacts to surface waters	MN DNR with stakeholder advisory group		December 2015	Jason Moeckel (MN DNR)
Island Lake Reservoir Technical Committee	Minnesota Power, MN DNR, NWS, Residents		Ongoing	Craig Schmidt (NOAA NWS)

<b>Iowa and Missouri Drought-Related Projects</b>				
<b>Project</b>	<b>Agencies/Entities Involved</b>	<b>Funding Source</b>	<b>Project Dates (or Ongoing)</b>	<b>Contact Affiliation</b>
Quantification and Water Quality Assessment of a Recharge Basin (Rural System #1)	Iowa Geological Survey (IGS-IIHR); Iowa DNR	Iowa DNR; Rural Water System #1	Ends June 30, 2017	Mike Gannon (IGS-IIHR)



Quantification and Water Quality Assessment of a Low-Head Dam at Osceola County Rural Water District (OCRWD)	IGS-IIHR; Iowa DNR	Iowa DNR; OCRWD	Ends June 30, 2017	Mike Gannon (IGS-IIHR)
Monthly and Bi-Monthly Water Summary Update for Iowa	Iowa DNR, USGS, Iowa Department of Ag and Land Stewardship, IGS-IIHR		Ongoing	Tim Hall (Iowa DNR)
Developing an Online Drought Curriculum for Extension Employees and Public	University of MO Extension; Univ of MO Ag Education	Univ. of MO Extension	Ongoing	Pat Guinan (MO State Climatologist)
Re-Evaluation and Update of the Des Moines River Regulation Plan (including low water/drought operations)	USACE, various stakeholders, public involvement	USACE	Ongoing	Maren Stoflet (USACE)
Sustainable Rivers Project – Des Moines and Raccoon Rivers (Iowa)	USACE, Nature Conservancy, Iowa DNR, NRCS, Iowa Flood Center	USACE-IWR; Nature Conservancy	Ongoing	Maren Stoflet (USACE)

Illinois and Indiana Drought-Related Projects				
Project	Agencies/Entities Involved	Funding Source	Project Dates (or Ongoing)	Contact Affiliation
Illinois State Water Plan Task Force	IL State Water Survey (ISWS), IL State Geological Survey, IL DNR, and other state agencies	IL DNR	Ongoing	Wes Cattoor (IL DNR)
Illinois Drought Response Task Force	ISWS, IL DNR, and other state agencies	IL DNR	Ongoing	Wes Cattoor (IL DNR)
Providing Input into the U.S. Drought Monitor	ISWS		Ongoing	Jim Angel (ISWS)
Water Supply Planning for the Middle Illinois Region	ISWS	IL DNR	Ongoing	Walt Kelly (ISWS)
Water Supply Planning for Kankakee Watershed	ISWS	IL DNR	Ongoing	Walt Kelly (ISWS)



Water Supply Planning for Northwestern Illinois Region	ISWS	IL DNR	Ongoing	Walt Kelly (ISWS)
Indiana's Water Shortage Plan	IN DNR, IN Dept. of Homeland Security, IN Dept. of Environmental Management	IN DNR	Ongoing	Mark Basch (IN DNR)
Indiana Volunteer Monitoring Network	IN DNR, USGS	IN DNR	Ongoing	Mark Basch (IN DNR)
Coop/CoCoRaHS Weather Station Monitoring of Temperature, Precipitation, and Evapotranspiration (Northern IN)	NWS, NOAA	NWS, NOAA	Ongoing	Sam Lashley (NWS)

### Ohio and Kentucky Drought-Related Projects

Project	Agencies/Entities Involved	Funding Source	Project Dates (or Ongoing)	Contact Affiliation
Climate and Health Workgroup	KY Department for Public Health (DPH)	Environmental Public Health Tracking	Ongoing	Colleen Kaelin (KY DPH)
Children's Environmental Health Summit	KY DPH	Environmental Public Health Tracking	December 1, 2016	Janie Cambron (KY DPH)
CSTE Climate and Disaster Epidemiology Workgroups	Council of State and Territorial Epidemiologists	CSTE	Ongoing	Jessica Wurster (CSTE)
EnviroHealthLink website	KY DPH	KY DPH	Ongoing	Colleen Kaelin (KY DPH)
EnviroHealthLink Mini-Grant Projects to Green River District Health Department and Louisville Metro Health and Wellness	KY DPH - EnviroHealthLink Program	Environmental Public Health Tracking	June 2016-Sept. 2017	Colleen Kaelin (KY DPH)
Kentucky Agriculture Science and Monitoring Committee	USGS, KY Geological Survey, KY Climate Center, and others	Various	Ongoing	Pete Cinotto



