# National Integrated Drought Information System (NIDIS) Workshop: Status of Drought Early Warning Systems in the United States June 17-19, 2008 Kansas City, Missouri

## Workshop Report

The National Integrated Drought Information System Act, (Public Law 109-430, December 2006):
"An Act to establish a National Integrated Drought Information System within the National Oceanic and Atmospheric Administration to improve drought monitoring and forecasting capabilities."

**Workshop Description**
The National Integrated Drought Information System (NIDIS), established by federal law in 2006, is responsible for improving drought early warning through research and through more targeted information dissemination. Five technical working groups, focused around critical aspects of drought risk assessment and decision support, were created to provide guidance on the implementation of NIDIS in the following areas: (1) education and public awareness, (2) integrated monitoring and forecasting, (3) interdisciplinary research and applications for risk assessment, (4) engaging the preparedness communities, and (5) the web-based drought portal for improving accessibility to usable drought risk information (NIDIS Implementation Plan, 2007).

As a step towards developing a drought early warning system, NIDIS implementation team members conducted a knowledge and service assessment workshop in June 2008 in Kansas City, Missouri, to discuss the status of Drought Early Warning Systems across the United States. The workshop brought together over 100 people, including researchers, decision-makers, and drought planners representing tribes, states and key sectors such as agriculture, energy, and water suppliers. Participants included representatives from local, state, federal, and tribal agencies, as well as academic institutions and private entities. This workshop marked one of the first times that such a wide variety of drought stakeholders from across the U. S. were brought together to discuss their drought resources, policies, strategies, issues, and needs.

The workshop was conducted as a series of sector panel discussions on the drought monitoring and early warning needs of agriculture, energy, urban water suppliers, river system managers, protected lands, and tribes. Breakout sessions focused on improving coordination between federal, state, and local monitoring and early warning systems; on developing and implementing drought management triggers for energy, water resources, and ecosystems; and on drought, climate, and sustainability. Although the workshop was organized by stakeholder sectors, the findings have been summarized according to NIDIS working groups to make it more useful for the implementation of NIDIS.

**Key Findings for Working Groups**
The key workshop findings and implications for the five NIDIS working groups are summarized below.

***Integrated Monitoring and Forecasting***
The goals for this working group are to emphasize the development of high resolution observational and forecast databases that will include, in the near term, increasing the density of soil moisture sensors, identifying relationships between precipitation anomalies and soil moisture, and promoting awareness of drought monitoring products derived from satellite remote sensing. The working group will also improve coordination among federal, state, and local drought groups and develop climate test beds to improve drought forecasts.

Workshop findings relevant to this working group are as follows:

- **Data and Products.** Currently stakeholders use a variety of data and products to monitor drought conditions, including station data, gridded products, climate and drought indices, text products, agricultural impacts, and blended products such as VegDRI. Their use varies widely according to location, sector, and other factors affecting preferences. However, it is important to note that virtually every panel discussed using the U.S. Drought Monitor; some stakeholders use it as the basis for decision-making, while others use it as a supplement to other information or to verify their own calculations.

  Participants expressed a need for real-time data and improved timeliness of products and tools. The automation and telemetry of data and COOP modernization were specifically identified as key issues. Other specific requests include:
  1. *Soil moisture*. All panels strongly called for the need for an increase in the soil moisture monitoring network. A panelist from the agriculture panel commented that "plants don't care about the amount of precipitation occurring 0.5 meters off the ground; precipitation is just a proxy to soil moisture data."
  2. *Streamflow and runoff*. The panelists on the energy panel were in unanimous agreement that streamflow data should be expanded and that the addition of data would improve forecasts. This sentiment was echoed by participants in the urban, agriculture, and water panels. A recommendation was also made for trend analyses of streamflow data.
  3. *Groundwater*. Participants agreed that more information about groundwater levels and trends is needed and that a groundwater monitoring network needs to be introduced.
  4. *Impacts*. Participants stated that they lack reliable impact data, especially regarding agriculture and water supply.
  5. *Paleoclimatic data*. Stakeholders have begun exploring the use of paleoclimate data in planning and would benefit from more information on how to use these data.
  6. *Data integration*. Specifically, participants mentioned wanting water supply data integrated with demand data.
  7. *Metadata.* Participants agreed that metadata needs to be included for data and products.

8. *Value-added products*. Participants cited the National Weather Service Drought Statements as "providing information on things people care about."

