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Creating a Web-Based Tool for Determining Drought Acknowledgments in State Plans

by

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A PROFESSIONAL PROJECT

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Abstract

Drought is a lingering and costly disaster and can cause billions of dollars of damage throughout the United States. Drought produces social, economic, and environmental impacts which makes it become a disaster. Due to the long-lasting and intense effects, drought research is needed to understand weather and climate more efficiently so that preparedness, mitigation, response recovery, and resilience is more effective. Policies that include drought mitigation are shown to reduce the likelihood that drought become disasters. The National Drought Mitigation Center (NDMC) has been working on a new web-based tool to identify which plans in a state address key aspects of drought planning. The goal is to incorporate comprehensive drought planning in existing drought, water, multi-hazard, and climate plans. How are plans addressing drought and risks associate with it? How can we tell states are addressing these comprehensively? Is more experience with drought a lead motivator for comprehensive planning? Does a state's tax base link to a more comprehensive planning approach? Using selected criteria inspired by James Schwab to view how states are addressing drought in their plans, interviews from key state drought planners, how often states are in a drought, and state tax revenues, we concluded that there is limited to moderate support that increased drought exposure is correlated with a greater comprehensive score and that a state's tax base is not determined to lead to improved planning. We found that a state's experience with drought is a lead motivator for state agencies to create drought plans and incorporate drought within other planning documents. It is recommended that if NDMC continues with the web-based tool and uses this approach to show each state's comprehensive planning efforts that they update plans often enough so that planners can view their progress and efforts in drought planning.

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Introduction

Drought is a lingering and costly disaster. It can cause billions of dollars of damage throughout the United States. Drought can have multiple different definitions, but a consistent theme of the definitions is that drought occurs when supplies cannot meet demand (Steinemann and Cavalcanti, 2006). When discussing drought plans or planning, a consistent theme is that drought plans can reduce drought losses (Steinemann and Cavalcanti, 2006).

Drought produces social, economic, and/or environmental impacts which makes it become a disaster. The agricultural sector is the most widely known sector to experience tremendous drought impacts, but other sectors can be impacted as well, such as water resources. Drought can affect water supplies such as a decrease of streamflows and the depletion of aquifers due to them not being recharged (Schwab, 2013). Weather extremes are predicted to increase as Earth's climate warms, creating a greater need and anticipation for drought planning to be a key mean of protecting communities, economies, and ecosystems.

There are three different definitions of drought: meteorological drought, agricultural drought, and hydrological drought. Meteorological drought is defined based on the degree of dryness and the duration of that. Hydrological drought is linked with the effects of periods of precipitation which includes the shortfalls on surface or subsurface water supply. Agricultural drought typically links characteristics of meteorological drought to agricultural impacts. This focuses on precipitation shortages, evapotranspiration, soil water deficits, the reduction of groundwater and reservoir levels, and other factors. Some people consider a fourth definition of drought, socioeconomic drought, which is associated directly with the supply of a commodity of economic good that is dependent on precipitation (Wilhite et al., 2014). Agricultural, hydrological, and socioeconomic droughts tend to place greater emphasis on human or social aspects of drought

with the management of natural resources. With hydrological and agricultural drought, there is no direct relationship between precipitation amounts and surface status and subsurface water supplies in water areas such as lakes, reservoirs, aquifers, and streams. Snowpack is the primary source of water in some areas like in the western US. In these areas, determining drought severity is complicated by infrastructures, institutional arrangements, and legal constraints.

Drought is a normal part of the climate and can vary from region to region. A tropical region that does not have rain for a week may be considered a drought, whereas a desert that recently had record rainfall can still be in a drought. In general, drought is defined as a lack of precipitation over an extended period, resulting in a water shortage (Steinemann and Cavalcanti, 2006). The effects of this deficiency are often called drought impacts. Natural impacts of drought can be made even worse by the demand that humans place on a water supply (National Drought Mitigation Center, 2018). Drought is also related to the timing and effectiveness of rain. This explains the reason why each drought is unique in terms of its climatic characteristics, spatial extent, and impacts.

From 1980 to 2019, the United States has sustained 258 weather and climate disasters where the overall damages/costs were at or exceeded \$1 billion (NOAA, 2020). The total cost of these disasters exceeds \$1.75 trillion (NOAA, 2020). For drought alone during the same period, the CPI-adjusted losses equal \$249.7 billion, making it the second costliest disaster in the United States after tropical cyclones (NOAA, 2020). These numbers only account for quantifiable losses with associated dollar values. It does not account for damages to ecosystems and indirect and less obvious effects of drought.

The drought of 2012 is a good reminder as to why drought planning is important. This drought was one of the costliest droughts in the country's history. This disaster affects the most

people among all the natural disasters, and it can occur anywhere on the planet. Drought planning should be conducted at all levels of decision-making, including federal and local water management agencies, tribal governments, water suppliers, and many more. When planning for drought, the public needs to be on board and aware. If the public is not on board, elected officials may find it difficult to act in the best interest of the state or community. Convening the public, as well as private and public organizations, is important for the purpose of developing drought protocols for identifying and reducing vulnerability as well as determining the actions different entities should take.

Historically, society enacts drought policy or regulations only during or after a drought event. Planning for the eventuality of drought is not always the case. Emergency relief and limiting water demands through mandatory water restrictions are measures governments take part in when drought is around, but this approach “has not reduced the economic losses or the level of inconvenience and suffering of the Nation’s citizens” (Vogel, 2018).

Due to its long-lasting and intense effects, drought research is needed to understand weather and climate more efficiently so that preparedness, mitigation, response, recovery, and resilience is more effective. Research focused on drought will lead to improved predictability across the nation and worldwide (Schwab, 2013). Policies that include drought mitigation are shown to reduce the likelihood that a drought become a disaster. Some policies and actions include setting up early warning systems, water conservation, and educating the public on drought and its impacts (Wilhite et al., 2014). Technology and other scientific advances are constantly changing, making room for drought-related improvements such as understanding drought indicators and indices. Drought indicators are variables that are used to describe drought conditions such as precipitation, temperature, and streamflow (World Meteorological Organization (WMO) and

Global Water Partnership (GWP), 2016). Indices are numerical representations of a drought's severity that inputs climatic and hydrometeorological data using indicators (World Meteorological Organization (WMO) and Global Water Partnership (GWP), 2016). This information can be useful in planning for decision-support tools for managing drought risks in multiple sectors.

Drought planning and response is important due to the public health impacts associated with it. Drought can lead to changes in water quality and the environmental impacts, which can cause serious consequences for human health. When drought is accompanied by high heat conditions, it can significantly impact the mental and physical health of people. Health is defined as a state of physical, mental, and social well-being, but everyone's health is shaped by a variety of factors and physical environment (Schwab, 2013). When drought occurs, typical daily activities, such as bathing, sanitation, food preparation, and recreation, can be severely impacted. These impacts can be more severe for vulnerable populations such as the elderly, young children, and disabled persons (Schwab, 2013). Along with this, people can feel stress and impacts on their mental health. Drought can cause a decrease in air and water quality, which can cause stress. It can also lead to financial concerns, lack of productive work, depression, anxiety, alcohol abuse, and even suicide. These outcomes are more common among individuals in rural areas (Schwab, 2013).

Climate change has been a hot topic over the past couple decades. There has been increased research since then as climate change has already been affecting the production and profitability of agricultural systems (Morris and Bucini, 2016). Drought is also a continuous problem on rangelands, and it is critical to adjust management practices to preserve natural resources alongside maintaining financial viability (Brown et al., 2016). Without support from ecosystems functions, short-term production agriculture is more vulnerable to extreme weather events such as drought and floods. The US is already feeling the impacts of climate change with the effects of rising sea-

levels, more intense storms, searing heatwaves, and more severe fires, floods, and droughts (Arroyo, 2017). Perceptions are different when it comes to climate change, despite scientific consensus about the event being human induced. In the agricultural setting, there is no consensus about climate change as some people feel that humans are not the problem and some feel that it is a made-up story to scare people (Church et al., 2017).

Researchers have pointed out that more cross communication is needed between scientists, advisors, and producers in terms of climate adaptation and mitigation strategies (Church et al., 2017). Drought has been a reoccurring event in the rangeland management area for more than 120 years (Brown et al., 2016). Little progress has been made in the effort to alleviate impacts for rangeland ecosystems and ranchers. For rangeland managers, limited information and experience with drought can limit which strategies are chosen to prepare for and respond to the disaster (Knutson and Fuchs, 2016). What is difficult is that though predicting regional exposure to drought has been helpful, it is limited in the ability to predict the impact of drought on both ecosystems and people. There are a variety of tools available for monitoring drought events from the United States Drought Monitor (USDM) to individual drought indices that can and should be used by farmers, ranchers, agencies, and other entities to understand drought and the impacts associated with it.