## Appendix B: Pre-Workshop Survey Results on Use of Existing Drought Tools

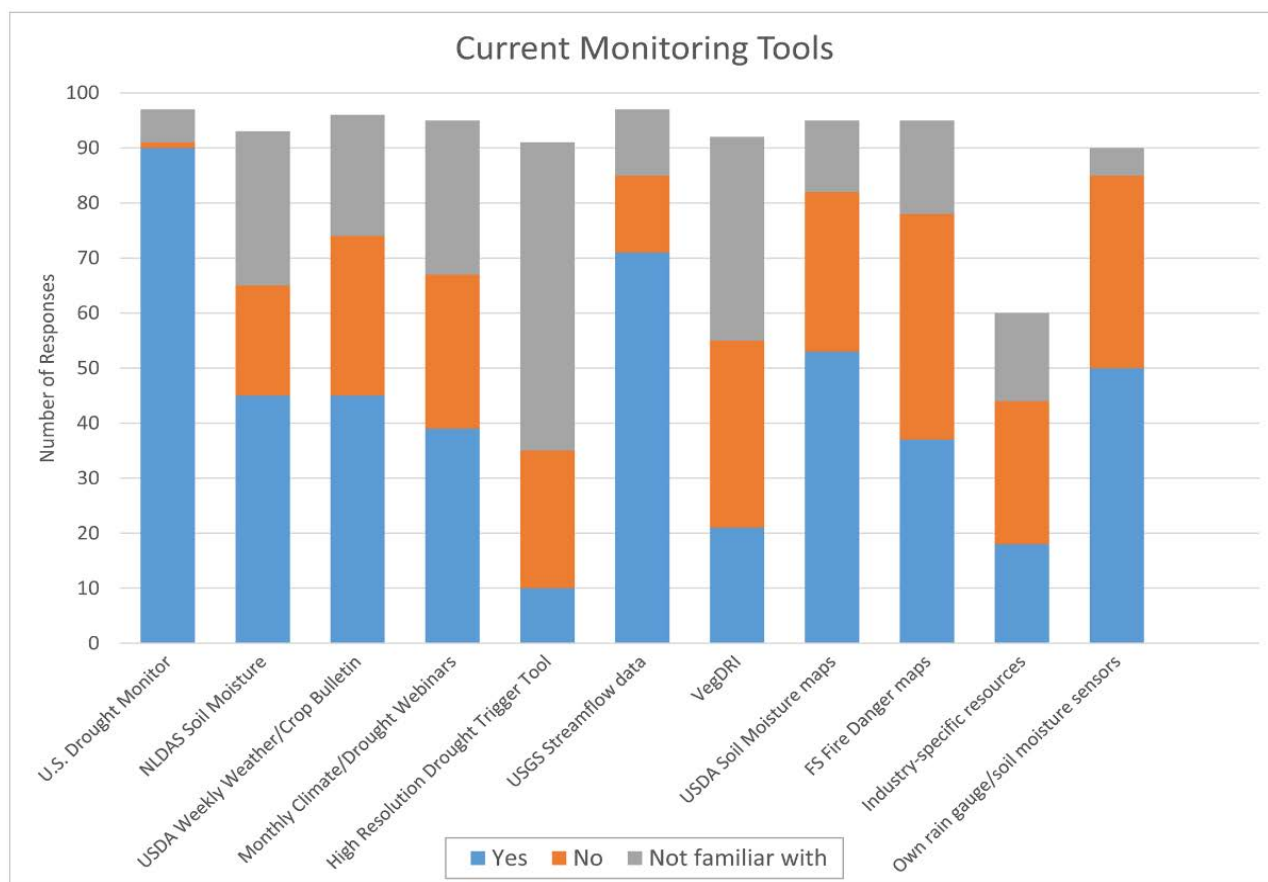


Figure i: Results from the pre-workshop survey (all four workshops combined) on how attendees use, do not use, or are not familiar with existing drought monitoring tools.