- **Monitoring Gaps.** Numerous gaps exist in monitoring and participants noted that more local data (i.e., sub-county level) is needed in the west, on tribal lands, and at high elevation sites. For example, the Fort Peck tribes have only two functioning weather stations for a four-county area. One panelist cited concerns of snow loads and roof failures as one justification for the need for more SNOTEL sites. He pointed out that typical SNOTEL sites are located between 6000 and 8000 feet and that populated valleys are usually between 5000 and 6000 feet. Others stated that improved snow water equivalent information would aid in forecasting snowmelt and streamflow.

  One noted, "data voids create problems for disaster declarations." As a result, counties that do not have stations must rely on data from neighboring counties. While stakeholders are calling for increased data collection, the number of monitoring sites has decreased in some areas due to a loss of resources. For example, tribal lands have lost weather and stream gauge monitoring sites as a result of budget cuts by the Bureau of Indian Affairs and the U.S. Geological Survey.

  Participants suggested that more research is needed on how neighboring stations correlate to surrounding areas, that more weather stations and data are needed in sensitive areas, and that alternative products such as satellite and re-analysis data could be used to increase the resolution of data. However, some participants said that there is no substitute for actual station data.

- **Coordination.** An entire panel discussion was dedicated solely to the topic of improving coordination. They focused on:

  1. *Data collection.* Some states, tribes, and other groups have set up their own monitoring networks to fill in the gaps in the federal system. This can create standardization issues because data are typically collected for a specific purpose and agencies and groups have varying degrees of frequency of data collection, station maintenance, and data standards. One panelist pointed out that because of these differences, "Not all data is appropriate for all uses."

     Participants agreed that it is necessary to develop a set of minimum standards for all monitoring programs. For this to be successful, input would be needed from regional state, local, and tribal levels. Some felt that mandates at the federal level may prevent a "bottom up" approach from working. Alternatively, participants suggested a rating of the quality and reliability of data. They recommended a classification system similar to the National Weather Service's first and second order data system. Providing incentives, such as free data archival by the federal government, would encourage groups to participate in these programs and submit their data.

While it is often the case, monitoring does not have to exist for a single purpose for multiple agencies to use the data. One participant noted, "We're all trying to measure two things: water and temperature. The bottom line is we just want the data." Multi-agency proposals and requests may stand a better chance of getting funded. Participants also recommended developing new partnerships and cost sharing between federal, state, and local agencies and cited USGS as having a long history of success with these.

2. *Data distribution*. Participants noted that in some situations people are collecting data and it is not being distributed or that they have data and because there is no one stop shop for data, others may not be aware of it.

   Participants cited the California Data Exchange Center (http://cdec.water.ca.gov/) and a multi-agency fire information site (http://www.myfirecommunity.net) as examples of ways to integrate data and information. In addition, they recommended that the drought portal serve as a national archive and/or record of existing data.

3. *Redundancy of data and products.* A lack of communication between agencies and groups can also create redundancy. For example, one participant stated that "many of the [products] that have been suggested are already being done internationally." On a domestic level, a participant noted that there are problems with different offices within the same agency using different data sets. Participants cite a lack of the following as the primary barriers to coordination: communication, agency agreements, and funding. Participants said that, for example, NRCS and NOAA generally have a good working relationship, but that it is on an office-by-office basis and no broad agreement exists. Conversely, some participants stated that they did not know that other agencies had weather offices.

   Participants felt that improving coordination and reducing redundancy in data and products would help fill gaps in monitoring. One noted, "the key is to figure out how we can work together to use the resources that we already have". NIDIS could serve a role in facilitating that communication.

   Participants recommended that NIDIS can also serve a role by identifying gaps and barriers that prevent agencies/groups from working together and by creating agency level agreements to provide "more cooperation and understanding at higher levels of government." In addition, they suggested identifying a liaison, person, or office to coordinate interagency or multi-partner monitoring. Some thought that the best results are achieved at the state/regional level and, as such, there should be regional teams to deal with issues of coordination.

- **Stakeholder Involvement.** Panelists discussed involving stakeholders in monitoring and impact reporting. Examples of these efforts include the U.S. Drought Monitor; the Community Collaborative Rain, Hail, and Snow (CoCoRaHS) network, which provides

localized precipitation data; and the Arizona Drought Watch, which when finished, will send monthly e-mail reminders to users for reporting impacts.

Participants cited the need for more stakeholder involvement in the U.S. Drought Monitor to ensure that local areas are accurately depicted, for the federal government to participate in local efforts, and for volunteer efforts to do more field reporting on agricultural lands.