Project Description

The National Drought Mitigation Center (NDMC) focuses an immense amount of their work in the drought field with a focus on mitigation and resilience. NDMC was established in 1995 with the mission “to reduce the effects of drought on people, the environment and the economy by researching the science of drought monitoring and the practice of drought planning” (National Drought Mitigation Center, 2020). It consists of a team of experts made of climatologists, remote sensing and information technology scientists, sociologists, planners and developers, geographers, analysts, and communicators. NDMC is best known for their involvement with the production of the USDM. The USDM is a partnership between NDMC, the National Oceanic and Atmospheric Administration (NOAA), and the United States Department of Agriculture (USDA) which gives a weekly report on the level of drought across the country. Policymakers use it as a snapshot to what is happening, which assists Senators and members of Congress in making cases for federal disaster intervention. NDMC participates in outreach programs and works with communities to develop drought plans based on a ten-step planning program.

NDMC had been working on a new web-based tool to identify which plans in a state address key aspects of drought planning. NDMC completed a test area of what the tool may look like using the Missouri River Basin (MRB), which includes the states of Kansas, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Wyoming (Appendix B, Figure 1). Note that Minnesota, Iowa, and Colorado are in the MRB, but are not represented in the test group due to each state not being covered by the MRB for at least 50% of the area.

The project is to create a web-based tool for determining drought acknowledgments in state plans. State plans include drought, multi-hazard, water, and climate plans. Drought provides a

focal point for planning for the adaptation to climate change, which may be a factor in some cases of drought. Though there is little that can be done to mitigate drought, extensive drought monitoring networks have been and can continue to be established. Historic drought assessments and current monitoring is needed for understanding past drought occurrences and the impacts. Planners can take appropriate actions to stem impacts before a hazard reaches a certain level if efficient monitoring is in place.

The toolkit is meant to be user-friendly with easy access and easy to follow. Users can select the state of interest to view plans under the ‘State’ category. They can also click on, ‘View a drought planning summary for each state’ to get an overall view of how a state is planning for drought. For example, here is Nebraska’s summary:

Drought planning in Nebraska takes place under multiple mission areas: emergency management set forth in its multi-hazard policy, basin planning processes, and in sub-state governmental entities known as Natural Resources Districts (NRDs). A stand-alone drought plan was established for the state in 2000, along with the Climate Assessment Response Committee (CARC), whose actions have since been incorporated under the 2014 multi-hazard plan. Primary jurisdictional partners for hazard planning and response include Nebraska Emergency Management Agency (NEMA), the Department of Natural Resources, the Department of Health and Human Services, Department of Economic Development, Department of Agriculture, and the Nebraska Historical Society. This multi-agency approach to drought mitigation and response will be strengthened by future integration with state water planning efforts at the basin level, as they are developed and led by the Department of Natural Resources. (National Drought Mitigation Center, 2018)

All states in the testing area have a summary. The summaries were created by NDMC and are based on the overall theme(s) that were found when looking at the state's plans. Some of the summaries and information for a state's plan may not be up to date as some states have updated their plans since the time of the mock website.

Below the 'State' category is the 'Plan Type' category where users can select either a drought, hazard, water, or climate plan or they can choose more than one plan type. Users who are not as familiar with the different plans can view the purpose of each plan type along with an example scope of action related to drought. For example, for a drought-specific mitigation or response plan, the user would see:

Purpose

Drought mitigation plans outline the impacts of drought, and ways to manage the risks associated with it before a drought occurs. On the other hand, a drought response plan is designed to address a specific function: contingency guidance during the time that a drought occurs. Some plans address both aspects of planning. These plans may be connected to emergency management and/or water planning procedures. A drought mitigation plan may consider land use patterns, population distribution and growth, water storage potential, and the needs of vulnerable social groups.

Example scope of action related to drought

Mitigation actions could include a vulnerability assessment that addresses water storage and consumption across sectors, or establishing a task force or monitoring committee. A drought response plan may identify specific actions to be taken (e.g. water use restrictions) when drought reaches a certain level or extent, according to a pre-identified indicator and threshold (a trigger). (National Drought Mitigation Center, 2018)

Below 'Plan Type' is 'Plan Criteria' where users can checkmark what interests them in a specific plan to see if a plan mentions specific drought criteria. The criteria give a glimpse of what is being asked or what is being looked at. The criteria selected was inspired by James Schwab, the former director of the American Planning Association's Hazard Planning Center. Schwab was contracted by NDMC to provide a planner's perspective on how and whether different kinds of plans addressed drought. The nine criteria are listed below (also listed in Appendix B, Figure 2), followed by the questions associated with them. If planners need to update their current plans to tailor more toward the drought hazard, these criteria are what planners should include in their updated plans.

- Drought Defined: Does the plan define or describe drought, or how its effects or threaten human, natural, or physical assets within the state?
- Drought Addressed: Does the plan specifically address aspects of planning for drought or its impacts?
- General Drought Preparedness: Does the plan include measures to generally be more prepared for drought?
- Mitigation Focus (Water Supply): Does the plan discuss the availability or adequacy of water resources and their ability to meet demand?
- Mitigation Focus (Water Conservation): Does the plan outline strategies for reducing water use, increasing efficiency, or decreasing waste?
- Triggers for Action: Are drought indicators connected to actions or measures outlined in the plan?
- Drought Response: Does the plan outline response actions during drought?

- Coordinates with Other Jurisdictions: Does the plan bring in multiple organizations across levels?
- Linkages with Other Plans: Does the plan mention other planning documents?

Research Purpose and Research Questions

Drought planning is becoming more mainstream and with the aid of NIDIS and NOAA's Sectoral Applications Research Program, NDMC was asked to do something like this for every state in the United States.

The purpose of this project is to update NDMC's online collection of state plans that address drought to include more plan types. NDMC's online database of plans have mainly included state stand-alone drought plans. NDMC aims to include drought planning in existing water, hazard, and climate plans for every state. Giving planners an accessible web tool where every known state plan is stored will create less of a headache for planners wishing to view what their state and other states are doing in terms of drought.

One of the questions we want to answer is do plans clearly address drought and mitigate the risks associated with it? How would we know that states have addressed this? Furthermore, is more experience with drought a lead motivator for states to take a more comprehensive planning approach than states with less historical drought? We would also like to know if a state's tax base is linked to more comprehensive planning. That is, do states with a higher per capita tax revenue have a more comprehensive planning approach to drought than states with a lower per capita tax revenue?

Drought management and planning will vary at the national, regional, and local level. There have been concerns about the effectiveness of drought management practices. The concern that arises is that impacts are said to be treated, rather than looking at the underlying causes

associated with the impacts (Wilhite et al., 2014). The hazard has been increasing in its severity, frequency, and duration. Throughout the world, governments focus on the responses of drought in a reactive way and are typically characterized as a crisis management. Drought relief or assistance for those affected most often causes more harm than good in terms of vulnerability to future drought episodes. Providing drought relief or assistance reduces self-reliance and increases dependence on government and donor organizations. Ensuring people are safe and are not at total loss is also key, but there needs to be a balance between emergency relief that provides a safety net for the most vulnerable and the promotion of self-reliance of drought policy based on risk reduction (Wilhite et al., 2014).

Even with drought increasing in frequency and the impacts associated with it, no efforts have been made at the global level to initiate and adopt national drought policies. Having an effective global effort will provide a framework for a proactive, risk-based management for dealing with the events of drought. Without comprehensive monitoring, early warning systems, impact assessment procedures, risk management tactics, drought preparedness plans, and emergency response programs, there will be a continuation in responding to drought in a reactive, crisis management way. Improving drought monitoring and early warning systems through any linking indicator to impacts can lessen the impacts of societal vulnerability. The main constraints on the early warning system implementation is the lack of drought policy framework, limited coordination institutions, risk management and reduction, and inadequate social impact indicators (Wilhite et al., 2014).

Drought preparedness programs have been increasing over the years as well and are considered a primary defense against drought hazards. NIDIS emphasizes the importance of drought programs, which would provide support tools for water users and decision makers

specifically. State plans and programs address monitoring, declarations, communication, and coordination for the most part, yet few states conduct post-assessments or impact assessments for when a drought occurs. “State drought officials recommended the following: (1) clear and relevant drought indicators and triggers; (2) frequent communication and coordination among state agencies, local governments, and stakeholders; (3) regularly updated drought plans; and (4) strong leadership that includes a full-time state drought coordinator” (Fontaine et al., 2014).

With this, we hypothesized that states engage in drought planning for the sake of minimizing drought impacts, even though drought planning is not required. We think that since drought is a part of the FEMA hazard planning framework that drought planning overall has increased. We hypothesized that states that are more drought-prone would link to more comprehensive planning overall. We also hypothesized that a state with a higher tax base revenue per capita would link to more planning efforts made by that state, given that the process of writing a plan can be costly.

Methods

With this project, we are aiming to seek out how states are incorporating drought into their planning. We plan to follow what NDMC has been doing by going through each state plan (drought, multi-hazard, water, and climate) and doing a search for the criteria that were created. Drought planning is a form of mitigation that will bring benefits to communities and sectors and involves looking at past impacts as it will provide a specific set of knowledge for a certain area to use for future planning.

There is not a national drought policy in the US as it would probably be challenging due to the split responsibilities between federal and state agencies. Therefore, states need to be responsible for including drought in their planning. Our plan to determine if states effectively

discuss drought in their planning is to create a spreadsheet listing each state, their plans, and the planning criteria. We will be using a scoring system where we will rank each state plan from 0 to 9. A state will receive one point if they answer each criteria question listed in the “Project Description” section of this paper. For example, for the criteria “Drought Response”, if the state receives a “Yes” for the question, “Does the plan outline response actions during drought?” then they will receive one point for answering this question in their state plan. Each state plan can receive up to nine points if they meet all the criteria. The maximum number of points a state could receive was 36, nine each for drought, water, hazard, and climate plan.