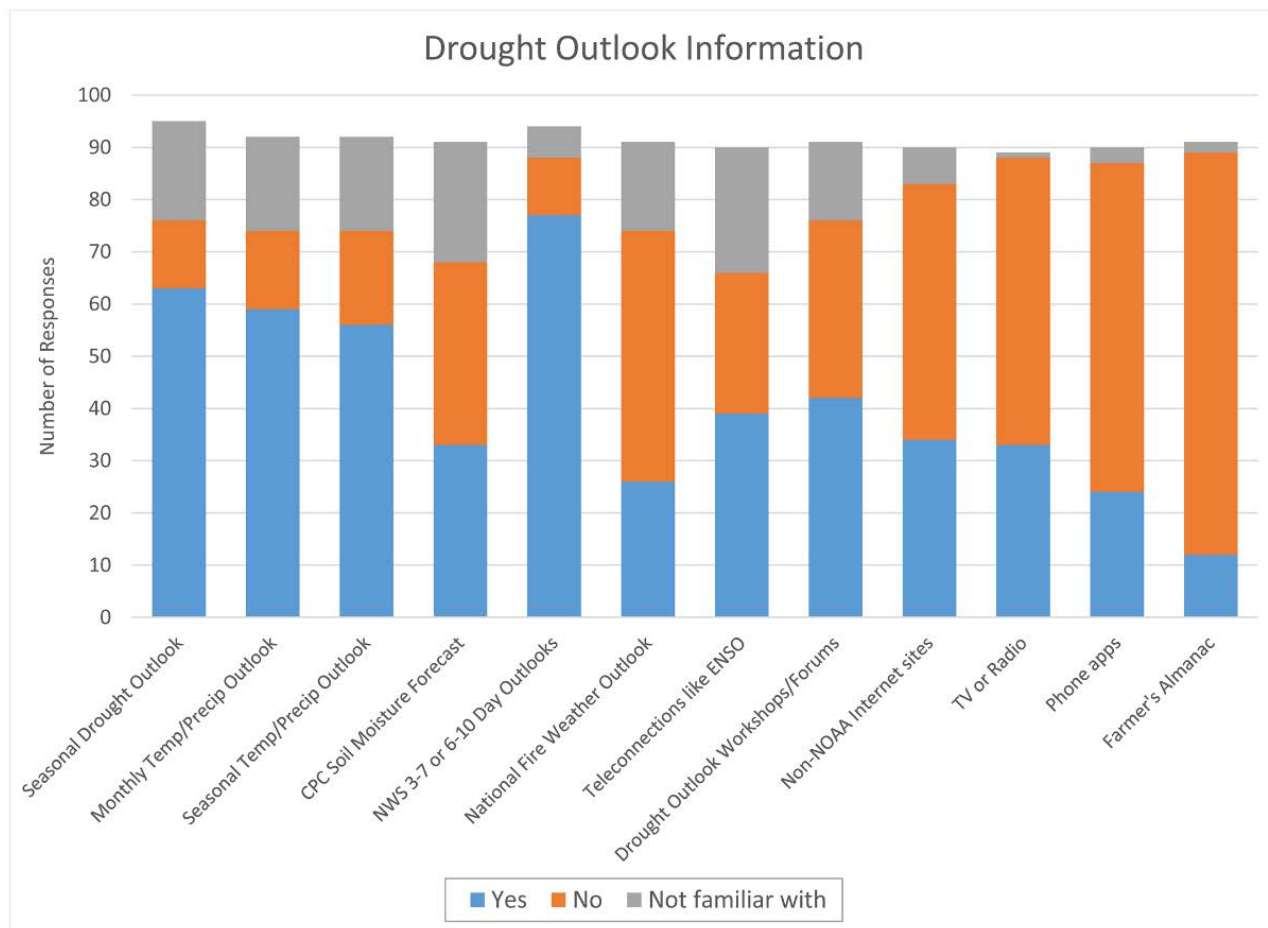


Figure ii: Results from the pre-workshop survey (all four workshops combined) on how attendees use, do not use, or are not familiar with existing drought outlook informational tools and resources.