- **Forecasts.** Participants said they need short and long-term forecasts and seasonal outlooks for monitoring and decision-making. For example, on the agriculture panel, one participant said, "We need all the tools we can get to help producers decide whether to plant today, next week, etc. We need these tools to help producers have a more realistic outlook on future decisions."

  While participants recognized that additional research would be needed, nearly all stated that improved forecast models and more reliable outlooks were needed for better planning. They cited a need for improvements in skill, timeliness, and in the type of forecast products offered. Some recommendations include:

  1. *Stream volume*. Participants would like to see, in general, better volume forecasts. Panelists from the energy sector specifically stated that they would prefer ensemble streamflow predictions that combine the current state of soil moisture and snowpack with historical meteorological sequences to give possible scenarios.
  2. *Humidity and wind*. Participants in the Protected Lands panel expressed the need for long-lead humidity and wind forecasts to mitigate fire problems.
  3. *Triggers*. Participants in the Drought Management Triggers panel commented that once triggers are in place, trigger forecasts would be useful because people want to know "at what point will the triggers actually be hit and something will happen."
  4. *Demand*. Some participants stated that demand should be predictable and that demand forecasts would give water providers more options and enable them to adjust water output as conditions warrant. Several people disagreed with this statement and pointed out that predicting demand would be difficult, especially in the west.
  5. *Drought probability forecasts*. Participants would like to see better drought prediction information and want forecasts in terms of probabilities.
  6. *Linking forecasts*. Panelists in the Protected Lands panel would like to see water demand forecasts linked to snowpack forecasts. They pointed out that there are mismatches between the two, which creates a problem for parks because parks are typically located (spatially) between the water supply (e.g., runoff) and the demand (e.g., urban and agriculture). Additionally, panelists would also like to see linkages between groundwater and surface water.

***Engaging the Preparedness Communities***

The goal of the engaging preparedness communities working group is to assist municipalities, states, tribes, and other entities in planning for and reducing the risks associated with drought. To accomplish this, the working group will facilitate communication and the development and improvement of collaborative networks for planning, monitoring, and research. Additionally, the group will help secure funding and develop criteria for conducting drought simulations for risk scenarios, post-drought assessments, and the generation of alternative options. The group will also highlight case studies and success stories from past droughts to assist communities in learning from others' experiences.

Workshop findings relevant to this working group are as follows:

- **Drought Planning Resources.** Workshop participants were invited because of their involvement with drought planning at various levels, including municipalities, states, tribes, and irrigation districts, and in specific sectors. Attendees described their drought programs, which varied in complexity among the communities. A common concern among the participants was a lack of adequate financial and staff resources for developing and implementing drought plans. Many drought teams and committees consist of a variety of individuals including municipal, state, and federal employees, tribal representatives, and other stakeholders in various sectors responsible for managing drought related risk. Some drought teams have full-time staff dedicated to drought. However, many teams rely on volunteers from agencies already in existence. In these cases, drought assessment is not the primary duty of those involved. Some participants felt that this volunteer approach results in "people wearing too many hats," while others said the volunteer approach "allows experts to do their job" by enabling them to focus on their sector as it relates to drought. Participants also pointed out that "inadequate financial resources can keep good plans from being implemented."

  Participants suggested that NIDIS could help in ways such as encouraging entities to develop plans within the constraints of their resources, providing sample drought plans for a variety of resource scenarios, and assisting communities in applying for resources through grant programs.

- **Coordination across boundaries.** By nature, drought planning tends to be a collaborative undertaking. Some examples of existing collaborations given by the participants are listed below.
  1. The U.S. Drought Monitor serves as an excellent example of collaboration between federal agencies, universities, and other stakeholders.
  2. States are either voluntarily participating in multi-state coordination or are forced to participate due to water compacts.
  3. Tribes work with federal agencies such as the Bureau of Indian Affairs, National Weather Service, Bureau of Reclamation and USGS as well as with universities through the NDMC and the NOAA RISA programs.

4. In some states the National Weather Service works with the state climatologists on developing the drought statements that are released to the public.
5. Some states have regular teleconferences with stakeholders do discuss drought monitoring and planning.
6. Sector-specific stakeholders collaborate on basin-wide or region specific issues.

