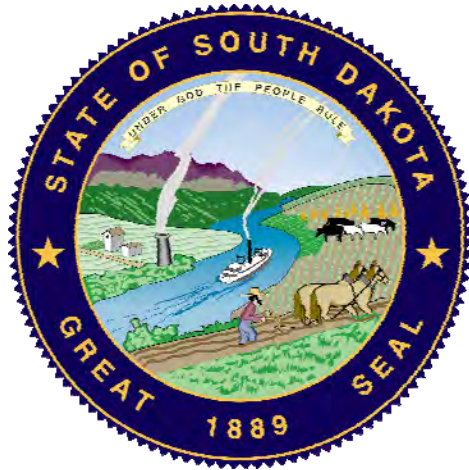

SOUTH DAKOTA DROUGHT MITIGATION PLAN



November 2015

Prepared by the
South Dakota Drought Task Force

In partnership with the
South Dakota Office of Emergency Management
Department of Public Safety

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Executive Summary

The South Dakota Drought Mitigation Plan (Plan) was developed to provide a strategy for the State of South Dakota to reduce the impacts of drought-related water shortages over the short and long term. There are two major components of the plan: the mitigation strategy and vulnerability assessment. The Plan was prepared in coordination with the State's Drought Task Force, which is comprised of various state agencies and co-chaired by the Departments of Agriculture and Department of Public Safety, Office of Emergency Management.

Included is a description of the process used to prepare the Plan and a profile of the drought hazard in South Dakota, including the nature of impacts and probability of occurrence. A drought vulnerability assessment discusses the past and potential impacts to six sectors that include agriculture, health and socioeconomic, tourism, water resources, wildland fire, and wildlife. The vulnerability assessment is covered in detail in Chapter 3. The mitigation strategy outlines the goals of the Plan and specific action items intended to meet those goals. Many of these mitigation actions can occur during drought and non-drought times. A capability assessment describes the State's pre- and post-disaster plans, policies, and procedures in place that already help manage and reduce drought impacts. The Plan describes funding sources that can be used to implement local mitigation projects and plans and a description of the process for implementation, monitoring and evaluating the Plan.

1 PREREQUISITE

The Drought Mitigation Plan (hereto referred to as the Plan or Drought Plan) was developed, reviewed and approved by the South Dakota Office of Emergency Management (OEM) and Drought Task Force (DTF) by direction of the Office of the Governor.

This Plan is a hazard-specific annex to the State of South Dakota Hazard Mitigation Plan and as such was prepared to be in alignment with the associated requirements of the Disaster Mitigation Act of 2000 (DMA or DMA 2000) (Public Law 106-390) and the implementing regulations set forth by the Interim Final Rule published in the Federal Register on February 26, 2002 (44 CFR §201.6) and finalized on October 31, 2007. Hereafter, these requirements and regulations will be referred to collectively as the DMA. The State of South Dakota assures it will comply with all applicable federal statutes and regulations in effect with respect to the periods for which it receives grant funding in compliance with 44 CFR Part 13.11(c). This Plan's update cycle will align with that of the South Dakota HMP.

2 PLANNING PROCESS

2.1 Description of the Planning Process

This section details the planning process conducted during 2014-2015 to develop the Drought Mitigation Plan. The State of South Dakota experienced a short-lived but severe drought in 2012 that extended into 2013. One of the outcomes of this drought was a recognition of the importance of having a long term drought mitigation planning strategy, based on a sector-driven vulnerability assessment. A structured plan development process based on multi-agency collaboration was utilized to produce this document.

2.1.1 Drought Planning Process

The process established for this planning effort is based on the Disaster Mitigation Act of 2000 planning and update requirements and the Federal Emergency Management Agency's (FEMA) associated guidance for state hazard mitigation plans. The DTF followed FEMA's recommended four-step mitigation planning process:

1. Identify and organize available resources
2. Identify hazards and assess risk
3. Develop a mitigation strategy and mitigation plan
4. Implement the Plan and monitor progress

The approach also incorporated the following ten step drought planning process developed by Dr. Donald A. Wilhite with the National Drought Mitigation Center (NDMC):

1. Appoint a Drought Task Force
2. State the purpose and objectives of the drought preparedness plan
3. Seek stakeholder participation and resolve conflict
4. Inventory resources and identify groups at risk
5. Prepare/write the drought preparedness plan
6. Identify research needs and fill institutional gaps
7. Integrate science and policy (Legislation)
8. Publicize the drought preparedness plan and build public awareness
9. Develop education programs
10. Evaluate and revise drought preparedness plan

2.1.2 Relationship to the State Hazard Mitigation Plan

This Plan is considered a drought specific annex to the State of South Dakota Hazard Mitigation Plan (HMP). The South Dakota statewide mitigation planning program is designed to coordinate the efforts of many state agencies and organizations in mitigation planning and programming on an ongoing basis. It is also intended to actively promote and coordinate

mitigation planning and programming by local jurisdictions. OEM is the lead agency for the State of South Dakota HMP umbrella document. The original umbrella document was updated in 2007, 2011, and 2013.

As the lead agency, OEM regularly coordinates with other agencies on concurrent state planning and risk management efforts. OEM in collaboration with the DTF took the lead on the development of the Drought Plan in 2014-2015, utilizing funding obtained from a FEMA Pre Disaster Mitigation (PDM) planning grant. A consulting firm (AMEC Environment and Infrastructure, subsequently renamed Amec Foster Wheeler heretofore referenced as Amec) was utilized to assist with the development of the Plan, including conducting a detailed vulnerability assessment and facilitation of the mitigation strategy with the DTF.

2.1.3 Drought Task Force

The development, implementation, and maintenance of the Drought Plan are the responsibility of the DTF under the leadership of OEM and the South Dakota Department of Agriculture. The DTF is made up of representatives of the principal state agencies and organizations with authorities, responsibilities, or expertise related to drought hazard mitigation programs. The DTF is a long standing organization comprised of various state agencies and co-chaired by the Departments of Agriculture and Department of Public Safety - OEM. Specific membership is discussed in Section 2.1.4 and Appendix A Planning Process Documentation. During the development of this Plan, the DTF participated in three major planning meetings between September 2014 and May 2015, which are summarized in Table 1.

Table 1 Drought Planning Meetings

Meeting	Date	Purpose
1. Project Kickoff	9/3/2014	Review Disaster Mitigation Act planning requirements, scope of work, and schedule Review role of DTF Discuss data collection needs Discuss stakeholder involvement
2. Vulnerability Assessment Workshop	12/11/2014	Review Plan objectives and schedule DTF membership update Public and stakeholder involvement recommendations Drought vulnerability assessment work session
3. Mitigation Strategy	5/7/2015	Present and discuss key findings from vulnerability assessment Revisit and revise goals Review and revise Plan maintenance and implementation strategy

Sign in sheets and summaries of these meetings are included in Appendix A Planning Process Documentation and on file with OEM.

Additional meetings related to public and stakeholder outreach are discussed in Section 2.2.2. In addition to these meetings the process included individual phone conversations and emails between Amec and OEM staff with various entities and agencies on the DTF. Amec staff also utilized emails and phone calls to interview DTF members for input on the vulnerability assessment and mitigation strategy.

2.1.4 Agency Involvement in Plan Preparation Process

During the revision to the Drought Plan, several individuals participated on the DTF and provided information and assistance to promote the development of the document. Appendix A identifies those that were involved or contacted for input in the update of this Plan or attended planning meetings.

The DTF consists of the following agencies/entities that form the core leadership of the team:

State

- Office of the Governor
- Department of Agriculture
 - *Division of Wildland Fire*
- Department of Environment and Natural Resources
- Department of Game, Fish and Parks
- Department of Health
 - *Office of Public Health Preparedness and Response*
- Department of Military
- Department of Public Safety
 - *Office of Emergency Management*
 - *Office of State Fire Marshal*
- South Dakota State University
 - *State Climatologist*
 - *Extension*
- Department of Social Services
 - *Division of Behavioral Health*
- Department of Tourism
- Department of Tribal Affairs
- Bureau of Information and Telecommunication

The DTF members were involved in the planning process through:

- Attending and participating in DTF meetings
- Providing available data requested
- Reviewing and commenting on Plan drafts and obtaining agency buy-in for relevant sections
- Assisting with public input/stakeholder process

During the development of the Drought Mitigation Plan, several agencies provided input, data, and technical expertise to support the Plan’s vulnerability assessment. Agencies were provided a series of worksheets designed to capture suggestions for stakeholder and public involvement and outreach. Stakeholders and DTF members filled out these questionnaires and worksheets, and the information directly contributed to the preparation of this Plan. During 2014 and 2015 specific agencies and organizations with relevant data were contacted through email and phone to solicit input for the Vulnerability Assessment. The following state agencies were appointed leads for the vulnerability assessment sectors and work with consultants from Amec to provide input in to the six sectors that are profiled in Sections 3.3-3.9.

- Water Resources Sector Lead – Department Environment and Natural Resources
- Health and Socioeconomic Sector Lead - Department of Social Services
- Agriculture Sector Lead – Department of Agriculture
- Wildfire Sector Lead - Department of Agriculture, Division of Wildland Fire
- Wildlife Sector Lead - Department of Game, Fish and Parks
- Tourism Sector Lead – Department of Tourism

DTF members reviewed and provided comment on the draft Plan. The document was shared electronically through email and Internet based file sharing methods. The draft vulnerability assessments for each sector were distributed to DTF sector leads prior to the other chapters to ensure accuracy of the content and provide reference for the development of the mitigation strategy. Comments on the complete draft were solicited during a one month period in July and then incorporated into a public/stakeholder review draft document.

2.2 Coordination among Agencies

2.2.1 Involvement of Federal and State Agencies

Federal and state agencies were integrally involved in the development of the information provided in this Plan and the umbrella HMP. Both federal and state agencies were represented on the DTF and participated in meetings previously listed. As indicated, these meetings served as a means to identify planning needs, assign roles and responsibilities to obtain pertinent information, provide for the exchange or transmission of the information, and specifically provide insight and data pertinent to the vulnerability assessment and mitigation strategies. In addition, the DTF provided a mechanism for federal and state agencies to review the draft Plan and provide comments that were incorporated into the final document.

Stakeholders

Stakeholders include other state and federal agencies or organizations that have an interest in drought monitoring, planning, mitigation, and response or provided information to support the Plan development. These entities are noted below.

-
- Department of Labor and Employment
 - Department of Social Services – Division of Economic Assistance
 - South Dakota School of Mines and Technology
 - National Drought Mitigation Center (NDMC) – University of Nebraska-Lincoln
 - National Oceanic and Atmospheric Association – National Integrated Drought Information System (NIDIS)
 - U.S. Army Corps of Engineers
 - U.S. Department of Agriculture - Natural Resources Conservation Service

2.2.2 Involvement of Interested Groups

The groups in the list that follows were identified by DTF members as interested groups. Many of these agencies provided feedback that improved the accuracy and content of the final draft. Others may be considered for additional involvement or outreach in the future.

Other Federal Agencies

- U.S. Geological Survey (USGS)
- National Oceanic and Atmospheric Association (NOAA)
- Federal Emergency Management Agency (FEMA)
- USDA – Farm Service Agency (FSA)
- USDA – Risk Management Agency (RMA)
- USDA – U.S. Forest Service (USFS)
- U.S. Department of the Interior (USDOI) – Bureau of Land Management (BLM)
- USDOI – National Park Service (NPS)
- USDOI – Fish and Wildlife Service (FWS)
- USDOI – Bureau of Indian Affairs (BIA)
- USDOI – Bureau of Reclamation (USBR)

Other Agricultural Organizations

- South Dakota Farm Bureau Federation
- South Dakota Cattlemen’s Association

Wildland Fire/Forest Health

- South Dakota Fire Chiefs Association

Other Local and State Government

- South Dakota County Emergency Managers
- Western Governors’ Association

Utility Providers

- Local water departments
- Rural water systems

Recreation/Tourism

- Chambers of Commerce

Conservation Organizations

- South Dakota Wildlife Federation
- Prairie Hills Audubon Society
- Sierra Club, South Dakota chapter
- South Dakota Trout Unlimited
- South Dakota Grassland Coalition
- Northern Prairies Land Trust
- American Farmland Trust
- Ducks Unlimited
- Pheasants Forever
- The Nature Conservancy
- Regional and county conservation districts

Other Organizations

- South Dakota Association of General Contractors
- South Dakota Voluntary Organizations Active in Disasters
- Golf Course Superintendents Association of America

Outreach Efforts

Public and stakeholder outreach was utilized to inform the Plan development and raise awareness of the Plan. A Stakeholder and Public Participation Plan was prepared to provide for a meaningful process through which South Dakota's citizens, public officials, and stakeholder groups could effectively participate in the development of the South Dakota Drought Mitigation Plan. The objectives of this document were three-fold:

- Recognizing that there are many levels of public and stakeholder participation, to provide for an effective mix of participation opportunities that meet the above bulleted purposes.
- Recognizing that not everyone participates in the same way or at the same time, to include a mix of participation strategies that provides for a broad and diverse set of participation opportunities across South Dakota.
- To build public support for the South Dakota Drought Mitigation Plan.

The Stakeholder and Public Participation Plan is included as Appendix B and synthesizes input from the DTF on stakeholder recommendations, public involvement and outreach opportunities. Stakeholder and outreach activities utilized during the planning process are summarized in **Table 2**.

Table 2 Stakeholder and Public Participation Plan Implementation

Timeframe	Stakeholder and Public Participation Activities	Highlights/Outcome
June 2015	Developed backgrounder on plan for distribution	
Jul-Aug 2015	Deployed Public Input Survey	1,450 Responses Summary in Appendix D
September 2015	Posted Plan for public review	25 Comments

Public and stakeholder input was solicited in various ways during the planning process. Early in the process the DTF was asked to identify through a worksheet specific groups or networks that might have an interest in drought and drought planning. A fact sheet was developed for DTF members to distribute at meetings or forums that explained the purpose of the Plan and how the public could obtain more information on the Plan. An online survey was designed to solicit input on drought-related concerns and impacts, as well as ideas on drought mitigation. The online survey opened on 7/6/2015 and closed on 8/31/2015. The link to the survey was distributed via email to members of the Drought Task Force, who were encouraged to broadcast the link far and wide through their constituent networks. The constituent networks were identified in the Stakeholder and Public Participation Plan (Appendix B). A total of 1,450 responses were collected. Survey results are summarized in Appendix D.

Survey Highlights:

- There is at least one survey result from each county in South Dakota
- 80% of the respondents identified themselves as a member of the public
- 43.3% of all respondents indicated that they were somehow negatively impacted by the 2012-2013 drought.
- Hunting and fishing ranked highest among respondents as being the factor most negatively impacted by the 2012-2013 drought.

DTF members were also encouraged to discuss the Plan development at various trade and industry meetings and conferences in 2014-2015. Before the Plan was finalized it was made available for public review in September 2015. The public review process produced limited feedback with only 25 responses, none of which warranted changes in the Plan.

2.3 Program Integration

2.3.1 Integration of Mitigation Planning with other State Planning Efforts

This Plan is an integral part of the South Dakota HMP. The South Dakota HMP profiles drought as a separate hazard, but does not give the enhanced detail that the Drought Mitigation Plan does.

The State of South Dakota is committed to the multi-agency mitigation strategy outlined in this Plan. A goal and related objective listed in this Plan in **Section 4.1** are related to this:

- Continue to maintain and enhance intergovernmental and interagency stakeholder coordination
 - Coordinate and provide technical assistance for state, local, tribal, federal, and watershed planning efforts

Section 4.3 Mitigation Actions provides additional detail on actions designed to improve coordination and integration efforts. Details on related planning programs and initiatives are also discussed in **Section 4.2** State Capability Assessment.

It is anticipated that this Plan be a reference to support local or tribal planning efforts. Related planning efforts may include:

- Local/Tribal multi-hazard mitigation plans
- Local/Tribal drought management plans
- Local/Tribal water conservation plans

This Plan does not address roles and responsibilities of agencies in response to a drought or drought emergency. Drought response is addressed within the State Emergency Operations Plan Drought Incident Annex.

Other drought-related initiatives took place simultaneous to the development of this Plan. This included the Western Governor's Drought Forum and a series of five regional workshops and webinars. Each regional Drought Forum workshop featured a case study on drought management. South Dakota Office of Emergency Management participated as a partner in the forum, which included attendance at a forum on drought impacts and solutions for various sectors in Tempe, Arizona (October, 2014), Sacramento, California (November, 2014), and Las Vegas, Nevada (December, 2014).

South Dakota State University representatives and DTF members also participated in the NIDIS Missouri River Basin Regional Drought Early Warning system development in 2014. The purpose of the effort was to bring together a diverse group of federal, state, tribal, local partners and stakeholders from the water- and land-management communities, to discuss and understand decision-makers' needs for drought, climate, weather, and water-related information and improving our capacity to meet those needs across the Missouri Basin. This included

engagement with participants from several South Dakota tribes at a workshop in Rapid City in September, 2014.

2.3.2 Integration of Mitigation Planning with FEMA Mitigation Programs and Initiatives

Mitigation planning associated with this document has strived to include the integration of other FEMA mitigation programs and initiatives. The mitigation component of this Plan conforms to the Standard State Hazard Mitigation planning requirements of the Disaster Mitigation Act of 2000 based on the FEMA Bluebook Multi-Hazard Mitigation Planning Guidance (2004, revised in 2008 and 2015 which becomes effective in 2016). FEMA does not have specific programs aimed at mitigating drought disasters. OEM is the primary state coordinating agency for all local emergency operation plans and hazard mitigation plans. OEM has the primary responsibility of working with local governments in developing, reviewing, and updating local hazard mitigation plans. Refer to the umbrella 2013 South Dakota HMP for further description of the integration of FEMA mitigation programs and initiatives in South Dakota.

3 VULNERABILITY ASSESSMENT

3.1 Identifying the Drought Hazard

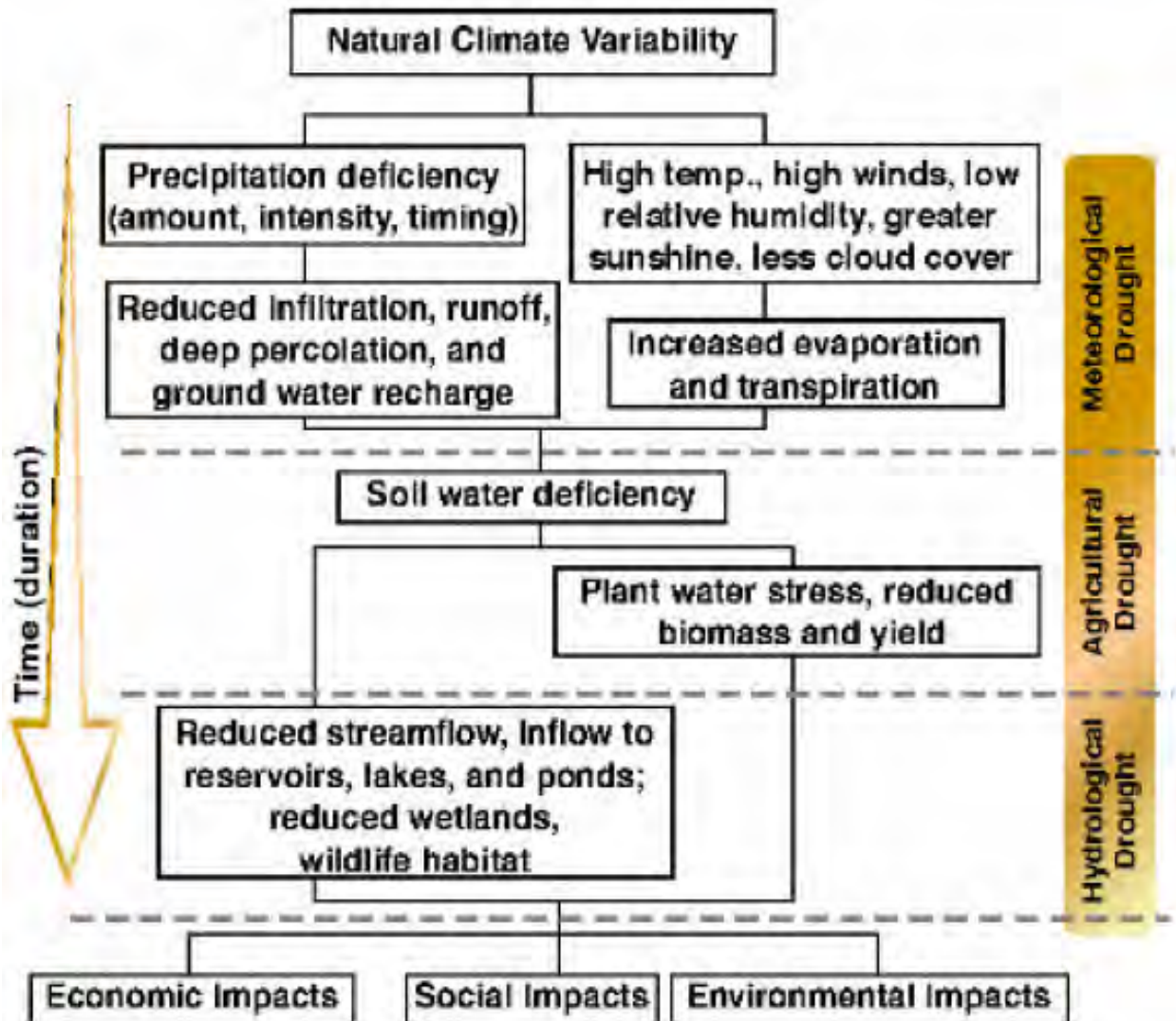
Drought has been identified as a hazard in the State’s multi-hazard HMP by the State Hazard Mitigation Team since the Plan’s first development in accordance with the DMA in 2004. Drought, along with flooding, winter storms, and wildfires, has been designated the highest planning consideration of ‘significant’ in the HMP based on past disaster history and population and property potentially at risk (numbers and dollars). A public and stakeholder online survey conducted during the 2013 update of the HMP ranked drought as the highest threat, second only to winter storm.