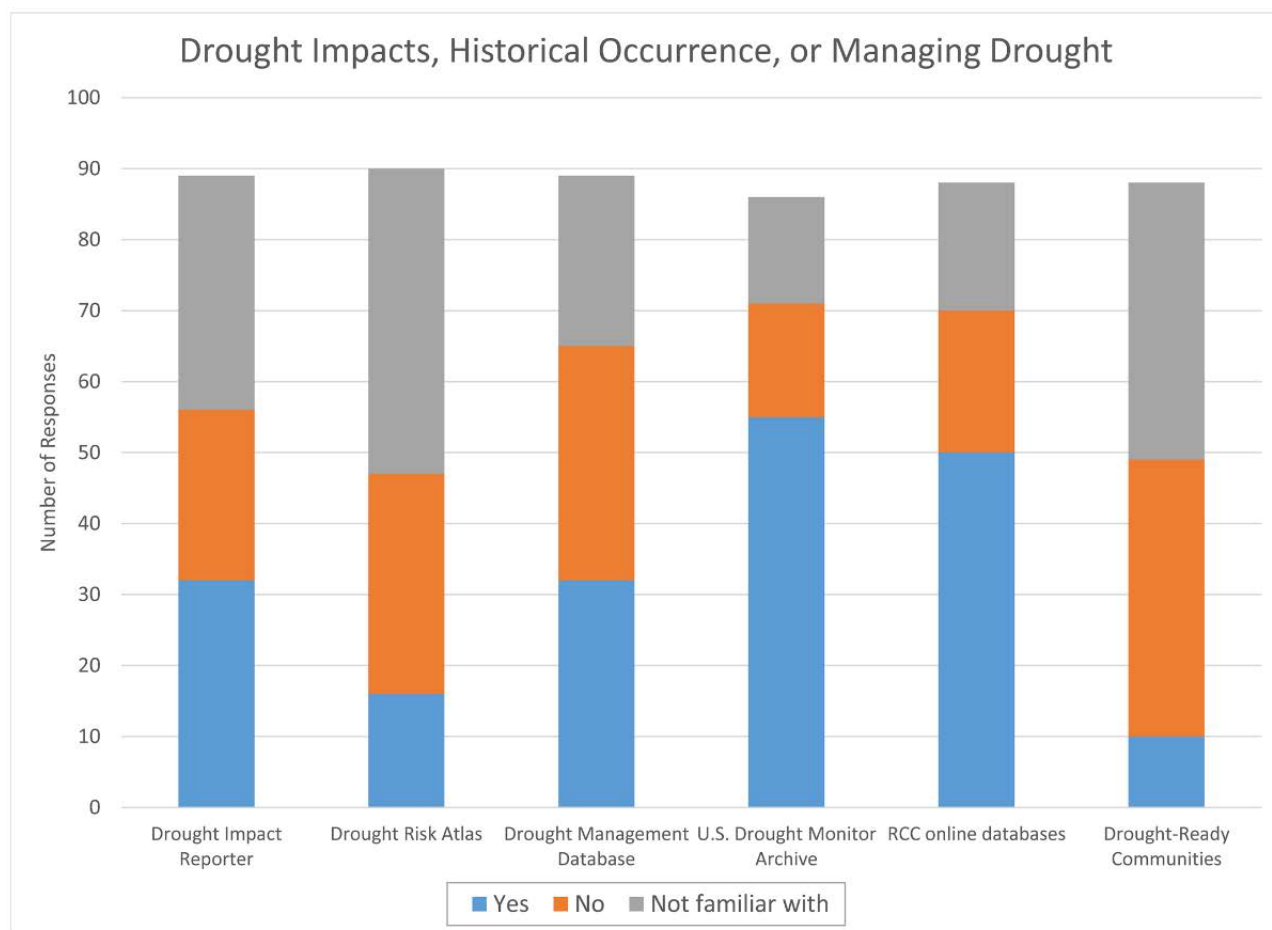


Figure iii: Results from the pre-workshop survey (all four workshops combined) on how attendees use, do not use, or are not familiar with existing tools or resources for drought impacts, historical occurrence, or managing drought.



## Appendix C: List of Existing Drought Tools with URL

This list is also available in [PDF format](#) through the Midwestern Regional Climate Center's website.