Although collaboration does take place on many levels, this workshop revealed that there is room for improvements in communication and coordination at all levels and for all aspects of drought programs (e.g., planning, monitoring, and research). For example, state drought panels/councils/task forces have pointed out that "they've had a problem with local groups declaring droughts on their own." States also encounter challenges and lawsuits due to the existence of multi-state compacts. As one participant said, "Each jurisdiction has a drought plan and different ways of monitoring. Communication and inconsistencies with restrictions occur across jurisdictions." While all acknowledged that it is necessary to work together to more effectively use resources and that cooperation helps to deal with drought and other crises, one participant pointed out a paradox in planning in that "states need to collaborate to manage interstate basins, but want to maintain their independence."

Participants mentioned the need for improvements in communication and coordination between the following groups: research, stakeholder, and decision-maker communities; federal and state agencies, tribes, and municipalities; basins that span political boundaries; and the public and private sector. Other recommendations included: assistance from NIDIS in facilitating coordination and improving communication, NIDIS serving as a bridge between science and policy, NIDIS coordinating with groups such as the American Water Works Association and the National Center for Atmospheric Research to develop books on risk assessment, and NIDIS facilitating contract agreements to provide localized information to government. Additionally, participants recommended that NOAA/NIDIS consider identifying a tribal liaison, or even regional tribal liaisons, to improve trust with the federal government and provide a better understanding of the political structure of the tribes.

- **Need for drought plans that consider the diversity of water users.** In discussions of planning considerations, participants expressed concerns that drought plans may not be robust because they do not adequately consider the diversity of water users (e.g., urban, agriculture, endangered species) and their cumulative effects. Participants from the energy sector noted that "significant planning is required to balance resource needs to meet system energy requirements." Stakeholders from the urban sector expressed the importance of urban water systems and the feeling that neither customers nor politicians understood the demand. Others pointed out that maintaining environmental flows is a critical issue and that associated restrictions may force people to make some really difficult decisions in times of drought.

  Workshop participants noted the absence of land and home developer communities at the workshop, and thought that they needed to be a part of future conversations on competing interests for water resources. Participants also thought that improvements in monitoring

and forecasting would help them better plan for and manage water use (For more detail, see *Integrated Monitoring and Forecasting* above).

- **Strategies to cope with uncertainty.** Workshop participants expressed their need to create drought plans that are flexible enough to account for uncertainty. Climate change was a particular concern among the participants and many were unsure how to address this in the planning process. Some used proxy and/or historical data to gain a better understanding of past drought (e.g., Colorado), while others felt that "we may now be in a zone where the past is not always useful for the future." Some use modeling (e.g., El Dorado Irrigation District) to determine how their plans perform under future climate scenarios, while others assume that the climate will stay the same because they do not know. Participants also commented that climate change redefines drought. For example, what will be considered an exceptional drought if the averages change? Population growth is an additional uncertainty that will affect communities' ability to plan for and deal with drought. Some states have begun to superimpose population growth with drought cycles and/or climate change (e.g., Texas, Colorado). Others recognize that this is important but are still investigating the best way to do this.

  Participants stated that they needed assistance in incorporating uncertainties associated with climate change and population growth into their drought management plans and into decision-making. They requested tools to address climate change to assist in the evaluation of long-term vulnerability and risk. An additional suggestion was for NIDIS to apply climate change scenarios to the forthcoming drought frequency atlas as a means to help with planning.

- **Accounting and planning for sustainability.** Workshop participants also discussed the need for sustainable practices, management, and growth in planning and mitigating for drought. Of concern were issues of balancing economic growth with the carrying capacity of basins and with non-consumptive water use. Stakeholders from the Southeast pointed out that growth is considered good and limiting permits goes against the economic system. Stakeholders from the West pointed out that non-consumptive needs were not a major economic factor in past droughts and were concerned with how to develop within the Colorado River Basin and still meet compact requirements. Panel discussions also included dialogue as to what sustainability actually means for different sectors. Agricultural stakeholders commented that for sustainability and food and agricultural security at the national level, we should encourage redundancy, with multiple production regions, so that a climate stress that leads to agricultural losses in one region can be compensated by production in another. Others thought that sustainability needed to be defined from the standpoint of cities or ecosystems because endangered species can take water away from urban areas.

  Participants expressed the need for strategies that would enable them to build buffers, efficiency, and robustness into their plans without reducing their ability to adapt. Participants also thought that moving toward sustainable practices would cost "a small

fortune over the next few years" and that NIDIS could help by creating a new economic model to help balance the trade-offs between economics and sustainability.

