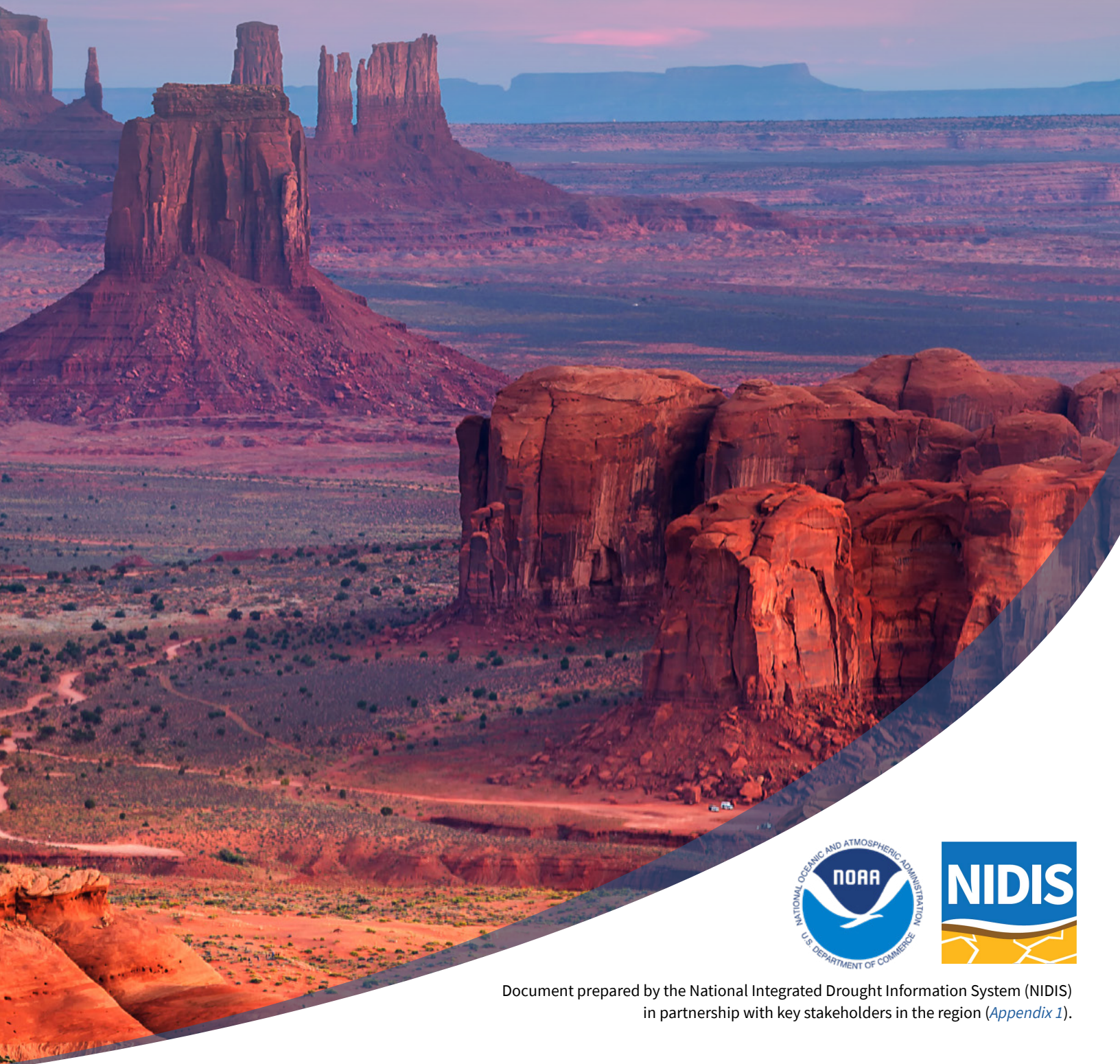
2021–2025

Intermountain West

Drought Early Warning System (DEWS) Strategic Action Plan



Document prepared by the National Integrated Drought Information System (NIDIS) in partnership with key stakeholders in the region (*Appendix 1*).

On the cover: Sunrise over Monument Valley Navajo Tribal Park near the Arizona-Utah border. Credit: Bill Vanan

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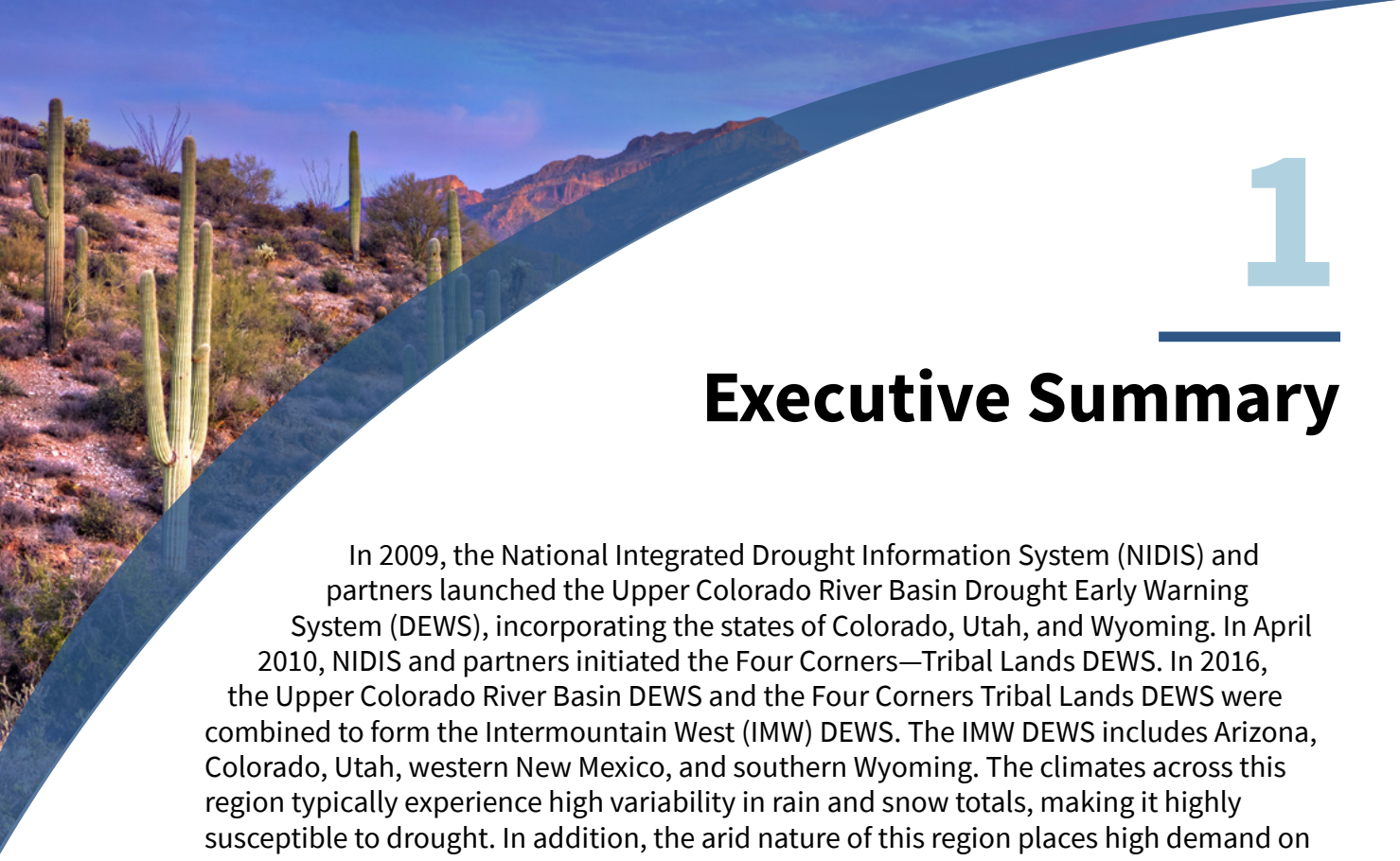


1

Executive Summary

In 2009, the National Integrated Drought Information System (NIDIS) and partners launched the Upper Colorado River Basin Drought Early Warning System (DEWS), incorporating the states of Colorado, Utah, and Wyoming. In April 2010, NIDIS and partners initiated the Four Corners—Tribal Lands DEWS. In 2016, the Upper Colorado River Basin DEWS and the Four Corners Tribal Lands DEWS were combined to form the Intermountain West (IMW) DEWS. The IMW DEWS includes Arizona, Colorado, Utah, western New Mexico, and southern Wyoming. The climates across this region typically experience high variability in rain and snow totals, making it highly susceptible to drought. In addition, the arid nature of this region places high demand on the Colorado River and other water sources.

The IMW DEWS 2021–2025 Strategic Plan is designed to set priorities and suggest measurable actions that can create value in this drought-prone region, with the ultimate goal of making stakeholders across the region more resilient during times of drought.

1.1 OVERVIEW OF THE 2021–2025 STRATEGIC ACTION PLAN

The 2021–2025 Strategic Plan was developed following a series of stakeholder meetings held virtually in October and November 2020. Each virtual meeting was focused on one of the following sector needs: Colorado River management and issues; water management (non-Colorado River); farming and cropping; livestock; recreation and tourism; and forestry, ecology, and fire management. Attendees were asked about how drought

WHAT IS NIDIS? In 2006 (Public Law 109-430), Congress authorized the National Integrated Drought Information System (NIDIS) with a mandate for interagency coordination and integrated drought research that builds upon existing federal, tribal, state, and local partnerships to create a national drought early warning system (DEWS). The program was reauthorized in 2014 (Public Law 113-86) and again in 2019 (Public Law 115-423).

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.

impacted their lives, their jobs, and their businesses. They were then asked to identify gaps and needs in the drought information they use and need. The output from each of these meetings was combined and distilled to identify common themes across sectors and strongly emphasised points within sectors. These meetings were used to guide the priorities and activities that are highlighted in this Strategic Action Plan. It should be noted that this plan is intended to be a "living document" that can evolve with the changing needs of people in the region. It is also a resource document that provides a snapshot of the current needs and gaps of drought early warning in the IMW DEWS, and can be used to objectively measure the alignment of future projects with the needs of the region.

The three priority areas for the IMW region for the next five years are:

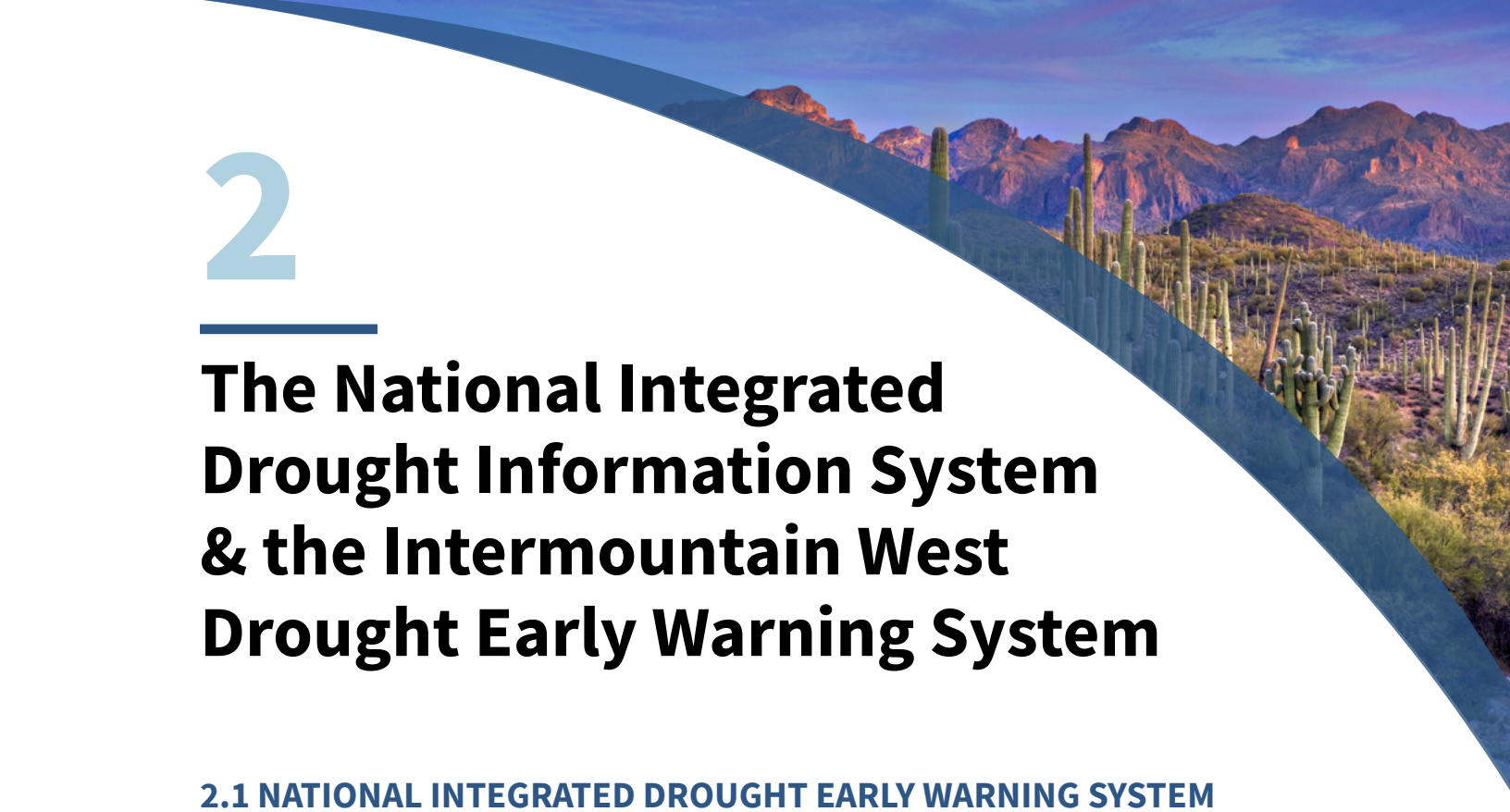
1. Build resilience and mitigate economic, human health, ecological, and other costs of drought.
2. Deliver earlier warning of drought than is currently available.
3. Improve or build a comprehensive understanding of drought impacts in the region.