Drought is a complex and a gradual phenomenon in South Dakota. Although droughts can be characterized as emergencies, they differ from other emergency events in that most natural disasters, such as floods or forest fires, occur relatively rapidly and afford little time for preparing for disaster response. Droughts typically occur slowly, over a multi-year period, and it is often not obvious or easy to quantify when a drought begins and ends. Drought is typically defined based on its effects or phases:

- **Meteorological** drought is usually defined by a period of below average precipitation.
- **Agricultural** drought occurs when there is an inadequate water supply to meet the needs of the state’s crops and other agricultural operations such as livestock.
- **Hydrological** drought is defined as deficiencies in surface and subsurface water supplies. It is generally measured as streamflow, snowpack, and as lake, reservoir, and groundwater levels.
- **Socioeconomic** drought occurs when a drought impacts health, well-being, and quality of life, or when a drought starts to have an adverse economic impact on a region.

Figure 1 relates these definitions to drought duration and potential impacts.

Figure 1. Causes and Impacts of Drought

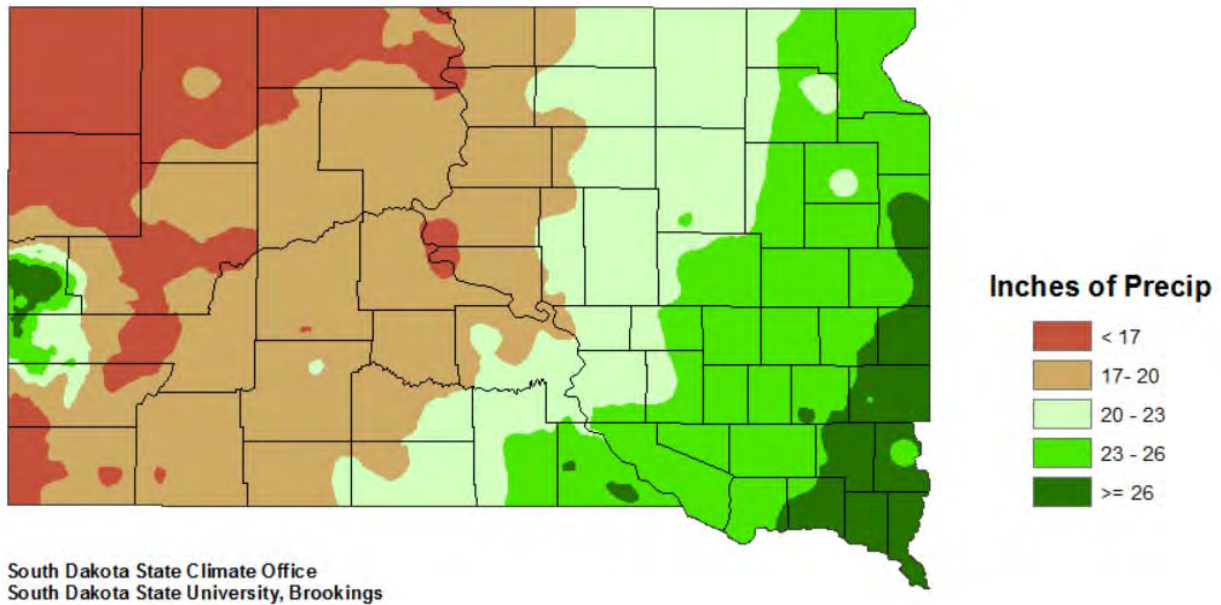


Source: National Drought Mitigation Center

3.2 Drought Hazard Profile

Drought is a natural part of the South Dakota climate, particularly in the more semi-arid western half of the State. Due to natural variations in climate and precipitation, it is rare for all of South Dakota to be deficient in moisture at the same time. Hydrologic conditions constituting a drought for water users in one location may not constitute a drought for water users elsewhere, or for water users that have a different water supply. The eastern half of South Dakota typically receives more precipitation than the western half, as depicted in Figure 2.

Figure 2. Average Annual Precipitation (inches) across South Dakota (1981-2010)



Drought impacts are wide-reaching and may come in different forms, such as economic, environmental, and societal. The most significant impacts associated with drought in South Dakota are those related to water intensive activities such as agriculture, wildfire protection, municipal usage, commerce, tourism, recreation, and wildlife preservation. A reduction of electric power generation and water quality deterioration are also potential effects. Drought conditions can also cause soil to compact, decreasing its ability to absorb water, making an area more susceptible to flash flooding and erosion. A drought may increase the speed at which dead and fallen trees dry out and become more potent fuel sources for wildfires. Drought may also weaken trees in areas already affected by insect infestations, causing more extensive damage to trees and increasing wildfire risk, at least temporarily. An ongoing drought which severely inhibits natural plant growth cycles may impact critical wildlife habitats. Drought impacts increase with the length of a drought, as carry-over supplies in reservoirs are depleted and water levels in groundwater basins decline. These impacts are explored further by sector in Section 3.4.

3.2.1 Location of Drought Hazards in South Dakota

No portion of the State of South Dakota is immune from drought conditions. The effects of drought vary based on where in the State it occurs, when it happens, and how long the drought persists. For example, a drought in East River (defined as the eastern half of the State east of the Missouri River) can greatly affect agricultural crops. A long-term drought is not needed to affect agricultural yields. Droughts of just a few weeks during critical periods of plant development can have disastrous effects on agriculture production. Droughts that occur in the Black Hills during winter months may affect winter sports related tourism and recreation. Droughts that occur in the western part of the state may increase the threat of wildfire in the wildland urban

interface areas. In summary, drought is one of the few hazards with the potential to directly or indirectly impact the entire population of the state, be it from water restrictions, higher water and food prices, reduced air or water quality, or restricted access to recreational areas (McKee and Doesken, 1999).

Tracking and monitoring drought impacts can be challenging. The Drought Impact Reporter from the NDMC is a useful reference tool that compiles reported drought impacts nationwide. Figure 3 shows reported total drought impacts for all South Dakota counties from 1980 to May 2015 in the following impact categories:

- Agriculture
- Business & Industry
- Energy
- Fire
- Plants & Wildlife
- Relief, Response & Restrictions
- Society & Public Health
- Tourism & Recreation
- Water Supply & Quality

Based on reports to the NDMC, all counties recorded some impact from drought, and most counties recorded moderate to major amounts of impacts; illustrating that drought affects all regions of the state in all impact categories at one time or another. The data represented is skewed, with the majority of these impacts from records within the past 10 to 15 years. Another important limitation of this data is its reliance on self-reporting.

Figure 3. Drought Impact Reporter for South Dakota (January 1980-May 2015)

3.2.2 Monitoring Drought in South Dakota

Because drought can be defined differently, based on the cause (lack of supply) and the effect (adverse impacts to water users), several methods have evolved to measure and assess drought. Severity, the most commonly used term for measuring drought, is a combination of the magnitude and duration of the drought. In order to assess the severity of a drought event it is necessary to monitor “normal” conditions as well as conditions during drought events. Individual indicators of drought conditions can be used in addition to indices that combine multiple indicators to give a more comprehensive set of information. Both traditional maps and graphs of precipitation, snowpack, and streamflow patterns and compilations provide valuable information for drought monitoring. Instrumental data are used extensively for monitoring precipitation, snowpack, streamflow, and reservoir levels, some of which are summarized below:

- Precipitation is measured daily at several locations across South Dakota. National Weather Service (NWS) stations have collected data for 100 years or more. The South Dakota Office of Climatology at South Dakota State University runs the South Dakota Mesonet, which

collects data from 30 weather stations around the state. Data from the Mesonet is used in the Office of Climatology's drought research.

- Streamflow is the net result of precipitation, snowmelt, evapotranspiration, infiltration, and groundwater recharge, as well as man-made influences such as irrigation diversions and reservoir storage and releases. The combination of streamflow readings and reservoir levels provides the best direct indication of available surface water supplies in each of South Dakota's river basins.

South Dakota also relies on volunteer weather watchers to monitor precipitation across the State.

These climate observation networks provide important data necessary to analyze recent and historic droughts and relate water availability to observed impacts. Years of experience, along with common sense, have shown that drought impacts are directly related to the following drought characteristics:

- Magnitude – how large the water deficits are in comparison with historic averages
- Duration – how long the drought lasts
- Spatial extent – what area is impacted by the drought

A variety of drought indices are used to track precipitation and water supply, as well as classify droughts that have occurred in the past. These indices help simplify and synthesize complex data to provide actionable information for planners and decision makers. Paleoclimatic techniques, such as measurement of tree rings, ice cores, pollens, and ancient lake levels, are also employed to study drought patterns and frequencies over the past several centuries. The following set of indices are most commonly used in South Dakota.

The **Palmer Drought Severity Index** is a complex soil moisture calculation that has been used by federal agricultural agencies to determine when to provide drought assistance. It requires weekly or monthly precipitation and temperature data as inputs. The Palmer Drought Severity Index uses a +4 to -4 scale. It uses a 0 as normal, and drought is shown in terms of negative numbers; for example, -2 is moderate drought, -3 is severe drought, and -4 is extreme drought.

The **Standardized Precipitation Index (SPI)** is fairly simple to compute but is often a robust index for describing drought patterns. The SPI values are based on the probability, calculated from the long-term precipitation record for a given location, of recording a given amount of precipitation over the stated time period, and these probabilities are standardized so that a value of zero always indicates the median precipitation amount. The SPI can be computed for different time scales, can provide early warning of drought and help assess drought severity, and is less complex than the Palmer Drought Severity Index. The SPI identifies a beginning and end for each drought, as well as an intensity level for each month in which the drought occurs. Table 3 shows the values for the SPI index. The challenge of utilizing SPI objectively is understanding the appropriate time scale and vulnerability for various known and potential impacts.

Table 3 **SPI Index**

SPI Values	Description
2.0 +	extremely wet
1.5 to 1.99	very wet
1.0 to 1.49	moderately wet
-.99 to .99	near normal
-1.0 to -1.49	moderately dry
-1.5 to -1.99	severely dry
-2 and less	extremely dry

Source: NOAA National Climatic Data Center

The **Crop Moisture Index** was developed from the Palmer Index, and was designed to evaluate short-term moisture conditions across major crop producing regions. It uses the average temperature and total precipitation for each week and compares the calculated index with the previous week. This is a better index to measure rapidly changing conditions and for comparing different locations.

In addition to the indices noted above the **U.S. Drought Portal**, which is a product of the National Integrated Drought Information System (NIDIS), is also used in South Dakota.

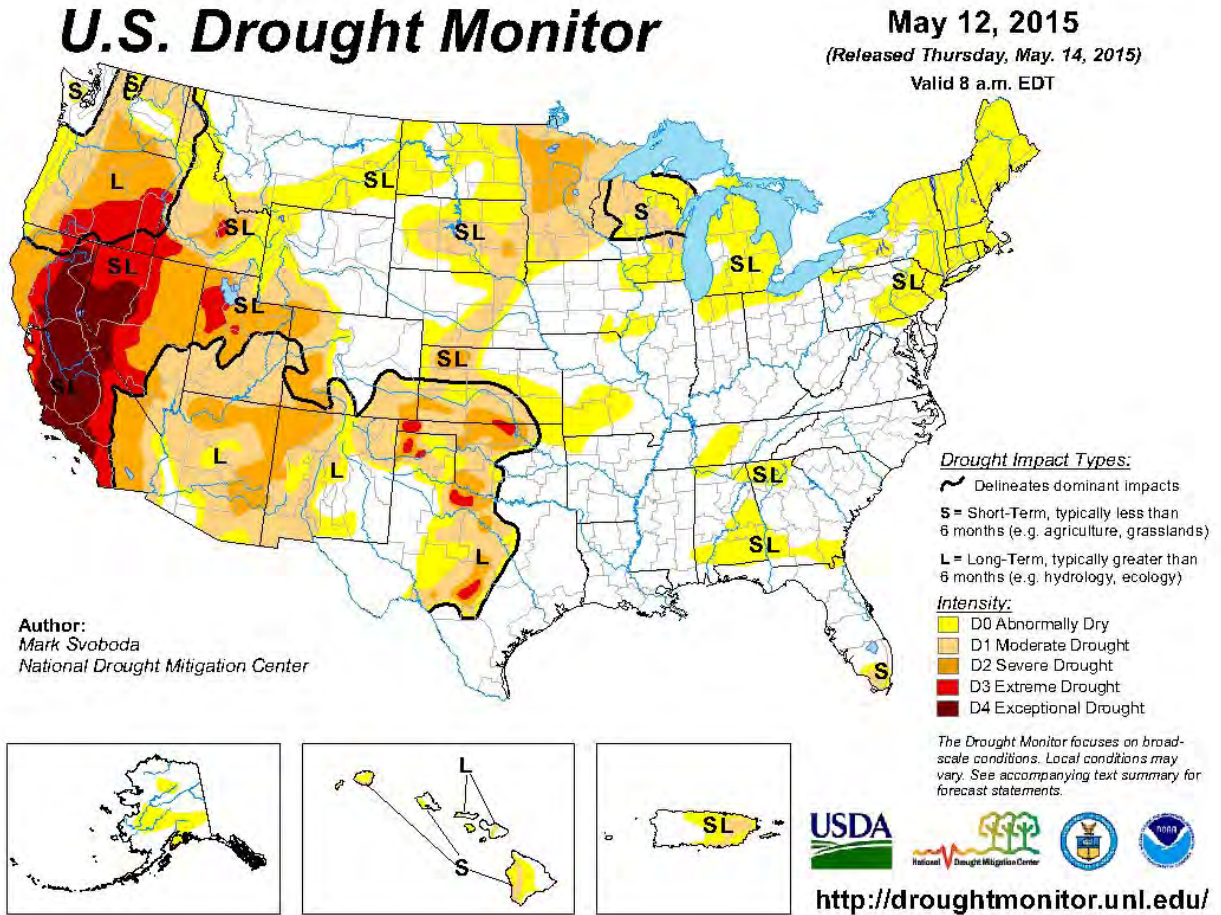
The U.S. Drought Portal is part of an interactive system to:

- Provide early warning about emerging and anticipated droughts
- Assimilate and quality control data about droughts and models
- Provide information about risk and impact of droughts to different agencies and stakeholders
- Provide information about past droughts for comparison and to understand 2013 conditions
- Explain how to plan for and manage the impacts of droughts
- Provide a forum for different stakeholders to discuss drought-related issues

A major component of this portal is the **U.S. Drought Monitor**. The Drought Monitor concept was developed jointly by the NOAA's Climate Prediction Center, the NDMC, and the USDA's Joint Agricultural Weather Facility in the late 1990s as a process that synthesizes multiple indices, outlooks and local impacts into an assessment that best represents drought conditions in a given year. The final outcome of each Drought Monitor is a consensus of federal, state, and academic scientists who are intimately familiar with the conditions in their respective regions.

A snapshot of the May 2015 drought conditions nationwide and specific to South Dakota can be found in Figures 4 and 5. The figures indicate dry conditions that are evident throughout much of the western and mid-western U.S. The majority of South Dakota is experiencing at least abnormally dry conditions, with moderate conditions throughout the eastern and central counties and severe conditions in a few eastern counties.

Figure 4. May 2015 U.S. Drought Conditions



Source: National Drought Mitigation Center

Figure 5. May 2015 South Dakota Drought Conditions

**U.S. Drought Monitor
South Dakota**

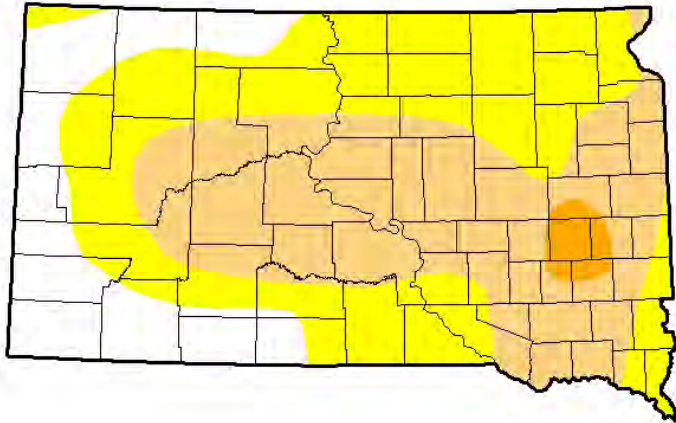
May 12, 2015

(Released Thursday, May. 14, 2015)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	18.71	81.29	41.02	1.94	0.00	0.00
Last Week <i>5/5/2015</i>	0.54	99.46	78.02	26.23	0.00	0.00
3 Months Ago <i>2/10/2015</i>	30.61	69.39	4.46	0.00	0.00	0.00
Start of Calendar Year <i>1/20/2014</i>	48.53	51.47	4.46	0.00	0.00	0.00
Start of Water Year <i>9/30/2014</i>	97.46	2.54	0.00	0.00	0.00	0.00
One Year Ago <i>5/13/2014</i>	82.53	17.47	9.81	0.00	0.00	0.00



Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:

Mark Svoboda
National Drought Mitigation Center



<http://droughtmonitor.unl.edu/>

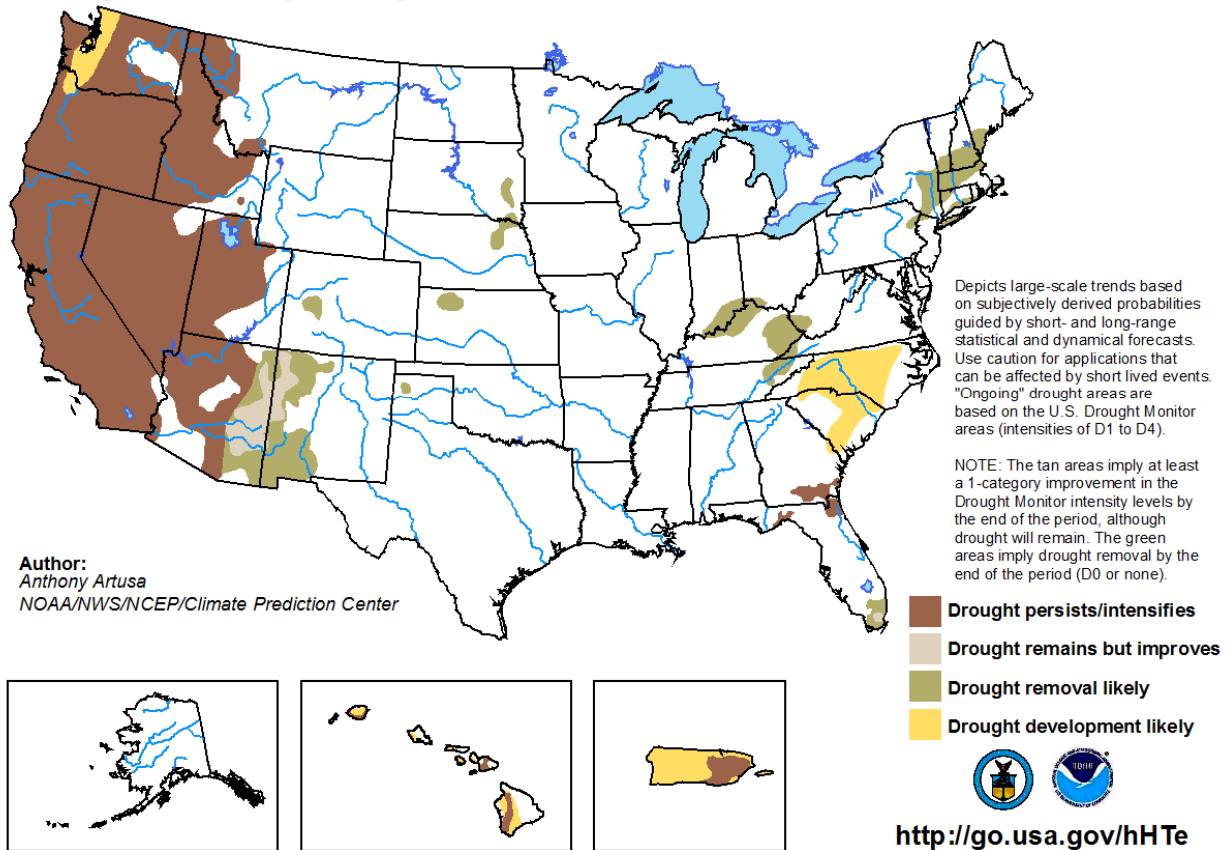
Source: National Drought Mitigation Center

The U.S. Seasonal Drought Outlook developed by NOAA synthesizes long-term forecasts to generalize drought tendencies across the nation. A sample of this product is shown in Figure 6.