- **Integration of science and policy.** Workshop participants commented that politics are often one of the biggest challenges in planning for and mitigating drought. One participant said, "Local elected officials are trying to get elected, and it's difficult for them to declare drought because of the political ramifications. We wish more of the scientific and technical data would be taken more seriously into consideration by local and state decision-makers. It's hard for local officials to declare drought when it might result in less tourism, less development. It's a balancing act, political as well as meteorological." Participants commented that "somewhere along the line, politics need to be removed from the equation."

  Participants suggested that NIDIS should provide research, tools, and data to support the decision-making process, but not get directly involved in advocating for particular policy changes.

- **Cultural and regional considerations.** Bringing together such a wide variety of drought stakeholders from across the U.S. was an educational experience for many of those involved. It provided them with an opportunity to learn about drought planning techniques and strategies used in other areas. This experience highlighted the fact that drought planning and mitigation cannot have a "one size fits all" approach. For example, the way that tribes view land and water needs to be considered in their drought plans. Some native people are opposed to pumping water out of the ground as fast as possible, and as a result, may lose their water rights. However, it is also important to note that not all tribes have the same issues. Similarly, water issues in the east differ from water issues in the west because water law in the east is governed by riparian rights whereas water law in the west is governed by prior appropriation. Some areas have faced drought and/or population-related pressures on water supply, while others have not.

  Participants recommended a regional approach to drought planning.

- **Evaluating, assessing, and updating drought plans.** A few workshop participants stated that their entity/agency uses drought exercises and simulations to test the effectiveness of their plans in a risk-free environment. The Interstate Commission on the Potomac River Basin, the El Dorado Irrigation District, and the Hualapai tribe all mentioned that they perform drought exercises. A participant conveyed the importance of these exercises in the following statement: "When institutions are confronted with massive change, often times the solutions are to pull back and set up an exercise and go through a mock planning session. To help reach beyond the normal assumptions, that's the way people can do it in a risk free environment, and not have to give up anything." Participants discussed the importance of conducting post-drought assessments and revising those parts of the plan that did not work.

Although some of the participants were already conducting the above activities, others request that NIDIS make available practice drought exercises and simulations and post-drought assessments.

***Interdisciplinary Research and Applications for Risk Assessment***

The goal of this working group is to develop and support a framework for collaboration between researchers and resource managers. Improved coordination between these groups will help develop field-tested drought risk indicators and triggers, and effective methodologies for impact assessment and loss estimation techniques. It will also help reduce duplication of research efforts.

Workshop findings relevant to this working group are as follows:

- **Need for additional research on climate change and drought.** Participants expressed concerns that past data and trends would not be a good indicator of the future for multiple reasons, which include climate change, an increase of non-consumptive needs, and changes in economics. Participants discussed the need for a better understanding of how climate change will affect drought frequency and severity. They desire a better understanding of how to address uncertainties related to climate change, and they would also like to see climate change scenarios applied to the forthcoming drought atlas. Additional discussion and recommendations regarding the influence of climate change on drought planning is discussed in the Engaging the Preparedness Communities section.

- **Need for development of critical indicators and triggers.** A considerable amount of discussion arose from workshop participants regarding trigger use, development guidelines, and needs. It can be concluded that while only a limited number of agencies/entities at the workshop are currently using triggers, many participants were interested in implementing triggers in the future. Participants expressed a need to connect triggers to, streamflow, snowpack, precipitation, soil moisture, and groundwater. They suggested that triggers should be customizable or user-defined, and stressed that regional characteristics must be considered in trigger development. Other guidelines for trigger development include: the consideration of temporal characteristics, the need for scientifically viable triggers with value-added information, and a recommendation that triggers be set to drought severity. Participants also suggested that triggers be non-circular. For example, water providers look at the U.S. Drought Monitor to decide on water restrictions and the U.S. Drought Monitor looks at the status of water providers to move the U.S. Drought Monitor level. Unresolved issues include whether or not triggers should be qualitative or quantitative, objective or subjective, or shown as actual data or visualized.

  Workshop participants suggested that NIDIS create a standard method for trigger development and monitoring and provide a model trigger-based drought plan for different regions of the United States.

- **Development of decision-support tools to help with preparedness.** Workshop participants would like to see "what if" scenarios developed to help identify vulnerability and improve communication across sectors and with stakeholder groups. They also suggested that NIDIS develop drought exercises and mock drought planning sessions. Additional discussion and recommendations regarding developing scenarios for drought planning can be found in the Engaging the Preparedness Communities section.