More details on each of these priorities are given in Section 4.3.

The following table contains desired outcomes that the IMW DEWS network will focus on, organized by components of a drought early warning system. More detailed information about these outcomes and the proposed suite of activities to help accomplish each one can be found in Section 5. Annual or biennial meetings will be used to reassess priorities and direct action within the DEWS during the life of the plan.

Planned Outcomes to be Accomplished by the IMW DEWS
NETWORK COORDINATION AND INTEGRATION
The IMW DEWS network is strengthened by improving drought communication and coordination.
Stronger network connections are made between the research community and primary producers, practitioners, and decision makers.
New partnerships are built in the IMW that enable the DEWS to reach currently underserved partners.
DROUGHT PREDICTIONS AND FORECASTING
Drought information is improved/developed and disseminated, regarding when drought will start and end, especially when multi-year drought is a possibility.
Drought predictions for low streamflow are available in the region.
Value-creating prognostic tools are expanded and/or improved.
Drought predictions for ecological drought impacts are available in the region.
DROUGHT OBSERVATIONS AND MONITORING

Planned Outcomes to be Accomplished by the IMW DEWS
Locations of monitoring stations are known, and gaps in coverage are addressed.
The U.S. Drought Monitor (USDM) is strengthened to better represent local conditions and impacts, especially in underrepresented rural and Tribal areas.
Ecological drought impacts and recovery are routinely observed and reported.
DROUGHT PLANNING AND PREPAREDNESS
Drought disaster relief programs, including insurance providers and customers, have improved access to high-quality, fit-for-purpose climate and weather data.
Agriculture businesses in the IMW region are more resilient to drought impacts.
Recreation and tourism businesses in the IMW region are more resilient to drought impacts.
Drought plans within the region are tested and improved.
DROUGHT COMMUNICATION AND OUTREACH
Public and mental health resources are easily accessed by those whose wellbeing is adversely affected by drought. While drought may be challenging, it should not be crippling or deadly.
Natural resource managers, forest and ecosystem managers, and other natural land managers have access to improved, high-quality, and impactful drought outreach materials and management tools.
Forecast probability and forecast uncertainty is clearly communicated.
INTERDISCIPLINARY RESEARCH AND APPLICATIONS
The mechanisms and climate dynamics of multi-year drought in the West are well understood, and can be used to provide early warning of multi-year drought events.
The regional propensity and vulnerability to drought now and in future climates on local, state, and regional scales is quantified and understood.
The suite of actions to prepare for and respond to drought, that increase resilience over the long term, are understood and shared.
Data, products, and services are improved and/or expanded to better serve the region.



2

The National Integrated Drought Information System & the Intermountain West Drought Early Warning System

2.1 NATIONAL INTEGRATED DROUGHT EARLY WARNING SYSTEM

Congress created NIDIS in 2006 (Public Law 109-430) with a mandate for interagency coordination and integrated drought research that builds upon existing federal, Tribal, state, and local partnerships to create a national DEWS. NIDIS is part of the National Oceanic and Atmospheric Administration (NOAA). The NIDIS program has been reauthorized in 2014 (Public Law 113-86) and again in 2019 (Public Law 115-423). NIDIS is working toward this goal by developing a network of regional DEWS across the nation. These regional DEWS utilize existing networks to make climate and drought science readily available, easily understandable, and usable; and to improve regional capacity to respond to and cope with drought.

A regional DEWS is supported by stakeholders, composed of relevant partners and community members across the region, including universities, the private sector, and federal, Tribal, state, and local entities. Stakeholders participate in the NIDIS consultation process and they support NIDIS priorities by leveraging existing resources, programs, and partnerships. This relationship ensures a robust, "ground-up" regional DEWS that is well-networked and responsive to the specific needs of each region.

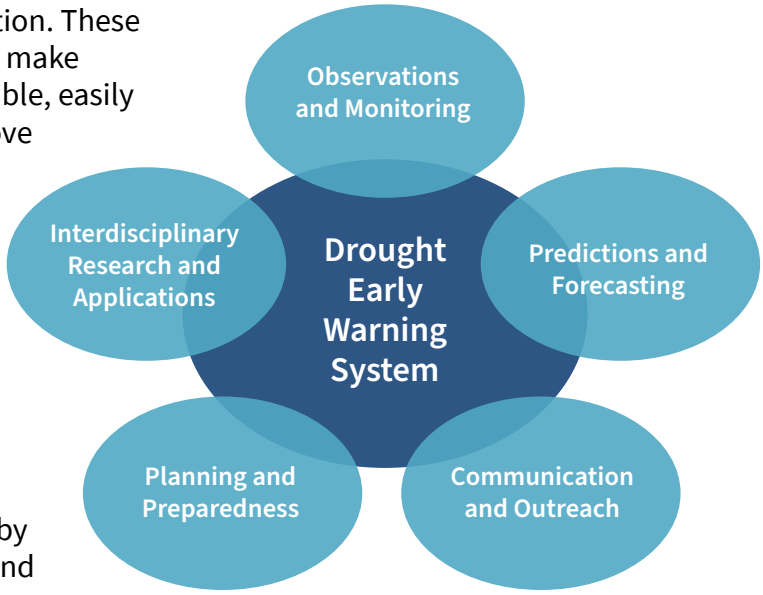


Figure 1: A Drought Early Warning System is made up of five components including Predictions and Forecasting, Observations and Monitoring, Planning and Preparedness, Communications and Outreach, and Interdisciplinary Research and Applications. Credit: NOAA NIDIS, Fiona Martin

2.2 COMPONENTS OF A DROUGHT EARLY WARNING SYSTEM

Early warning is the provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to act to avoid or reduce their risk and prepare for effective response. In the case of drought, five components (*Figure 1*) have been identified as necessary for drought early warning. In order for these systems to be successful, they must support efforts to understand past, present, and future conditions and to plan proactively and respond using an adaptive management process that applies learning to improve future outcomes. Activities and actions in one component inform those in other components, and in the early warning system itself there is feedback and learning that informs and improves the system over time.

2.3 BRINGING IT TOGETHER ACROSS SCALES

NIDIS employs a systems, or holistic, approach to identify gaps, foster collaboration, facilitate information flow and informed decisions, and integrate the five components of drought early warning both across and within regional DEWS. This capitalizes on the strengths in part of the system to address needs in another. The regional DEWS provides a foundation on which a national early warning system rests (*Figure 2*). Regional gaps, needs, and input are incorporated into national products and processes. Initiatives that cross DEWS boundaries, or are larger than any one regional DEWS, are elevated to be addressed holistically by NIDIS and partners at a national scale. This includes complex issues such as the close relationship between drought and wildland fire or drought and public health, which require larger investments in research and targeted decision support tools. In the same way, these national efforts, products and learning can be assessed for relevance, validated, tailored, and then incorporated into the regional DEWS. It is this cross-scale exchange of information and learning that helps to improve our capacity for national early warning across diverse sectors of the economy.

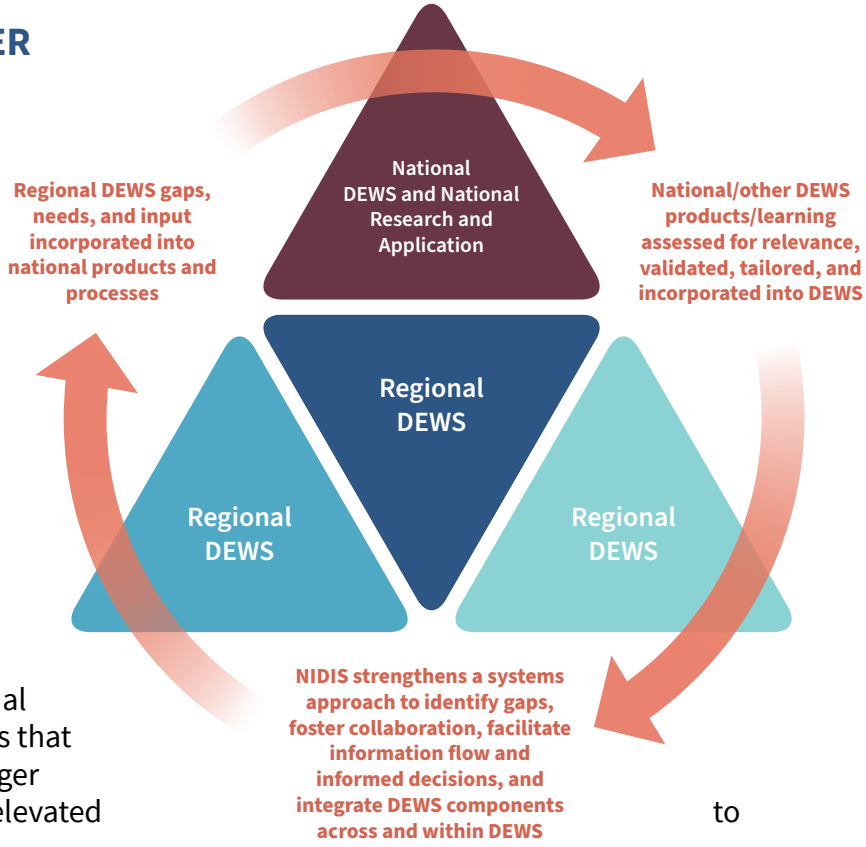


Figure 2: This diagram illustrates the regional DEWS as the foundation of a national DEWS and how the needs of the regions inform activities at the national level and how learning is shared across the components of the system. Credit: NOAA NIDIS, Fiona Martin

3

The Intermountain West DEWS

3.1 DROUGHT IN THE INTERMOUNTAIN WEST

Drought can take different forms across the IMW. This region includes many different climatic, geographic, economic, and social conditions. These include deserts and forests, fertile valleys and alpine peaks, densely populated cities, and some of the most remote landscapes in America. A drought in the Sonoran Desert of Arizona and California may look very different from a drought in the Wasatch Mountains of Utah. Droughts may onset quickly and last a season or come on gradually and last decades.

The monsoon is a dominant driver of summer precipitation in the Southwest, while the jet stream has a greater impact on weather systems in the northern states. The Rocky Mountain regions rely on winter snowpack and stored runoff to manage water resources through the usually dry summer months. In the northern part of the IMW region, precipitation usually comes from synoptic scale weather patterns, such as cold fronts, and is strongly influenced by the position of the jet stream. The Southwest usually receives rainfall from the summer monsoon, but winter snowpack in the southwest is necessary for water resources management.

Figure 3: Location and spatial extent of the Intermountain West (IMW) Drought Early Warning System (DEWS). Credit: NOAA NIDIS, Fiona Martin

Much of the Southwest has been in drought for nearly two decades; in Arizona, only eight of the last 20 years have seen above median precipitation, two years have been in the upper 25% of historical precipitation records while seven years have been below the lowest 25% of records. Since 1980, estimated losses due to drought have exceeded $7B in the Southwest region.