Figure 6. Seasonal Drought Outlook June 18 - September 30, 2015

U.S. Seasonal Drought Outlook
Drought Tendency During the Valid Period

Valid for June 18 - September 30, 2015
 Released June 18, 2015



Source: NOAA Climate Prediction Center

3.2.3 Drought History in South Dakota

Several times since the late 1800s South Dakota has experienced widespread, severe drought. The most dramatic occurred in the 1930s and 1950s when many states, South Dakota included, were affected for several years at a time. Several other significant droughts occurred in the 1970s, 1980s, 2000s, and 2010s. Following this section is a history of drought declarations. Details on the more significant droughts conclude the discussion of drought history.

USDA Disaster Declarations for South Dakota

The Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans (EM) to producers suffering losses in those counties and in counties that are contiguous to a designated county. Historically, USDA Secretarial Disaster Declarations must have been requested by a governor's authorized representative or by an Indian Tribal Council leader. Damages and losses prompting disaster designation must be due to a natural disaster and a minimum of 30 % production loss in at least one crop in the county must have occurred. The

Secretarial Disaster Declaration is widely used and makes low-interest loans and other emergency assistance available for those affected, e.g., to farmers and ranchers in the case of agricultural disasters due to drought. Under a new streamlined process by the Farm Services Agency (FSA), a nearly automatic USDA Disaster Declaration can be made if any portion of a county has experienced eight consecutive weeks of severe drought according to the U.S. Drought Monitor (Congressional Research Service, 2013). Table 4 lists the disaster declarations related to drought for South Dakota from 2008 to the present. The calendar year is listed, along with the type of hazard, and the primary affected counties. As can be seen in Table 4, numerous counties were declared in 2012 and 2013.

Table 4 USDA Secretarial Disasters 2008-Present

Year	Primary Affected Counties
2008	Custer, Day, Fall River, Grant, Gregory, Hughes, Hutchinson, McCook, McPherson, and Stanley
2009	No primary affected counties
2012	Bennett, Bon Homme, Butte, Charles Mix, Clay, Custer, Davison, Day, Douglas, Fall River, Grant, Gregory, Haakon, Hanson, Hutchinson, Jackson, Jerauld, Jones, Kingsbury, Lawrence, Lincoln, McCook, Meade, Minnehaha, Pennington, Shannon, Todd, Tripp, Turner, Union, and Yankton
2013	Bennett, Bon Homme, Butte, Charles Mix, Clay, Corson, Custer, Dewey, Fall River, Gregory, Haakon, Harding, Hughes, Jackson, Jones, Meade, Mellette, Pennington, Perkins, Potter, Shannon, Stanley, Sully, Todd, Tripp, Turner, Union, Yankton, and Ziebach
2014	No primary affected counties

Source: USDA –Farm Service Agency

Major Droughts

A comprehensive compendium of historical drought information for South Dakota is difficult to find. The following is a summary of information on major droughts that have affected South Dakota, much of it based on data compiled from the National Climatic Data Center (NCDC) and State HMP.

1889–1905 – This multi-year, statewide drought was most severe between 1894 - 1896 and 1898 - 1901.

1910-1914 – This drought was worse in the western half of the state but regional impacts varied. It was most severe in 1911.

The 1930’s Drought – The Dust Bowl drought severely affected much of the United States during the 1930s. The drought came in three waves, 1934, 1936, and 1939-1940, but some regions of the High Plains experienced drought conditions for as many as eight consecutive years. The soil, depleted of moisture, was lifted by the wind into great clouds of dust and sand which were so thick they concealed the sun for several days at a time. They were referred to as “black blizzards.” The period itself is known as the dust bowl. The “black blizzards” were caused by sustained drought conditions compounded by years of land management practices that left topsoil susceptible to the forces of the wind.

The agricultural and economic damage devastated residents of the Great Plains. The Dust Bowl drought worsened the already severe economic crises that many Great Plains farmers faced. In the early 1930s, many farmers were trying to recover from economic losses suffered during the Great Depression. To compensate for these losses, they began to increase their crop yields. High production drove prices down, forcing farmers to keep increasing their production to pay for both their equipment and their land. When the drought hit, farmers could no longer produce enough crops to pay off loans or even pay for essential needs. Even with federal emergency aid, many Great Plains farmers could not withstand the economic impacts of the drought. Many farmers were forced off of their land. One in ten farms changed possession at the peak of the drought. The agricultural and economic damage devastated residents of the Great Plains.

Many factors contributed to the severe impact of this drought and in its aftermath a better understanding of the interactions between the natural elements (e.g., climate, plants, and soil) and human-related elements (e.g., agricultural practices, economics, and social conditions) of the Great Plains developed. As a result, farmers adopted new cultivation methods to help control soil erosion in dry land ecosystems; consequently, subsequent droughts in the region have not had the same impact.

The 1950s Drought – Fueled by post-war economic stability and technological advancement, the 1950s represented a time of growth and prosperity for some Americans. But while much of the country celebrated a resurgence of well-being, many residents of the Great Plains and southwestern United States were suffering. During the 1950s, the Great Plains and the southwestern U.S. withstood a five-year drought, and in three of these years, drought conditions stretched coast to coast. The 1950s drought was characterized by both decreased rainfall and excessively high temperatures. The first effects of the drought were felt in the southwestern U.S. in 1950 and by 1953 conditions had spread to Oklahoma, Kansas, and Nebraska. By 1954, the drought encompassed a ten-state area reaching from the mid-west to the Great Plains, and southward into New Mexico. The area from the Texas panhandle to central and eastern South Dakota, western Kansas, and central Nebraska experienced severe drought conditions. The drought maintained a stronghold in the Great Plains, reaching a peak in 1956. The drought subsided in most areas with the spring rains of 1957. A disaster of this magnitude can create severe social and economic repercussions, as was the case in the southern Great Plains region. The drought devastated the region's agriculture, with crop yields in some areas decreased as much as 50%. Excessive temperatures and minimal rainfall scorched grasslands typically used for grazing. With grass scarce, hay prices rose, forcing some ranchers to feed their cattle a mixture of prickly pear cactus and molasses. By the time the drought subsided in 1957, many counties across the region were declared federal drought disaster areas (NCDC, 2003).

The 1975-1976 Drought – This drought was short but severe, and similar to the 2012-2013 drought in agricultural impacts. This drought resulted in the State's only drought emergency declaration (FEMA-3015-EM in 1976) to date.

The 1980-1982 Drought – This was a statewide drought that was most severe in 1981 and rated as a 10-25 year event.

The 1988-1992 Drought – This drought contributed to large wildland fires in the Black Hills. Conditions became so severe that the state considered using cloud seeding, despite the bad press associated with cloud seeding in the aftermath of the 1972 Rapid City flood.

The 2002-2007 Drought – The State also experienced significant droughts in 2002-2007. South Dakota dealt with impacts such as switching some reservoir intakes to river intakes in 2002-2003 because the reservoir levels receded below the intake. Water recreation declined in 2006. The 2002-2007 drought also exacerbated wildland fire risk, leading to a particularly bad fire season during 2006. The impacts of this drought are discussed in greater detail by sector in Chapter 3 Vulnerability Assessment.

The 2012-2013 Drought – The 2012-2013 drought wasn't as lengthy as other droughts but did have significant agricultural impacts. Shutoff orders were issued to water rights holders in the spring of 2012. The 2012-2013 drought actually created some positive aspects by offsetting the impacts of the floods during 2010-2011. The impacts of this drought are discussed in greater detail by sector in Section 3 Vulnerability Assessment.

Winter-Spring 2015 Drought - South Dakota experienced its driest January-April of any year on record since the late 1800s. Dry conditions continued across much of the state until mid-May when unusually copious rainfall continued into June and virtually eliminated drought conditions and caused flooding issues instead.

Other historic droughts. An article in the *Proceedings of the South Dakota Academy of Science* suggests that South Dakota has seen droughts worse than the 1930's Dust Bowl. The article summarizes a study of tree core data in the Black Hills conducted to learn more about early historical drought in South Dakota. The results of the study are illustrated in **Table 5** which indicates that dry periods as long as 15 to 20 years have occurred in the past. (Source: Bunkers, M.J., L.R. Johnson, J.R. Miller, and C.H. Sieg. 1999. Old Black Hills Ponderosa Pines Tell a Story *Proceedings of the South Dakota Academy of Science*, Vol. 78.)

Table 5 Duration and Magnitude Estimates of 15 Dry and 15 Wet Spells in South Dakota

Rank	Dry Periods			Wet Periods		
	Years	No. Years	% of Max	Years	No. Years	% of Max
1	1531-1551*	21	100.0	1429-1448*	20	100.0
2	1325-1344*	20	90.8	1284-1297*	14	80.3
3	1859-1873	15	82.5	1559-1574*	16	66.0
4	1397-1411*	15	73.0	1609-1617	9	53.6
5	1710-1725	16	65.8	1762-1769	8	35.7
6	1780-1791	12	51.3	1882-1892	11	31.5
7	1933-1942	10	50.0	1683-1695	12	30.0

8	1753-1761	9	43.5	1792-1806	15	28.1
9	1660-1668	9	44.7	1903-1910	8	27.2
10	1580-1598*	9	32.2	1962-1969	8	26.1
11	1852-1857	6	29.7	1773-1779	7	24.4
12	1956-1961	6	29.6	1832-1842	11	21.1
13	1467-1472*	6	27.0	1726-1733	8	21.0
14	1377-1388*	12	26.3	1943-1947	5	20.6
15	1637-1640	4	24.8	1641-1645	5	19.5

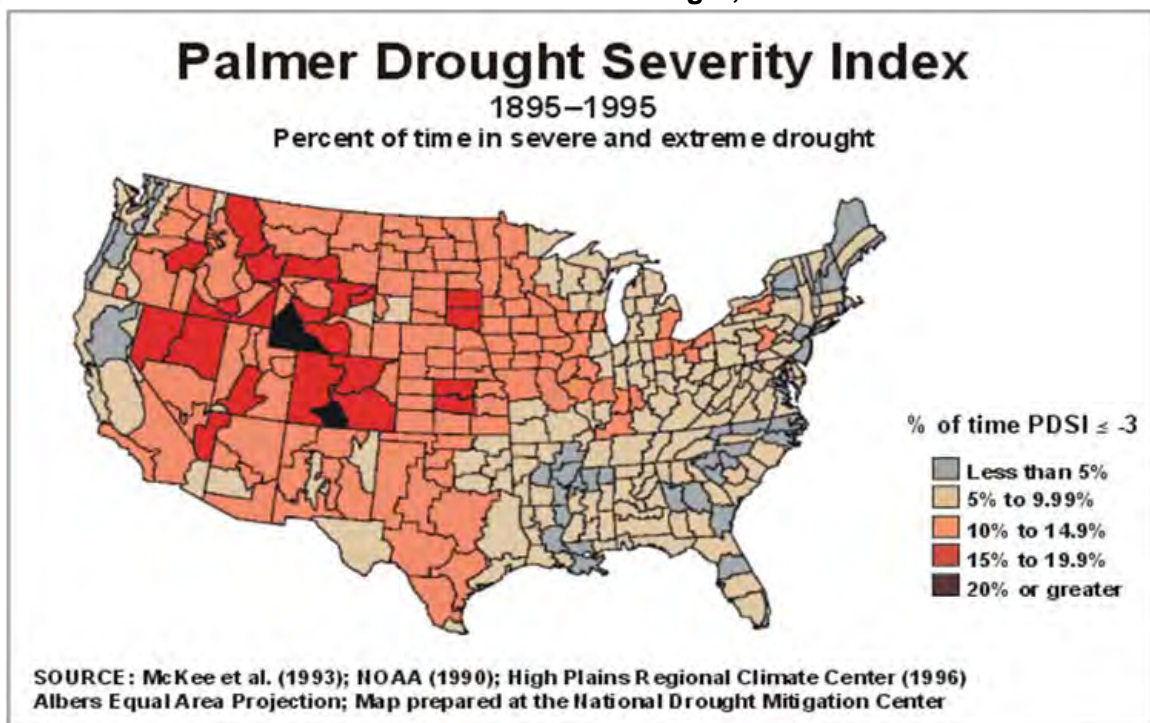
Source: Bunkers, M.J., L.R. Johnson, J.R. Miller, and C.H. Sieg. 1999. Old Black Hills Ponderosa Pines Tell a Story. *Proceedings of the South Dakota Academy of Science*, Vol. 78.

Note: *Sample size <5 trees and is likely not adequate to reliably infer precipitation patterns.

Probability of Future Droughts

Figure 7, from the NDMC website, illustrates that most of South Dakota has experienced severe or extreme drought between 15 and 19.9% of the time over a 100-year period. Based on the tree ring research noted previously, which spans a period of roughly 400 years, multi-year droughts as significant as the 1930's drought or worse occur on average every 57 years. Based on historical records (10 in the past 118 years, counting the 2002-2007 dry spell and other multi-year events as one event) notable droughts have occurred somewhere in the state on average about every 12 years, which is equivalent of an 8% chance any given year. Climate change could increase the frequency of drought in South Dakota in the future. The next section discusses climate change as it relates to the probability of future droughts and its general implications for the State.

Figure 7. United States: Percent of Time in Drought, 1895–1995



Climate Change

The intensity and frequency associated with the drought hazard profiled in this Plan are based on historic events. Climate change has the potential to alter the nature and frequency of drought events in the future. The National Climate Assessment provides an in-depth look at climate change impacts on the U.S on a regional basis (<http://nca2014.globalchange.gov/report>). The report details the multitude of ways climate change is already affecting and will increasingly affect the lives of Americans. A team of more than 300 experts guided by a 60-member Federal Advisory Committee produced the report, which was extensively reviewed by the public and experts, including federal agencies and a panel of the National Academy of Sciences. South Dakota is part of the Great Plains region which includes the states of Kansas, Montana, Nebraska, North Dakota, Oklahoma, Texas, and Wyoming. The science summarized in the report points to increasing mean temperatures in the Great Plains. This will lead to increased evaporation and drought frequency, which will compound water scarcity problems. In parts of the region, this will constrain development, stress natural resources, and increase competition for water among communities, agriculture, energy production, and ecological needs. Communities that are already the most vulnerable to weather and climate extremes will be stressed even further by more frequent extreme events occurring within an already highly variable climate system. Changing extremes in precipitation are projected across all seasons, including higher likelihoods of both increasing heavy rain and snow events and more intense droughts. As a case in point, the state experienced extreme wet-dry pendulum swings in recent years from wet to dry (2011-2012) and record breaking dry to wet (winter/spring of 2015).

3.3 Vulnerability by Sector – Overview

Until recently, drought assessment and management has, in most states, been largely response oriented. A detailed vulnerability assessment can assist with the development of targeted drought mitigation and response strategies. A comprehensive drought vulnerability assessment is challenging due to the wide variety and far reaching impacts of drought which are often not consistently tracked. Because of these challenges the science and process of drought vulnerability assessment is not well developed, at least when compared to other natural hazards such as flood and earthquake. This vulnerability assessment creates a new platform for drought risk assessment by developing an initial drought vulnerability assessment approach that highlights drought exposure and adaptive capacity for sectors, county-by-county where possible, within South Dakota.

The Vulnerability sectors included in this study were determined by the DTF, based on sectors typically affected by drought. They include:

- Water Resources Sector
- Health and Socioeconomic Sector
- Agriculture Sector
- Wildfire Sector

-
- Wildlife Sector
 - Tourism Sector

The approach developed for this Plan used a hybrid quantitative and qualitative approach. Quantitative elements of the vulnerability assessment were conducted where sound data existed to support this, or where data could be developed efficiently. A focus of the quantitative approach was to quantify impacts and the ability to reduce and mitigate those impacts, both short term and long term. Each sector analysis also includes recommendations on what data will be required to improve this approach in the future. Qualitative information, particularly data gained from interviews, was also introduced where appropriate. Results have been analyzed spatially in a GIS and are presented in map form within each sector to illustrate how drought vulnerability varies across the state, where feasible. The following sections discuss vulnerability by sector, beginning with Water Resources which also provides a framework of water supplies and uses within the State.

3.4 Water Resources

3.4.1 Introduction to Water Resources in South Dakota

South Dakota predominantly consists of cropland and rangeland with the Missouri River flowing through the middle of the State. The Missouri River, along with its tributaries, drains the majority of the State with exception to the Minnesota Valley lowland in the northeast corner which is drained by Big Stone Lake and Lake Traverse. **Figure 8** shows the major surface water features and a general overview of the groundwater aquifers.¹

The land east of the Missouri River is mainly flat prairie covered by rich black deposits of glacial-drift soil. Large bands of cultivated cropland, pastureland and haymaking areas run in a north to south direction. In the northeast there are many shallow lakes among rolling glacier created hills. The land west of the Missouri River mainly consists of rolling terrain covered by medium-to-fine-texture residual soil with scattered areas of heavy sticky mud when wet. The area is predominantly grasslands marked with cropland, pastureland and pockets of barren land. The western section of the State also includes the badlands, an area known for its impressive erosion formations and the Black Hills which is named for the evergreen forests that cover the State's highest terrain. The highest concentrated areas of urban development are centralized around Rapid City, Aberdeen, Brookings, Pierre and Sioux Falls.

Precipitation

The average annual precipitation in South Dakota is about 19 inches, although as shown in **Figure 9**, the amount of precipitation geographically varies considerably. Semi-arid conditions

¹ Detailed maps of the subsurface aquifer systems in South Dakota are not yet currently available throughout the State. Public agencies continue to invest in this effort.

occur in the northwestern part of the State with less than 17 inches of average annual precipitation. The southeast generally consists of semi-humid conditions averaging over 26 inches of annual precipitation. Areas in the Black Hills can also receive an annual average precipitation of greater than 26 inches.