In addition to the planning document analysis, we have conducted telephone interviews in December 2018 with drought planning leaders from five state agencies that were either updating their drought plan or have recently published their updated plan. These states were Colorado, Oklahoma, New Mexico, Utah, and Minnesota. The participants from these interviews are cited anonymously as P1-P5 (Appendix A).

Results

Inventory of the Plans

To start, we outline the four types of plans and provide an example of the scope of action in regards of drought. After that, we will investigate some key findings. These plan definitions were created from a combination of various state planning documents, federal legislations that guide the development of multi-hazard plans, and consultation from James Schwab. Each type of plan can typically be distinguished by their purpose or scope of action.

- Drought Plan- Drought plans can be response or mitigation focused. Mitigation plans will outline the impacts of drought and discuss ways to mitigate those impacts. Response plans are designed to discuss specific functions of state governments. Some states address both

aspects of planning for drought and these plans may also be connected to emergency management or water planning procedures. With mitigation plans, they tend to include a vulnerability assessment that address water consumption and other water-related topics. With response plans, they may include specific actions to be taken such as water restrictions when drought reaches a specific level.

- Water Plan- Water plans typically discuss managing and monitoring the supply and quality of water resources within a state. They may have a mitigation focus on water supplies and/or water conservation. These plans may focus on geographic or demographic characteristics, depending on the state and what their focus is. Water plans may include actions regarding water resources, water use, and the ability to meet the needs of the community. Surface and groundwater management will more than likely be discussed in these plans.
- Multi-Hazard Mitigation Plan- Multi-hazard plans are meant to reduce the loss of life and property by minimizing the impacts of these hazards. Every state in the United States has a hazard mitigation plan as it is required under the Disaster Mitigation Act of 2000 to receive certain types of non-emergency disaster assistance. These plans identify hazards in a series of profiles to include hazards such as drought, flood, and winter storms. Each state will cover different hazards as some hazards are more specific to an area. For example, hurricanes do not need to be covered in the more inland states. These plans may aid in coordinating local government actions and may either be called Pre-Disaster Mitigation Plans or Multi-Hazard Mitigation Plans
- Climate Action Plan- A climate plan is the newest form of state plan that may address drought and other climate-related topics. The purpose of these plans is to consider the

impacts of climate change as well as preparing and adapting to these changes. They are comprehensive roadmaps that will outline the activities an entity takes to reduce greenhouse gas emissions. Climate plans may consider mitigation measures such as energy conservation. In terms of drought, these plans may consider the risk of drought and other related topics. Other risks that may be looked at is snowpack for states that are dependent of it.

State Ranking

This section is where we will present some plan content scoring information and give information about the plans. In terms of planning for drought, Connecticut, California, Oregon, Colorado, and Pennsylvania had the most comprehensive plans across all four plan types. However, if we do not consider climate plans as a part of their scores, Connecticut, New Mexico (tied at 24), Montana, Hawaii, Oregon, and Rhode Island (tied at 23) would have the top scores.

Table 1 (Appendix C) shows the results of the plan content analysis broken down by individual scores for drought, water, multi-hazard, and climate plans. The table also shows the total scores when combining all four plan types as well as the total scores without climate plans. Climate plans are a newer form of a planning document, so not every state has one. We wanted to provide a chance to evaluate each state without this plan type as most states lack one. Due to multi-hazard mitigation plans being the only type of plan that is federally mandated, it is not surprising that some states do not have a drought, water, and/or climate plan.

Lacking or Vague Definition of Drought and Demographic Factors Contributing to Drought Planning

Water plans appeared to be the most inconsistent when it comes to talking about drought and its impacts. Not all these plans gave a formal definition of drought, rather they defined drought as the impacts it creates via the drought sub-definitions (hydrological, agricultural, meteorological, and socioeconomic). Multi-hazard plans seemed to be this way as well. The plans that do not have a formal definition of drought are plans that are not designed to address drought. For hazard mitigation plans, 49 of the plans define drought in some way (all except for Alaska).

Water plans do address drought by understanding and discussing its existence. For example, some plans will state that drought can cause there to not be enough water to meet needs. Some plans do not define the term “drought” but will mention the term multiple times. These plans usually talk about planning for drought, understanding its effects, and presenting historical droughts. There are plans that talk about human causes such as increased demand of water especially when there is a decreased water supply. In sum, the common denominator for water plans in terms of drought focus on the existence or management of water shortages rather than the causes.

Some regions are more drought-prone than others and can be defined as a precipitation deficit. Drought can be observed by lack of snowpack, low flows in rivers and/or streams, dry soils, among other things. Climate can change often, so all areas can experience drought similarly because every area will be able to see the periods when precipitation and other determinants are lower than average. To narrow it down, there are drought-prone states, which means that some states experience drought more often than others. Figure 3 (Appendix B) is a map of the continental United States displaying the percentage of drought each state has been from 2000-2019. Data for

this map came from the U.S. Drought Monitor, which has been tracking drought conditions across the country since 2000.

According to the map, the southwestern and western regions (west of the Mississippi River) of the US experienced more drought than any other part of the country (shown in orange, red, dark red). The Great Lakes and northeastern regions experience drought the least (shown in yellow and white). The map shows that six states have experienced some level of drought at least 40% of the time between 2000 and 2019. Nevada and Arizona, highlighted in dark red, are the states that have experienced drought the most. Given this data, we should expect the states with the darker shades to discuss drought, planning for drought, and its impacts more frequently in their state plans.

We can look at each state's plan scores and compare it to the percentage of weeks each state was in a drought. Table 2 (Appendix C) shows each state's plan score along with the percentage of weeks they experienced drought between 2000-2019. The states that experienced 40% or more weeks in drought have been highlighted in a red-pink color to point out the states that we should expect greater plan scores.

Of the six states being in drought for 40% or more weeks, one of them has a significantly low score. Looking at the total scores, Arizona has a score of 20, California has a score of 27, Idaho and Nevada have 19, New Mexico has 24, and Utah has 8. The highest score each plan can receive is a 9, meaning that the highest score a state can overall receive is a 36. No state received this score. Without including climate plans, the highest score a state can receive is 27 and zero states received a perfect score with this either. Looking at these scores compared to their percentage in drought, every state has a lot of room to update or create a state plan that discusses drought in depth.

The per capita tax revenue data shows that the top ten grossing states are North Dakota, Hawaii, Vermont, Connecticut, Minnesota, California, Delaware, New York, Massachusetts, and New Jersey. These states collected between \$4,373 to \$6,521 per resident each year. Of these states, California, Connecticut, and Hawaii are among the top-ranking states for drought planning, receiving a 27, 30, and 24, respectively. New York (21), Massachusetts (20), and New Jersey (21) are among the mid-tier ranked, while North Dakota (9), Vermont (15), Minnesota (10), and Delaware (10) are among the lower-ranking states.

Given this information, the relationship between state tax revenue and planning for drought is not fully supported. On the other hand, the relationship between drought planning and drought exposure has a low to moderate support. States that experience drought more often are more likely to have and develop more comprehensive planning regardless of their financial situation. The interviews we conducted support this to an extent. When asked how far along their state was with updating their drought plan and why they were updating it, one planner said, “The reason the drought plan was being updated is due to a direct executive order from the governor which was issued in July and we were given direction to work on revising the drought plan in maybe late August to early September and we were asked to get it done by the end of the calendar year” (P3). Another participant mentioned that their state has a semi-arid climate and experience drought frequently and that 9 out of 10 years, the state experiences some level of drought, D1 or higher (P1). When asked if their state was running into any obstacles for updating their plan, one participant stated that every plan update costs around \$75,000 to \$100,000, which is expensive for them. They also said that it can be challenging to get stakeholders together in one place (P1). Another participant said that time was a huge constraint, along with the fact that not many people

in the state have knowledge in drought policies and management (P2). The reasons for updating their plans and the challenges mentioned were common themes among all the state planners.

Drought Vulnerability and Drought Planning

States are designing their own mitigation programs with the absence of federal directives. They do not always do this independently. States tend to have workshops or use other networking methods to assess the needs and vulnerabilities of the state. Planners need to keep up with the latest research on drought and its impacts to plan for the hazard successfully and effectively. This is especially true for states that are more vulnerable. A state's vulnerability is driven by the lack of precipitation, how susceptible the state is to drought, and whether it is prepared for impacts. Figure 4 (Appendix B) is a map of the continental US and each state's drought vulnerability and its drivers that was compiled from a 2020 NOAA-funded assessment regarding state vulnerability (Stevens, 2020).

The red map shows each state's vulnerability, which is a combination of the three maps below: sensitivity (blue), exposure (orange), and ability to adapt (purple). The darker colors of each map represent a higher overall drought vulnerability. Sensitivity is the likelihood of negative economic impacts and is based on the percentage of agricultural land, number of cattle, the state's reliability of hydropower, and recreational lakes. Exposure shows how often a state experiences drought and what assets are at risk when drought occurs. The ability to adapt is how a state can cope with and recover from drought, which is highly dependent on whether the state has a drought plan, how equipped it is to irrigate land, and its financial strength (Stevens, 2020).