- **Better understanding of drought impacts.** There was substantial discussion from a variety of sectors about the types of impacts that typically occur during drought. Another primary topic of discussion was regarding how current ecological problems are exacerbated by drought and climate change, making it difficult to identify the primary factors responsible for impacts. For example, one participant mentioned how a particular pond is severely is affected by a combination of long-term drought and other factors such as seepage, evaporation, and increased discharge in spring, which makes it difficult to pinpoint the primary culprit of long-term pond decline. Specific external factors that can magnify drought impacts include population growth, water pollution, aging infrastructure, commodity prices, and consumptive water use. More research is needed to determine the magnitude of these external factors.

  There was very little discussion regarding methods for collecting impact information. Arizona did mention that local impact groups, coordinated by extension agents and emergency managers, are just starting to collect this information and enter it into an interactive web tool called Arizona Drought Watch. However, numerous participants pointed out the need to better quantify drought impacts, and they expressed the desire for guidance in determining relevant impact information to collect. Also, there was an interest in understanding and learning how to use both qualitative and quantitative types of impact information. Additionally, it was pointed out by one National Weather Service (NWS) employee that NWS offices need more impact information related to low-flow situations.

***Education and Public Awareness***

The goals for this working group are to provide the public with an awareness of the risk associated with drought conditions for their localities, and to point to ways to minimize those risks through individual and collective measures. NIDIS' education and awareness effort will build on the strengths of existing education and information networks.

Needs identified at the workshop included:

- **K-12 educational programs**. Participants cited a need for NIDIS to be involved in K-12 education. One participant noted, "There's no consistency across the West as far as education programs go. Arizona gives it full funding, and others do not. Texas has developed consistent messages."

- **Informal education**. Participants recommended that NIDIS develop formal and informal education programs, such as educational opportunities at national parks. Drought affects

national parks, but that may or may not raise visitors' awareness of drought. A participant in the Protected Lands panel stated, "There has been a recent push for Parks to be 'climate friendly' and to reduce their environmental impact. This is not specific for drought. Current drought-specific communication is at the mercy of whoever is around at the time." Another participant added, "It's a matter of personal initiative, not mandated, but it is a high priority with many people (especially with climate change). Parks present good opportunities to educate visitors about drought, climate, ecosystems, etc., but it is largely up to the inclination of the ranger on staff."

- **Coordinated messages so that the public doesn't get confused**. Developing good relationships with the media would help ensure that drought conditions and any needs for public response are accurately portrayed. Developing a multi-faceted communication strategy would help make up for some of the shortcomings of mass media. One participant noted that a TV meteorologist once told viewers, "It's been a long dry spell, so you should water to protect your landscaping." That was not during the growing season. The local utility then had a record demand in mid winter. Another said, "Our biggest issue is that our media markets don't care about which area you're in. You will have different entities in media markets, and when you present something, everyone's water use will drop. You need to present something to be curtailment specific."

- **Underlying willingness to change water use patterns**. Key underlying messages and concepts need to be identified and communicated. Water suppliers have an array of strategies for communicating with customers, including rate structures, raising rates, incentives for xeriscaping, installing meters, and requesting or requiring conservation. Campaigns to change behavior and perceptions have met with mixed success. One participant said, "Customers and politicians don't understand the issues facing urban water supplies." A better-informed public might also help de-politicize discussion of drought and water supply. Despite the occasional intractability of the public, the participant continued, "Strictly speaking, no one manages a drought. What the state attempts to manage is people's response to drought."

- **Need to acknowledge local differences**. Public awareness campaigns and conservation efforts should be tailored to the needs of a particular locality, bearing in mind that some areas have not faced the possibility of water shortages in the same way as other places. Some places, such as California, have fairly high awareness of drought and water as a limited renewable resource. Others have not experienced real strain on water supplies. "If they're getting multiple wakeup calls, [our] area is still snoozing away," a water sector panelist said. "[Ours is] a water-rich area in many ways because of the major rivers that flow through it."

- **Need a broad-based set of initiatives for improving public awareness of and education about water issues.** NIDIS can help create a better-informed public that would be more receptive to stakeholders' communication about drought and water. Specific strategies recommended included using the drought portal to disseminate information, gauge public

perceptions to assess the success of educational programs, and present success stories and case studies. For example, people need a better understanding of the role of drought and water in delivering ecosystem benefits and services. "You could do simple examples for K-12, but you should be able to come up with more complex systems. If you put it out there for individuals to see the consequences of what happens upstream and downstream, they might become interested in the bigger picture. One of the things we did in the NRCS was cumulative effects. If you do something at 100 different farms, you're going to have cumulative effects. Eventually you need to look at things for a holistic, hover-above type approach, so some strategies need to look at the bigger picture."