Figure 8. Major Surface and Groundwater Features

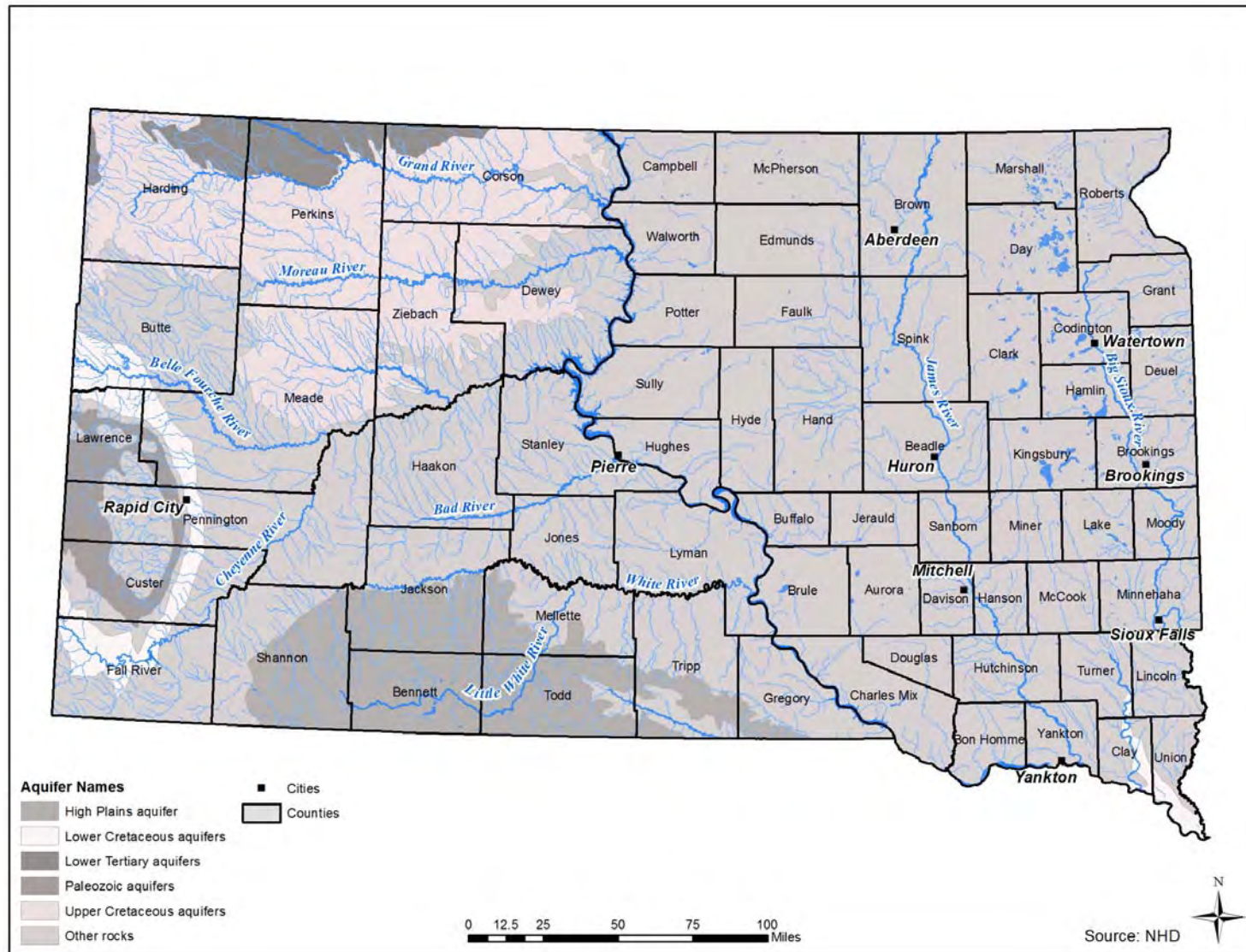
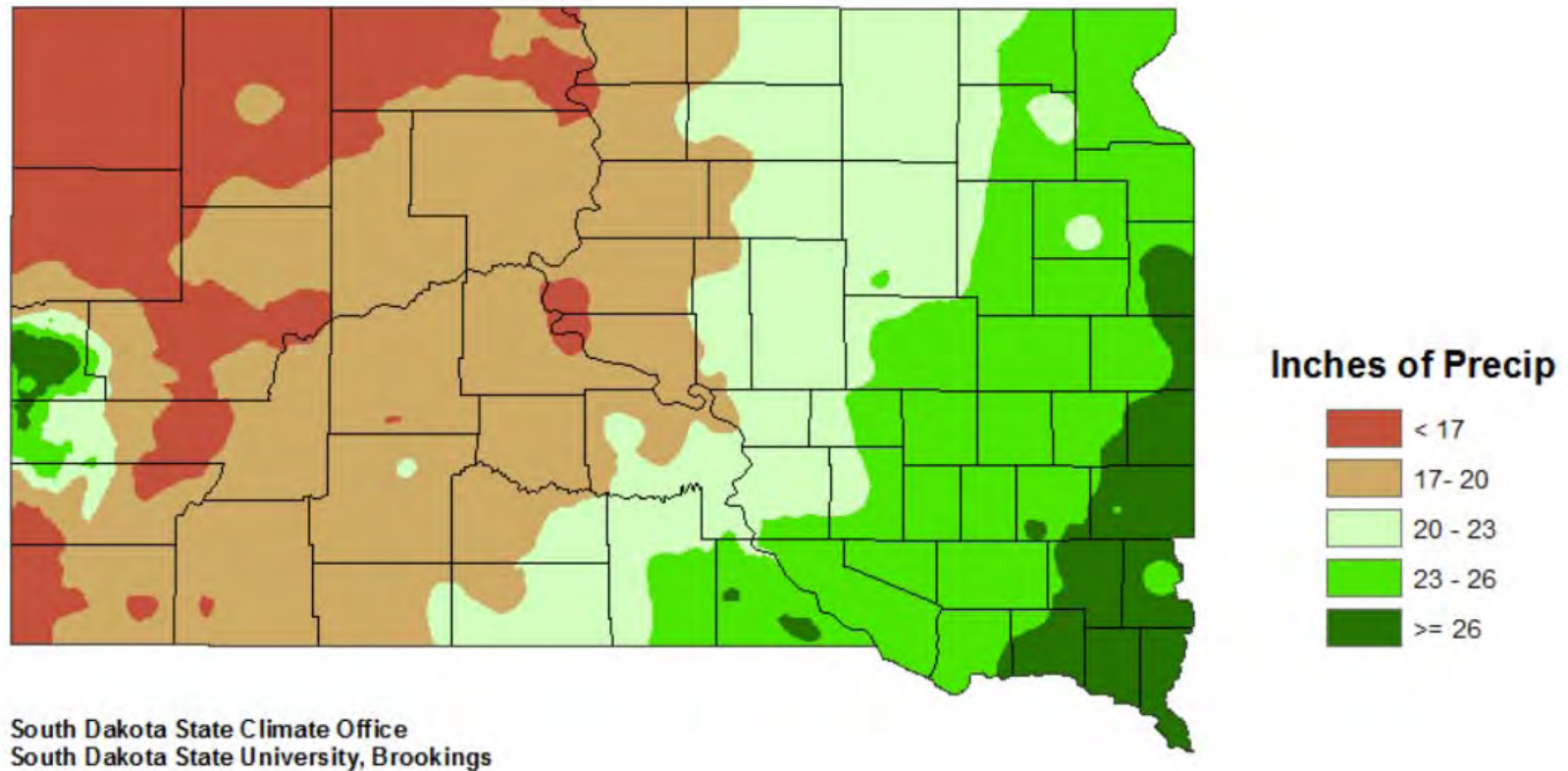


Figure 9. Average Annual Precipitation (1981 – 2010)



Surface and Groundwater Use

Water is an essential resource for the livelihood and economic prosperity of South Dakota. A complex interwoven system of underground aquifers, reservoirs, natural lakes, rivers and streams meet both the environmental and human needs of the State. **Figure 10** shows the total amount of water used on a county basis and **Figure 11** shows the percentage of surface and groundwater used within each county. These water use data were compiled from a national 2010 United States Geological Survey (USGS) study.

The counties with the high range of water use (30,000 to 58,000 acre-feet), in Figure 10, support the larger urban areas in South Dakota and/or have a relatively high demand for agricultural irrigation water.² Figure 11 shows that the southwest and central portion of the State along the Missouri River corridor tend to rely more heavily on surface water than groundwater. The northeast portion of the State and certain counties in the southeast depend on pumping groundwater for over 75% of their supply.

According to South Dakota water law, all water is the property of the people of the State. All water users, with the exception of smaller scale domestic users^{3,4} must obtain a water right permit. This includes irrigation, municipal and rural, commercial and industrial, suburban housing and domestic, fish and wildlife/recreation and institutional use. Applications for new water right permits are reviewed by the Department of Environment and Natural Resources (DENR) to assess the potential for injury to other water users and then a notice is published in the county where the project works is located.⁵ Anyone may file a petition to support or oppose the application. A permit can be issued without a hearing if no one contests the application and the user is granted a water right license once the project is developed and the water is put to beneficial use. If an application is contested, a hearing is scheduled with the State Water Management Board (seven member Board appointed by the Governor) for consideration under which the Board decides whether to approve the application. The ownership of water rights may be transferred by filing notice of the transfer with the Water Rights Program. A change in use (i.e. from irrigation to suburban use), change in point of diversion or other change may be permitted as long as it does not unlawfully impair existing rights, is for a beneficial use and is in the public interest.

² Water demands by individual sector are discussed in further detail in Section 3.2.

³ Domestic users that exceed 25,920 gallons per day or a peak pumping rate of 25 gpm must obtain a water right permit.

⁴ Examples of domestic water uses are: 1) drinking, washing, sanitary, and culinary uses by an individual or household, 2) irrigation of a noncommercial garden, trees, etc. not exceeding one acre in size, 3) stock watering, and 4) 18 gallons per minute for use in schools, parks, and public recreation areas.

⁵ South Dakota water law does not distinguish the difference between alluvial (groundwater that is hydrologically connected to the stream) and deeper bedrock groundwater (groundwater not connected to the surface water system). As discussed in Section 3.1.2, State water law does not allow the “mining” of groundwater where the average quantity of water annually pumped from an aquifer is greater than the estimated recharge to the aquifer. A limited exception to “no mining” is made by SDCL 46-6-3.1 for water distribution systems.

Figure 12 shows the location of diversions for the State’s surface water right licenses and **Figure 13** shows the groundwater right licensee locations. These water rights have been developed, put to beneficial use and received a water right license issued by the State. **Figure 12** indicates that the largest concentration of surface water right permits are on streams in the southwest portion of the State. **Figure 13** shows that the highest density of groundwater right permits occur near and northwest of Rapid City, in the southeast portion of the State and in several pockets near Brookings, Huron and Sioux City.