Looking specifically at the red map, the most vulnerable states are Montana, Iowa, and Oklahoma while the least vulnerable states are California, Delaware, Massachusetts, and Connecticut. Comparing the most vulnerable states to the comprehensive planning scores,

Montana received a 24, Iowa received a 16, and Oklahoma received an 11. The least vulnerable states, California, Delaware, Massachusetts, and Connecticut, received a 27, 10, 20, and 30, respectively. This shows that being more vulnerable to drought does not correlate with increased drought planning. These maps can help planners and decision-makers identify what makes their state vulnerable, which can lead to better planning overall.

Discussion

We found limited to moderate support that increased drought exposure is correlated with a greater comprehensive planning score. We could not determine that a state's tax base would lead to improved planning. This tells us that a state's experience with drought is a lead motivator for state agencies to create drought plans as well as incorporate drought within other planning documents. This is not the case for every state though. For example, Utah has experienced drought for 40-50% of weeks from 2000-2019 but received a relatively low planning score in comparison to other states, particularly in the western portion country. On the flip side, some states that did not experience as many weeks in drought, such as Pennsylvania and Connecticut, received higher scores.

More comprehensive drought planning is linked to other issues in a state such as water quality and quantity, climate change, and other natural hazards. This is one of the reasons why states received a higher evaluation score under our framework. Since drought is incorporated with other issues within a state, it makes sense that drought can be under the directive of a variety of agencies such as water supply, climate, emergency management, and natural resource agencies. The type of agency may have an impact on a state's comprehensive planning score. Decision-makers in general have an impact on how a state plans for drought as well.

Water resource management decisions are a state's responsibility, which is a big factor in how a state approaches drought planning since it varies on how much they experience drought and strained water supplies. Which part of the country a state is can also be a determinant in how they plan for drought. The United States lacks a national drought policy and clear designated responsibilities for drought management. The Disaster Mitigation Act of 2000 is the closest federal policy to drought planning, given that it prioritizes hazard mitigation efforts and coordination among state and local governments.

Since climate plans are a newer form of planning, we decided to provide scores with and without a climate plan. After multiple discussions with the staff at NDMC, we concluded that climate plans are more politically motivated than any other plan type, thus causing some states to not have one. It is possible that the climate plans that were used for the purpose of this project are no longer recognized as state planning documents by that state. This can be due to a political shift within the state as well as other factors. We concluded that if a state has had some sort of effort in the creation or implementation of a state climate plan, that we would use that plan towards that state's overall score in the hopes that states include climate planning in their overall state planning efforts.

Some states were given an "NA" as their score. This either means that the state does not have a plan for that plan type, the state has an outdated plan (over 20 years old), the state was planning to release a plan at the time of our evaluation, or the state is using a website with planning materials and did not have a document for us to refer to.

Conclusion

Drought planning, preparedness, and mitigation reduces the likelihood that a drought will become a disaster. Drought is a normal part of the climate and can never be avoided. Early warning systems and reducing and conserving water are common ways to mitigate and prepare for drought, but these are things that need to be a team effort. It is important to educate the public about drought and its impacts so that they can be better prepared. Lack of an informed public can make drought mitigation challenging for states. There is no federal drought plan and there is no requirement as to what states must have to plan for drought. Additionally, there seems to be a lack of consensus on which indicators link to drought occurrences to trigger actions. Given these items, it is not clear how states should plan for droughts, but it is important for states to have a plan so that they can reduce the costs of the disaster. All states should have some sort of combination of a hazard, climate, water, or standalone drought plan to further mitigate and understand drought and its impacts.

To investigate how states plan for drought and how comprehensive their planning is, we collected and analyzed all state drought-related documents for all of the US. Along with this, we have conducted five interviews of key state drought planners that were in the process of updating their state drought plans. Our findings have supported that drought is a complex hazard that can never be fully understood and can be difficult to plan for. Due to the impacts drought has on multiple sectors, it is important to acknowledge that drought planning requires a multi-agency approach. We found that water plans may lack a clear definition of drought, which may be because these plans seem to heavily focus on the influences that humans have on water resources rather than impacts from meteorological sources.

Drought is more frequent in the western United States, meaning these states should be up to date with current drought knowledge. Our findings show that this is not the current case as we found that some states more prone to drought lack comprehensive planning while some temperate states highly consider drought in their planning efforts.

Recommendations

This project has been an ongoing effort over the past couple years. We were able to code almost every plan through 2019 but are still missing some. The state plans that were coded came directly from NDMC's website since NDMC collects state-level plans that address drought, including plans focused on water, other hazards, and climate. The collection of state plans is an ongoing effort as well. The staff at NDMC are always keeping an eye out for updated plans but can sometimes miss when a state releases an update. With that, some of the scores that were given to each state is not the most current. Some plans did have an update that was not in the NDMC database at the time of coding, meaning the older state plan (if applicable) was used, which may have altered that plan's score.

It is important to note that states could have updated their plans since the time of this paper being written. It is recommended that if NDMC continues this project and uses this approach to show each state's comprehensive planning efforts that they update plans and scores to correspond with the updated plans. NDMC can compare old scores with new scores to see what states have been doing differently to tackle drought and can provide guidance for states if they require additional assistance.

It is recommended that NDMC continues their web-based tool efforts with the visual representation of the state planning documents as shown in Figure 1 (Appendix B). NDMC is known for their continued drought mitigation and resilience efforts, so it is important to continue

making these efforts. Though there are some updates that need to be made to ensure all plans are current through 2019, NDMC should look at plugging the plans into the draft website and mapping those out to match the Missouri River Basin test area. Once this occurs, NDMC should reach out to state planners to get their opinions on the website before finalizing and publishing it. The target audience is state planners (though, anyone can use it), so we would want to make sure that state planners are able to understand and use the tool before making it a finalized planning tool.

If a state uses a website as their form of state plan, it should be included in the evaluation process. It appears that many states do it this way or have intentions on doing it this way and they should be given credit for their comprehensive planning efforts. Each state and department may approach planning in different ways, so we should include those different approaches, especially if the state does recognize it as their go-to state plan. It may be beneficial to reach out to state planners every year or every other year to ensure that NDMC's collections of plans are accurate and up to date. When this occurs, the scoring/evaluation can be updated on the web-based tool to show the most current state planning efforts. The goal is to get states to include more comprehensive drought planning in their existing drought, water, hazard, and climate plans.

References

- Arroyo, Vicki. 2017. "State And Local Climate Leadership In The Trumppocene". *Carbon & Climate Law Review* 11 (4): 303-313. doi:10.21552/cclr/2017/4/6.
- Bolinger, Becky. 2019. "How Drought Prone Is Your State? A Look At The Top States And Counties In Drought Over The Last Two Decades". *National Integrated Drought Information System*. <https://www.drought.gov/drought/news/how-drought-prone-your-state-look-top-states-and-counties-drought-over-last-two-decades>.
- Brody, Samuel D. 2003. "Are We Learning To Make Better Plans?: A Longitudinal Analysis Of Plan Quality Associated With Natural Hazards". *Journal Of Planning Education And Research* 23 (2): 191-201. doi:10.1177/0739456X03258635.
- Brown, Joel R., Doug Kluck, Chad McNutt, and Michael J. Hayes. 2016. "Assessing Drought Vulnerability Using A Socioecological Framework". *Rangelands* 38 (4): 162-168. doi:10.1016/j.rala.2016.06.007.
- Church, Sarah P., Michael Dunn, Nicholas Babin, Amber Saylor Mase, Tonya Haigh, and Linda S. Prokopy. 2017. "Do Advisors Perceive Climate Change As An Agricultural Risk? An In-Depth Examination Of Midwestern U.S. Ag Advisors' Views On Drought, Climate Change, And Risk Management". *Agriculture And Human Values* 35 (2): 349-365. doi:10.1007/s10460-017-9827-3.
- Federation of Tax Administrators, 2019, "State Tax Revenue". <https://www.taxadmin.org/2019-state-tax-revenue>.
- Knutson, Cody, and Brian Fuchs. 2016. "New Tools For Assessing Drought Conditions For Rangeland Management". *Rangelands* 38 (4): 177-182. doi:10.1016/j.rala.2016.05.003.
- Morris, Katlyn S., and Gabriela Bucini. 2016. "California's Drought As Opportunity: Redesigning U.S. Agriculture For A Changing Climate". *Elementa: Science Of The Anthropocene*. doi:10.12952/journal.elementa.000142.
- National Drought Mitigation Center, 2018, "Missouri River Basin Plan Search". <http://ndmctest.unl.edu/MRBPlanSearch.aspx>.
- National Drought Mitigation Center, 2020, "About Us". <https://drought.unl.edu/AboutUs.aspx>
- NOAA. "Billion-Dollar Weather And Climate Disasters: Overview". 2020. *NOAA National Centers For Environmental Information*. <https://www.ncdc.noaa.gov/billions/>.
- Schwab, James C. 2013. *Planning and Drought (PAS 574)*, American Planning Association. Planning Advisory Service, 2013, Chicago, IL

Schwab, James. 2018. State Plans in the Missouri Basin DEWS Region: Summary of Drought-related Content. Unpublished consulting report to the National Drought Mitigation Center.