In addition to (and because of) the highly variable precipitation, all five states in the IMW turn to groundwater and the over-allocated Colorado River for a consistent water supply. The Colorado River is the main water source for most of the IMW, and winter snowpack in the Colorado Rockies usually sets the tone for drought conditions across most of the region from year to year. The IMW DEWS helps foster interstate coordination to cope with current and future droughts, growing water demands, and supports increased communication and collaboration among scientific, water, and land management communities.

The Southwest is a desert climate that is characterised by low and highly variable annual precipitation. Drier than normal periods in the Southwest somewhat align with the El Niño–Southern Oscillation climate pattern. The Water Resources Research Center at the University of Arizona has shown that, for winter precipitation in Arizona, La Niña produces a strong tendency toward average to below average precipitation while El Niño years show high precipitation variability, which, on average, leans toward above average winter precipitation.

In most historical droughts in the IMW, impacts are numerous across economic sectors and usually continue for a few years after the meteorological drought recovers. Snow droughts, for

Red Mountains between Ouray and Durango, Colorado. Credit: Allan Plucinik

Figure 4: Map showing locations of major dams in the Colorado River basin of the United States and Mexico. Source: Shannon1/Maps licensed under Creative Commons 3.0

example, can greatly affect wintertime recreation while at the same time diminish forage amounts on grazing lands resulting in shortages of food for cattle in the following summer. Often, the economic impact of severe drought lasts for several years after the drought ends. The economy of most rural and regional locations in the IMW is primarily based on agriculture, mostly beef and hay production. Purchasing supplemental feed for livestock is the most costly agricultural impact from drought in the region. Many producers will need to tap into feed or cash reserves to manage through the drought, which will take time to restore. Some farm businesses will need to access loans, which will take time to pay back. When a producer has to sell down their herd it may take up to a decade to restore the herd to the same predrought size.

American bison (*Bison bison*) grazing on dry grass in the Kaibab National Forest. Coconino County, Arizona. Credit: Michele Vacchiano

3.2 A SHORT HISTORY AND CONTEXT

The IMW DEWS was launched as the Upper Colorado River DEWS in 2009 to meet the diverse needs of stakeholders who needed information on drought conditions. A range of decision support services were provided by local, regional, and national climate services organizations working together, including: NIDIS; NOAA's Regional Integrated Sciences and Assessments (RISA) teams; state climatologists; regional climate centers; NOAA's regional climate services programs; NOAA's Climate Prediction Center; and the National Drought Mitigation Center (NDMC). Decision support services included monitoring of drought conditions, data analysis, planning and preparedness assistance, and several stakeholder engagement activities. These efforts brought together decision-makers and resource managers from regional, state, and local entities, professional associations, and independent farmers and ranchers to discuss drought.

3.3 INTERMOUNTAIN WEST DEWS PROGRESS TO DATE

The previous IMW DEWS Strategic Plan from 2017–2018 focused on four priorities: (1) Improve Decision Making to Enhance Drought Planning and Preparedness; (2) Improve Understanding and Utilization of Drought and Climate Science; (3) Enhance Drought Monitoring and Research; and (4) Integrate and Develop Collaborative Information Networks. Activities around these priorities were carried out over the life of the plan and included several workshops, research projects, webinars, and networking opportunities. The current strategic plan builds on the strengths and previous accomplishments

achieved within the DEWS over the past 12 years.

The following table summarizes some of the key outcomes and progress that have been made by partners in the IMW DEWS from the preceding strategic plan. This is not an exhaustive list, but it provides a sense of how drought early warning capacity was enhanced in the IMW region.

Key Outcomes and Progress from 2017–2018 Strategic Plan
IMPROVE DECISION MAKING TO ENHANCE DROUGHT PLANNING AND PREPAREDNESS
Assess Drought Vulnerability of Wind River Indian Reservation (WRIR) to Inform Tribal Planning. In partnership with the Office of the Tribal Water Engineer, the National Drought Mitigation Center, North Central Climate Science Center, and Western Water Assessment (WWA), a NOAA RISA team, NIDIS facilitated the development of a *WRIR Drought Mitigation and Response Plan* in December 2017.
Analyze Decision Model for Climate Adaption on Ranches and Rangelands. With NIDIS support, WWA analyzed and tested a *decision support model* using various drought indices (i.e., gridded precipitation, EDDI, and USDM) to evaluate the effect of different drought triggers and insurance products in reducing drought risk for producers, in order to fully incorporate the USDA Risk Management Agency range insurance program into the decision model
Assess Climate, Drought, and Extreme Heat Resilience in Arizona and New Mexico. With NIDIS support, the Climate Assessment for the Southwest (CLIMAS; a NOAA RISA team) expanded its existing regional assessment activities to cover a diverse representation of communities in Arizona and New Mexico, to better understand (1) current concerns and plans regarding climate and drought risk and resilience (with a specific focus on drought and heat); and (2) needs for additional information and services. These assessments focused on urban, rural and Tribal communities.
IMPROVE COMMUNICATION AND UTILIZATION OF DROUGHT AND CLIMATE SCIENCE
Intermountain West Climate Dashboard. WWA produces the *Intermountain West Climate Dashboard*, which consists of a series of graphics based on various drought and climate indices that provide an array of water and climate information for states in the Intermountain West that are automatically updated when each respective product posts new data or information.
Web Videos/Digital Shorts. The Colorado Climate Center developed a series of short explanatory web videos providing consumer friendly explanations of a variety of complex topics and drought indices and tools. These videos provide engaging, detailed explanations about the various products and indices displayed or discussed as part of the weekly drought assessments. After watching these digital shorts, viewers and listeners will better understand drought science. Examples of videos: *Assessing Drought in the United States* *Measuring the Water Cycle* Full list of videos are available at the *NIDIS YouTube Channel*.

Key Outcomes and Progress from 2017–2018 Strategic Plan

DROUGHT MONITORING AND RESEARCH TO IMPROVE DROUGHT EARLY WARNING

Enhance Coverage and Use of Community Collaborative Rain, Hail and Snow (CoCoRaHS) Network. CoCoRaHS (*www.cocorahs.org*) provides the IMW DEWS with valuable citizen science drought information. NIDIS has supported CoCoRaHS in forming partnerships between local, regional, state, and federal agencies and citizen scientists at the ground level. With this support there has been a measurable increase in active CoCoRaHS volunteers (25% in WY and UT, and 10% in AZ, CO, and NM) from Spring 2017 to Spring 2019.

NIDIS has also supported the collection of Drought Impacts using *Condition Monitoring Reports* where volunteers nationwide have the ability to report general conditions of their local area. These reports help populate the NDMC's Drought Impact Reporter.

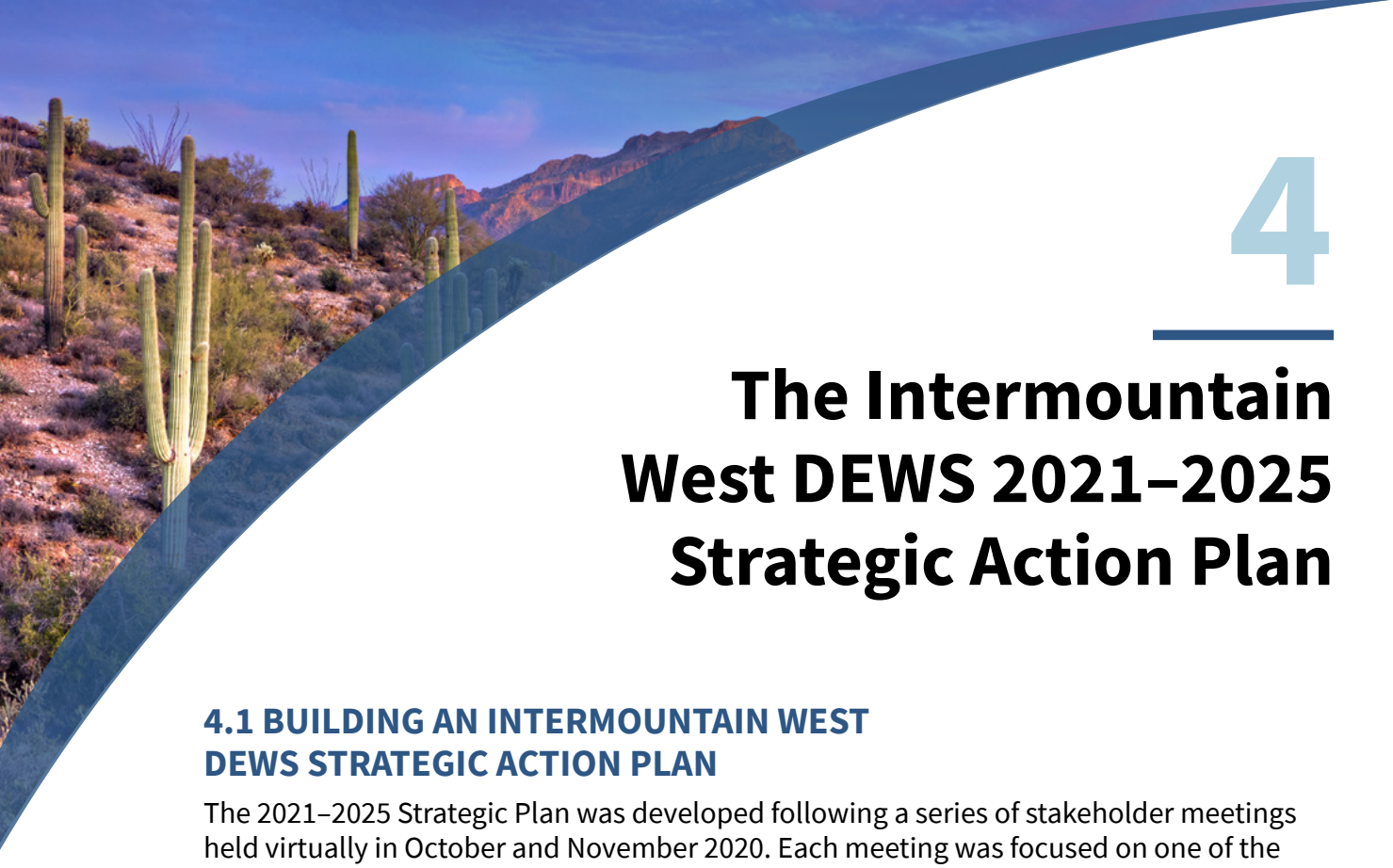
Enhance the Usability of the Evaporative Demand Drought Index (EDDI). EDDI was developed with strong support from NIDIS by researchers with NOAA Earth Systems Research Laboratory (ESRL) Physical Science Division (PSD; now the Physical Science Laboratory), and the Western Regional Climate Center (WRCC)/Desert Research Institute (DRI). The index was promulgated and tested operationally in partnership with the Colorado Climate Center, North Central Climate Science Center, and WWA. EDDI is a drought index that can serve as an indicator of both rapidly evolving flash droughts and sustained droughts, both of which are common in the IMW DEWS region.

In 2017, EDDI was a new tool, and new users wanted to know how EDDI relates to other more common drought indicators, and how EDDI reflects and anticipates on-the-ground drought impacts. WWA developed an online *EDDI User Guide* to inform users in these areas, drawing from the expertise of the broader EDDI team at NOAA ESRL/PSD and DRI. WWA also held at least one webinar training to introduce the EDDI User Guide.

Impact Assessments of the 2017–2018 Drought in the Southwest. In may 2019, NIDIS released some *Southwest Drought Impact Assessments* for states in the Southwest US, and the region as a whole, that were impacted by the 2017–2018 drought. These assessments considered the economic, ecological, and sociological impacts of drought.

INTEGRATE AND DEVELOP COLLABORATIVE INFORMATION NETWORKS

Integrate Drought and Climate Science into Wildfire Management Planning and Policy. In October 2015, NIDIS, WRCC/DRI, NDMC, and other partners hosted the Integrating Drought Science and Information into Wildfire Management Workshop in Boise, Idaho. To continue the conversations from that workshop, NIDIS held three additional workshops in spring 2017, winter 2018, and spring 2018, followed by a post-workshop report. In addition to these workshops, NIDIS also recently completed the NIDIS Drought and Wildland Fire Nexus (NDAWN) strategy, which defines the needs and challenges of fire managers to effectively utilize drought information and aims to meet those needs and to establish a robust drought and wildland fire decision-support information network.