Figure 10. Annual Water Use in 2010

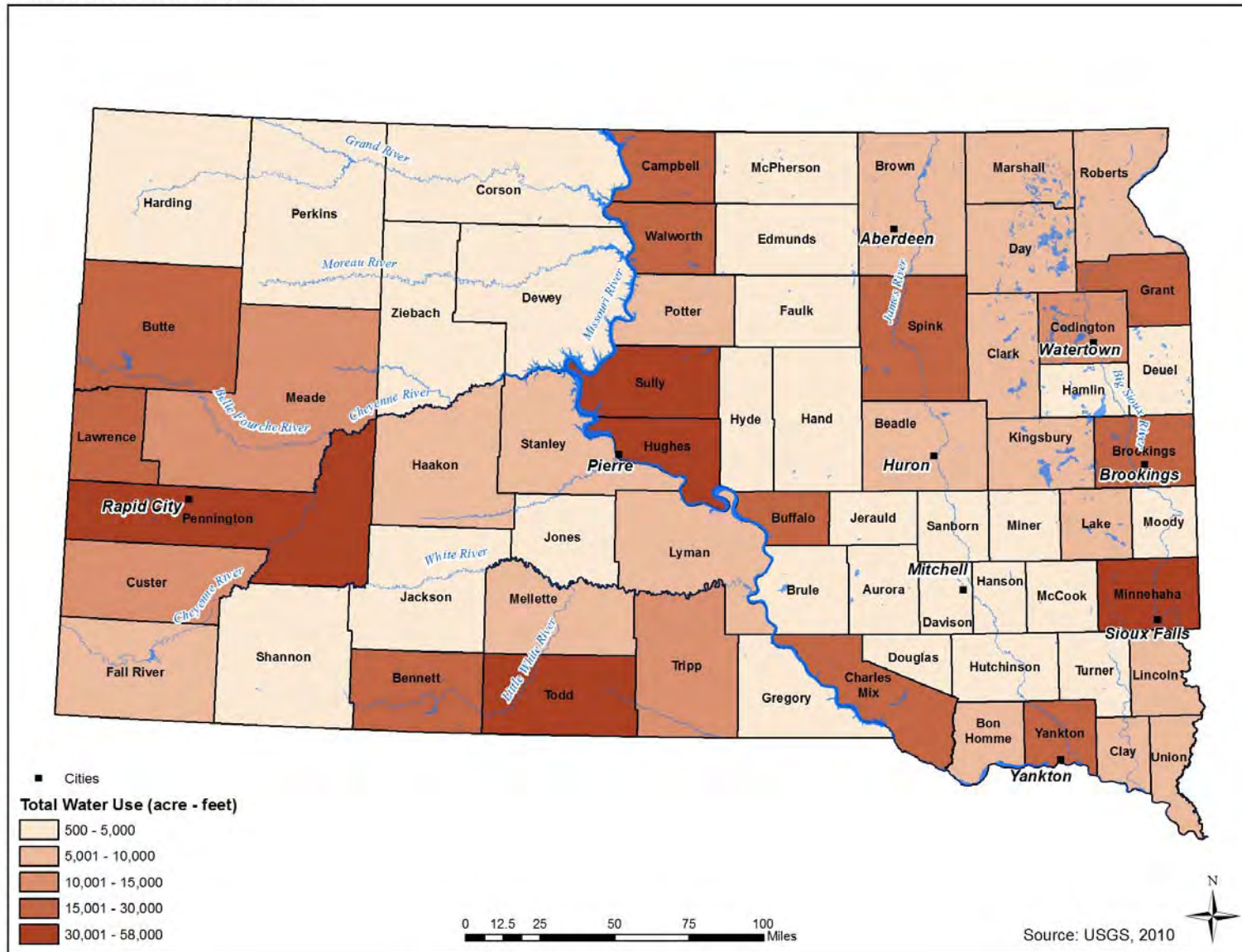


Figure 11. Percentage of Surface and Groundwater Use in 2010

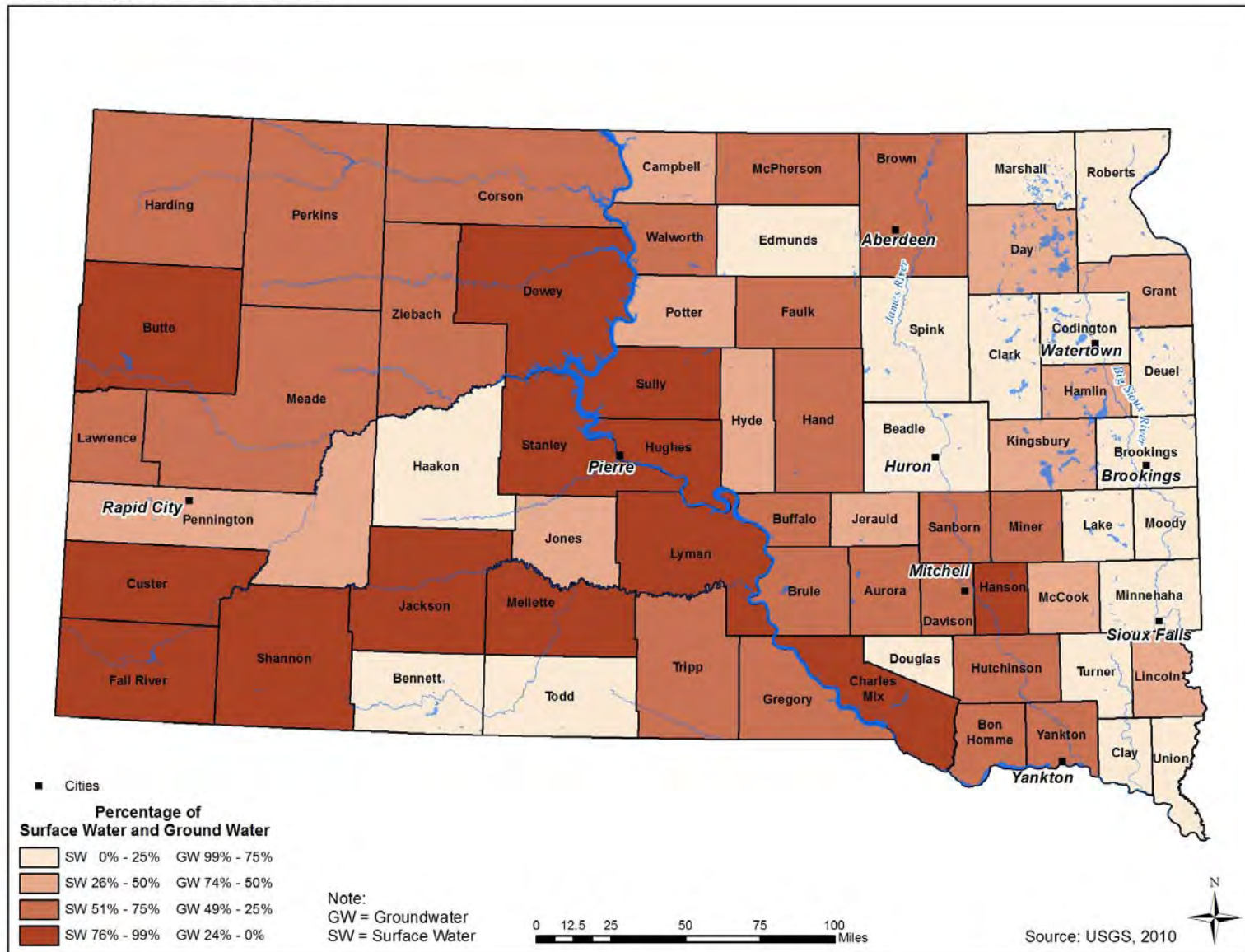


Figure 12. Surface Water Right Licenses

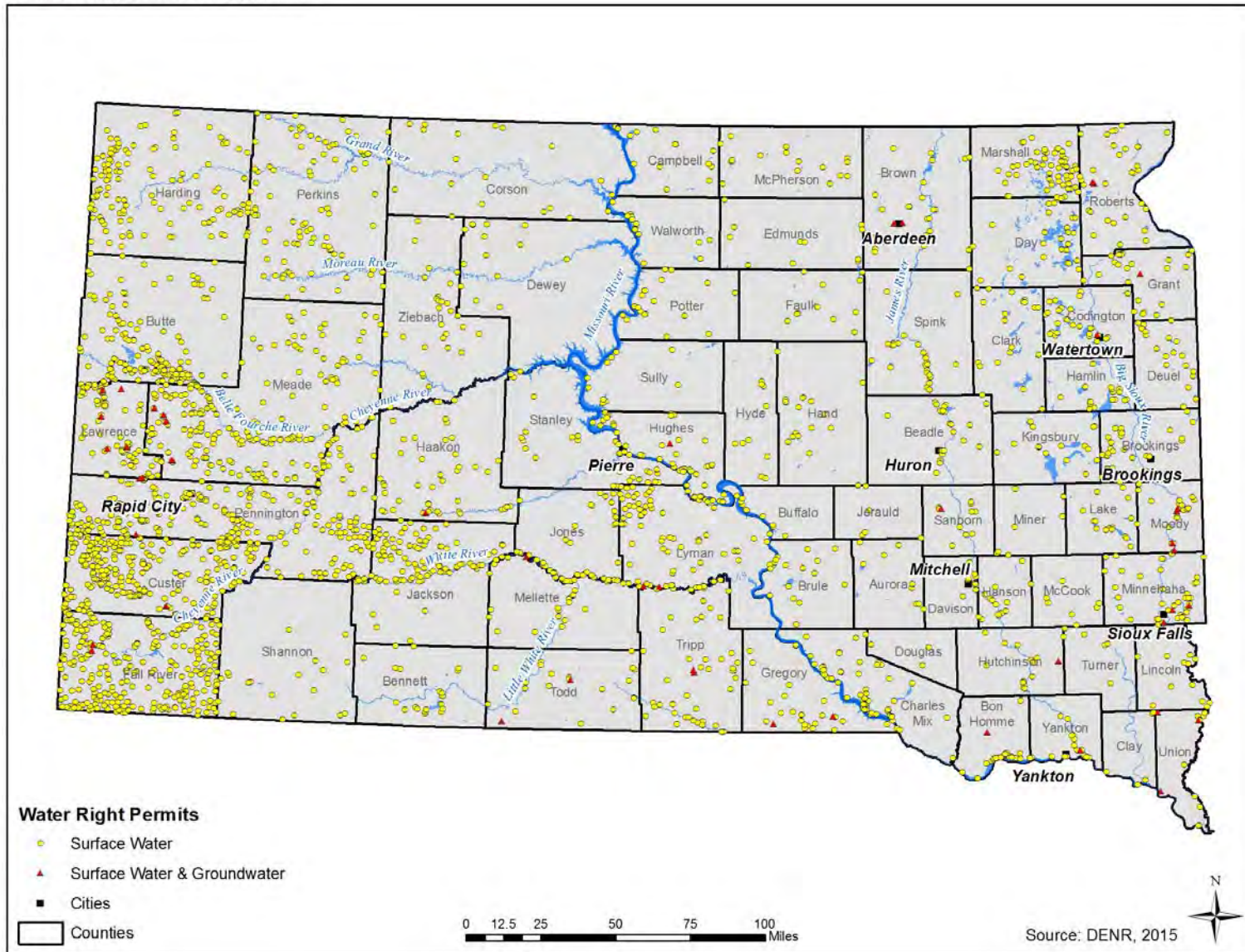
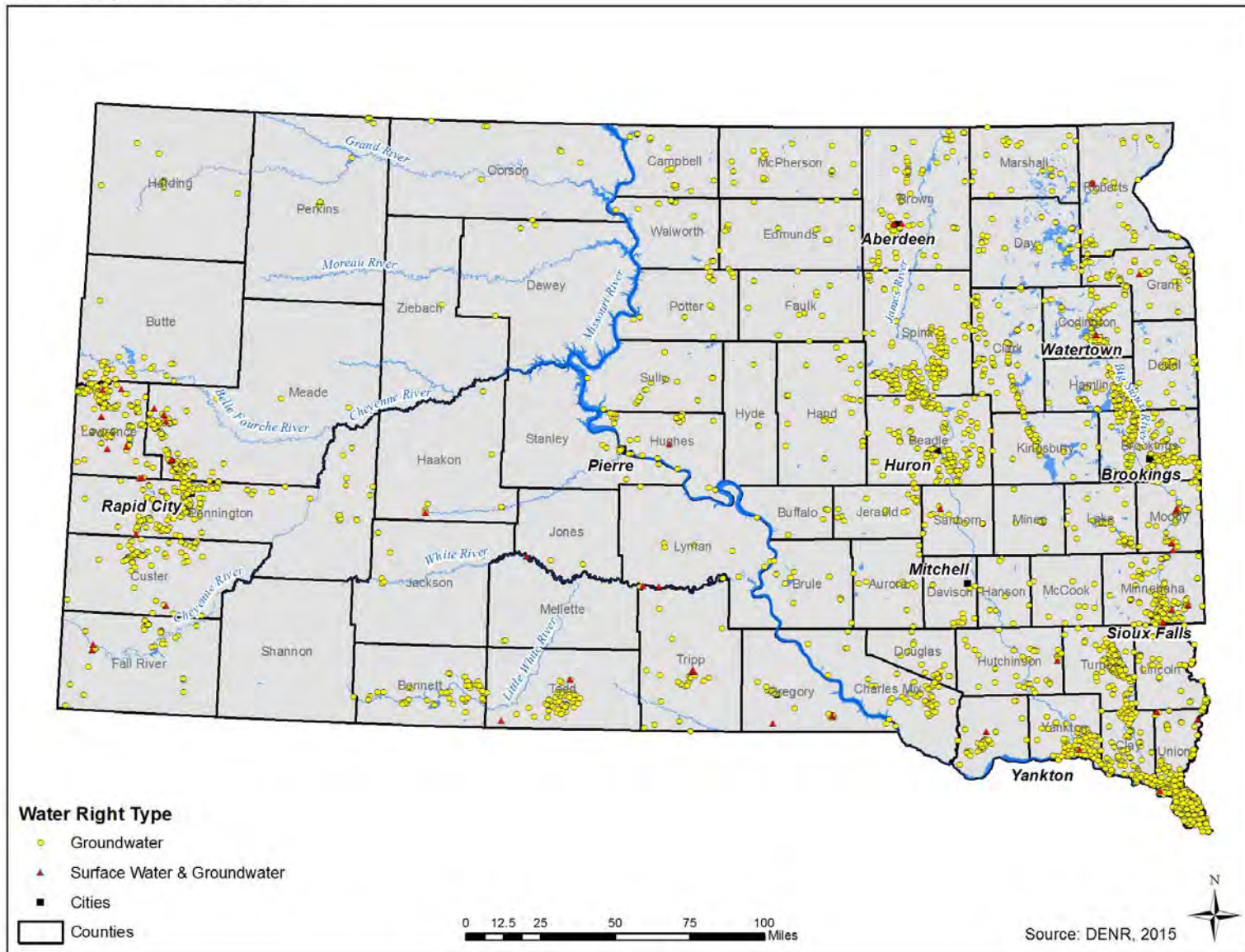


Figure 13. Groundwater Right Licenses



Missouri River Corridor

The Missouri River system provides a significant source of surface water for South Dakota. The Missouri River is the longest river in the United States, beginning in the Rocky Mountains of south central Montana and flowing 2,341 miles to its mouth near St. Louis. The system is the largest reservoir system in the United States containing over 73.1 million acre-feet of storage within a watershed that covers one-sixth of the continental United States. As shown in **Figure 14**, there are six mainstem reservoirs where four of the reservoirs, Oahe Dam (Lake Oahe), Big Bend Dam (Lake Sharpe), Fort Randall Dam (Lake Francis Case) and Gavins Point Dam (Lewis and Clark Lake), are located in South Dakota. The reservoirs are operated by the Army Corps of Engineers' Missouri River Basin Water Management Division (Corps) for the following eight authorized purposes: navigation, flood control, irrigation, hydropower, municipal and industrial water supply, water quality, recreation, and fish and wildlife habitat.

Figure 14. Missouri River Basin

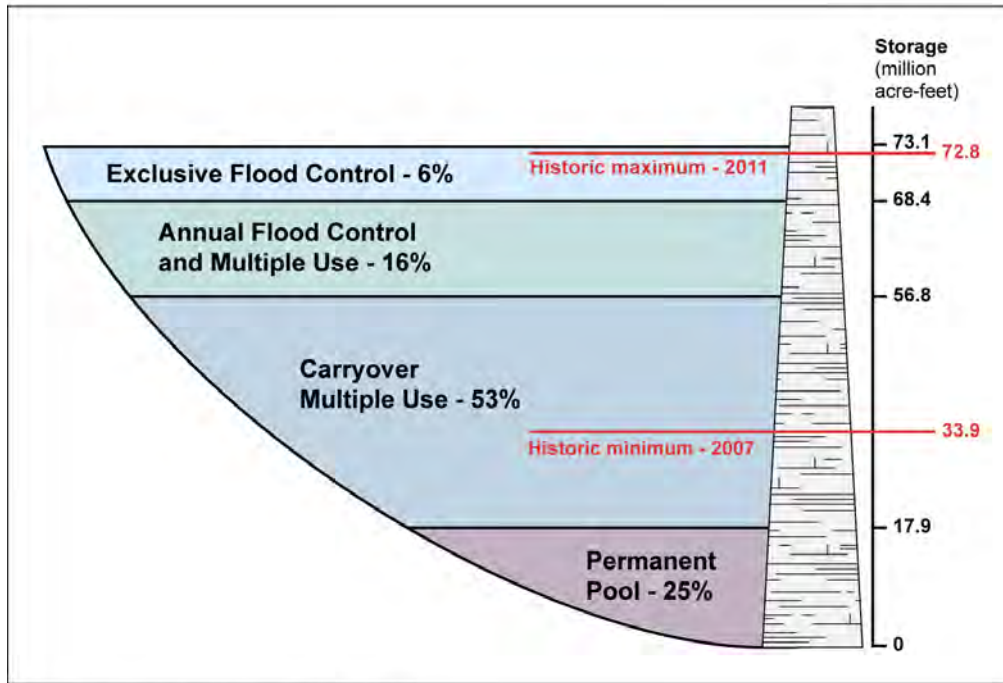
Operations are guided by the Missouri River Basin Mainstem Reservoir System Master Water control Manual (Master Manual). The Master Manual includes specific operational procedures

for the main system in conjunction with the tributary reservoir water control plans. This provides an effective means for integrated flood control and conservation operations. Each of the six reservoirs has an Annual Operating Plan (AOP) that is prepared on a yearly basis using the water control criteria of the Master Manual. For operational purposes, each of the reservoirs' storage is divided into the following four zones:

- Permanent Pool - includes about 25 percent of the system's storage capacity. It is operated to be full at all times to maintain a minimum amount of water in the reservoirs for minimum hydropower production, minimum irrigation diversion levels, and minimum reservoir elevations for the water supply, recreation, and fish and wildlife in and along the reservoirs and reservoir-based recreation.
- Carryover Multiple Use Zone - storage for irrigation, navigation, hydropower, water supply, recreation, water quality control, fish and wildlife. This zone is operated to maintain downstream river flows. These flows are still maintained in successive dry years although at lower levels. In years when there is not a drought, this zone is designed to be full prior to March 1, when the runoff year begins. During droughts, the storage in this zone supports the aforementioned eight authorized purposes, although at lower levels.
- Annual Flood Control and Multiple Use Zone - provides storage space for spring and summer runoff and is used year-round to support the eight authorized purposes. The Master Manual specifies that this zone be empty on or about March 1 of every year. Any water that is stored in this zone during the spring and summer is intended to be released prior to the next runoff season typically starting at the beginning of March.
- Exclusive Flood Control Zone - used to store floodwaters in extreme and unpredictable floods. It is emptied as quickly as downstream conditions permit.

Figure 15 illustrates the storage zones for the entire system (six reservoirs).

Figure 15. Storage in the Missouri River System



Source: U.S. Army Corps of Engineers. | GAO-14-741

3.4.2 Vulnerability of Water Resources Sector to Drought

The entire State of South Dakota is vulnerable to drought, however, impacts can significantly vary depending on geographic region. For instance, drought in the eastern portion of the State is mainly an issue for row crops while in other areas, population growth is stressing water supplies during dry periods. This section addresses the water resource impacts South Dakota has experienced during periods of drought, drought implications associated with the Missouri River System and future drought vulnerability related to population growth. An introduction to the types of water use throughout the State and associated drought implications associated with different types of sector water use is also provided

Drought Impacts

Precipitation, streams, rivers, lakes, reservoirs and groundwater are used to meet a diverse set of water resource needs within the State. Each of these water sources can be impacted during drought periods, resulting in a complex interlinked array of environmental, economic and societal impacts. The following bullet points summarize drought impacts related specifically to the State’s water resources.

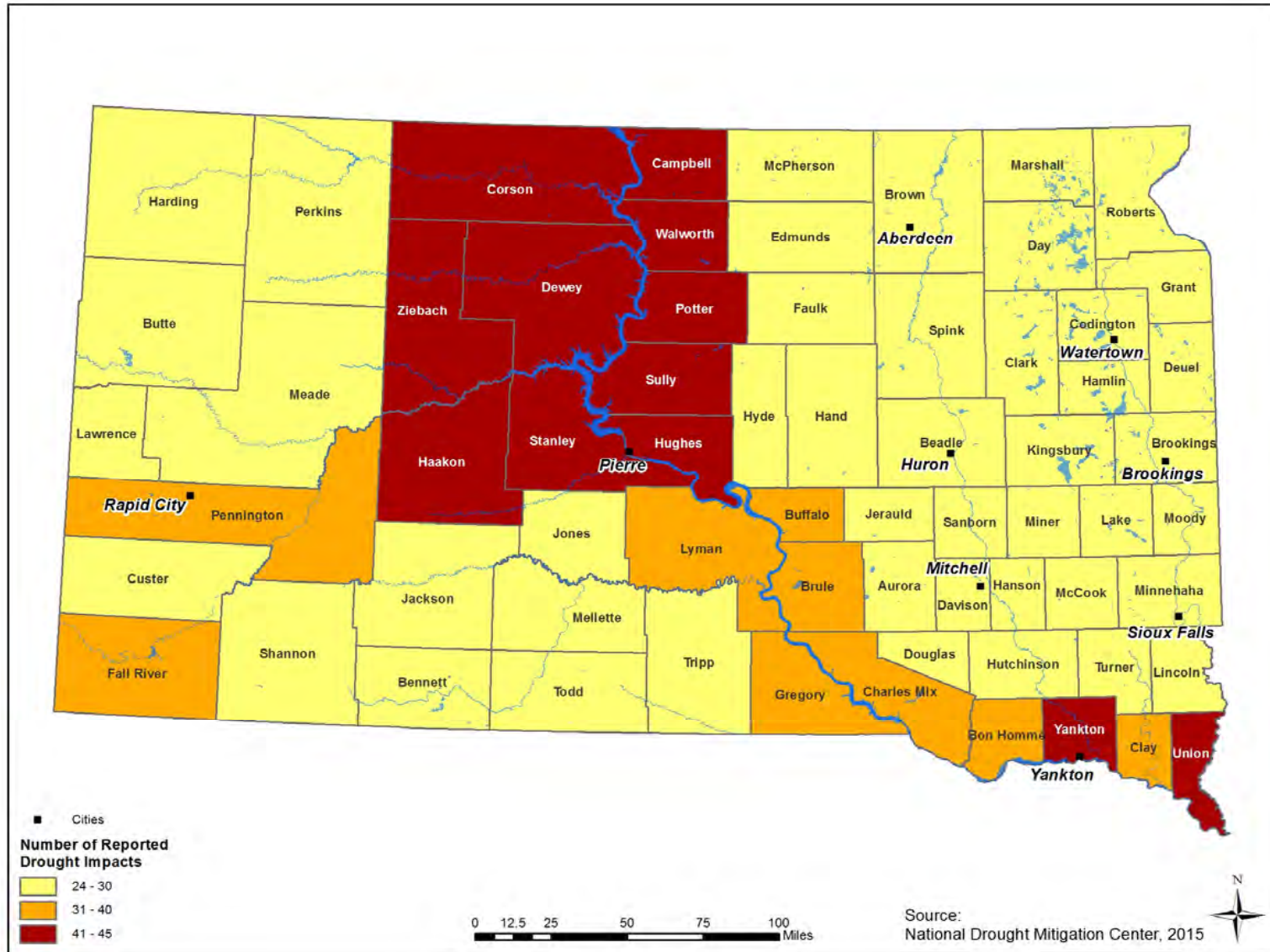
- Lower precipitation – During dry periods, precipitation in both the form of rain and snow is below normal, resulting in less moisture in the soil, less runoff into the streams and less recharge to the underlying aquifers.

-
- Lower streamflows – Reduced runoff results in lower stream flows which can reduce water availability to water users that divert directly from the stream, lower water levels below diversion intake elevations and result in a variety of adverse impacts to river navigation, hydro power production, water quality and aquatic habitat.
 - Lower lake and reservoir levels – Less runoff can result in lower lake and reservoir levels causing a variety of recreational and environmental impacts. Water supply availability can also be stressed in regions where water users rely on reservoir storage to meet their needs.
 - Decline in groundwater levels – Groundwater levels can decline, increasing well pumping costs and causing shallow wells to dry up. Natural systems such as wetlands that depend on shallow groundwater can also be adversely impacted.

South Dakota has experienced a variety of impacts from previous droughts. Water resource sector impacts reported to the Nation Drought Mitigation Center can include dry wells, voluntary and mandatory water restrictions, changes in water rates, easing of water restrictions, increases in requests for new well permits, change in water use due to water restrictions, greater water demand, decreases in water allocation of allotments, installation of alternative water pumps and water intakes, changes to allowable water contaminants, water line damage or repairs due to drought stress, drinking water turbidity, change in water color or odor and declaration of drought watches or warnings.⁶ **Figure 16** shows the number of these impacts reported for each county from January 1, 1980 to April 13, 2015. The greatest number of drought impacts reported to the NDMC occur in counties in the central portion of the State and along the Missouri River corridor. This is likely associated with water supply access and water quality issues associated with water level fluctuations along the Missouri River system during droughts.

⁶ Sources: Natural Hazard Mitigation Plan, 2014

Figure 16. Historical Water Supply and Water Quality Impacts (Drought Impact Reporter 1980-2015)



Factors that Impact Water Resources Vulnerability to Drought

South Dakota's vulnerability to drought and the resulting implications are complex and depends on a multitude of interrelated factors. Specific regions and water users are more vulnerable than others depending on water rights administration and seniority of water rights, legal limits to water appropriation, the physical connection between surface and groundwater, Missouri River system operations, regional growth and development trends and the types of water use predominant in a regional area.

Administration of Water Rights

South Dakota water rights are administered based on the "Doctrine of Prior Appropriation" where the first in time (water rights with a senior priority) is the first in right. The priority is determined by the date of filing the water right application. Senior water rights with an older priority date have the first right to use water over water rights of a more junior priority (more recent priority date). This is with exception to individual domestic uses which regardless of priority date, have the first priority to divert.⁷ The DENR is responsible for administering the water.

Administration of the prior appropriation system may be perceived as a drought impact to a junior water user that is "shut-off" (prohibited from diverting water) during a drought. However, on a system-wide basin level, water rights administration may be viewed as an adaptive capacity because it provides the means to allocate water during periods of drought shortages and provides a level of predictability where water users of junior priority are more likely to be curtailed relative to other senior user depending on the severity of drought conditions.

The vulnerability of a particular water user depends on the type of use, the priority date and source of water. Domestic water users are the least likely of all water users to be shut-off and therefore exhibit the least amount of vulnerability during drought. Users with senior water rights are also less likely to be shut-off than junior water right holders and are therefore less vulnerable to drought. The location of the source water also plays a key role in vulnerability. Water users that divert from the Missouri River have not historically been shut-off as a result of water supply shortages. In other words, the Missouri River has sufficiently met the water supply needs of its diverters in South Dakota during historical droughts. However, occasionally the water level within the Missouri River has receded below the intake elevations. While the Corps continues to adjust operations to minimize such water level declines, it is legally the responsibility of the user to construct a means to continue to divert water.

⁷ Domestic use is defined as water from other than a common water distribution system that does not exceed 25,920 gallons per day (which is 18 gpm pumped 24 hours per day) or a peak diversion rate of 25 gallons per minute (gpm). Domestic use does not include public municipal use which relies upon a water distribution system to convey water to multiple users.

Water users that divert from smaller streams can be more vulnerable to drought. Some diverters are located along ephemeral streams throughout the State which only flow during the high runoff season. These streams may have very little to no water during drought periods, physically inhibiting users from diverting. Other rivers in South Dakota including the James River, Cheyenne River and Big Sioux River are commonly administered, resulting in the curtailment of water users during dry periods. For example, on the James River, water users (with exception to domestic) must cease diverting by August 10 of every year. Users may individually apply for extensions and in wet years these extensions may be granted. However, in dry years, users may be required to cease irrigation prior to August 10th. Shut-offs prior to August 10 were required on the James River during the 2006 drought.

There is a broad range of sophistication used to administer the rivers. Some of the main rivers (e.g., James River) are monitored with USGS flow gages and the conditions that warrant a curtailment are clearly stated as a particular measured flow rate (cfs) in the water right licenses. Other rivers are not gaged. The criteria that warrant a shut-off for these systems are based on previous hydrologic studies and past experience administering these systems. Administration could be improved in the future by installing flow gages that enable a more efficient and accurate means to administer these river systems.

Legal Limits to Water Appropriation

The approval of both surface water and groundwater rights requires review of the DENR and solicitation to the public, informing other users in the local area of the application and the opportunity to contest such an application that could cause injury to local water rights. South Dakota water law prohibits the mining of water where more water is taken out of the system on an average basis than what is put in. The DENR reviews all applications to ensure that such over appropriation of river systems does not occur. Similarly, State law prohibits the withdrawals of groundwater in excess of the acreage estimated annual recharge of the groundwater source. The DENR maintains over 1,500 monitoring wells to assess groundwater levels and assure that such mining is not occurring. There are a few areas in South Dakota where new surface and groundwater right permits are not allowed because of the potential for over appropriation. This is different than many other states in the western United States where groundwater aquifers and river systems are mined and over appropriated.

The legal process described above, limits the amount of water that can be appropriated, reducing drought vulnerability by limiting the demand placed on a surface and groundwater systems. While junior surface water users have been shut-off during drought periods, many more junior users would have been shut off if new users were allowed to develop water in a basin that is fully appropriated. While records indicate that groundwater levels have declined in some aquifers during dry periods, groundwater levels have not declined to such a point during a drought where the State has required junior groundwater right holders to cease pumping of wells. This is largely attributed to the legal restriction of mining the aquifer.

Connection between Surface and Groundwater

Drought can result in the reduction of groundwater levels, increasing pumping costs and drying up shallow wells. Decreasing groundwater levels can also reduce the amount of water available to wetlands and gaining streams that depend on surficial groundwater. However, such gaining streams and wetlands may exhibit a greater resilience to drought, if groundwater levels are stable and provide a consistent supply of water during dry periods. For instance, unconfined, alluvial aquifers such as the High Plains Aquifer, which is located along the southern boundary of South Dakota, in Shannon, Jackson, Bennett, Mellette, Todd, Tripp and Gregory Counties, can be a source of water for gaining streams. If groundwater levels do not decrease significantly during short-term droughts, groundwater may still serve as a stable source to these gaining streams, reducing impacts to instream flows and wetland habitat.