Steinemann, Anne C., and Luiz F. N. Cavalcanti. 2006. "Developing Multiple Indicators And Triggers For Drought Plans". *Journal Of Water Resources Planning And Management* 132 (3): 164-174. doi:10.1061/(asce)0733-9496(2006)132:3(164).

Stevens, Alison. 2020. "The U.S. Drought Vulnerability Rankings Are In: How Does Your State Compare?". *Climate.Gov*. <https://www.climate.gov/news-features/featured-images/us-drought-vulnerability-rankings-are-how-does-your-state-compare>.

Vogel, Sarah. 2018. "An Analysis Of Water Management Strategies In Drought Prone Areas". Masters, Duke University.

Wilhite, Donald A., Mannava V.K. Sivakumar, and Roger Pulwarty. 2014. "Managing Drought Risk In A Changing Climate: The Role Of National Drought Policy". *Weather And Climate Extremes* 3: 4-13. doi:10.1016/j.wace.2014.01.002.

World Meteorological Organization (WMO) and Global Water Partnership (GWP), 2016: Handbook of Drought Indicators and Indices (M. Svoboda and B.A. Fuchs). Integrated Drought Management Programme (IDMP), Integrated Drought Management Tools and Guidelines Series 2. Geneva.

Appendix A: Interviews

2018 Plan Update Interviews

UT, NM, OK, MN, CO

Interview Prompt

Looking back at 2018, it seems as though more states than usual are updating their drought plans. We are interested in understanding the driving motivation behind these updates. As a starting point, we would like to do a brief story for our quarterly newsletter, DroughtScape, and for our annual report.

Could we find a time to speak with you about efforts to update your state drought plan? We will not take over 30 minutes of your time.

P1, Colorado

How far along is your state in updating its state drought plan?

The state just finished their update. The plan was approved by their board in September. They went to their Division of Homeland Security to be integrated into their all-hazards mitigation plan. The way theirs work is that it is a stand-alone plan, but it is also an appendix of the all-hazards mitigation plan. It was preliminarily submitted to FEMA and there were a couple of small tweaks to be made. After that, it goes to the Governor for a final approval. Colorado is going for the enhanced status for their entire all-hazards mitigation plan with FEMA and this process takes bit longer, so this is what they will be working on in 2019. Going to the enhanced status almost means continual updates because you must continually report to FEMA on the progress being made. The state has not reached enhanced status because their plan was expiring,

and they had to complete something by December 31, 2018. Then, they will spend all next year getting the enhanced. The enhanced status would also include the drought piece.

Why did your state start updating its plan this year? What motivated this?

- *Additional questions: What drought impacts are you trying to avoid? What would be the worst drought impacts for which your agency is responsible?*

“As you guys know, we are a semi-arid state, and we have drought frequently. Nine out of every 10 years unfortunately, the state is experiencing some level of drought, D1 or higher.” They try to be proactive in making sure that their mitigation actions are up to date, that it is continual, and that they are partnering with the proper people. They are also addressing and focusing on areas that are heavily susceptible to drought impacts. For them, the agricultural and tourism sectors are the most susceptible to drought impacts. Every year, they are working on some sort of project. They mainly go back and look at and update the vulnerability assessment every five years because it is costly. They have been checking how vulnerability changes from county to county or by sector to sector since the last update. This tells them if measures are working or not. They always look at everything for updates, especially incorporating climate change. There are a mix of reasons why they are motivated to update their plan including FEMA, the state’s needs and desires, and/or their partner’s needs and desires. They want to make sure they are using their resources.

Colorado is looking at an economic impact assessment for this past year and it should be done by June 2019. It will look specifically at tourism and recreation. This will help them see what is going on every year as to what the impacts are and how they can better target them. They

expanded their partnership with this because they want to show that they are willing to help with drought impacts.

As far as agriculture, it depends on the county. Impacts are still being shown from previous droughts and not all the recent drought. Colorado is trying to work with decision makers with this, emphasizing that drought does not stop hurting just because there is rain or snow. It is hurting because people lose what their family for generations had worked for, and they would have to rebuild their stock. They cannot expect agriculture to bounce back right away. "We're still seeing some of those suppressed impacts as a result of not even just this drought, but the previous drought. So that's what we're really trying to work with decision makers on is understanding drought doesn't stop hurting just because we start to get rain or we start to get snow, it's hurting because people are losing these genetics and it takes decades, if not generations, to rebuild this stock, and so we can't expect agriculture to just bounce back."

Was there a specific experience or contact with a person(s) or agency that prompted the update?

FEMA is one of the agencies that prompted the update. Colorado hired a contractor and they also have meetings with state and federal agencies that are stakeholders.

What if any organizations have been helpful in supporting the update process?

Stakeholders on the state and federal levels have always been helpful to Colorado. They also appreciate NDMC's help with resources and guidance in the plan update process. It was mentioned that the state can sometimes have a difficult time in seeing what other states are doing or what can be done in moving forward because Colorado is known as being the leaders in this

area, so many states look up to them and ask them what they have done in the past. “We recognized that we’re a leader on this in the nation and sometimes leading from the front can be lonely since there’s no one to look to for really good ideas and that’s something we’ve struggled with is that people are constantly asking us for feedback and what worked for us. We’ve really struggled with how do we make this better? Or how do we improve this? Or how do we make this more meaningful?” There are not many or any states that have done more or something different than Colorado in terms of this. Colorado wants to continue to have the best tools and wants to try new things, but there are not always many options out there.

What, if any, resources have been helpful?

They do a huge literature search as a part of their update and always gets information from that. They use RISA (Regional Integrated Sciences and Assessments) heavily because their RISA Western Water Assessment Team does a lot of climate work, so they rely on them a bit for emerging technology and approaches. They also have a drought task force that had been active due to the drought. They meet monthly when activated.

Are you running into any obstacles, such as resource constraints?

The biggest thing is that updating plans is costly. What Colorado does is expensive as every update for them ends up being \$75-\$100 thousand. They are cash funded agency, so they can typically find the money, but it is overall expensive to do. What is also difficult is that when planning for drought, returns will not be seen until further down the road, so telling agencies that they will save money does not always fly because they will not see it right away. Colorado thinks

they have seen the value of being proactive and that is why they can justify that cost. They want to do more with their developing visualization tool, but they do not have the money for that.

As for stakeholder constraints, it can be a challenge to get people to meet in one place because they are a big state. They get a lot of engagement from the agriculture community and local government. It can also be a challenge that the people engaging want more funds from the state for them to implement specific projects, but there is only so much that can be done.

Another challenge in general is balancing conservation, storage, and demand in terms of water.

Side notes that were discussed:

It was noted that some states are updating plans due to the FEMA five-year update cycle, which many states are aligned on the years those cycles are. This means that the FEMA approval process may be the driver of the drought plan updates. Historically, not many states included drought in their plans because they did not have to, and it is just an afterthought for them.

P2, Oklahoma

How far along is your state in updating its state drought plan?

They are in the very early/initial stages of the process. They had a meeting in June. The Oklahoma Climate Survey is finishing up the report summary. They had a meeting about issues related to drought in the drought plan, so the next step for them would be in the spring, and that meeting will focus specifically on the plan and the updating features. It is estimated that out of a 12-step process, for example, they are probably at step two or three. In regard to the drought plan, they knew there was a problem when they started talking about it.

Why did your state start updating its plan this year? What motivated this?

There have been on-and-off attempts since 2011 for a plan update. The old plan was written in 1997 and the reason that one happened was because of a short-term winter drought that was a billion-dollar event over the 1995-96 winter season. Winter droughts are very devastating in the state because of winter wheat production and the loss of livestock. For the 1997 drought plan, the Water Resources Board drafted the plan because a member of the board had gone to a meeting regarding drought and drought planning some years prior, so they became familiar with drought planning, including the 10-step process. It came out through some early NDMC invites, so there were some connections with NDMC in the past. In 2011, there was some inadequacy when they were in a multi-year drought. Communications and strategies did not exist at the time the original plan was written, such as the internet, which did not quite have the power to monitor drought or give information. The Drought Monitor did not exist at this time as well, which will need to be incorporated in the new plan. During the drought of 2011-14, there were a couple meetings that were hosted by the Oklahoma Emergency Management, which is the lead agency for drought monitoring in the state. They got some agencies together for one meeting and discussed drought, but it never went further than that. This happened a few times. In 2015, it was more of a wet year and state agencies were not pushing for an update. The update process was driven by the Climate Survey. It appeared at many wanted an update, but no one wanted to lead it, which is why the Climate Survey picked it up.

Why did your state start updating its plan this year? What motivated this?

- *Additional questions: What drought impacts are you trying to avoid? What would be the worst drought impacts for which your agency is responsible?*

The state is trying to avoid all drought impacts, but from an economic standpoint, agricultural impacts are a big one. “There’s a very close connection between winter wheat, which is our major crop, and cattle because they can graze during the winter. So, if there’s no winter wheat crop, then there’s no feed for cattle and so it cascades very quickly through the market.” Associated with this is that hay must be hauled from elsewhere, which can be costly. Wildfire issues are also a problem. They have had mega fires over the last three years in the region in western Texas into the Oklahoma panhandle. These appear to have a relationship with drought due to the drying out of fields. Water issues are mentioned as well, and a lot of these issues are addressed in the state water plan. This plan is said to have good strategies. For the drought of 2011-14, no one ran out of water even though reservoirs were at a record low. There are smaller issues mentioned as well such as water quality and water supply. Health impacts are mentioned in terms of water, such as blue-green algae. Ecological impacts and tribal impacts are mentioned. Corn and plants can affect tribal groups because certain plants are needed for tribal ceremonies. It was emphasized again that agriculture and livestock are the biggest impacts.