### Current Monitoring Data and Tools

Tool	URL
U.S. Drought Monitor	<a href="http://droughtmonitor.unl.edu/">http://droughtmonitor.unl.edu/</a>
Midwest Climate Watch	<a href="http://mrcc.isws.illinois.edu/cliwatch/watch.htm">http://mrcc.isws.illinois.edu/cliwatch/watch.htm</a>
cli-MATE	<a href="http://mrcc.isws.illinois.edu/CLIMATE/">http://mrcc.isws.illinois.edu/CLIMATE/</a>
State climate offices	<a href="https://www.stateclimate.org/">https://www.stateclimate.org/</a>
Monthly Great Plains and Midwest Climate/Drought Webinars	<a href="http://mrcc.isws.illinois.edu/multimedia/webinars.jsp">http://mrcc.isws.illinois.edu/multimedia/webinars.jsp</a>
High Resolution Drought Trigger Tool	<a href="http://climate.ncsu.edu/drought">http://climate.ncsu.edu/drought</a>
<b>Drought Indices</b>	
Crop Moisture Index	<a href="http://www.cpc.noaa.gov/products/analysis_monitoring/regional_monitoring/cmi.gif">http://www.cpc.noaa.gov/products/analysis_monitoring/regional_monitoring/cmi.gif</a>
Estimated Precipitation Needs	<a href="http://www.cpc.noaa.gov/products/analysis_monitoring/regional_monitoring/addpcp.gif">http://www.cpc.noaa.gov/products/analysis_monitoring/regional_monitoring/addpcp.gif</a>
Evaporative Stress Index (ESI)	<a href="https://www.climate.gov/maps-data/dataset/evaporative-stress-index-maps">https://www.climate.gov/maps-data/dataset/evaporative-stress-index-maps</a>
Evaporative Demand Drought Index (EDDI) ( <i>experimental product</i> )	<a href="http://wwa.colorado.edu/publications/reports/EDDI_2-pager.pdf">http://wwa.colorado.edu/publications/reports/EDDI_2-pager.pdf</a>
Keetch-Byram Drought Index	<a href="http://mrcc.isws.illinois.edu/VIP/indexKBDI.html">http://mrcc.isws.illinois.edu/VIP/indexKBDI.html</a>
Palmer Drought Severity Index	<a href="http://www.cpc.noaa.gov/products/analysis_monitoring/regional_monitoring/palmer.gif">http://www.cpc.noaa.gov/products/analysis_monitoring/regional_monitoring/palmer.gif</a>
Palmer Z-Index	<a href="https://www.ncdc.noaa.gov/oa/climate/research/prelim/drought/palmer.html">https://www.ncdc.noaa.gov/oa/climate/research/prelim/drought/palmer.html</a>
Standardized Precipitation Index	<a href="https://www.ncdc.noaa.gov/oa/climate/research/prelim/drought/spi.html">https://www.ncdc.noaa.gov/oa/climate/research/prelim/drought/spi.html</a>
Vegetation Drought Response Index (VegDRI)	<a href="http://vegdri.unl.edu/">http://vegdri.unl.edu/</a>
<b>Regional/Nationwide Network Data</b>	
Regional/national data networks	<a href="http://mrcc.isws.illinois.edu/data_serv/dataNetworks_regl.jsp">http://mrcc.isws.illinois.edu/data_serv/dataNetworks_regl.jsp</a>
USDA Soil Moisture Maps	<a href="http://www.cpc.ncep.noaa.gov/products/monitoring_and_data/topsoil.shtml">http://www.cpc.ncep.noaa.gov/products/monitoring_and_data/topsoil.shtml</a>
VIC Soil Moisture	<a href="http://www.hydro.washington.edu/forecast/monitor/">http://www.hydro.washington.edu/forecast/monitor/</a>
NLDAS Drought Monitor Soil Moisture	<a href="http://www.emc.ncep.noaa.gov/mmb/nldas/drought/">http://www.emc.ncep.noaa.gov/mmb/nldas/drought/</a>



USGS Streamflow Data	<a href="http://waterdata.usgs.gov/nwis/rt">http://waterdata.usgs.gov/nwis/rt</a>
USGS Groundwater Data for the Nation	<a href="https://waterdata.usgs.gov/nwis/gw">https://waterdata.usgs.gov/nwis/gw</a>
RiverGages.com: Water Levels of Rivers and Lakes (USACE)	<a href="http://rivergages.com">http://rivergages.com</a>
USACE Water Resources Data	<a href="https://water.usace.army.mil/">https://water.usace.army.mil/</a>
Condition Monitoring Reports from CoCoRaHS	<a href="http://www.cocorahs.org/ViewData/ListconditionmonitoringReports.aspx">http://www.cocorahs.org/ViewData/ListconditionmonitoringReports.aspx</a>
Evapotranspiration Data from CoCoRaHS	<a href="http://www.cocorahs.org/Content.aspx?page=et">http://www.cocorahs.org/Content.aspx?page=et</a>
Potential Evapotranspiration from the Regional Mesonet Program	<a href="http://mrcc.isws.illinois.edu/cliwatch/mesonets/soilTemp.html">http://mrcc.isws.illinois.edu/cliwatch/mesonets/soilTemp.html</a>
<b>State-Specific Data</b>	
State mesonet data	<a href="http://mrcc.isws.illinois.edu/data_serv/dataNetworks.jsp">http://mrcc.isws.illinois.edu/data_serv/dataNetworks.jsp</a>
Illinois High-Resolution Precipitation Data	<a href="http://www.isws.illinois.edu/atmos/statecli/mpe-maps/mpe-maps.htm">http://www.isws.illinois.edu/atmos/statecli/mpe-maps/mpe-maps.htm</a>
STORMS (State of Ohio Rain Monitoring System)	<a href="http://storms2.ema.state.oh.us/home.php">http://storms2.ema.state.oh.us/home.php</a>
<b>Sector-Specific Resources</b>	
Forest Service Fire Danger Maps	<a href="http://www.wfas.net/index.php/fire-danger-rating-fire-potential--danger-32">http://www.wfas.net/index.php/fire-danger-rating-fire-potential--danger-32</a>
Percentage of Crops and Livestock Located in Drought (USDA)	<a href="https://www.usda.gov/oce/weather/Drought/AgInDrought.pdf">https://www.usda.gov/oce/weather/Drought/AgInDrought.pdf</a>
USDA Weekly Weather and Crop Bulletin	<a href="http://www.usda.gov/oce/weather/pubs/Weekly/Wwcb/">http://www.usda.gov/oce/weather/pubs/Weekly/Wwcb/</a>