Additionally groundwater levels in the High Plains Aquifer in Bennett, Shannon, and Jackson counties have risen 5 to 10 feet compared to estimated pre-development levels.⁸ The long-term increase in groundwater levels can be of benefit to the gaining streams in these counties. If groundwater levels remain relatively stable during a drought, gaining streams can maintain a certain minimum baseflow that would not be evident in other streams without a groundwater connection. Conversely, in Todd County and a small portion of Bennett County, long-term water level declines of 5 to 10 feet have been observed. These declines can increase the local area's vulnerability to drought by reducing the ability of the aquifer to recharge the gaining streams.

Missouri River System Operations

Regulating the Missouri River Mainstem Reservoir System is essentially a repetitive annual cycle. The majority of the forecasting and runoff modeling simulation is for the purpose of making operational decisions conservatively based on the likelihood of drought. The three upper reservoirs are large compared to other Corps reservoirs, which enables the reservoir system to use the stored water during extended drought periods to meet a diminished level of service to all of the authorized purposes (with exception to flood control). During droughts, water is released from the large carryover multiple-use zone to meet downstream needs and there is less water stored in the zone.

However, despite the presence of this multi-use zone that can function as a drought reserve, all authorized purposes except for flood control, are affected negatively during extended droughts. The authorized purposes most affected are:

⁸ McGuire, V.L., 2014, Water-Level Changes and Change in Water in Storage in the High Plains Aquifer, Predevelopment to 2013 and 2011-13, U.S. Geological Survey Scientific Investigations Report 2014-5218, 14 p. Available at <http://dx.doi.org/10.3133/sir20145218/>.

-
- Recreation in the upper three large system reservoirs (Ft Peak Lake in Montana, Lake Sakakawea in North Dakota and Lake Oahe in South Dakota) due to water level declines;
 - Navigation in the lower portion of the System;
 - Intake access on the upper three large System reservoirs and in the river reaches between the reservoirs and downstream reaches;
 - Cold water reservoir fishery species;
 - Reservoir and river water quality; and
 - Irrigation and hydropower production.

The impacts can range from minor to very severe.

The minimum daily flow requirements for the Missouri River System for water supply are designed to prevent operational problems at municipal and thermal powerplant intakes. However, there are periodically issues related to intake elevations and river access. The Corps continues to make adjustments to the System to help ensure that river supplies are appropriately conveyed to intakes. However, access to Missouri River water is ultimately the responsibility of the entity using the supply. During droughts, river water supply and water quality (specifically thermal effects) can be a major consideration if the Corps' service level is dropped below the minimum service level from April through November to conserve water in the System. Water supply shortages are rarely an issue along the System, but supply intakes to the system have been affected by droughts in the past.

Dry conditions in 2012 and the spring of 2013, resulted in extreme to exceptional drought conditions throughout the Missouri Basin. Total runoff into the Missouri River mainstem reservoir system was 77 percent of normal in October of 2012. As drought conditions persisted through 2012, the Corps made reservoir release decisions based on the Master Manual guidelines, while exercising some flexibility. The Corps' release decisions and communication during the 2011 flood and 2012-2013 drought affected multiple stakeholders including navigators, municipalities that divert water from the river, farmers that use water from the river for irrigation and conservationists with an interest in protecting fish and bird habitats. An excerpt from a United States Government Accountability Office report summarizes the Corps operations during the 2012 to 2013 drought period:

In 2012, the reservoirs were sufficiently full on March 15 to support full-service to navigation, meaning flows high enough for a 9-foot deep channel. On July 1, there was a sufficient volume of water in the reservoirs for the Master Manual to call for a full-length navigation season, which the Corps executed. According to a Corps report describing its management of the reservoir system in 2012, severe drought in the lower basin during the summer required higher-than-normal releases from Gavins Point to maintain the navigation flows called for in the Master Manual. Similarly, winter releases are to be based on the volume of water in the reservoir system on September 1. In 2012, the reservoirs were depleted by the drought, and the Master Manual called for minimum winter releases of 12,000 cfs from Gavins Point. However, water intake owners in the lower basin were concerned about maintaining access to the river at those low

flows, particularly since the 2011 flood scoured the river bottom in many areas. According to the Corps report describing reservoir management in 2012, the Corps exercised the flexibility in the Master Manual and elected to keep winter releases at 14,000 cfs to prevent municipalities and power plants from losing access to the river.

Drought conditions persisted into 2013, and the reservoir system was 7.4 MAF below the top of the Carryover Multiple Use zone on April 1. Due to the low volume of water in the reservoirs, the Corps continued implementing drought conservation measures, according to Corps officials. For example, navigation releases during April through June were at a minimum service level, meaning flows were high enough for an 8-foot-deep channel. The drought began to ease in parts of the basin during the summer due to rainfall and associated runoff. The higher volume of water in the reservoirs in July led to a slight increase in release rates for navigation, as well as a full 8-month navigation season. Runoff into the Missouri River reservoirs was about average in 2013 at 25.1 MAF, although water levels in the upper three reservoirs remained low.⁹

The Corps conducts an extensive level of forecast modeling to regulate reservoir releases in response to hydrologic conditions and downstream needs. Hydrologic data such as precipitation, snowpack and soil moisture are used as input data for the modeling. Forecasts are done on a monthly or if needed on a more frequent basis, to simulate expected annual runoff for the remainder of the calendar year. The modeling incorporates current data on basin conditions (i.e. soil moisture and snowpack) as well as long-range weather forecasts and historical trends. On a weekly basis or more frequently if needed, the Corps also develops a forecast of reservoir inflows, outflows, storage and power generation for the next three to five weeks. This model uses streamflow and reservoir levels in combination with basic monthly forecasts to set daily and weekly reservoir releases. According to the United States Government Accountability Office report:

‘Experts... agreed that the Corps made appropriate release decisions during the [2011] flood and [2012, 2013] drought, given that neither the flood nor drought could have been predicted and the Corps’ need to follow the guidelines in the Master Manual. These experts did not suggest changes to the Master Manual due to the 2011 flood or subsequent drought.¹⁰

Experts also remarked that improvements could be made to the Corps existing forecasting techniques by improving the collection of streamflow, precipitation, soils moisture and plains snowpack data as well as by incorporating probabilistic forecasting techniques into their existing modeling methods.

The NDMC Drought Impact Reporter contained several impacts related to drought along the Missouri River System during 2005. These impacts included municipal water supply intakes affecting the Standing Rock Sioux and Cheyenne River tribes, boat ramp access issues, and

⁹ United States Government Accountability Office, 2014. Report No. GAO-14-741.

¹⁰ United States Government Accountability Office, 2014. Report No. GAO-14-741.

recreation/tourism impacts. A synopsis of these can be referenced in the Health and Socioeconomic Sector discussion.

Growth and Development Trends

Vulnerability to drought is highly dependent on the level of stress that water demands place on surface water systems and underlying aquifers. Water demand is largely a function of the number of people living in a certain area, growth trends and types of water use. According to U.S. Census Bureau estimates, the 2014 population in South Dakota was about 853,000 people. **Figure 17** shows South Dakota's 2014 population on county level based on estimates from the U.S. Census Bureau. This figure shows that the most populated counties, Pennington, Brown, Minnehaha and Lincoln, contain the State's larger urban centers. With exception to Hughes County, the central portion of the State is the least populated.

There are certain counties in the State that are experiencing population growth while others are declining in population. As shown in **Figure 18**, the rural counties of Haakon, Jones, Campbell, Hyde, Miner and McCook have experienced population declines ranging from 22% to 15% from 2000 to 2014. During this same period, six South Dakota counties have grown by over 15%. Lincoln County, south of Sioux Falls, has experienced the greatest level of growth with a growth rate of 114% from 2000 to 2014 while Brookings, Minnehaha, Union, Custer and Pennington have experienced population increases from 16% to 50%.¹¹ Additional details on population trends is provided in the Health /Socioeconomics sections.

The availability of water supplies in some of these areas is becoming an issue as the population increases, particularly in Sioux Falls and other areas that depend on the Big Sioux River. Rapid City, in the Black Hills is also experiencing water availability challenges related to population growth that can be exacerbated during dry periods. In the western portion of the State, there is concern regarding the need of water for people and rangeland. According to the 2014 State Hazard Mitigation Plan, interim population projections issued by the U.S. Census Bureau in 2009 suggests that South Dakota's population will continue to grow but percentages increase will decline through 2020. After 2020, population growth is projected to level off and begin to decline slightly after 2025.¹²

Areas can best reduce their drought vulnerability by effectively planning for reliable future water supplies. Such planning can include the acquisition of water rights of senior priority which are most reliable during periods of drought. According to State water law, senior water rights can be transferred among water right owners in addition to the beneficial use and place of use associated with a particular right as long as it does not injure other users. Such water right transfers offers flexibility where water can be transferred to different types of users. This is important in areas where urban centers are growing and are in need of reliable senior water rights to meet their

¹¹ 2014 U.S. Census Bureau Population Estimates

¹² South Dakota State Hazard Mitigation Plan, 2014.

needs. The transfer of water rights is an adaptive capacity that reduces drought vulnerability by enabling cities and other new water users within a region to acquire reliable senior supplies.

Figure 17. 2014 Population by County

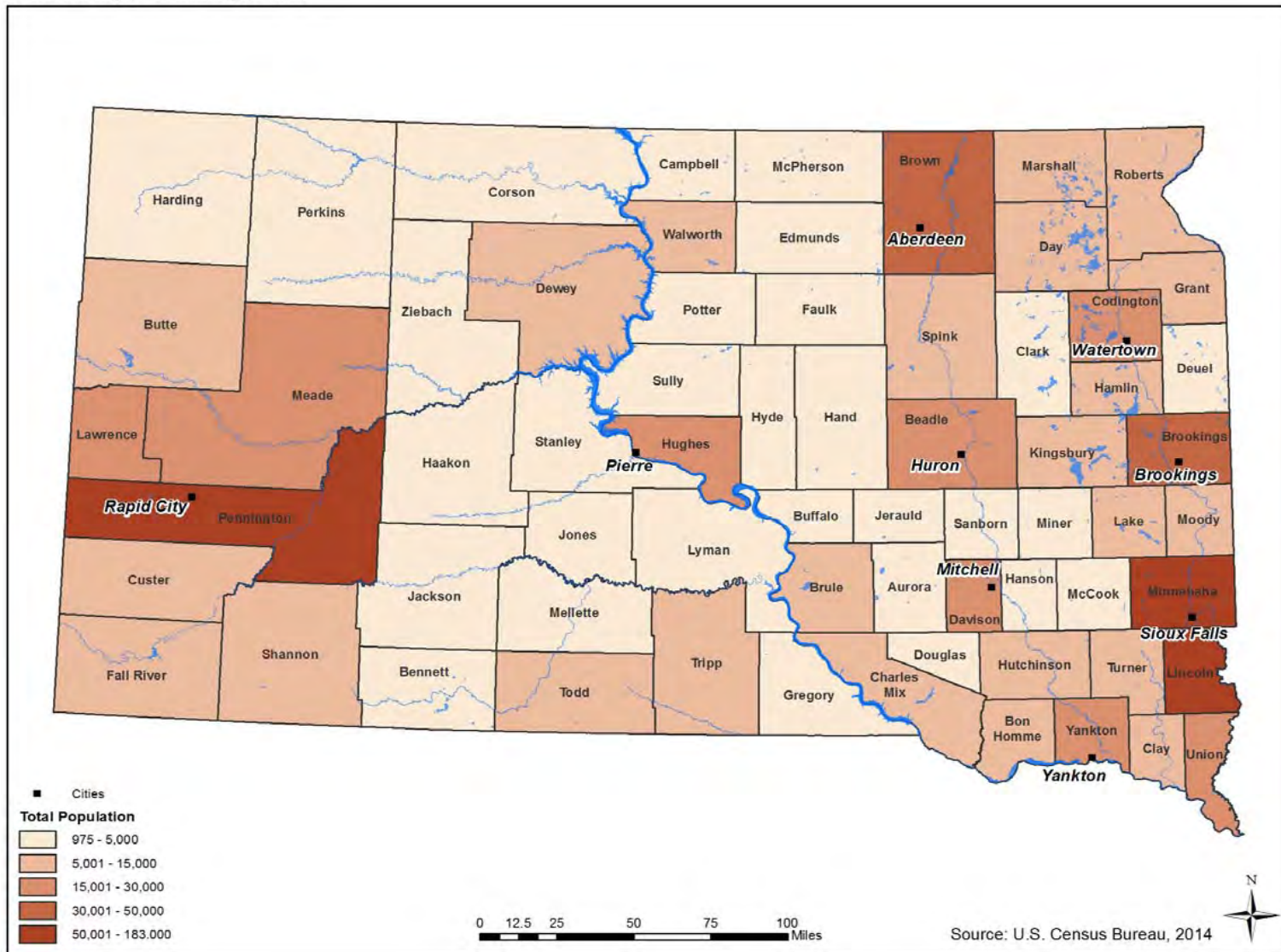
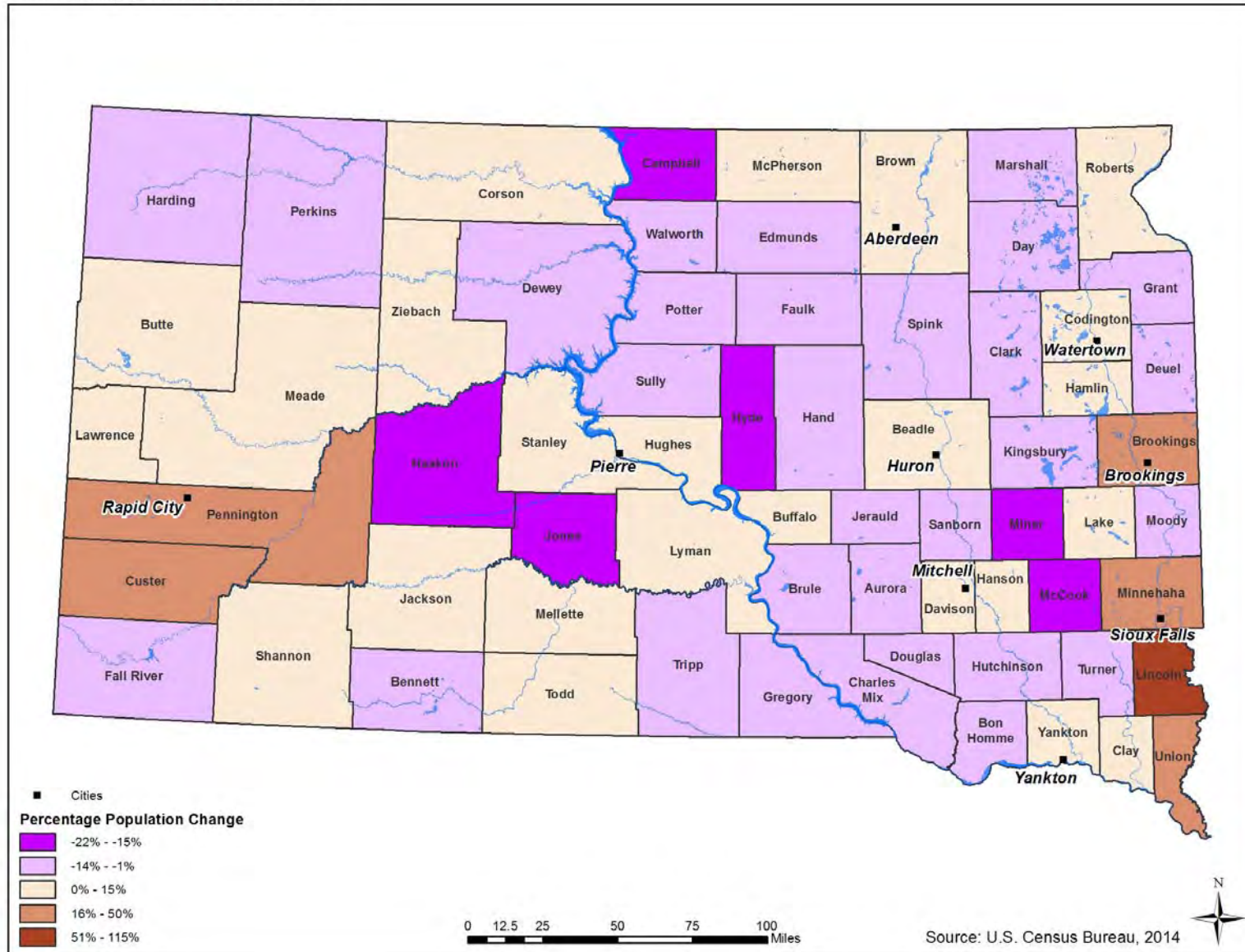


Figure 18. Percentage Change in Population from 2000 to 2014

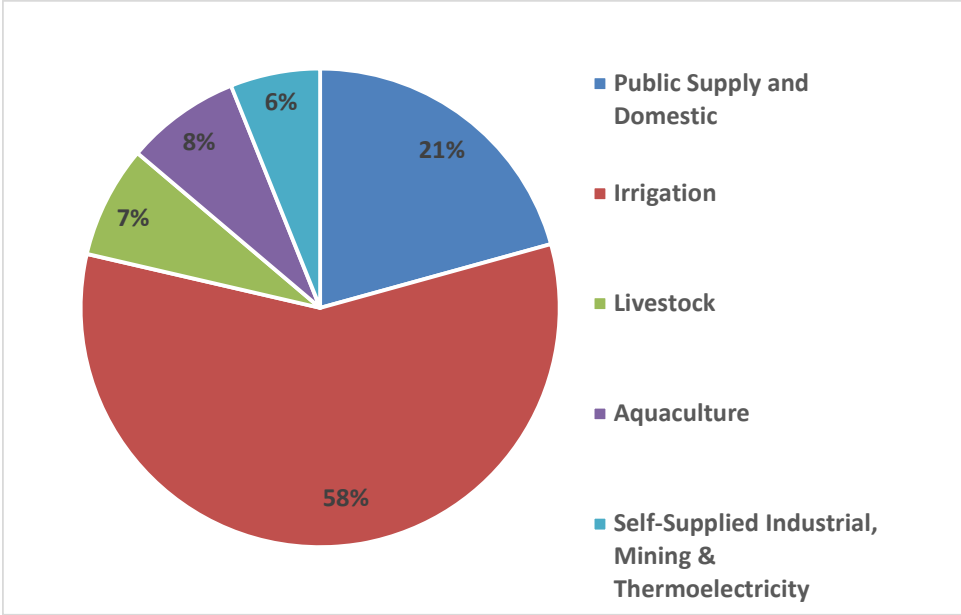


Types of Water Demands (Sector Water Use)

The magnitude and specific impacts drought has on a certain area is dependent on the types of water use within the local area and the sensitivity of how water use reductions can impact the local sectors. This section introduces sector water demands on a county level based on a nationwide USGS water use study.¹³ While the types of water demands presented herein from the USGS study do not exactly match the sectors discussed in subsequent sections of this Plan, these data provide a general introduction to drought vulnerability related to sectorial water use. It was noted by the Department of Tribal Affairs representative on the DTF that the water resources data presented in this study may not accurately reflect tribal water resources in some cases.

Figure 19 shows that irrigation composes 58% of South Dakota’s water use followed by public supply and domestic uses composing 21% of total use. Aquaculture, livestock and self-supplied industrial, mining and thermoelectricity use a smaller portion of the water with percentages of 8%, 7%, and 6%, respectively.

Figure 19. Total Surface and Groundwater Use by Demand Type



Source: USGS, 2010

¹³ Maupin, M.A., Kenny, J.F., Hutson, S.S., Lovelace, J.K., Barber, N.L., and Linsey, K.S., 2014, Estimated use of water in the United States in 2010: U.S. Geological Survey Circular 1405, 56 p., <http://dx.doi.org/10.3133/cir1405>.

Figure 20 shows that the amount of surface and groundwater used for irrigation significantly varies throughout the State. The counties with the highest irrigation water use are Sully and Hughes counties along the Missouri River which primarily rely on surface water, and Bennett and Todd counties along the southern border which primarily rely on groundwater. Irrigation water shortages in these counties would have a greater local impact on the agricultural industry than in counties that do not heavily rely on irrigation. **Figure 21** shows that the counties with the greatest amount of livestock water use are Tripp, Charles Mix, Hutchinson and Beadle. Water shortages to livestock in these counties would likely have a greater economic impact on the industry than for instance in Lawrence County, where water use for livestock is relatively low.