4

The Intermountain West DEWS 2021–2025 Strategic Action Plan

4.1 BUILDING AN INTERMOUNTAIN WEST DEWS STRATEGIC ACTION PLAN

The 2021–2025 Strategic Plan was developed following a series of stakeholder meetings held virtually in October and November 2020. Each meeting was focused on one of the following sector needs: Water Management; Colorado River Issues; Farming and Cropping; Livestock; Recreation and Tourism; and Forestry, Ecology and Fire Management. Each meeting followed an open discussion format where attendees were asked about how drought impacted them, their jobs, and their business. They were then asked to identify gaps and needs in the drought information they use and need. The take-aways from each of these meetings were combined and distilled to the priorities and activities that are highlighted in this Strategic Action Plan for 2021–2025. The issues, priorities, and proposed activities listed here are intended to become a resource that provides a snapshot of the current needs and gaps of drought early warning in the IMW DEWS, and can be used as a standard to objectively measure the alignment of future projects with the needs of the region. In consultation with regional stakeholders, this Strategic Action Plan may be extended beyond 2025.

Irrigation of a crop in the desert. Credit: LHBLLC

4.2 PURPOSE AND EMERGING ISSUES

Sector-focused virtual meetings to inform this Strategic Action Plan were held during a time when severe drought was affecting the western U.S. Much of the discussion was centered around the impacts of the current

drought, and attendees discussed the financial and nonfinancial costs of drought in the region, and common drought-related problems among those within the sectors.

A few common themes arose from several meetings, and these are identified as emerging issues which should lead to priority actions/activities for the region, including:

- **Drought and wildfire.** Wildfire is a big drought-related issue for rangeland livestock operators, especially those with public lands grazing allotments. Concerns were expressed about how to keep animals safe from wildfire, how to rescue animals in harm's way, and where they can graze during and after wildfire. Wildfire also impacts recreation and tourism, as well as fish and wildlife management. In 2020, the state of Colorado issued hunting license refunds for fire-scarred areas, and the Colorado wildfires of 2020 interrupted operations at fish hatcheries where post-fire impacts included runoff and water quality issues.
- **Multi-year drought.** The single biggest challenge to surface water management in the IMW DEWS region is planning for, and managing through, a multi-year drought. A multi-year meteorological drought also presents a considerable challenge to groundwater management, as water providers often pull from groundwater storage when surface water cannot meet water demand.
- **Drought early warning capabilities.** Regional stakeholders expressed a need for more early-warning capabilities than are currently available. There is a lack of accurate weather data in rural and remote regions of the West and some drought-related decisions are being made based on observations that are taken 50 or more miles away. There is (or there is perceived to be) limited forecast capability for seasonal precipitation patterns such as snowpack and monsoon deficiencies. There is a clear tie between drought early warning and Pasture, Rangeland, Forage (PRF) insurance, which could provide economic resilience to drought in the region.
- **Future climate patterns.** The West is prone to seasonal drought, multi-year drought, decadal drought, and multi-decadal megadrought. How are these climate patterns changing, and what does the future of drought look like in the West?
- **Tribal communities.** The interaction with Tribal communities in the Intermountain West is an important aspect of drought planning. Traditional knowledge can help build drought resilience, and Tribal Nations/Tribal citizens may be considered a key beneficiaries of many DEWS activities (in accordance with NIDIS' Tribal Engagement Strategy 2021–2025 all NIDIS endeavours that pertain to Tribal nations will acknowledge Tribal sovereignty and federal Tribal trust responsibility).

The priorities and activities listed below were developed in consultation with regional stakeholders. The list of activities in this Strategic Action Plan are intended to be accomplished in partnership with those and other stakeholders in the region. NIDIS may take a leadership role in some activities, and may take a supportive role in others that are led by partners (*see Appendix 1*).

4.3 THREE KEY PRIORITIES FOR 2021–2025

The following three key priorities were developed by NIDIS and are based on the common themes listed above, discussions within the meetings, and feedback from regional partners. The three key priorities for the Intermountain West region for the next five years are:

1. Build resilience and mitigate economic, human health, ecological, and other costs of drought. Since 2010 drought has cost over 3 billion dollars in economic impacts across the region (*https://www.ncdc.noaa.gov/billions/time-series/SWCR*), where rural farming communities were hit the hardest; however, other groups, such as hydropower production and tourism were also financially impacted. Droughts are a compounding hazard which correlate with increased morbidity and mortality rates due to reduced water and air quality, more frequent heat waves, and increased stress (e.g. on farm business). Some ecosystems are permanently changed by drought as water quality deteriorates, and drought tolerant invasive species flourish. Building resilience and mitigating costs is intended to result in less financial loss, few or no lives lost from primary or secondary drought impacts, and ecosystems that are more resilient to drought effects. This will be accomplished by understanding the decisions that stakeholders in the region make when dealing with drought, and focusing on activities that create measurable value and meaningful impact within the region.

2. Deliver earlier warning of drought. Enhance collaboration, coordination, and two-way communication among national, Tribal, state, and local partners, universities, data service providers (public and private), drought resource providers, vulnerable communities, and other DEWS regions. These enhanced efforts could strengthen drought early warning, preparedness, and resilience across the Intermountain West to provide more advanced notice than is currently available.

3. Improve or build a comprehensive understanding of drought impacts in the region. This includes:

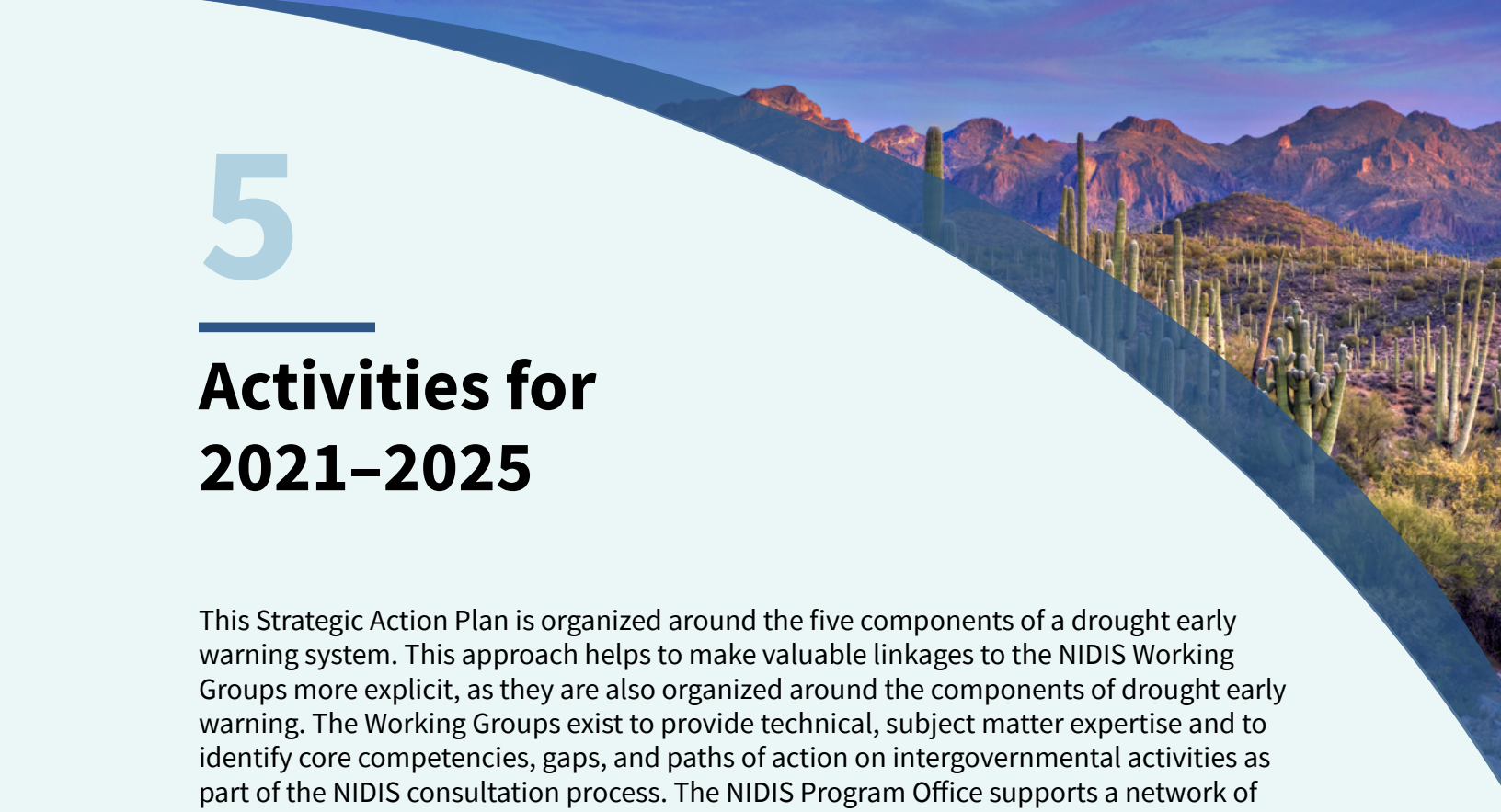
    a. Quantifying the propensity and vulnerability to drought now and in future climates on local, state, and regional scales.

    b. Understanding the likelihood of both short-term (seasonal to annual) and long-term (multi-year to decadal-scale) drought.

    c. Making clear connections between drought indicators and potential drought impacts such as wildfire, groundwater depletion, and ecosystem degradation.

4.4 STRATEGIC ACTION PLAN UPDATE CYCLE AND PROCESS

This strategic action plan covers five years, and is considered a living document. Through annual or biennial DEWS meetings, priority activities will be selected, additional activities can be proposed, and the Strategic Action Plan may be adapted to address emerging issues, as needed.



5

Activities for 2021–2025

This Strategic Action Plan is organized around the five components of a drought early warning system. This approach helps to make valuable linkages to the NIDIS Working Groups more explicit, as they are also organized around the components of drought early warning. The Working Groups exist to provide technical, subject matter expertise and to identify core competencies, gaps, and paths of action on intergovernmental activities as part of the NIDIS consultation process. The NIDIS Program Office supports a network of regular communication and information sharing among these Working Groups to ensure meaningful engagement and effective collaboration on priorities and activities.

5.1 IMW DEWS NETWORK COORDINATION AND INTEGRATION

In building on the progress made from the 2017–2018 Strategic Plan (see Section 3.1 above), this current Strategic Action Plan includes activities intended to strengthen the DEWS network coordination and integration. Networks and partnerships require time and attention to be maintained and to grow. The need exists to support partners, convene the network around various drought-related topics, and identify key lessons to share within and across the DEWS. This convening role is a key aspect of what NIDIS provides to the IMW DEWS.

Outcome 1.1: The IMW DEWS network is strengthened by improving drought communication and coordination.

Activity 1.1a Hold annual or biennial DEWS partner meetings to strengthen networks and enhance coordination among partners.

Activity 1.1b Improve engagement with Tribal nations in the IMW.

Activity 1.1c Strengthen mechanisms of communication and coordination amongst partners and engaging new partners.

Activity 1.1d Contribute to and lead activities with the existing Drought Learning Network in partnership with the USDA Southwest Climate Hub and NDMC.

Outcome 1.2: Stronger network connections are made between the research community and primary producers, practitioners, and decision makers.

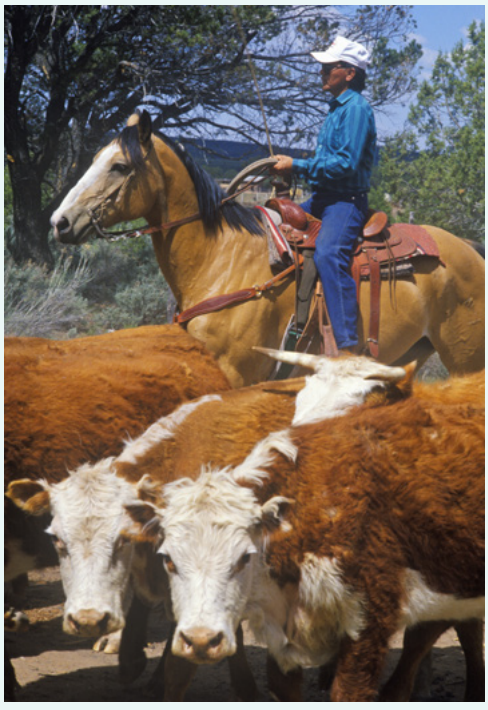
Activity 1.2a Make a concerted effort to communicate applicable drought research findings through University Extension Offices and Extension professionals in the IMW.

Activity 1.2b Host at least one topic-based workshop (e.g., climate change, fire, or drought observations and monitoring) that would encourage networking among both researchers and practitioners.

Outcome 1.3: New partnerships are built within the IMW Region that enable the DEWS to reach currently underserved partners.