Was there a specific experience or contact with a person(s) or agency that prompted the update?

Earlier efforts with emergency management and the water resources board has been particularly interesting and they have had contact with them throughout the process. The water resources board has had interest for some years with updating the plan. The emergency

management has the authority and is the lead agency. They have been interested but has not had the time to commit to it. The Climate Survey/State Climate Office had the capacity to take it on and have been the leaders in the project.

What, if any, organizations have been helpful in supporting the update process?

The assistant state climatologist, the state climatologist, and the director of the Water Resources Board has been supportive and helpful with the update. The emergency management has helped a bit too with different roles and responsibilities. The Department of Environmental Quality was extremely interested when they had their meeting in June. They may eventually have a bigger role in the update process. At the national level, the state has been working with the NOAA RISA group as they have been providing resources with the process. Through RISA, they had funding come through NIDIS.

What, if any, resources have been helpful?

Funding through the NOAA RISA has been helpful with the process. For instance, the funding helped provide food for those who came to the June meeting. Funding is also helpful for paying for participant travel expenses to come to meetings. Oklahoma does not meet often regarding the plan update. They anticipate their next meeting be in the February/March (2019) area. It is difficult getting people together because of schedules. They hope to get meetings to be an annual thing. The Drought Management Database on NDMC's website has been a tremendous resource. It has been helpful in finding best practices from other states that could apply in Oklahoma.

Are you running into any obstacles, such as resource constraints?

The biggest obstacle is time. Another huge constraint is the fact that there are not many people in the state with expertise in drought policies or drought management. Outside of the state, NDMC has been helpful with drought resources. For the people involved in the process, they have other tasks to worry about as well as which takes the plan update longer to get going.

P3, New Mexico

How far along is your state in updating its state drought plan? What else is involved and what are the next steps?

They are at the very final stages of their draft plan. They anticipate being fully completed with it within the next few days. “The reason the drought plan was being updated is due to a direct executive order from the governor which was issued in July and we were given direction to work on revising the drought plan in maybe late August to early September and we were asked to get it done by the end of the calendar year.”

Why did your state start updating its plan this year? What motivated this?

Was answered in above paragraph.

What drought impacts are you trying to avoid? What would be the worst drought impacts for which your agency is responsible?

They are the main agency, and they are the ones that respond to water quantity, so they try to avoid anything to do with water such as water shortages/availability.

*Was there a specific experience or contact with a person(s) or agency that prompted the update?
Any further details about the governor's directive?*

The prolonged drought was around since October 2017 and the Governor had ordered for the New Mexico Drought Plan be revised as necessary based off existing state strategies, including the Surface Water Act, evaluations of drought impacts, and recommendations of appropriate response mitigation actions should be taken. New Mexico's drought plan was prepared in 2002 and since then, there has been responses from governors' executive orders and have had some updates throughout the years.

How much is FEMA-mandated planning factoring into the drought plan?

The way it works in New Mexico is that the Governor's Drought Task Force is currently shared by the Office of the State Engineer and there are many agencies that are members of the drought task force with one of them being the Department of Homeland Security and Emergency Management. They did work with them, but it is not a FEMA requirement. But in the state hazard mitigation plan, it is a requirement (Interviewee was reluctant to speak for FEMA), but there is a drought section and the team provided input for that. The plan got approved in September 2018 and the plan needs an update every five years.

What, if any, organizations have been helpful in supporting the update process?

Many of the organizations have been outlined in the acknowledgement page of their draft plan. Some being the NM Economic Development, NM Tourism, NM Environment Department, etc. They work with state agencies and the climate office and they worked with NDMC.

What, if any, resources have been helpful?

A representative from NDMC came out for one of their meetings, which was helpful for them. They also worked with a representative from NIDIS, who has not been able to be as involved. The National Weather Service has been very helpful. New Mexico has a drought monitoring work group that meets every month regardless of where the state is at in terms of drought levels. This group is comprised of the state climatologists, the weather service, state agencies, and federal agencies.

The work group is different than the drought task force. The drought task force had to meet every quarter for two years as per an executive order in 2012. In this recent executive order, the drought task force reviews and recommends actions to the governor and other governing bodies in the state in accordance with the all-hazards emergency management act. Regardless of conditions, the task force hopes to meet at least once per year.

Are you running into any obstacles, such as resource constraints?

It was mentioned that there was a tight time frame for this update as they only had about three months to complete the project. Funding was also a key issue. There was a section that they wanted to include but could not be due to lack of funding. It was said that New Mexico is generally a poor state, so resources are always a concern for them. They did work with a contractor with this update and funding was an issue overall.

P4, Utah

How far along is your state in updating its state drought plan?

They are not as far as they wanted to be. They got into the process of evaluating where their current plan is and outlining where it needs to go as well as changes that need to be made. They are also in the process of getting stakeholder and public outreach efforts with getting feedback on it.

Why did your state start updating its plan this year? What motivated this?

It was mainly because all their 29 counties were in a primary or contiguous drought. The governor issued an emergency declaration in October regarding drought since it was a low snow-pack year and a dry summer. Due to this, Utah has been looking at their current drought plan and mentioned that since they are looking at the document more, they see more things that they would like to update and/or change in the document to make it better.

What drought impacts are you trying to avoid? What would be the worst drought impacts for which your agency is responsible?

Utah tried to create resiliency in their system regarding having the proper storage, the proper distribution centers, and promoting conservation for the use of water. They try to avoid drought impacts as they occur and then reevaluate additional mitigation efforts that they can do to reduce those impacts. They are concerned about agricultural, environmental, and economic impacts. They are working with NIDIS and the Southwest region to develop a drought economic assessment of the 2018 drought, with is in conjunction with Utah State University. With the

economic assessment, they are looking at historic drought as well as the 2018 drought because they have more data with the recent drought.

Was there a specific experience or contact with a person(s) or agency that prompted the update?

Especially with this year's drought, they want to fill in gaps in their previous plan and they want to look at how information is received. There is a hole in their state with getting NDMC being able to get data back from local areas. It is covered well on the Colorado River side of the state, but as for the rest of the state, NDMC has not been getting the feedback they need. This was brought to P4's attention by some of the farm service agencies and some of the locals that there needs to be better mechanisms for getting feedback for NDMC to get information from them.

What, if any, organizations have been helpful in supporting the update process?

They have received help from NIDIS and the Western Water Assessment last year and they had a drought workshop. They brought in drought experts from the southwest regions of Colorado, New Mexico, and Arizona to talk to them about their drought plans, things that worked, and the challenges faced. State municipalities, the Department of Agriculture, and the Department of Health were in on it as well, and the goal was to educate everyone on drought and how it can be mitigated. They have mentioned a YouTube link with recordings of their workshops and who they bring in.

What, if any, resources have been helpful?

Workshops seem to be very helpful for Utah. NIDIS has been very helpful as well as the Western Water Assessment as they helped with creating a network for the southwest region. It has been helpful for Utah to know who the drought people are in other states and areas. There have been some local water conservancy districts and utilities who are currently studying drought contingency planning, including River Basins and Salt Lake City Public Utilities (who also spoke at the workshop) and this has been helpful with connecting state and local level issues.

Are you running into any obstacles, such as resource constraints?

Time and money are mentioned as obstacles. An interesting obstacle Utah has been facing is employee turnovers and employee retirement. This unfortunately delayed getting the plan finished, which is why they are not as far as they hoped to be at this time. P4 mentioned that there are many different drought signals and maps such as NIDIS's and the USDM, so trying to determine which is best has been an issue, especially with P4 being new to the position and needing to pick up tasks quickly. P4 has been doing a lot of research as to which trigger to use in the plan.

“When you only face drought every seven years or whatever it is, there can be a long gap between evaluating the needs between what happened to the drought, what were the impacts, and how do we address this, and I think that's one of the things we want to achieve in our new plan. We're not waiting seven years to look at the plan, that we're having these developed relationships that we're meeting every year or twice a year, whether there's a drought or not so that it doesn't catch us off guard in a sense.”

Side notes that were discussed:

They have different task forces for different areas, such as agriculture and supply. They all meet to give the governor information about all the aspects that are affected by drought.

They currently have a drought response plan, and they want to develop a drought mitigation plan so that they are not just response, but also mitigating future impacts of drought.

P5, Minnesota

How far along is your state in updating its state drought plan?

The Minnesota State Climatologist Office in April 2017 was working with regional drought climatologists in monitoring drought. P5 helped with the drought monitor and decided to bring some knowledge back to his state and looked at their drought plan. “I was astounded by what I found in the sense there wasn’t a lot of detail at all about the drought hazard in general, what it means for the state of Minnesota, and what the general drought impacts there are in Minnesota.” P5 said they can deal with drought using their current drought plan, but the current plan can make it a bit difficult. One of P5’s first tasks was to convince their supervisor to update the plan, which seemed to be a green light. Right now, they are in the pre-planning stages of the plan. They need to figure out what they need to do and how they want to go about it. They have been looking at other state drought plans posted on NDMC’s website. P5 has been in touch with NDMC to get access to drought planning documents.