### Drought Forecast or Outlook Information

Tool	URL
CPC Seasonal/Monthly Drought Outlook	<a href="http://www.cpc.ncep.noaa.gov/">http://www.cpc.ncep.noaa.gov/</a>
CPC Monthly Temp/Precip Outlook	<a href="http://www.cpc.ncep.noaa.gov/">http://www.cpc.ncep.noaa.gov/</a>
CPC Seasonal Temp/Precip Outlook	<a href="http://www.cpc.ncep.noaa.gov/">http://www.cpc.ncep.noaa.gov/</a>
CPC Soil Moisture Forecast	<a href="http://www.cpc.ncep.noaa.gov/soilmst/mrf.shtml">http://www.cpc.ncep.noaa.gov/soilmst/mrf.shtml</a>
CPC U.S. Hazards Outlook	<a href="http://www.cpc.ncep.noaa.gov/products/predictions/threats/threats.php">http://www.cpc.ncep.noaa.gov/products/predictions/threats/threats.php</a>
NWS 3-7 or CPC 6-10 Day Outlooks	<a href="http://www.wpc.ncep.noaa.gov/medr/medr.shtml">http://www.wpc.ncep.noaa.gov/medr/medr.shtml</a> <a href="http://www.cpc.ncep.noaa.gov/products/predictions/610day/">http://www.cpc.ncep.noaa.gov/products/predictions/610day/</a>
National Fire Weather Outlook	<a href="http://www.srh.noaa.gov/ridge2/fire/">http://www.srh.noaa.gov/ridge2/fire/</a>



Teleconnection information like ENSO	<a href="http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/ensso.shtml">http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/ensso.shtml</a>
U2U Climate Patterns Viewer	<a href="https://mygeohub.org/groups/u2u/cpv">https://mygeohub.org/groups/u2u/cpv</a>
Eastern Area Coordination Center Outlooks	<a href="https://gacc.nifc.gov/eacc/predictive_services/outlooks/outlooks.htm">https://gacc.nifc.gov/eacc/predictive_services/outlooks/outlooks.htm</a>
Farmer's Almanac	<a href="http://www.almanac.com/">http://www.almanac.com/</a>

## Historical Drought Occurrence, Drought Impacts, or Managing Drought

Tool	URL
NDMC Drought Impact Reporter	<a href="http://droughtreporter.unl.edu/map/">http://droughtreporter.unl.edu/map/</a>
NDMC Drought Risk Atlas	<a href="http://droughtatlas.unl.edu/">http://droughtatlas.unl.edu/</a>
NDMC Drought Management Database	<a href="http://drought.unl.edu/droughtmanagement/Home.aspx">http://drought.unl.edu/droughtmanagement/Home.aspx</a>
U.S. Drought Monitor Archive	<a href="http://droughtmonitor.unl.edu/MapsAndData/MapArchive.aspx">http://droughtmonitor.unl.edu/MapsAndData/MapArchive.aspx</a>
Regional Climate Center online databases (e.g., ACIS, cli-MATE)	<a href="http://www.rcc-acis.org/">http://www.rcc-acis.org/</a> <a href="http://mrcc.isws.illinois.edu/CLIMATE/">http://mrcc.isws.illinois.edu/CLIMATE/</a>
Drought-Ready Communities: A Guide to Community Drought Preparedness	<a href="http://drought.unl.edu/Planning/PlanningProcesses/DroughtReadyCommunities.aspx">http://drought.unl.edu/Planning/PlanningProcesses/DroughtReadyCommunities.aspx</a>
Climate at a Glance	<a href="https://www.ncdc.noaa.gov/cag/">https://www.ncdc.noaa.gov/cag/</a>
Risk Management Agency Data Indemnity Maps	<a href="http://www.rma.usda.gov/data/indemnity/">http://www.rma.usda.gov/data/indemnity/</a>
Useful to Usable (U2U) Decision Support Tools	<a href="https://mygeohub.org/groups/u2u">https://mygeohub.org/groups/u2u</a>



## Appendix D: Summary of Post-Workshop Survey Results

Following the Midwest DEWS regional workshops in Minnesota, Iowa, Illinois, and Ohio that took place in November and December 2016, an online evaluation survey was sent to workshop participants. Of the 113 participants invited to take the survey, 41 responded. Their responses are summarized below.