Figure 20. 2010 Irrigation Water Use by County

Figure 21. 2010 Livestock Water Use by County

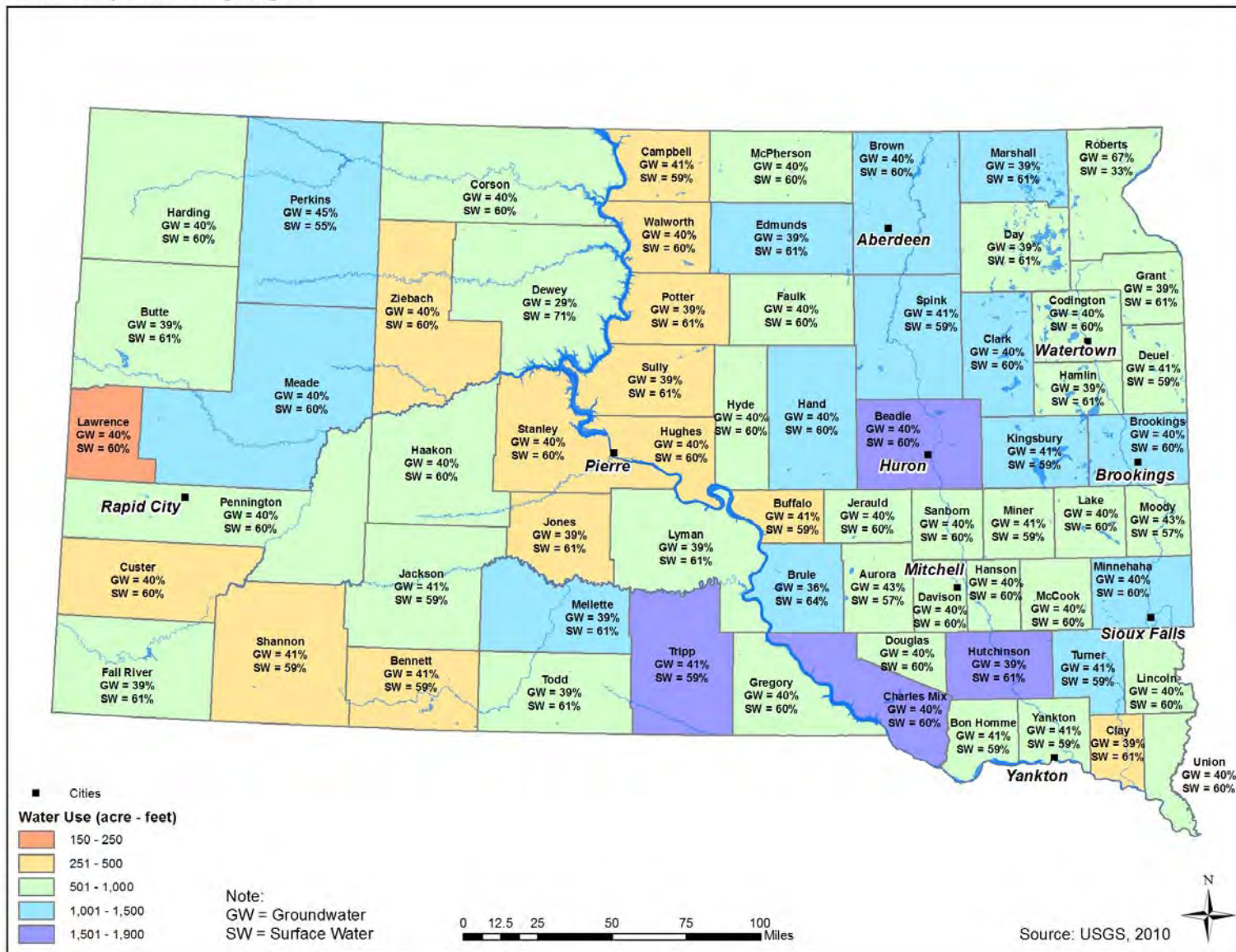


Figure 22 shows the amount of water used for public supply and domestic water use. Counties with the greatest amount of use including Pennington, Minnehaha and Yankton are located in large urban centers. These counties are also growing in population placing a greater stress on the availability of future water supplies. Water supply planning and drought planning should be encouraged in these areas to ensure a reliable supply in the future, especially during dry periods.

As previously mentioned, there is a key difference in how the State administers the water rights for domestic and public water supply distribution systems. Domestic water use is administered with a very senior priority, meaning that domestic water users would be least likely of any other type of water user to be shut-off during a very severe drought. On the other hand, public water supply *systems* may be less senior and be more vulnerable during drought periods. Public municipal supplies require storage and/or senior water rights to ensure a reliable supply in dry periods.

Figure 23 shows the amount of water used by aquaculture. While the majority of the State does not employ aquaculture on a large scale, there are a few counties where water usage is significant. This includes Pennington, Lawrence and Custer counties near the Black Hills and Day, Roberts, Brookings and Yankton counties in the eastern portion of the State. This industry highly relies on good quality water for industrial purposes. The vulnerability of these water users depends on seniority of water rights.

Figure 24 shows the amount of water used by the self-supplied industrial, mining and thermoelectricity industries. Water use ranges from 6,000 to 12,000 acre-feet in Grant, Minnehaha and Lawrence counties. These counties use the greatest amount of water and could experience greater drought impacts on the self-supplied industrial, mining and thermoelectricity industries than in other counties that use little to no water for such purposes.

Figure 22. 2010 Public Supply and Domestic Water Use by County

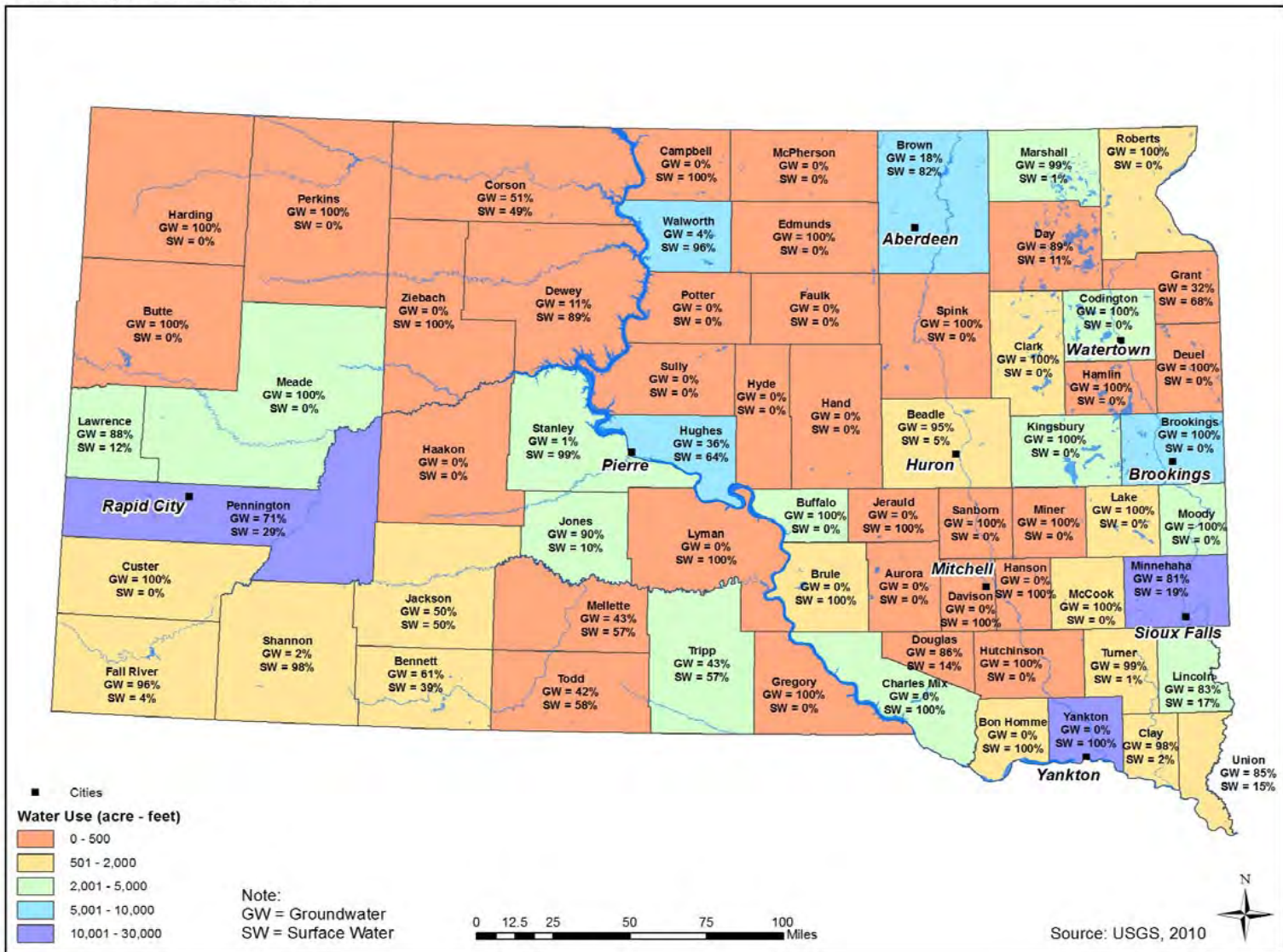


Figure 23. 2010 Aquaculture Water Use by County

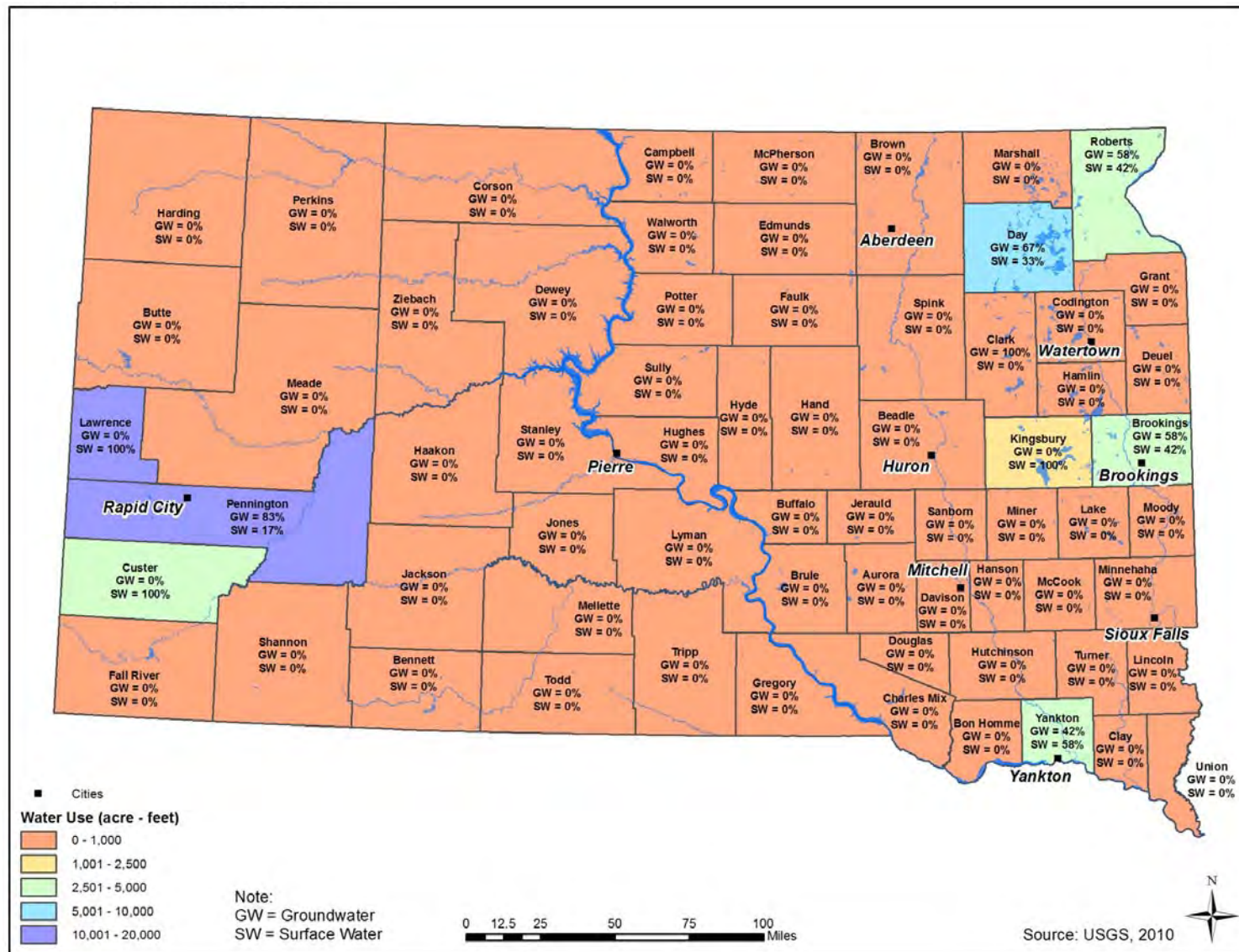
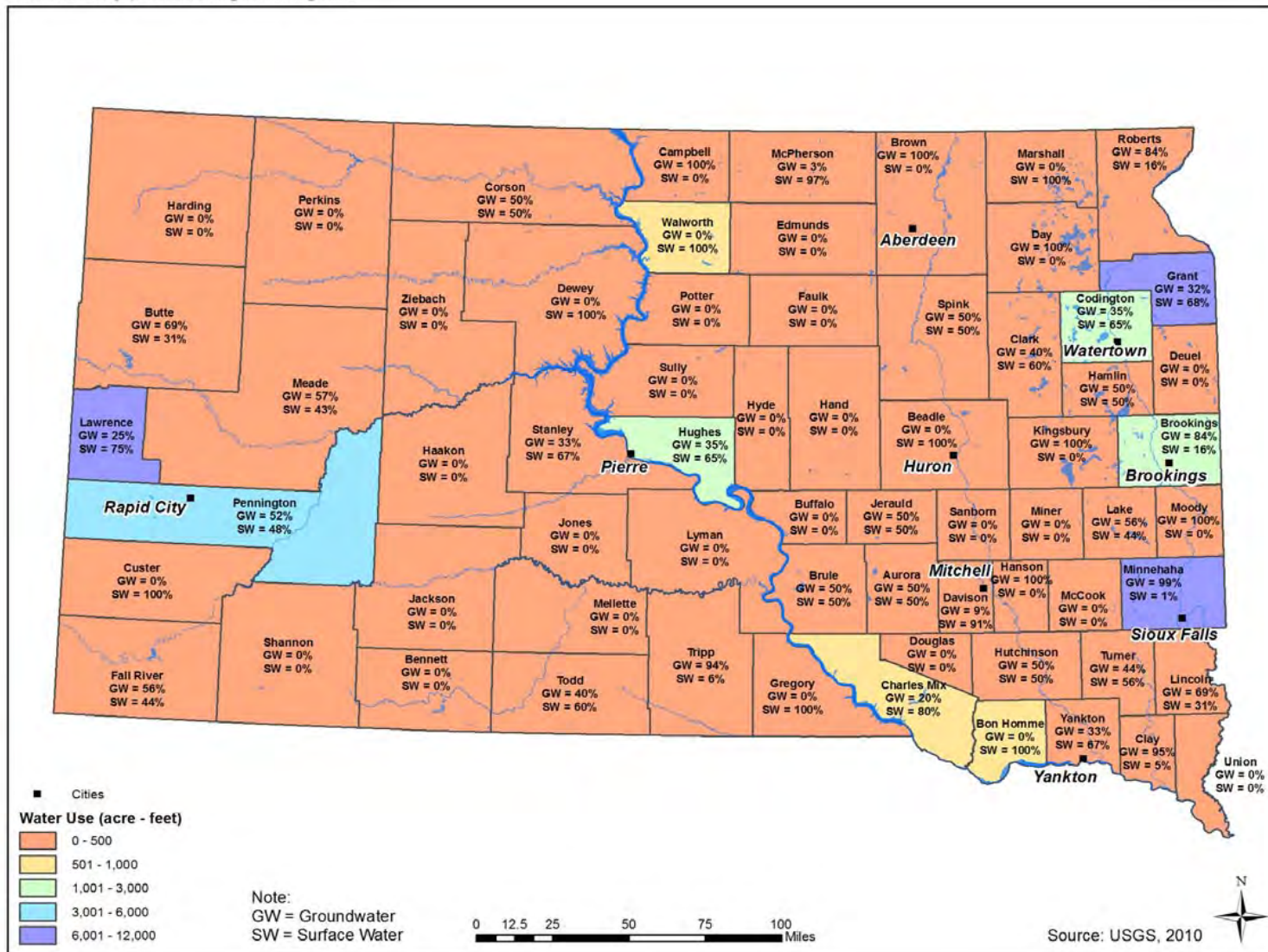


Figure 24. Self-Supplied Industrial, Mining and Thermolectricity



Estimating Potential Losses

The monetary losses associated with the water resources sector typically result in direct economic losses within the other sectors addressed in this Plan. For instance, the decline in available irrigation water can impact crops yields resulting in a reduction of annual crop revenue. Declines in reservoirs can impact fish and fishing access resulting in a reduction of fishing licenses for the year which impact both the wildlife and tourism sectors. Declines in groundwater can increase pumping costs which impacts all sectors that rely on pumping groundwater. Each sector included in this Plan goes into further detail on losses associated with drought to the extent feasible.

3.4.3 Summary of Identified Vulnerabilities and Adaptive Capacities

Table 6 summarizes the vulnerabilities and existing adaptive capacities associated with the water resource sector. New adaptive capacities that have been identified through this planning process are also included.

Table 6 Summary of Vulnerabilities and Adaptive Capacities

Water Resource Asset	Identified Vulnerabilities	Adaptive Capacities	
		Existing or Implemented in the Past	Potential Options for Consideration
Precipitation (rain and snow)	<ul style="list-style-type: none"> • Reduced rainfall • Reduced snowpack 	<ul style="list-style-type: none"> • Early drought warning systems (i.e. Drought Monitor) • Weather forecasts • Snowpack, rainfall and other drought indicator monitoring • Cloud seeding 	<ul style="list-style-type: none"> • Continue to improve drought monitoring and outreach coordination efforts • Domestic rainwater harvesting to capture moisture when there is rain •
Surface water (rivers, streams, natural lakes, reservoirs, wetlands)	<ul style="list-style-type: none"> • Declines in streamflows • Declines in reservoir levels • Less surface water is available for wetlands and other aquatic habitat • Reduction in surface water supplies • Concentration of contaminants • Degradation of water quality 	<ul style="list-style-type: none"> • Modify reservoir system operations to mitigate for drought impacts • Design reservoir systems to address drought mitigation (i.e. Missouri River) • Legal restrictions to developing in fully appropriated surface water systems • Changes to allowable water contaminant restrictions • Administration of surface water (i.e. shut-off junior water users) • Installation of alternative water pumps and intakes to continue to divert surface water • Monitoring of drought indicators such as rainfall, reservoir levels, soil moisture and snowpack. 	<ul style="list-style-type: none"> • Install additional streamflow gages to improve monitoring and efficiency of water administration • Collect more hydrologic data, improve existing data and incorporate probabilistic forecasting techniques to assist the Corps in making reservoir release decisions on the Missouri River • Improve collection of streamflow, precipitation, soil moisture and plains snowpack data.

Water Resource Asset	Identified Vulnerabilities	Adaptive Capacities	
		Existing or Implemented in the Past	Potential Options for Consideration
Groundwater	<ul style="list-style-type: none"> • Declines in groundwater levels • Increased pumping costs • Decrease in well production • Dry wells 	<ul style="list-style-type: none"> • Legal restrictions to developing fully appropriated aquifers • Groundwater level monitoring • Deepen existing wells • Drill new wells to make up for shortage in supply 	<ul style="list-style-type: none"> • Continue to improve groundwater level monitoring (i.e. install more monitoring wells) • Develop detailed mapping and understanding of the State's groundwater aquifers • Study surface/groundwater interaction in critical areas • Groundwater administration (i.e. curtail pumping of junior wells) • Locally regulate amount of pumping to minimize groundwater declines
Water demand	<ul style="list-style-type: none"> • Hotter temperatures result in increased evaporation and evapotranspiration • Increase in water demand • Increase in requests for new well permits • Change in water use due to water restrictions • Voluntary and mandatory water restrictions • Water administration "tightens" and junior users are curtailed • Water line and damage or repairs due to drought stress • Drinking water turbidity, color and/or odor • Population growth in certain counties 	<ul style="list-style-type: none"> • Water supply planning • Improve irrigation efficiency techniques • Promote municipal water conservation efforts 	<ul style="list-style-type: none"> • Intensify water resource planning efforts in areas where population growth and development could stress available water supply in the future • Intensify water resource planning efforts in areas where particular sector(s) are of significant risk in future droughts • Encourage the development of local drought management plans • Leasing and/or permanent transfer of senior water rights

3.4.4 Recommendations

Framework for Future Drought Vulnerability Studies

The magnitude in which South Dakota's water resources are vulnerable to drought is very complex and varies based on the drought resiliency of each local region. Water tends to be more plentiful in the eastern and central portion of the State and therefore during drought, which provides a buffer against drought. However the eastern part of the state may be less adaptable to a longer term drought, or a short term growing season drought. The central region has seen impacts due to fluctuations of the Missouri River and associated reservoir system. The western region in general has less abundant water supplies, but is more accustomed to semi-arid

conditions and therefore may demonstrate a greater level of drought resiliency within certain sectors and local areas.