***Web-based Drought Portal***

The U.S. drought portal will create a point of entry for quality controlling, archiving, and disseminating drought related data and information that is tailored for various user communities. The portal will work by combining NIDIS related data and information from the other four working groups with tools necessary to exchange and integrate data on various space and time scales, and among various formats.

In summary, workshop participants articulated that the drought portal should:

- **Serve as a means to increase awareness of existing data, tools, and products.** Workshop participants noted that the portal could serve as a means of bringing more attention to existing early warning tools such as drought indices, fire danger indices, precipitation and snow data, weather and climate summaries, and also long range forecasts. It was noted that the most logical approach would be to use existing tools and products as opposed to developing new products. Furthermore, it was mentioned that the portal would be the ideal location for an archive of existing datasets, and would provide a means of showing users any available data. The portal would be an asset to collaboration, because it would provide a place for multiple entities to have access to the same data and information, and provide a means of communication among groups.

  Participants suggested that the NIDIS portal provide access to existing datasets and also advertising which datasets are available. This will help reduce duplication of efforts.

- **Provide a means of communication among groups.** Participants mentioned that the portal would provide groups a better opportunity to communicate and collaborate with one another. It was noted that NIDIS workshops won't be occurring as frequently as needed to allow for face to face interaction, so using a web medium such as the portal would provide the best opportunity to collaborate. The participants felt that the ability to communicate with entities that are developing products was important in order to ensure that input is being received from a user's local area.

  NIDIS can help foster communication and collaboration by continuing to develop the communities aspect of the portal.

- **Serve as a place for localized products and information gathering.** A number of participants provided details on useful tools or products that are used at a local scale. These tools and products ranged from localized forecasts provided via email to statewide methods of drought impact collection to press releases concerning drought conditions. The portal would be a logical location to provide access to these products.

  NIDIS can help disseminate best practices by using the portal to provide centralized access to various local products.

- **Provide information for year-to-year risk management practices.** Several participants suggested that the portal could serve as a means to get timely information on drought risk management to producers. The information could change from year to year based on drought conditions. The portal could also help bring different sectors together, such as water managers and economic planners.

  Participants stated that the NIDIS portal can provide as much information on drought risk management as possible, including risk management information based upon current conditions. It was also noted that the portal could help producers by teaching them how to understand and use available datasets, thus allowing them to use existing data more effectively. The portal can also encourage multiple sectors to combine information and ideas on risk management practices.

- **Help create consistency among drought products.** A common theme that emerged from the proceedings was the lack of consistency amongst datasets developed by different agencies. It was mentioned that a set of standards needed to be developed, and there needed to be a mechanism to allow multiple agencies to be involved. It was also suggested that data need to be prioritized by importance to the potential users, but there is no current method of determining which user groups to target first.

  The NIDIS portal can help by providing a location for agencies to collaborate and develop a set of data standards. The portal also gives users the ability to provide input about their data needs including which datasets would be most useful, potential useful datasets that need to be developed, and improvements that would make current datasets more useful. This would also help portal developers determine which user groups should be targeted.

- **Help facilitate and provide feedback on improvements to existing products.** Participants had a number of recommendations for improvements to existing products:
  1. *Graphics/display* – a number of products such as the Palmer Drought Severity Index and the Crop Moisture Index need to be presented in a better, more useable graphic format
  2. *U.S. Drought Monitor improvements* – create a Hydrologic Drought Monitor, make it accurate to the sub-county level, incorporate bark beetle information, incorporate

evapotranspiration in some areas, reduce the temporal scale to less than one week, include more data sources
3. *User feedback* – portal web pages should allow people to give feedback on each of the available products
4. *Background information* – allow users to see background information on each of the products (i.e. forecast discussions)
5. *Hydrologic information* – visualization of reservoir conditions, inventory of dams, voluntary and mandatory water restrictions, basin scale hydrologic drought information

The NIDIS portal can help by allowing users to provide feedback and input regarding existing products. The portal can also provide more background information on existing products to give users a better understand of how the products were developed.

- **Make available numerous types of educational information.** The participants felt that educational information should be an important part of the portal. It was suggested that the media should be brought on board in order to get maximum publicity for the portal. Specific information that was specifically requested included:
    1. the meaning of drought conditions – put current conditions into a historical context
    2. assistance in understanding seasonal forecasts
    3. drought policies
    4. funding needs and priorities
    5. cultural issues – how these issues play a role in planning for and dealing with drought (i.e. tribal beliefs about water and water use)
    6. success stories and case studies – what if scenarios performed at the local scale
    7. sustainable practices and development – teach people about sustainability, and sustainable practices
    8. awareness of NIDIS – inform the public about NIDIS and how they can participate in and benefit from it

**Additional Findings**

In addition to the findings relevant to the NIDIS working groups, workshop discussions yielded several findings that did not appear to fit within the charge of any particular working group. Summaries of these findings are highlighted below.