Overall, respondents said the workshop was *very to extremely effective* for improving communication about drought among sectors, government levels and geographic areas, as well as for learning from others how they monitor and respond to drought, plan for drought, and/or deal with drought challenges. In addition, they thought the workshop was *moderately to very effective* for developing strategies that improve drought early warning and resiliency in the Midwest (Table 1).

	<i>Extremely effective</i>	<i>Very effective</i>	<i>Moderately effective</i>	<i>Slightly effective</i>	<i>Not effective at all</i>
Improving communication	22%	51%	20%	7%	0%
Learning about drought management	15%	59%	24%	2%	0%
Developing drought early warning strategies	10%	32%	51%	7%	0%

Table 1: Respondent results for the question, "In general, how effective was this workshop for each of the following?"

### Workshop Outcome: Communication and Networking

100% of the respondents said they met a person they did not know before who could be a beneficial contact in the future, and 85% said they identified and/or discussed potential collaborations for the future. These responses demonstrate the effectiveness of the workshop in improving communication and learning from others. One person elaborated, "As someone who is relatively new to the drought community, it was great to meet with colleagues and learn from experts in the field, gaining valuable knowledge and building connections with those I may be working with in the future." Another said, "It was a great opportunity to collaborate with people working in the drought field and to see what their experiences have been related to working with my agency and what we can do better."

Over 85% of respondents said it was somewhat to extremely likely that they would pursue new collaborations because of the workshop. Most (83%) also said they planned to learn more about drought management and over 70% said that they would consider a different approach to drought-related problems. One person described how the workshops helped them consider new approaches, saying, "I came away with a better understanding of how my counterparts in other states deal with drought. This gave me a better perspective for assessing activities within my own state." Another said, "I had not had any exposure to drought planning to date. But as a local [county] planner I now have a greater understanding of the tools and resources available to move drought planning onto our local planning radar." Another respondent asked that future DEWS workshops also include opportunities to learn from other DEWS regions.



### Workshop Outcome: Use of Drought Tools and Resources

Each workshop included a focus on drought management tools and resources. After the workshops, respondents said they were most likely to use the U.S. Drought Monitor and MRCC website, but also said that they were likely to use many of the other tools presented (Figure iv).