Activity 1.3a Improve consultation with Tribal nations and bring additional federal partners to the table, including EPA, Indian Health Services, and the Bureau of Indian Affairs, etc. Work with regional partners who already have strong relationships with regional Tribal Nations (e.g., Quivira Coalition). Or, where appropriate, work directly with regional Tribal communities (Pueblos, Ndé/Apache, Diné/Navajo, the Southern Ute Tribe, and others), and Tribal colleges and universities to improve the availability and relevance of drought information for communities.

Activity 1.3b Build and maintain on-the-ground networks to facilitate two-way communication between those engaged in the DEWS and the public, to optimize the dissemination of information (e.g., early warning information, response options, preparedness activities).



Navajo cowboy herding cattle in Arizona. Credit: Joseph Sohm

Activity 1.3c Strengthen the partnership between NIDIS and the National Weather Service (NWS) to deliver timely information concerning drought through Weather Forecast Offices, and the Colorado Basin River Forecast Center.

Activity 1.3d Expand the IMW email listserv, use more diverse channels to reach new stakeholders, and work with local partners to improve communications with stakeholders in ways that are meaningful.

5.2 PREDICTIONS AND FORECASTING

There are many challenges to improved drought predictions and forecasting. Drought characteristics and physics must be understood in space and time for droughts to be predicted with skill. While larger efforts are aimed at improvements in areas such as subseasonal-to-seasonal forecasting, there are things that

can be done with partners to better communicate the uncertainties of predictions and forecasting, and to make this information more accessible and useful in this region.

Outcome 2.1: Drought information is improved/developed and disseminated, regarding when drought will start and end, especially when multi-year drought is a possibility.

Activity 2.1a: Improve communication on drought persistence and amelioration forecasts. This will include, but is not limited to: emailed drought status updates; regional webinars; and targeted, sector-specific drought information briefings. Information in February, for spring and summer, would be especially beneficial for strategic, on-farm decisions (*see Appendix 2*).

Activity 2.1b: Work with the Climate Prediction Center, NWS forecast offices, and other NOAA partners, universities, and relevant state agencies to communicate user needs to forecast developers and encourage forecast improvement where possible (*see Appendix 2*).

Activity 2.1c: Invest in research around the causes and predictability of multi-year drought (see the Interdisciplinary research section below). Additionally, communicate the research outcomes within the region—with the ultimate goal of improving early warning of multi-year drought events.

Activity 2.1d: Assessment of seasonal Southwest monsoon climate outlooks (viability and forecast skill), and value of such a forecast product for rangeland management and others affected by the Southwest monsoon. The assessment can include investigation into questions such as, “Are there types of forecasts at the beginning of the monsoon season that are more useful/skillful than others?” and “If a skillful monsoon forecast were available, what decisions would it inform and how much value could it create?”

Outcome 2.2 Drought predictions for low streamflow are available in the region.

Activity 2.2a: In coordination with the National Water Center, the Colorado Basin River Forecast Center, other NOAA partners, and local water providers, improve streamflow forecasts to include low streamflow prognostic information at both weather and climate timescales.

Outcome 2.3 Value-creating prognostic tools are expanded and/or improved.

Activity 2.3a: In partnership with the USDA and other federal partners, assess the value of prognostic, decision support tools including pasture condition forecast. What changes are needed? Who uses these tools, and what are they used for? How much value would expansion or improvement create? Etc.

Activity 2.3b: In response to the outcomes of Activity 2.3a, and in alignment with expressed stakeholder needs, support research that would expand or improve

Sheep in front of red buttes in Monument Valley Navajo Tribal Park. Southern Utah near the Arizona border. Credit: Joseph Sohm

prognostic, decision support tools, or other pasture forecast models.

Activity 2.3c: Work with private sector representatives[1] (such as those engaged in precision agriculture) to (1) understand what private sector prognostic tools are available, and (2) find ways to get NOAA's predictions into tools people already use.

Activity 2.3d: Develop forecast products targeted to people who are deciding to purchase agricultural insurance for drought.

Outcome 2.4 Drought predictions for ecological drought impacts are available in the region.

Activity 2.4a: In building on the current (2021–2023) project with the Colorado Climate Center, partner with universities, federal, state and Tribal partners to: (a) clarify what drought information is useful for forest and other natural resource managers in the IMW DEWS region; (b) identify what decisions that information would influence; and (c) estimate what value would be created by a tailored drought forecast for ecological stakeholders.[2]

Activity 2.4b: Collect, research, and deliver information on forest management best practices during drought events, including planning resources to enhance drought preparedness in the forest management sector. In partnership with the Colorado Climate Center, build drought early warning capacity in Colorado through increasing condition monitoring in forests.

1 "NIDIS may engage with the private sector to improve drought monitoring, forecast, and communication if the National Oceanic and Atmospheric Administration (NOAA) determines such partnership is appropriate, cost-effective, and beneficial to the public and certain decision-makers;" Public Law No: 115-423 (01/07/2019), National Integrated Drought Information System Reauthorization Act of 2018

2 There are still many unknowns about what an effective ecological drought prediction would look like. This activity will help answer these questions: What does an ecological drought look like in the IMW?; How is it different for forests, alpine regions, and deserts?; How do natural resources managers know they are in a drought?; What timeframe do they make strategic and operational decisions?; Even if we could provide a perfect forecast at the ideal lead time, what would they do with that information?; and What parts of their operation could they change?

5.3 OBSERVATIONS AND MONITORING

Dwindling snowpack on Mount Humphrey, the highest peak in Arizona, near Flagstaff. Credit: Matthew Mellinger

There is a general consensus that more in situ measurements, including for snowpack and soil moisture, are needed across the IMW. Stakeholders repeatedly identified the problematic lack of accurate weather data in rural, remote, and topographically complex regions of the West. This is especially problematic for livestock producers who are trying to access PRF Insurance, or who are trying to make stocking decisions for complex terrain based on very coarse temporal and spatial resolution data. Precision livestock management requires high-resolution, real-time observations. Monitoring and recording drought impacts is also important to stakeholders in the region. Improvements to observation and management capacity should be accomplished through the continued support of existing stations and networks—in addition to new stations being deployed in areas lacking coverage.

Outcome 3.1: Locations of monitoring stations are known, gaps in coverage are addressed, and gridded datasets are improved such that datasets (gridded and point data) may be trusted and used more effectively in decision making.

Activity 3.1a Understand key gaps in stations, with analysis including remote sensing data, to determine where additional stations are needed. Determine how ongoing programs (e.g. Remote Automatic Weather Stations—RAWS, etc.) and initiatives might be leveraged to meet these needs holistically.

Activity 3.1b Support existing and new research on how to provide the most improved accuracy to gridded datasets over the complex topography of the IMW. This can include: improvements to statistical processes, a merger of remote sensed and in situ observations, and/or an investigation of where strategically placed observation sites and multi-sensor coordination will improve the representativeness of gridded datasets. Where appropriate, explore ways to apply this research.

Activity 3.1c Engage with Tribal nations and Tribal colleges to install weather/mesonet stations on Tribal lands to increase drought monitoring for the tribes in this region. This includes identifying funding sources that could be used (e.g., U.S. Bureau of Reclamation (USBR) Water Smart Program, Natural Resources Conservation Services (NRCS) programs, Conservation District Programs) and/or programs with which to coordinate and partner (e.g., Tribal Soil Climate Analysis Network [NRCS]).

Activity 3.1d In building on previous work (for example, that done at the University of Arizona[3,4]), examine what other metrics might be monitored (e.g., stock ponds), including the complexities that might affect the data and meaning (outtake and input levels in stock ponds, associated soil types, and seepage) to better understand local conditions.

Outcome 3.2 The U.S. Drought Monitor (USDM) is strengthened to better represent local conditions and impacts, especially in underrepresented rural and Tribal areas.

Activity 3.2a: Work with NDMC to update drought impact tables for the states of Arizona, Colorado, New Mexico, Utah and Wyoming based on input from the region.

Activity 3.2b: Work with local partners to improve the input into the USDM including active drought conditions reporting through established channels such as the CoCoRaHS conditions monitoring reports, the NDMC Condition Monitoring Observer Reports, social media, or the Drought Impact Reporter.

Activity 3.2c Encourage participation in citizen science activities and crowdsourced data collection through programs like CoCoRaHS, CrowdHydrology, the National Phenology Network, and others.

Outcome 3.3 Ecological drought impacts and recovery are routinely observed and reported.

A key challenge for grazers in western WY and CO is a lack of data (on forage and soil moisture) from forest understories, where livestock graze during the summer.

Activity 3.3a: In coordination with the other local, state, federal (BLM, USFS Rocky Mountain Research Center, etc.) and university partners, help document ecological drought impacts in forests and other natural lands. This could include documenting springs and other shallow water sources that are highly susceptible to change from drought, but are routinely used for watering grazing stock.

Activity 3.3b: Similar to Activity 3.2c, above, work with groups such as the Colorado Climate Center to encourage participation in forested regions in citizen science activities and crowdsourced data collection through programs like CoCoRaHS, CrowdHydrology, the National Phenology Network and others.

3 University of Arizona 2017 report for the Hopi Tribe *https://climas.arizona.edu/sites/default/files/pdfhopidroughtfinalreport2017.pdf*

4 Meadow, A. M., M. A. Crimmins, and D. B. Ferguson, 2013: Field of dreams or dream team? Assessing two models for drought impact reporting in the semiarid southwest. Bull. Am. Meteorol. Soc., 94, 1507–1517, *https://doi.org/10.1175/BAMS-D-11-00168.1*.

5.4 PLANNING AND PREPAREDNESS

Dry forest conditions near Flagstaff, Arizona. Credit: Lisa Aird

Across the IMW, partners have made great improvements in communicating and responding to drought. Much of recent progress was made through efforts from the last IMW DEWS Strategic Plan. However, there is still a desire to take explicit preparedness actions on the ground that build resilience. Planning and preparedness efforts in the IMW should effectively communicate what needs to be done before a drought and what should be done during a drought to successfully emerge from drought conditions unscathed. These planned activities will be different for various regions, economic sectors, and business sizes.

Outcome 4.1: Drought disaster relief programs, including insurance providers and customers, have improved access to high-quality, fit-for-purpose climate and weather data.

Pasture, Rangeland, Forage (PRF) insurance is a parametric insurance product based on a rainfall index from NOAA's Cooperative Observer Network (COOP) weather stations and formatted on a 17-square-mile gridded dataset. Insurance customers can pick the index based on their desired productivity factor. PRF insurance is designed to be used as an insurance or an investment. Because it is based on COOP data, and some regions (e.g., central Utah) do not have a COOP station, the gridded data may have questionable accuracy. The intersection of climate information in that decision is very clear; at the prospect of drought, a farmer may purchase PRF insurance as a one-time decision each year and the decision is disconnected from other operational decisions. Thus, a desired outcome within the IMW DEWS is to provide accurate rainfall information that supports PRF insurance, both for providers and customers.

Activity 4.1a Engage with PRF insurance providers (public and private) to understand the PRF products, process and the data used in the decision making process, both for the provider and the customer. Also, understand the economic implications of a sparse data network to the insurance risk management for both the providers and the customers.

Activity 4.1b Work with groups such as the University of Arizona's project tracking COOP stations and Rainfall Index, and the University of Colorado, Boulder's Earth Lab project on USDM—PRF Insurance Comparison Tool and the USDA's Pasture, Rangeland,

Forage Pilot Insurance Program to improve PRF decision support data and to increase its accessibility.

Activity 4.1c Make efforts to improve the accuracy and trustworthiness of the data being used in PRF insurance decisions. This may include working with the COOP network or considering other datasets with better spatial and temporal coverage in some regions.

Outcome 4.2: Agriculture businesses in the IMW region are more resilient to drought impacts.

Activity 4.2a Develop a list (database) of regional programs, practices, and assistance used to build resiliency and appropriate (strategic) drought response(s). Programs and partners may include state and federal government partners (NRCS, BLM, USBR, and others), and grassroots partnerships like local feed markets or grazing exchanges. This list may include on-farm infrastructure upgrades while in drought. This database of drought response tools will be hosted on existing *drought.gov* pages.

Activity 4.2b Work with heat health advocates and local extension professionals to promote heat warnings for dairy producers and feedlot operators, if not already available.

Activity 4.2c Work with local partners to support regional peer-to-peer network(s) (such as the Southwest Drought Learning Network) devoted to sharing ideas about drought preparedness and resilience, infrastructure projects, case studies, and success stories.

Outcome 4.3: Recreation and tourism businesses in the IMW region are more resilient to drought impacts.