They want to update their Drought Task Force since it has not been updated since 2009. The task force will serve as a board of directors. They are also looking at smaller task forces for different sectors such as agriculture and tourism.

Why did your state start updating its plan this year? What motivated this?

A lot of it has to do with the number of important parts that the old plan was missing. They noticed that there is not a lot of language in the plan relating to agriculture and there is nothing regarding tourism or wildfires. P5 said they need to do a better job with responding to drought in the different sectors and build their coping capacity on each of those. Knowing what their impacts are and how to respond are huge factors in updating the plan and understanding the experts and who to contact when drought is present.

What drought impacts are you trying to avoid? What would be the worst drought impacts for which your agency is responsible?

They are trying to avoid everything, but as noted above, the old plan barely mentions agriculture and does not mention things such as wildfires and tourism. The top two sectors are agriculture and water resources.

Was there a specific experience or contact with a person(s) or agency that prompted the update?

Nothing specific comes to mind with a specific experience or contact. P5 mentions it was mainly the Department of Natural Resources recognizing that there is an opportunity to update the drought plan and to do so before something terrible happens. Workshops did help a little as mentioned earlier in the interview.

What, if any, organizations have been helpful in supporting the update process?

So far, other than sub-agencies within the Department of Natural Resources in Minnesota, NDMC has been helpful. P5 also touched based with a representative from South Dakota and their region's head of the United States Department of Agriculture climate office.

What, if any, resources have been helpful?

The resource that has been the most helpful are the drought planning documents from NDMC.

Are you running into any obstacles, such as resource constraints?

At the moment, they are not running into any obstacles and this is mainly due to them being in the pre-planning stages of the drought planning process. They are not at the point of obstacles, but it is assumed that there will be some eventually.

Appendix B: Figures

The Missouri River Basin Plan Area

MISSOURI RIVER BASIN PLAN SEARCH

MRB Plan Search

Drought planning happens in many contexts. States variously address drought in multi-hazard plans, water plans, climate change plans, and stand-alone drought plans, among others. This search tool identifies which plans in a state address key aspects of drought planning, and cites examples.

Plan Type by State



Figure 1: The Missouri River Basin DEWS Region Test Area. The legend is found in Figure 2. Each state is given their own icons, signifying the types of state plans they had as of 2018 when this test was done (MRB Plan Search, 2018).

Plan Types and Criteria

State

All States ▾

View a drought planning summary for each state.

Plan Type

- 🌵 Drought Plan
- ⚠️ Hazard Plan
- 💧 Water Plan
- ☀️ Climate Plan

View the definition of each plan type.

Plan Criteria

- | | |
|--|--|
| <input type="checkbox"/> Drought Defined | Does the plan define or describe drought, or how its effects threaten human, natural, or physical assets within the state? |
| <input type="checkbox"/> Drought Addressed | Does the plan specifically address aspects of planning for drought or its impacts? |
| <input type="checkbox"/> General Drought Preparedness | Does the plan include enactable measures to generally be more prepared for drought? Ideally, these measures would be enacted in advance of a drought, and could involve establishing a drought task force, identifying resources for managing and mitigating drought, an action plan, or public education. |
| <input type="checkbox"/> Mitigation Focus (Water Supply) | Does the plan discuss the availability or adequacy of water resources and their ability to meet demand? |
| <input type="checkbox"/> Mitigation Focus (Water Conservation) | Does the plan outline strategies for reducing water use, increasing efficiency, or decreasing waste? These could be long- or short- term. |
| <input type="checkbox"/> Triggers for Action | Are particular drought indicators connected to actions or measures outlined in the plan? |
| <input type="checkbox"/> Drought Response | Does the plan outline response actions during drought (e.g. reducing demand)? Are reactive measures outlined as a form of pre-planning? |
| <input type="checkbox"/> Coordinates with Other Jurisdictions | Does the plan bring in multiple organizations across levels? |
| <input type="checkbox"/> Linkages with Other Plans | Does the plan mention other plan documents? |

Get Plans

Figure 2: Selecting Criteria. User can select which state they want to look at as well as the plan type and plan criteria. Users would be able to check the boxes they wish to look at to see if a state has these criteria in their plans. After everything is checked, the user would click on “Get Plans” where results will show (MRB Plan Search, 2018).

% Weeks in Drought

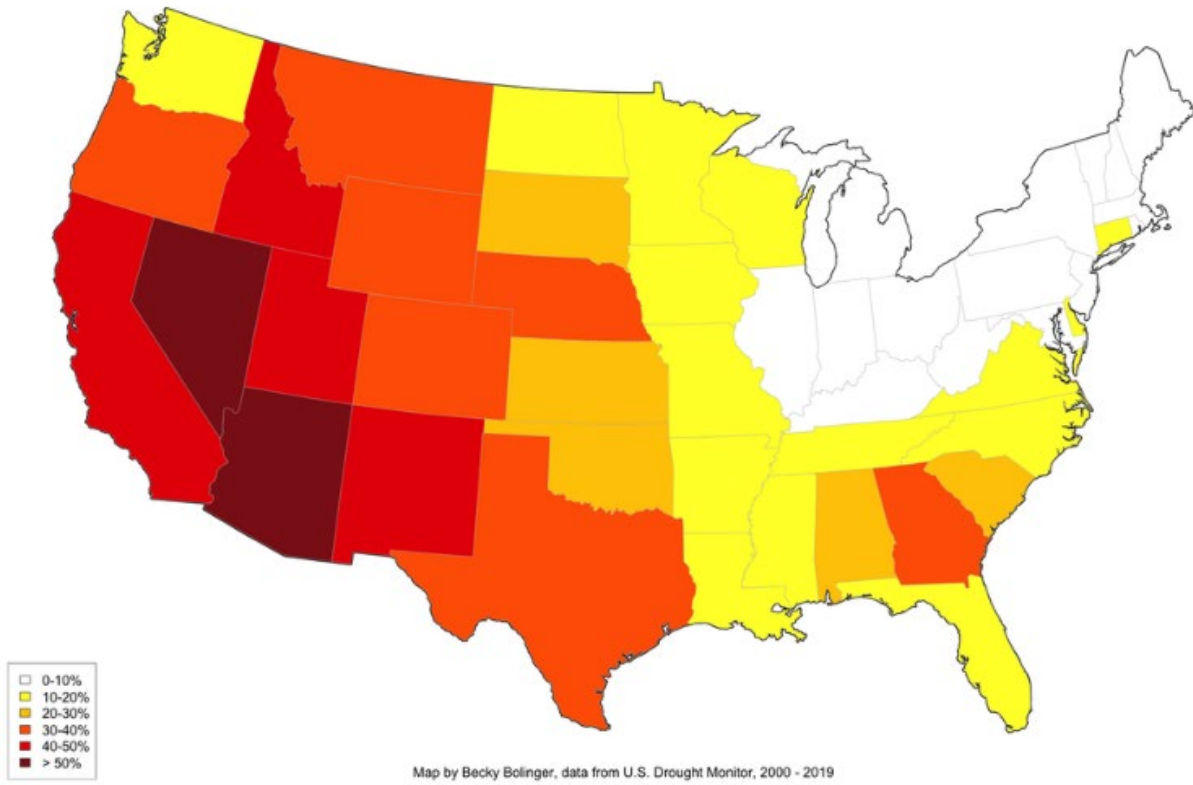
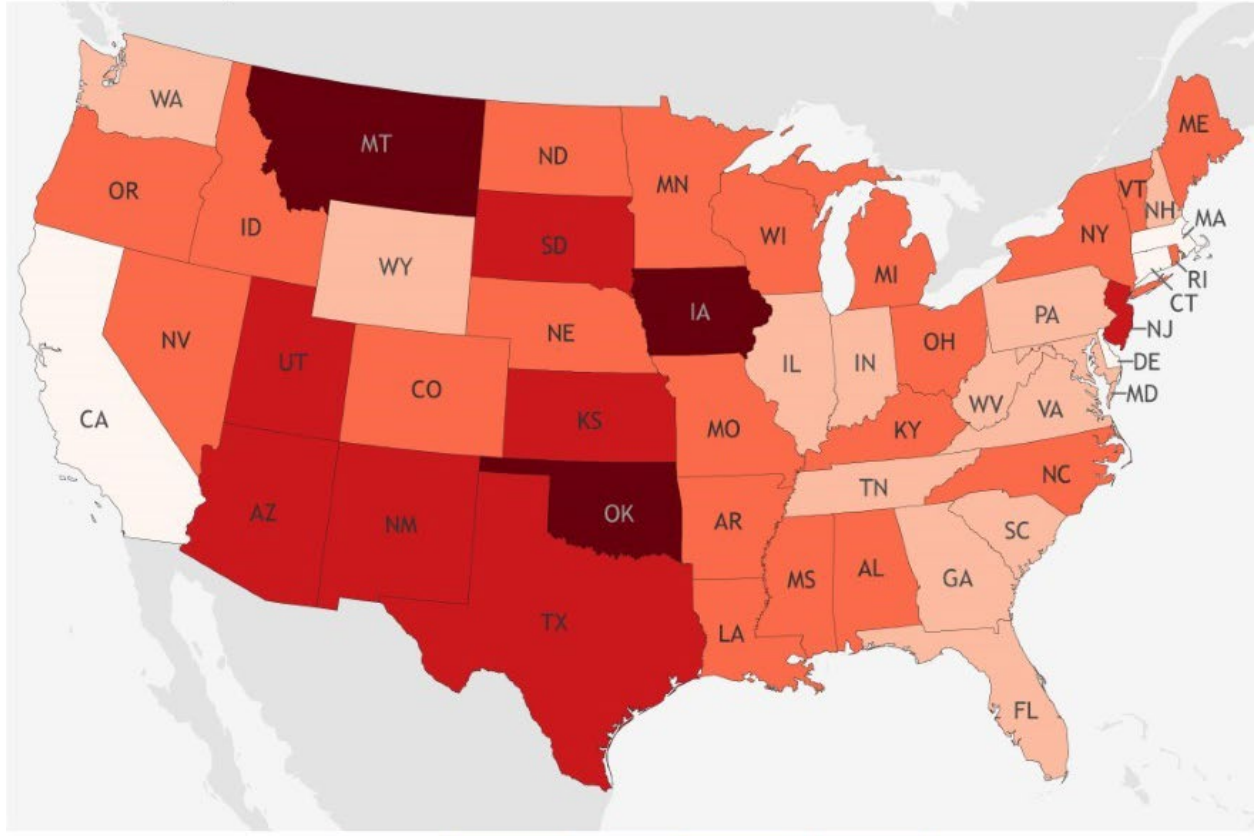