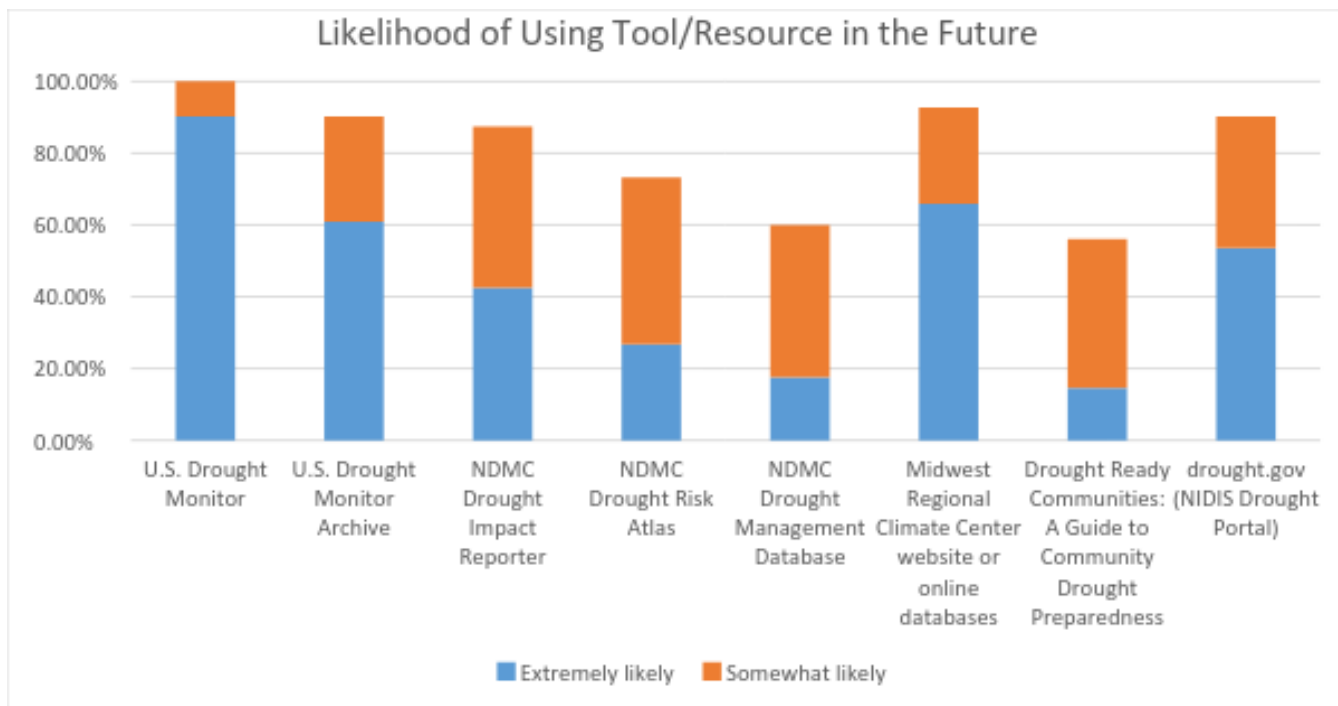


Figure iv: Respondent results for the question, “Based on your current knowledge of each of the following, please indicate how likely it is that you will consult the tool, resource, or process in the future.”



### Workshop Outcome: Shaping the Future of the Midwest DEWS

Workshop participants felt that the most important function of the Midwest DEWS should be to foster a collaborative network of drought-focused water, land, and climate professionals throughout the region, while also showing support for a range of other potential DEWS functions (Figure v).

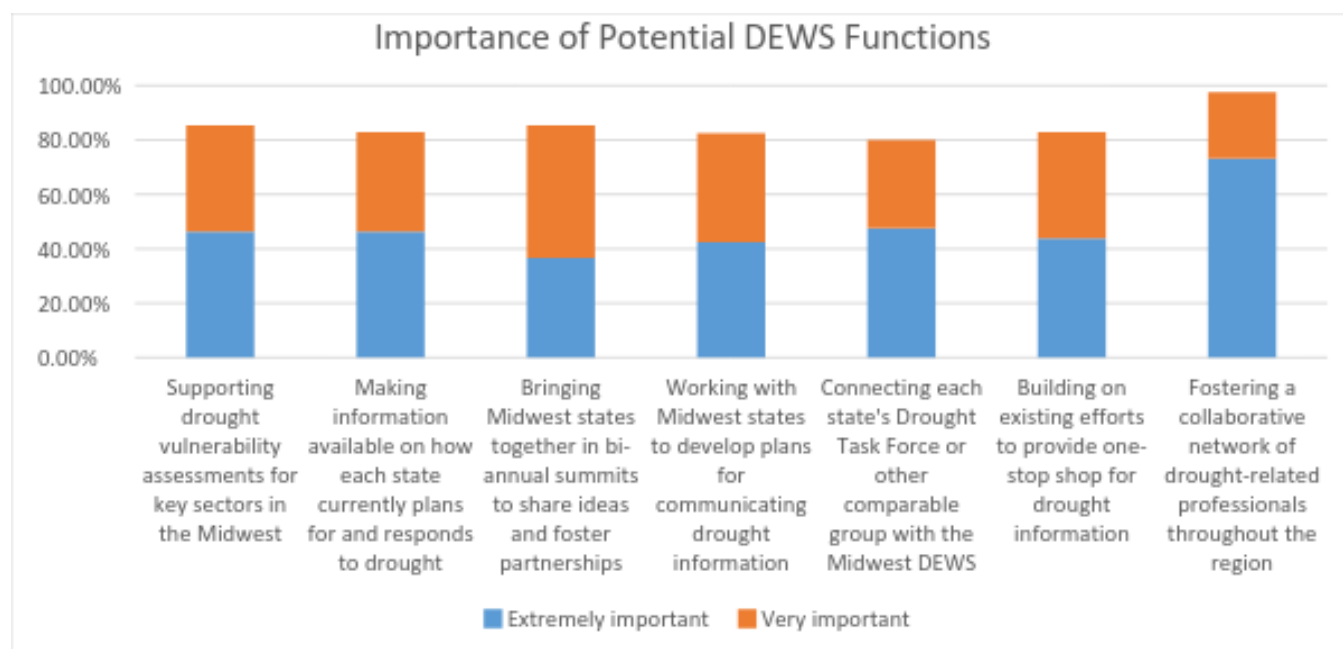


Figure v: Respondent results for the question, "How important is it to you that the Midwest DEWS address each of the following?"