Drought impacts the outdoor recreation and tourism industry in the IMW during all four seasons. Drought can lead to a shortened ski season for winter resorts, as well as an extended wildfire season (e.g., 2020). Drought impacts river flow which leads to a decrease in white water rafters being able to operate, and anglers not being able to experience the rivers. Drought impacts hunting by increasing fire danger and changing game numbers and behavior. Stakeholders expressed a desire to know what is being tried when it comes to drought adaptation by other recreation and tourism groups.

Activity 4.3a Create a learning network to facilitate peer-to-peer knowledge sharing among recreation and tourism groups. Use this learning network to facilitate formal connection between state drought coordinators and local tourism groups where formal channels do not already exist.

Activity 4.3b Work with tourism industry representatives to help coordinate tourism-appropriate drought messaging to the average traveler that things are dry and what that might mean for their recreation experience. Help the public understand how drought intersects with and impacts recreation and tourism opportunities. Use *https://www.drought.gov/sectors/recreation-and-tourism* as a repository for drought

related travel information. Messages for tourists might include information regarding statewide fire bans including a map showing regions with fire restrictions, which state parks are still open in those regions, and the advice from the park service about how to safely enjoy the outdoors in those areas. *Drought.gov* already includes ski resort information but, with advice from the ski industry, could also include a message that ski resorts are still open, but expect more manmade snow this year, or similar.

Activity 4.3c Work with federal partners, such as the Small Business Administration to collect and disseminate information on resources available for small businesses that have been impacted by drought.

Outcome 4.4: Building on work done through the 2017–2018 IMW DEWS Strategic Plan, Drought plans within the region are tested and improved

Activity 4.4a Support states and Tribal nations who are updating drought and related plans to move to more proactive plans with technical information, research, tools, and lessons learned from other states and Tribal nations.

Activity 4.4b If requested, and when/where appropriate, help test drought plans through scenario planning exercises for states, industry, water managers, and/or others.

5.5 COMMUNICATION AND OUTREACH

View of downtown Phoenix, with the Sonoran desert in the foreground. Credit: Gregory E. Clifford.

The IMW DEWS network has grown since the inception of the DEWS and a variety of stakeholders were present at the planning meetings in October and November 2020. Some stakeholders have been actively working with the DEWS since its inception in 2009, while others were relatively new to the concept of a DEWS and expressed a need for greater awareness of who NIDIS is, what we do, our mission, and what a DEWS hopes to accomplish. The activities listed in this section try to accommodate both groups, the long-time partners and the new partners in the region. One of the improvements that was recommended by local stakeholders is drought information, including forecast tools, that are tailored to the specific needs of individual sectors, such as natural resource managers, similar to the information that is already available for the agriculture sector. This tailored information should include mental health services and Tribal communities who are currently assumed

to be underserved by climate information.

Outcome 5.1: Public and mental health resources are easily accessed by those whose well being is adversely affected by drought. While drought may be challenging, it should not be crippling or deadly.

Activity 5.1a Promote existing mental health resources: Wyoming Ag stress website, WY extension farm stress website, Utah extension mental health website, and any other relevant resources that are available in the region.

Activity 5.1b In alignment with NIDIS' national initiatives on drought and public health, and outcomes of the 2020 Drought and Public Health workshop in Tucson, work with rural and regional public health professionals to create drought messages that are tailored to and appropriate for public health service providers. These may include dust and smoke related air quality alerts, and promoting healthy mental well-being in times of drought.

Outcome 5.2: Natural resource managers, forest and ecosystem managers, and other natural land managers have access to improved, high-quality, and impactful drought outreach materials and management tools.

Activity 5.2a Prioritize building better communication and networks with natural resource managers in the IMW DEWS region to understand what information is needed, what format is useful, and what channels work best.

Activity 5.2b Work with regional partners (e.g., Regional Climate Adaptation Science Centers (CASC), WWA, etc.) to develop tools and resources that are tailored to natural resource managers' needs and will create value.

Activity 5.2c Encourage natural resource managers to report drought impacts through established channels such as the CoCoRaHS conditions monitoring reports, the NDMC Condition Monitoring Observer Reports, social media using #Drought, or the Drought Impact Reporter. Also encourage participation in citizen science activities and crowdsourced data collection through programs like CoCoRaHS, CrowdHydrology, the National Phenology Network, and others.

Outcome 5.3: Forecast probability and forecast uncertainty is clearly communicated.

Activity 5.3a Work with local experts (universities and/or state climate offices) and national forecast creators/producers to communicate forecasts, their probability and uncertainty, including forecast skill by season and area, in a way that will meet the needs of those who use them. This includes, where appropriate, the production of new forecast products that may be based on existing forecast data, but consider the decision-making process of end users.

Activity 5.3b Work with Extension professionals from land grant universities in the region to provide training or other tools that help people get the most from drought/

Kayaking on the Colorado River between Lees Ferry and Glen Canyon Dam. Credit: Jim David

rainfall/temperature outlooks. Also, use feedback from Extension professionals and their stakeholders to inform the production of new, and impactful forecast tools.

5.6 INTERDISCIPLINARY RESEARCH AND APPLICATIONS

There are still many questions to answer in the region concerning drought evolution and impacts to inform early warning products and services. For example: How can we better quantify regional propensity and vulnerability to drought now and in future climates on local, state, and regional scales? How does the surface water/groundwater interaction in the region change during drought? What practical methods can be used within the IMW DEWS to improve drought resilience? How can we better predict multi-year drought? While building on the progress made from the last IMW DEWS Strategic Plan, we are committed to continue to work closely with colleges and universities within the region, including Tribal colleges and other minority serving universities where possible, to research these questions.

Outcome 6.1: The mechanisms and climate dynamics of multi-year drought in the West are well understood, and can be used to provide early warning of multi-year drought events.

Activity 6.1a Support research focused on the following questions: What are the climate factors in a multi-year drought and how are they different from single-year or single-season drought events? What drives the multi-year variability? How predictable are multi-year drought events and what predictive indicators are available? Within the IMW, what is the typical frequency, intensity, and duration of drought? Do the multi-year–to–multi-decadal drought events in the paleoclimate record provide an analogue for future drought events, or do changing climate features, such as increasing temperature, mean that future events may be different from those seen before?

Activity 6.1b Perform a review of what multi-year drought research has already been done and bring attention to any actionable research.

Outcome 6.2: The regional propensity and vulnerability to drought now and in future climates on local, state, and regional scales is quantified and understood.

Activity 6.2a Support research and tools that help people in the IMW understand the climate they live, work and play in. Build on the outcomes of current projects, such as the University of Alabama project to create Intensity-Duration-Frequency curves for low streamflow in the Salt Lake Valley. Answer questions such as: How likely are extreme dry conditions? What is the rainfall variability like? and How likely are rapid swings from wet to dry conditions?

Activity 6.2b Use the IMW DEWS *Drought.gov* pages as a place to access drought climatological information for the region. This may include information like rainfall variability and monthly mean evaporation rates.

Activity 6.2c Consider Southwest monsoon variability as a mechanism for drought development or suppression in the desert Southwest. Support research regarding monsoon variability and predictability.

Outcome 6.3: The suite of actions to prepare for and respond to drought, that increase resilience over the long-term, are shared and understood.

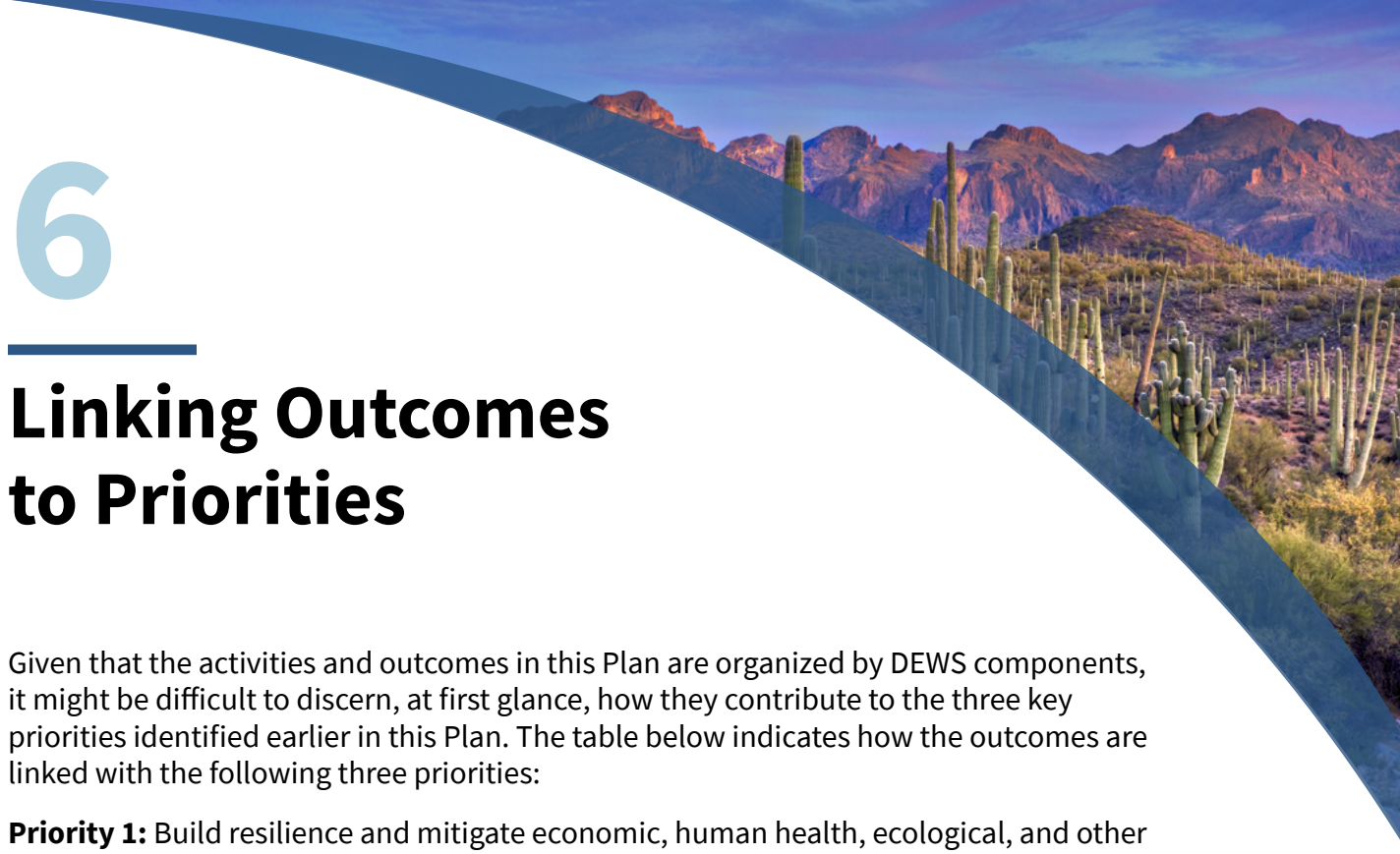
Activity 6.3a Support research to explore the root causes and/or solutions that are common to multiple complex problems (e.g., drought, flooding, wildfires, reductions in soil quality) to provide better guidance on which adaptation actions have the potential to result in co-benefits and avoid maladaptation. This should include wildfires, which is a priority issue in the Intermountain West, and should align with existing research goals as outlined in NIDIS' NDAWN strategy.

Activity 6.3b Support research to prioritize adaptation actions. Determine what actions are more impactful that can be implemented now (e.g., forecasting, long-term analytics, state and local plans, water storage, ecosystem restoration).

Outcome 6.4: Data, products, and services are improved and/or expanded to better serve the region.

Activity 6.4a Investigate how much would increased observation network density improve the accuracy of gridded data sets, especially in mountainous regions? Where could strategically placed weather observations create the largest impact in data accuracy?

Activity 6.4b Examine drought response needs between large and small farming operations to better understand where their needs overlap and where they are different. Consider the range of responses to the range of drought (moderate to severe). Work with data providers to ensure access to data, products, and services are fit for purpose for a range of operations sizes.



6

Linking Outcomes to Priorities

Given that the activities and outcomes in this Plan are organized by DEWS components, it might be difficult to discern, at first glance, how they contribute to the three key priorities identified earlier in this Plan. The table below indicates how the outcomes are linked with the following three priorities:

Priority 1: Build resilience and mitigate economic, human health, ecological, and other costs of drought.

Priority 2: Deliver earlier warning of drought.

Priority 3: Improve or build a comprehensive understanding of drought impacts in the region.