- **Mitigation Activities.** Workshop participants discussed mitigating activities that their entity had undertaken or planned to undertake to help reduce the impact of drought. Some examples that were provided are listed below.
    1. The Hualapai Tribe is being pro-active with drought and climate change. They have begun emphasizing water storage as opposed to water drilling by constructing new water catchments and pipelines on the reservation. They have also eradicated invasive plants, implemented watershed plans for sub-basins, and involved youth in the drought planning process.

2. The Yakima Nation believes that preparation for drought is just as important as prediction. They are working to restore a natural waterway on the Yakima River and participate in numerous water conservation projects. Additionally, they have formed a water transfer working group to deal with emergency transfers to help avoid disruptions in the natural system. They have diversified their economy to help build in resilience.
3. The city of Aurora has implemented several measures to augment their water supply. They have implemented "Prairie Waters," one of the largest water reuse programs in the United States; secured senior water rights; and are trying out a rotational program with agricultural communities, which allows them to take land and water in and out of agricultural production in response to drought conditions.
4. Tom Schrempp from WaterOne, which serves the Kansas City Metro area, discussed the building of new infrastructure (e.g., dam with a fish passage and a new pumping facility) to increase the reliability of getting water out of the river during low flows.

- **Demand Management.** Water suppliers described various conservation and curtailment activities used to reduce demand during peak use or drought. These include:
    1. *Pricing Incentives*. Pricing incentives are one way to send signals to customers to reduce use at peak times or during drought. In a true drought emergency, some believe that price adjustments and rationing are the only way to get the message across. However, these methods can be very unpopular with customers and can cause conflict at the local level. One participant also noted, "You see some conservation for a few years after a rate hike but eventually people forget about it and become used to it."
    2. *Progressive stages of conservation*. Progressive stages of water conservation are another method used to reduce demand. In one case, stage one at educates customers on saving water. Stage two imposes mandatory odd/even water use restrictions, and stage three imposes severe restrictions.
    3. *Public education campaigns.* Public education campaigns can be used to encourage the general population to cut back on their water use. These campaigns have varying degrees of effectiveness. In Kansas City, they have focused on outdoor water use and lawn irrigation and believe that this has an effect. San Diego used the 20 gallon challenge, which attempted to get people to try to conserve at least 20 gallons per day. However, they found that this campaign was not very effective. Additionally, workshop participants noted that issues arise when some municipalities have restrictions and other do not due to water rights.
    4. *Lawn irrigation audits.* Audits of lawn irrigation systems can improve the efficiency of water application.
    5. *Less than 24/7 availability*. One participant posed the question, "Does water have to be on 24 hours a day?" It isn't in all parts of the world.
    6. *Curtailment.* Water suppliers said that it is harder to ask customers to curtail water use after Labor Day and in the winter because they are already using less water.

- **Aid Strategies.** In the Agricultural sector panel discussions, workshop participants discussed the need for revision of aid strategies. They identified the following two shortcomings in crop insurance programs:
    1. The programs do not consider differences in climate risks among regions. As a result, less risky regions subsidize regions with greater climatic variability.
    2. Many insurance products are too inflexible. For example, requirements to plant by a certain date may encourage farmers to not plant at all during years when wet conditions delay planting. It may be worthwhile to investigate whether seasonal forecasts and crop models can be used to modify insurance products to delay the date of last covered planting if updated forecasts predict sufficient time remaining in the crop season.

- **Water Rights.** Discussions regarding water rights arose in the Tribal and Urban sector panels, primarily from participants from the western part of the U.S. The use of water in many western states is governed by the doctrine of prior appropriation, which means that the allocation is essentially based upon the motto, “first in time, first in right.” Tribal participants discussed the following points regarding water rights: existing water rights and appropriations during drought years, interest in acquiring water rights, compacts and agreements with states, and legal hurdles. Municipalities, such as Aurora, CO, also have interests in acquiring water rights. For example, this city has been diligent in establishing a foothold for direct water rights. Their approaches include buying agricultural properties with senior water rights and consumable water and trying to get storage rights for reservoirs.