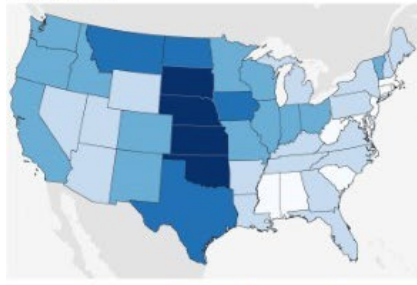
Figure 3: Map displaying the percentage of drought across the United States (Bolinger, 2019)

State Rankings of Drought Vulnerability and its Drivers

Drought Vulnerability Index



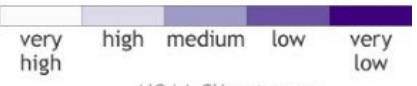
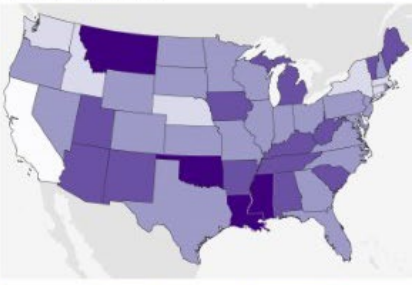
sensitivity



exposure



ability to adapt



NOAA Climate.gov
Data: Engström et al., 2020

Figure 4: Drought vulnerability and its drivers (Stevens, 2020)

Appendix C: Tables

State Plan Scores

State	Drought Plan	Water Plan	Multi-Hazard Plan	Climate Plan	Total	Total Without Climate Plan
Alabama	7	6	7	NA	20	20
Alaska	NA	NA	0	NA	0	0
Arizona	9	7	4	NA	20	20
Arkansas	NA	6	3	NA	9	9
California	8	5	8	6	27	21
Colorado	9	6	6	4	25	21
Connecticut	9	6	9	6	30	24
Delaware	5	NA	5	NA	10	10
Florida	7	NA	5	5	17	12
Georgia	6	3	4	NA	13	13
Hawaii	8	8	7	1	24	23
Idaho	9	2	8	NA	19	19
Illinois	8	NA	4	0	12	12
Indiana	9	NA	4	NA	13	13
Iowa	6	5	5	NA	20	20
Kansas	9	7	6	NA	22	22
Kentucky	7	1	7	NA	15	15
Louisiana	NA	NA	3	NA	3	3

Maine	0	NA	5	2	7	5
Maryland	6	NA	5	5	16	11
Massachusetts	7	3	7	3	20	17
Michigan	NA	2	5	NA	7	7
Minnesota	4	1	5	NA	10	10
Mississippi	NA	NA	2	NA	2	2
Missouri	9	2	6	NA	17	17
Montana	9	6	8	1	24	23
Nebraska	8	NA	7	NA	15	15
Nevada	6	7	6	NA	19	19
New Hampshire	9	5	4	1	19	18
New Jersey	5	9	7	NA	21	21
New Mexico	9	6	9	NA	24	24
New York	8	NA	7	6	21	15
North Carolina	8	1	4	NA	13	13
North Dakota	NA	1	8	NA	9	9
Ohio	5	NA	4	NA	9	9
Oklahoma	NA	5	4	NA	9	9
Oregon	8	9	6	6	29	23
Pennsylvania	6	7	9	5	27	22
Rhode Island	7	9	7	NA	23	23

South Carolina	7	8	5	NA	20	20
South Dakota	8	NA	7	NA	15	15
Tennessee	6	4	6	NA	16	16
Texas	7	8	7	NA	22	22
Utah	NA	NA	8	NA	8	8
Vermont	8	1	6	NA	15	15
Virginia	9	8	4	1	22	21
Washington	9	NA	6	6	21	15
West Virginia	6	6	2	NA	14	14
Wisconsin	7	NA	6	NA	13	13
Wyoming	9	0	2	NA	11	11

Table 1: Plan score results for all 50 states with overall total and total without climate plans added to the score. All scores are compiled from the original content coding. Scores reading “NA” indicate that; the state has no plan for that category, the state has an outdated plan, the state was planning to release a plan at the time of our evaluation, or the state does not have a document to refer to (i.e. has a website used for planning purposes).

Plan Scores, Weeks in Drought, and State Tax Revenue

State	Total	Total Without Climate Plan	Percent of Weeks in Drought from 2000-2019*	Total State Tax Revenue, 2019 (\$ million)**	Per Capita, 2019**
Alabama	20	20	20-30%	11,577	2,361
Alaska	0	0	NA	1,781	2,434
Arizona	20	20	>50%	18,164	2,495
Arkansas	9	9	10-20%	10,218	3,386
California	27	21	40-50%	188,235	4,764
Colorado	25	21	30-40%	15,870	2,756
Connecticut	30	24	10-20%	17,994	5,047
Delaware	10	10	10-20%	4,596	4,719
Florida	17	12	10-20%	44,800	2,086
Georgia	13	13	30-40%	24,713	2,328
Hawaii	24	23	NA	8,208	5,797
Idaho	19	19	40-50%	4,884	2,733
Illinois	12	12	0-10%	42,501	3,354
Indiana	13	13	0-10%	20,171	2,996
Iowa	20	20	10-20%	10,584	3,355
Kansas	22	22	20-30%	10,030	3,443
Kentucky	15	15	0-10%	12,896	2,886
Louisiana	3	3	10-20%	11,749	2,527
Maine	7	5	0-10%	4,674	3,477
Maryland	16	11	0-10%	23,606	3,905

Massachusetts	20	17	0-10%	31,805	4,614
Michigan	7	7	0-10%	30,270	3,031
Minnesota	10	10	10-20%	28,176	4,996
Mississippi	2	2	10-20%	8,289	2,785
Missouri	17	17	10-20%	13,181	2,148
Montana	24	23	30-40%	3,169	2,965
Nebraska	15	15	30-40%	5,755	2,975
Nevada	19	19	>50%	9,745	3,164
New Hampshire	19	18	0-10%	2,969	2,184
New Jersey	21	21	0-10%	38,844	4,373
New Mexico	24	24	40-50%	7,428	3,542
New York	21	15	0-10%	91,621	4,710
North Carolina	13	13	10-20%	29,316	2,795
North Dakota	9	9	10-20%	4,970	6,521
Ohio	9	9	0-10%	30,147	2,579
Oklahoma	9	9	20-30%	10,732	2,712
Oregon	29	23	30-40%	13,960	3,310
Pennsylvania	27	22	0-10%	43,132	3,369
Rhode Island	23	23	0-10%	3,724	3,515
South Carolina	20	20	20-30%	11,221	2,179

South Dakota	15	15	20-30%	1,940	2,193
Tennessee	16	16	10-20%	14,827	2,171
Texas	22	22	30-40%	63,330	2,184
Utah	8	8	40-50%	9,968	3,109
Vermont	15	15	0-10%	3,429	5,495
Virginia	22	21	10-20%	26,286	3,080
Washington	21	15	10-20%	27,992	3,676
West Virginia	14	14	0-10%	5,938	3,313
Wisconsin	13	13	10-20%	20,039	3,442
Wyoming	11	11	30-40%	2,111	3,647

*Table 2: Total plan score results for all 50 states along with the percent of weeks in drought they were in from 2000-2019 (with the exception of Hawaii and Alaska since they were not including in Figure 3), and total state tax revenues and per capita revenue from 2019. Data obtained from Bolington, 2019 (denoted with symbol *) and the Federation of Tax Administrators (denoted with symbol **).*