Mapping Outcomes to Priorities in the IMW DEWS Strategic Action Plan			
	PRIORITY 1 Build resilience and mitigate loss	**PRIORITY 2** Deliver earlier warning of drought	**PRIORITY 3** Improve understanding of drought impacts
Outcome 1.1	X	X	
Outcome 1.2		X	X
Outcome 1.3	X	X	
Outcome 2.1	X	X	X
Outcome 2.2	X	X	X
Outcome 2.3	X	X	
Outcome 2.4	X	X	X
Outcome 3.1	X	X	X
Outcome 3.2			X
Outcome 3.3		X	X

Mapping Outcomes to Priorities in the IMW DEWS Strategic Action Plan			
	PRIORITY 1 Build resilience and mitigate loss	**PRIORITY 2** Deliver earlier warning of drought	**PRIORITY 3** Improve understanding of drought impacts
Outcome 4.1	X	X	
Outcome 4.2	X		
Outcome 4.3	X		
Outcome 4.4	X		
Outcome 5.1		X	
Outcome 5.2	X		
Outcome 5.3	X	X	X
Outcome 5.4	X	X	
Outcome 6.1	X	X	X
Outcome 6.2	X	X	X
Outcome 6.3	X		X
Outcome 6.4	X		X

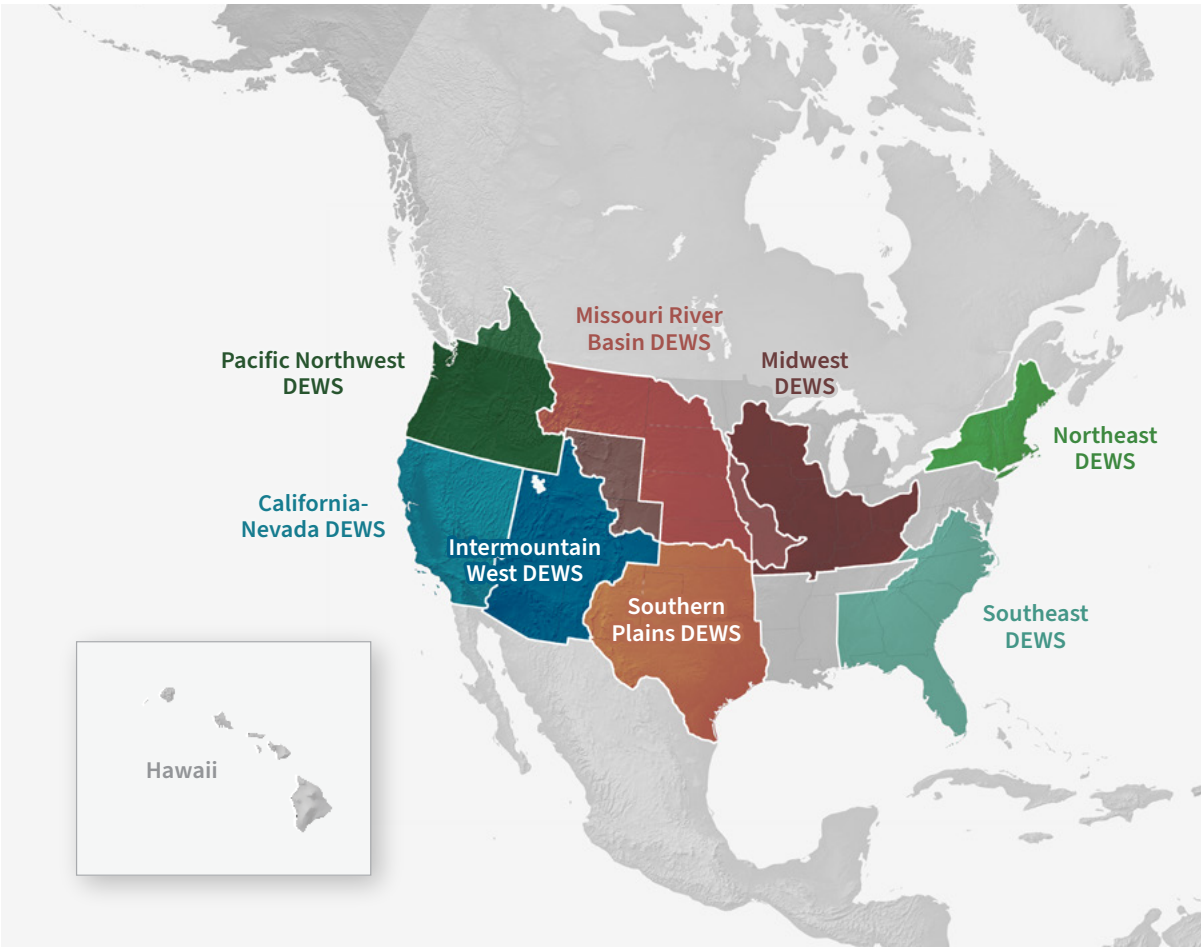


Figure 5: Map of regional Drought Early Warning Systems (DEWS). Credit: NOAA NIDIS, Fiona Martin

7 National & Cross-DEWS Initiatives

NIDIS has implemented regional DEWS as the foundation on which to provide national drought early warning, in recognition that impacts and early warning information differ across the regions. There are also challenges that cross multiple regions or require a coordinated effort at the national level. These include issues like the complex interactions of drought and wildland fire, drought and human health, Tribal engagement, drought impact reporting and analysis, linking drought triggers and indicators, the NIDIS Coping with Drought grant program, understanding a healthy water cycle and healthy soil, and soil moisture monitoring. Regional DEWS have the ability to tap into these larger initiatives where there is interest and need, again providing an opportunity for cross regional and scalable (regional to national) learning and progress. The table below illustrates some of these linkages as they apply in the IMW.

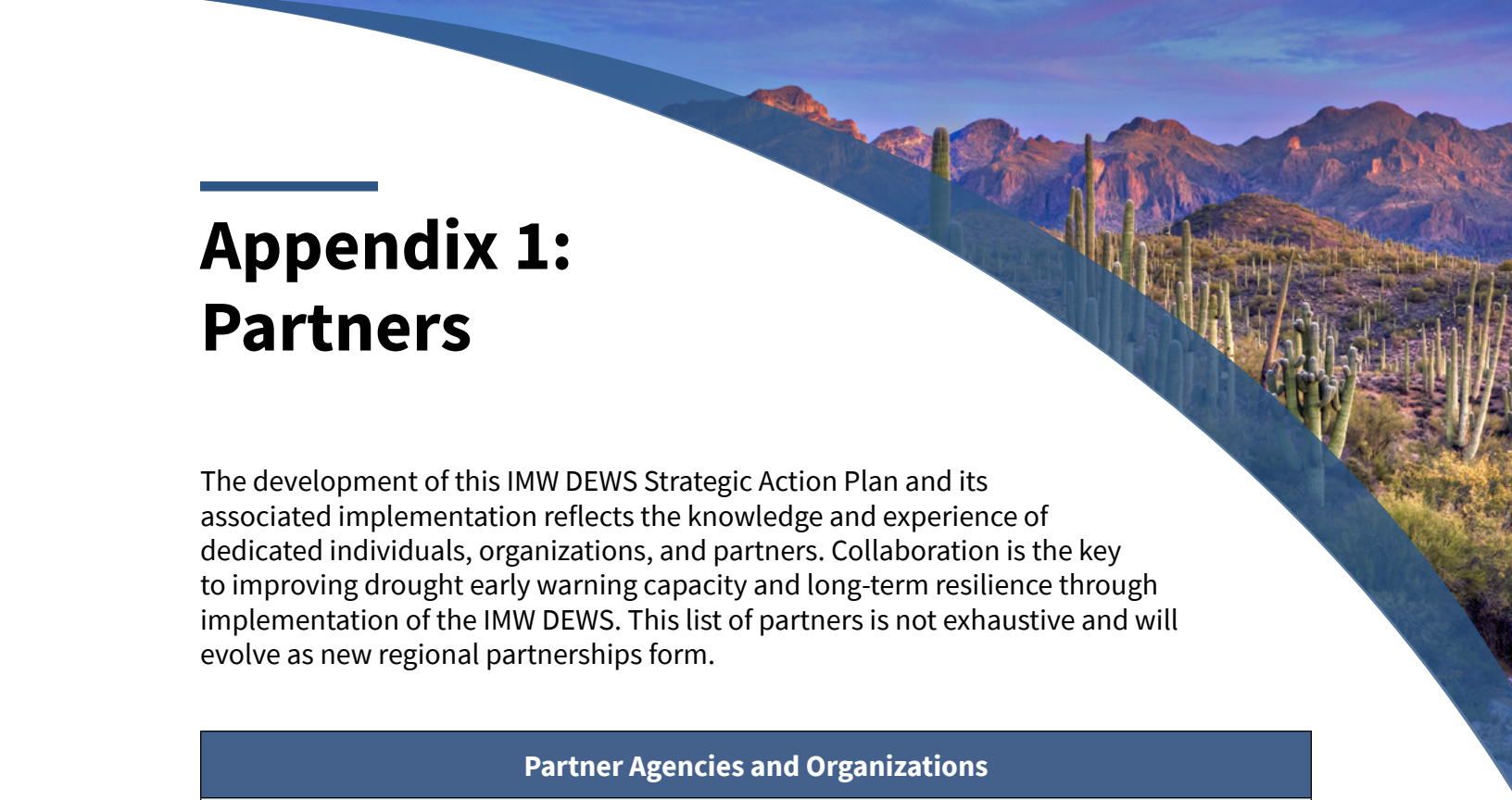
National/Cross-DEWS Initiatives	IMW DEWS Activities
Weather Research and Forecasting Innovation Act of 2017 (Weather Act)	The Weather Act calls for NOAA to prioritize weather research in part to improve forecasts and warnings for protection of life and economy, to improve understanding of forecast capabilities for atmospheric events and their impacts, and to make reliable and timely foundational forecasts of subseasonal (2 weeks to 3 months) to seasonal (3 months to 2 years) forecasts of temperature and precipitation. While there are many other initiatives included in the Weather Act, these are the areas that NIDIS also has a strong interest in, in terms of drought early warning. NIDIS is making and leveraging investments in regards to the same temporal scale as they apply to drought in partnership with the NWS regional and local forecast offices, the Climate Prediction Center, and the Office for Oceanic and Atmospheric Research. The IMW region has some especially difficult forecast challenges, for example, where tropical and extratropical weather systems interact creating high seasonal climate variability. Activities 2.1a, 2.1b, 2.1c, 2.1d, 2.2a, and 2.3c, 2.3d will provide a regional application to these national initiatives.
Water Prediction Center/NOAA Water Initiative	NOAA has multiple efforts aimed at water security that NIDIS plays a role in. The Water Initiative aims to improve the Nation's water security by providing science-based information and services that address vulnerability to water risks and enabling greater efficiency and effectiveness in the management of water resources. NOAA will advance this mission primarily through transforming integrated water prediction services in collaboration with decision makers, partners, and users. In addition, the Water Prediction Center focuses on collaborative research to inform essential emergency management and water resources decisions across all time scales. NIDIS is involved in efforts to enhance drought prediction and monitoring, looking at applications of the National Water Model to drought early warning and serving as part of these initiatives where they intersect with drought. Activities 2.2a and 6.1a, will provide a regional application to these national initiatives.
Tribal Engagement Strategy	NIDIS's *Tribal engagement strategy* was written for the Missouri River Basin and the Midwest DEWs but is being applied nationally. There are many similarities in the gaps and needs in the Missouri River Basin and Midwest DEWS and the IMW DEWS. By considering the principals of engagement that are enumerated in the Tribal Engagement Strategy and engaging the Tribal nations of the Intermountain West in a meaningful way, we will achieve many of the outcomes in both documents. Activities 1.1b, 1.3b, 2.4a, 3.1c, and 4.4c will provide a regional application to these national initiatives.

National/Cross-DEWS Initiatives	IMW DEWS Activities
National Coordinated Soil Moisture Monitoring Network	There is a clear need for increased observation network density in the IMW, and some of these data gaps apply to soil moisture sensors. The National Coordinated Soil Moisture Monitoring Network Strategy will have impactful applications within the region. Activity 3.1b will contribute to this national effort.
NIDIS Drought and Wildland Fire Nexus Strategy (NDAWN)	The NIDIS *Drought and Wildland Fire Nexus (NDAWN)* defines the needs and challenges of fire managers to effectively utilize drought information and aims to meet those needs and to establish a robust drought and wildland fire decision-support information network. A recently completed NASA DEVELOP project improved a tool for the Great Plains to incorporate drought information into daily fire risk maps. There is a desire to expand the geographic coverage of this tool. Activities 2.3b, 4.3a, and 6.3a may have some application to this national program.
NIDIS Coping with Drought	NIDIS uses the Coping with Drought federal funding opportunity to address research needs gathered through the consultative process within the DEWS. The outcomes of applied research funded through the CWD program will be transferred to the DEWS. For example, the FY20 competition is focused on indicators, impacts, and triggers which aligns with priorities 1, 2 and 3 for this region.
Drought and Human Health	NIDIS is engaged in developing a Drought and Human Health Strategy. There are opportunities to hold regional workshops on the topic. Activities 2.1b, 5.1a, 5.1b may contribute to this national initiative.
Drought Impact Reporting and Analysis	NIDIS is involved in efforts nationally to improve reporting and analysis that can inform what is happening at the state and region. Activities 3.2a, 3.2b, 3.2c and 5.2c will all help with drought impact reporting and analysis in the region.
Improving Indicator Use and Linking to Triggers	A common refrain from partners across the DEWS is the desire to better understand which indicators and indices should be used for a region/state both spatially and temporally as well as for different sectors. There are national efforts with NDMC and internationally with the Commission on Environmental Cooperation to contribute answers to these questions. Deliberate efforts to share learning across these initiatives will hopefully accelerate this work. Activities 4.4a and 4.4b will contribute to this national and international effort within the IMW region.

National/Cross-DEWS Initiatives	IMW DEWS Activities
National Drought Forum	The National Drought Forum held in 2019 resulted in ten priority actions, many of which are reflected in the IMW strategic action plan. These include, but are not limited to, work to improve flash drought forecasts, enhancements to observations and monitoring and decision support tools (Outcomes 2.3, 3.1, 3.3, and 4.1), better quantification of drought impacts (Outcomes 3.2, 3.3, 6.1 and 6.2), and ecosystem restoration to mitigate drought impacts (Outcomes 3.3 and 5.2). The synergies between priorities at the regional and national effort should amplify our progress in addressing these complex challenges.

7.1 LINKAGES TO REGIONAL PARTNERS AND INITIATIVES

NIDIS has a mandate to work across the federal government, coordinating drought related activities with other federal agencies, and to build upon and leverage existing partnerships, networks, and initiatives. This is especially important in the regional DEWS where these partners and regional organizations are key to realizing success in the region. In the IMW, key regional partners include the USDA Southwest and Northern Plains Climate Hubs, WWA, the National Drought Mitigation Center, the USGS Southwest and North Central CASCs, the Climate Assessment for the Southwest NOAA RISA team, the NOAA Western Regional Climate Center, and the state Climate Offices. The activities above call out many places where linkages are being made with these regional partners and programs. These linkages have been key in much of the past progress and will continue to be key moving forward. Additional partners, programs, assistance, and activities offer additional beneficial linkages that can be developed and built upon to identify more resources, to work across more agencies, to leverage more partnerships, and to utilize more assistance that will result in more efficiency and effectiveness of everyone's contributions and increase co-benefits.



Appendix 1: Partners

The development of this IMW DEWS Strategic Action Plan and its associated implementation reflects the knowledge and experience of dedicated individuals, organizations, and partners. Collaboration is the key to improving drought early warning capacity and long-term resilience through implementation of the IMW DEWS. This list of partners is not exhaustive and will evolve as new regional partnerships form.

Partner Agencies and Organizations
Arizona Department of Forestry and Fire Management
Arizona Department of Water Resources
Arizona State Climate Office at Arizona State University
Climate Assessment for the Southwest (CLIMAS, a NOAA RISA team)
Colorado Parks & Wildlife
Colorado State University (CSU) • Colorado Climate Center • CSU Extension
Colorado State Water Availability Task Force
Colorado Tourism Office
Jordan Valley Water Conservancy District
National Drought Mitigation Center (NDMC)
National Oceanic and Atmospheric Administration (NOAA) • National Weather Service, Weather Forecast Offices • National Weather Service, Colorado Basin River Forecast Center • National Weather Service, Western Regional Climate Center
New Mexico State University—New Mexico Climate Office

Partner Agencies and Organizations
RTI Innovation Advisors (a NASA Contractor)
Salt Lake City Department of Public Utilities
The Grand Canyon Trust
University of Arizona • Cooperative Extension
University of Utah
University of Wyoming—Extension
U.S. Bureau of Reclamation
U.S. Army Corps of Engineers
U.S. Department of Agriculture (USDA) • Agricultural Research Service (ARS) • Farm Service Agency (FSA) • Northern Plains Climate Hub • Southwest Climate Hub • U.S. Forest Service (USFS)
U.S. Department of the Interior (DOI) • U.S. Bureau of Reclamation (USBR) • U.S. Geological Survey (USGS) • Southwest Climate Adaptation Sciences Center (SC CASC) • North Central Climate Adaptation Science Center (NC CASC)
Utah Department of Agriculture and Food
Utah Division of Water Quality
Utah Division of Water Resources
Utah State University • Agricultural Extension • Utah Climate Center
Western Water Assessment (WWA, a NOAA RISA team)

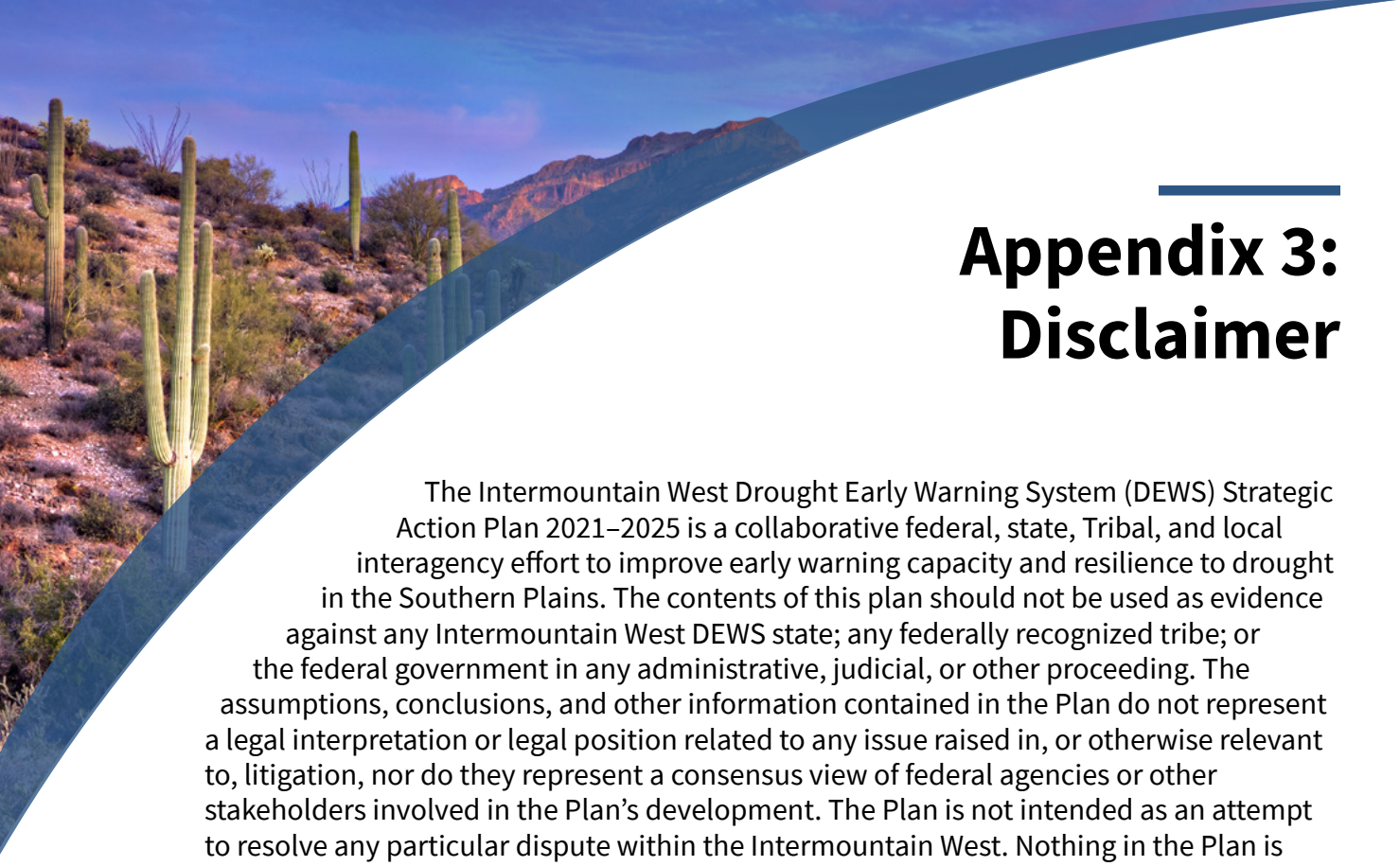
Appendix 2: Critical Forecast Timeframes & Decisions in the Intermountain West

Sector-focused stakeholder meetings in the Intermountain West DEWS region revealed the following information about critical forecast timeframes and the decisions that could be made with good forecasts at each lead time. This list represents the needs expressed in the agriculture meetings, but is incomplete and should be expanded upon.

Forecast lead time	Decisions made
Weeks to Months	• Agriculture could purchase feed or water
Months to Seasons	• Cropping would decide which crop variety to plant • Buy or sell livestock • Within this timeframe, Livestock producers would also like to know if the season will start bad but turn good or vice versa.
Seasons to Years	• Water managers would begin planning for a multi-year drought. • If a drought will be a multi-year event, livestock producers want to know as soon as possible to reduce their herd or decide to move cattle to another location • For livestock management, the ideal forecast lead time would be 6 months to begin planning in the winter for summer pasture conditions.

Based on this information, forecast improvement priorities should include:

1. Forecasts in Jan/Feb for spring and summer provide the most value to livestock producers and farmers.
2. Will there be any extreme event throughout the season (e.g. heat waves, early frosts, etc.)?
3. General timing of rainfall events, e.g. “The outlook for the next three months shows increased odds of below normal rainfall, most rainfall for the season is expected in the first month”



Appendix 3: Disclaimer

The Intermountain West Drought Early Warning System (DEWS) Strategic Action Plan 2021–2025 is a collaborative federal, state, Tribal, and local interagency effort to improve early warning capacity and resilience to drought in the Southern Plains. The contents of this plan should not be used as evidence against any Intermountain West DEWS state; any federally recognized tribe; or the federal government in any administrative, judicial, or other proceeding. The assumptions, conclusions, and other information contained in the Plan do not represent a legal interpretation or legal position related to any issue raised in, or otherwise relevant to, litigation, nor do they represent a consensus view of federal agencies or other stakeholders involved in the Plan's development. The Plan is not intended as an attempt to resolve any particular dispute within the Intermountain West. Nothing in the Plan is intended to, nor shall the Plan be construed so as to, interpret, diminish, or modify the rights of any Intermountain West state, any federally recognized Tribe, or the federal government under federal or state law or administrative rule, regulation, or guideline.

Finally, all parties recognize that partners participating in this process may disagree over the appropriate scope, methods, results, or interpretation of technical analyses performed in developing or implementing this DEWS. As such, neither the Plan, nor any work performed pursuant to it, shall be attributed to any organizations or individuals by virtue of their participation as a partner in this process. Nor shall any party be deemed to accept or agree with any particular assumption, conclusion, and other information contained in the Plan or its resulting studies, unless explicitly stated by those parties.

Appendix 4: Acronyms

BLM	Bureau of Land Management
CLIMAS	Climate Assessment for the Southwest
CoCoRaHS	Community Collaborative Rain, Hail and Snow
COOP	Cooperative Observer Network
CSU	Colorado State University
DEWS	Drought Early Warning System
DOI	Department of the Interior
DRI	Desert Research Institute
EDDI	Evaporative Demand Drought Index
ESRL	Earth Systems Research Laboratory
IMW	Intermountain West
NASA	National Aeronautics and Space Administration
NDMC	National Drought Mitigation Center
NDAWN	NIDIS Drought and Wildland-Fire Nexus
NIDIS	National Integrated Drought Information System
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Services
NWS	National Weather Service
PRF	Pasture, Rangeland, Forage
PSD	Physical Sciences Division
RISA	Regional Integrated Science and Assessments
SW CASC	Southwest Climate Adaptation Sciences Center
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USDM	United States Drought Monitor
USGS	United States Geological Survey
WRCC	Western Regional Climate Center
WRIR	Wind River Indian Reservation
WWA	Western Water Assessment

Document prepared by NIDIS in partnership with key stakeholders in the region.