Additional studies and data collection are necessary to further characterize and, where possible, quantify drought vulnerability in different regions of the State. This section presents a framework for how future regional and State drought vulnerability studies may be conducted to further qualitatively characterize and quantify the vulnerability of the water resources sector to drought.

A more refined vulnerability framework could consist of the following three steps.

- Step 1 - Identify key indicators that may be used to represent the sensitivity of water resources sector to drought within a region. Such indicators may include groundwater levels, streamflows, soil moisture and snowpack. These indicators not only help to assess the condition of the water resources but are also commonly used to monitor drought.
- Step 2 – Collect indicator data necessary to characterize the water resource within the designated area under baseline (average normal conditions) and drought conditions. It is important that data is collected on a regular, consistent basis in order to capture the seasonality of such indicators while also properly characterizing the water resource on an annual basis. Such data is useful in understanding the water resource in wet, average/normal and dry conditions.
- Step 3 – Develop metrics that reflect the drought vulnerability of an area based on Steps #1 and #2.

Data collection is critical to the methodology outlined above. **Table 7** identifies the types of data that can be useful for a drought vulnerability assessment and identifies potential data gaps.

Table 7 Data Collection for Enhancing Vulnerability Assessment

Water Resource Asset	Data	Notes on Data Availability
Precipitation and atmospheric conditions (rain and snow)	<ul style="list-style-type: none"> • Rainfall • Snowpack • Soil moisture • Maximum, average and minimum atmospheric temperatures 	<ul style="list-style-type: none"> • CocoRaHS rainfall data • Weather stations maintained by the National Weather Service, Federal Aviation Administration, High Plains Regional Climate Center, National Oceanographic and Atmospheric Administration/National Weather Service, South Dakota Department of Transportation and the National Forest Station¹⁴ • National Drought Mitigation Center Drought Risk Atlas Data
Surface water	<ul style="list-style-type: none"> • Reservoir levels 	<ul style="list-style-type: none"> • DENR maintains biannual reservoir level

¹⁴ Source: http://climate.sdstate.edu/w_info/Maps/stations/stations.shtml

Water Resource Asset	Data	Notes on Data Availability
(rivers, streams, natural lakes, reservoirs, wetlands)	<ul style="list-style-type: none"> • Streamflows • Applicable water quality data (i.e. temperature, dissolved oxygen) 	<ul style="list-style-type: none"> • data • DENR in partnership with the USGS maintain 52 stream gages of real time and historical data
Groundwater	<ul style="list-style-type: none"> • Groundwater levels • Applicable groundwater quality data (i.e. salinity) • If applicable, monitoring of groundwater and surface water interaction 	<ul style="list-style-type: none"> • DENR maintains an observation well network of over 1600 wells providing groundwater level and groundwater quality data
Water demand	<ul style="list-style-type: none"> • Evaporation and evapotranspiration estimates • Annual water demands by sector • Water administration data (dates when water users were shut-off) 	<ul style="list-style-type: none"> • DENR has publically available records on all surface and groundwater right permits and licenses • DENR maintains a spatial database of all surface and groundwater right permits and licenses • Historical administration/mandatory shut-offs are recorded for each individual water right • USGS has conducted a study every 5 years estimating South Dakota's water use on a county basis

Recommended Next Steps

Many of the existing and suggested adaptive capacities listed in **Table 6** and the data needs listed in **Table 7** require a combination of data collection efforts, regional studies, or further consideration/feasibility analysis. Recommendations for additional follow up activities are provided below. These activities will improve the State's ability to understand the relationship between water resources and drought and identify adaptive capacities that more effectively address adverse drought impacts.

- Maintain or enhance existing adaptive capacity activities noted in **Table 6**. Consider additional adaptive capacity alternatives noted and develop related mitigation action strategies.
- Conduct a thorough assessment of the State's drought monitoring efforts and identify specific improvements that can be made to improve monitoring. Identify funding sources for such future efforts.
- Identify regions in the State where pilot studies can be conducted comparing pre-determined baseline metrics in normal years relative to drought years. Such metrics may be developed using data such as precipitation, streamflows and reservoir data.

-
- Improve the administration of water rights by installing streamflow gages to monitor flow rates and use such data to specify specific flow conditions (cfs) for curtailment. This can improve water use efficiency on the river in dry periods.
 - Develop a centralized database where users can download administrative curtailments on a specific stream. This can improve the State’s ability to track drought impacts.
 - Improve spatial mapping of aquifers within the State and associated groundwater level trends.
 - Develop a centralized database to collect drought impacts when a drought occurs.
 - Encourage water resource planning efforts in areas where population growth and development could stress available water supply in the future and in areas where particular sector(s) are of significant risk in future droughts.
 - Encourage local drought management plan development for municipal water providers.
 - Conduct a survey of municipal and industrial water providers to obtain information regarding perception of drought risk and impacts from 2012-2013 drought.
 - Study surface/groundwater interaction in critical areas to characterize how this interaction may change in wet, average and dry years and how a drought may impact downstream water needs.

3.5 Health and Socioeconomic Sector

3.5.1 Introduction

Although they can be the most difficult to track and quantify, the health and socioeconomic impacts of drought can reach the largest number of people and linger long after other more direct impacts have resolved. Health and socioeconomic impacts can include: decreased public health, greater unemployment, reduced income, poor housing sales, residential and business relocations, weakened tax base, diminished quality of life, and increased crime rates.¹⁵ A decline in public health can result from “compromised quantity and quality of potable water, increased recreational risks, effects on air quality, diminished living conditions, compromised food and nutrition, and increased of incidence of illness and disease”.¹⁶ In addition to the potential to impact the largest number of people, health and socioeconomic impacts can be both cascading impacts as well as compounding impacts in relationship to the other sectors. In many cases drought impacts are based on specific experiences and un-reported incidents. As a result, a comprehensive statewide analysis for many of the issues noted in this section is not available. An analysis based on best available data and a framework for moving forward is presented here.

¹⁵ Klein, Bobbie, and Brad Udall. 2004. 2008 Drought Impact Report, A report to the governor. *Natural Hazards Observer* (July 2004):5-6.

¹⁶ Kalis, Martin A., Mark D. Miller, and Rachel J. Wilson. 2009. Public Health and Drought. *Journal of Environmental Health* 27 (1):10-11.

The Drought Task Force identified three subsectors under the Health and Socioeconomic sector:

- Economics
- Behavioral Health
- Physical/Public Health

Economics

The economic impacts of drought can be far-reaching and long-lasting. Although all sectors can be impacted by drought, those sectors most affected that translate to economic impacts include: agriculture, wildlife-related recreation, and tourism. Within each industry in this subsector, the following economic impacts can occur as a result of drought:

- Reduced Income
- Higher Unemployment
- Higher Indebtedness
- Stunted Industry Growth

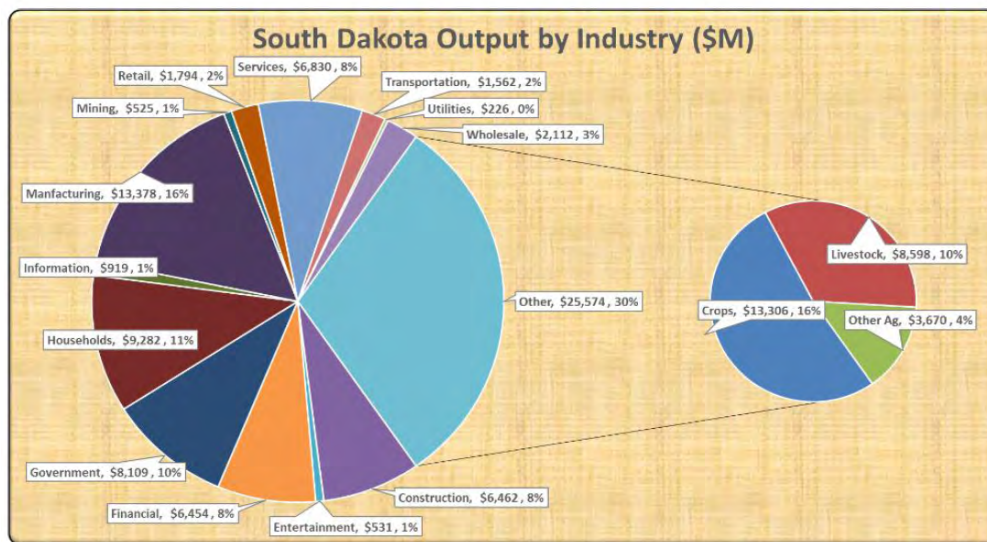
Agriculture

While this section summarizes the economic contribution of the agricultural industry in South Dakota, additional details for the agriculture sector resources and their vulnerability to drought can be found in Section 3.6. **Figure 25** provides a breakdown of economic output by industry.

Agriculture is considered to be the life-blood of South Dakota. It is the State's #1 industry. With more than 19 million acres of cropland and 23 million acres of pastureland, farmers and ranchers in the State are key drivers of the South Dakota economy. Agriculture in South Dakota provides the base for many agri-food industries including: food processing, manufacture of farm machinery, and the manufacture of farm chemicals and fertilizer. In 2012, agriculture and ag-related industries accounted for \$25 billion of South Dakota's total output, translating to more than 30%. Since 2012 was a severe drought year, the South Dakota Department of Agriculture added the crop insurance indemnities by county to the crop sales as reported by the 2012 Census of Agriculture to determine the adjusted contribution of agriculture to the economy. In total, agriculture-related jobs in 2012 contributed 115,651 jobs. This translates to 1 in every 5 jobs in South Dakota being involved in agriculture production of agriculture-related industries. Of the 66 counties in South Dakota, 37 derive at least one-half of their total output from agriculture and agriculture-related industries.¹⁷

¹⁷ 2014 South Dakota Ag Economic Contribution Study, South Dakota Department of Agriculture, September 2014

Figure 25. South Dakota Output by Industry (\$M), 2012



Source: 2014 South Dakota Ag Economic Contribution Study, South Dakota Department of Agriculture, September 2014

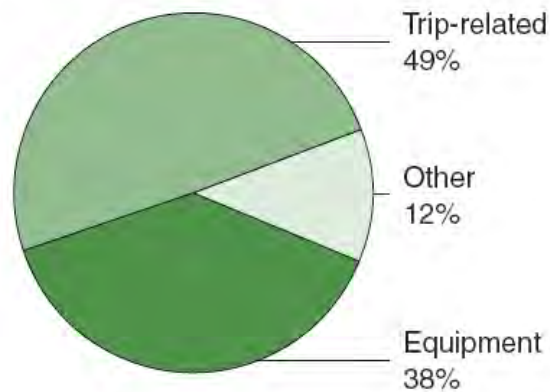
Wildlife-Related Recreation

While this section summarizes the economic contribution of wildlife-related recreation in South Dakota, additional details for the wildlife sector resources and their vulnerability to drought can be found in Section 3.8.

Wildlife-related recreation activities are not only favorite pastimes for Americans; they are the focus of many businesses that support the country’s economy. Wildlife-related recreation includes fishing, hunting, and wildlife-watching activities as well as all the gear and equipment required that support such activities (**Figure 26**). In 2011 662,000 South Dakota residents and nonresidents fished, hunted, or wildlife watched.¹⁸ This is in comparison to the 2011 population of the state of 824,171. These hunters, anglers, and wildlife-watchers purchase gear, trucks and boats; they also fill their gas tanks and coolers, stay at motels and resorts, buy hunting clothes, and pay fees for permits, licenses, and processing game hunted for consumption. When drought impacts the abundance of wildlife or the quality of the recreation experience, individuals may reduce their participation in this type of recreation, which can in turn, cause economic losses to those businesses that are geared around providing goods and services related to wildlife-associated recreation. According to the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, South Dakota residents and non-residents spent \$1.2 billion on wildlife-related recreation in South Dakota.

¹⁸ U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. *2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation*.

Figure 26. Wildlife-Associated Expenditures in South Dakota by Residents and Nonresidents, 2011 (Total: \$1.2 Billion)



Source: U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

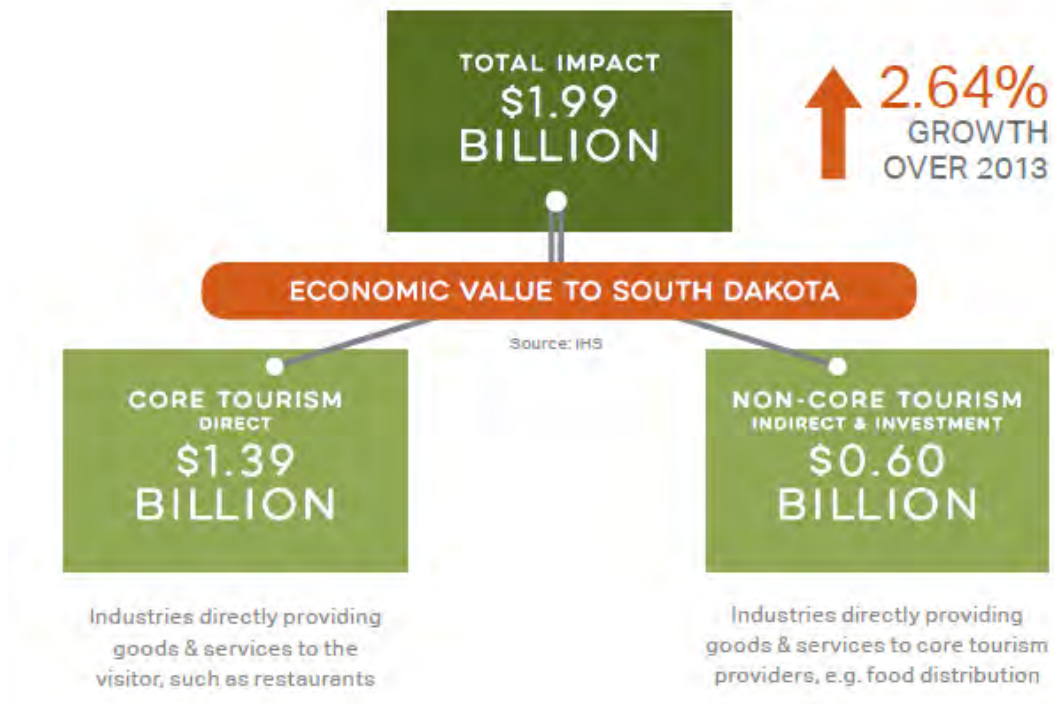
Tourism

While this section summarizes the economic contribution of tourism in South Dakota, additional details for the tourism sector and vulnerability to drought can be found in Section 3.9. It should be noted that there is some cross-over in the Wildlife-related Recreation Industry and the Tourism Industry (**Figure 27**).

In 2014, direct spending by travelers to South Dakota averaged \$3.8 Million per day. This translates to \$1.39 Billion from core industries directly providing goods and services to the visitors, such as restaurants. Another \$0.60 Billion was contributed by industries that provide goods and services to core industries. The combined total of the economic value of tourism to South Dakota was \$1.99 Billion, up 2.64 percent from 2013.¹⁹

¹⁹ South Dakota Department of Tourism Annual Report, 2014

Figure 27. Travel Industry Economic Impact in South Dakota, 2014



Source: South Dakota Department of Tourism Annual Report, 2014, http://sdvisit.com/tools/annualreport/_pdf/2015/15annrpt.pdf

Several of the activities that draw tourists that can be impaired by drought include:

- Hiking
- Boating
- Snowmobiling
- Camping
- Canoeing
- Fall foliage tours
- Fishing
- Horseback riding

Behavioral Health

Drought can impact behavioral health as a result of direct financial stress and general economic downturn. Additionally, some of the more common stress-relieving activities such as exercise and other outdoor activities may be impaired or less enjoyable as a result of drought. The combination of increased financial stress and impaired ability to relieve stress can result in the following behavioral health issues:

- Depression
- Anxiety
- Suicide
- Substance Abuse

There is a large body of literature on “farm crisis in behavioral health.” Financial farm stress can lead directly to psychological distress that can manifest through depression, substance abuse, increased farm accidents and suicide.²⁰ Additionally, parks and green spaces are very important to behavioral health, and improve quality of life in a variety of ways. For example, a survey of desk workers found that those with a natural view from their desk found their job more challenging and were less frustrated. Another study found that people who view nature after stressful situations show “reduced physiological stress response, as well as better interest and attention and decreased feeling of fear and anger or aggression”²¹. While neither of these studies specifically considered the impacts of drought on behavioral health, given the proven importance of natural areas in urban areas, the health costs of plant die off or brown out during drought should be considered.

Physical/Public Health

Public health issues during drought generally stem from impaired water quality and air quality. The South Dakota Department of Environment and Natural Resources is responsible for air and water quality monitoring in South Dakota. As of 2015 they have not had sufficient resources to analyze the relationship between drought and public health variables. As such, there is not systematic spatial data available for South Dakota. Based input from the South Dakota Drought Task Force, including the Department of Health, the major drought-related impacts can be identified. However, future work should focus on quantifying these impacts. The key public health issues identified in this project are as follows:

- Impaired Water Quality
- Impaired Air Quality,
- Increases in Fungal Infections
- Increased vector-borne diseases.

²⁰ Fetsch, R. J. 2007. Managing stress during tough times.

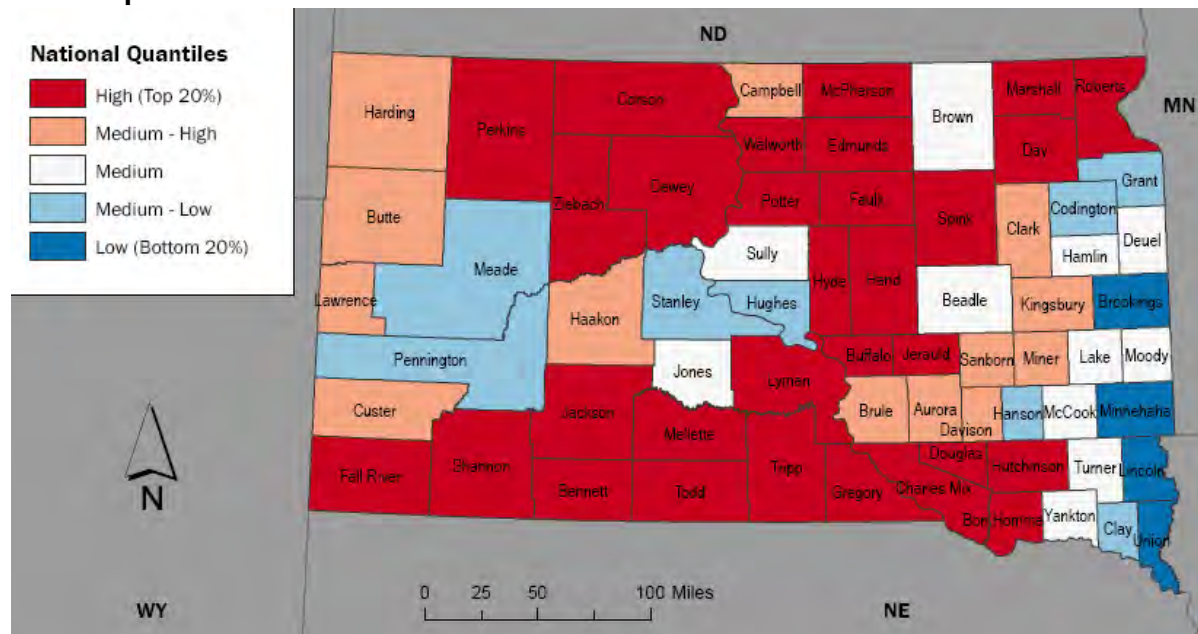
²¹ Wolf, Kathy. *Urban Nature Benefits: Psycho-Social Dimensions of People and Plants* 1998. Available from <http://www.naturewithin.info/UF/PsychBens-FS1.pdf>.

3.5.2 Vulnerability Assessment of the Public Health and Socioeconomic Sector

Overview

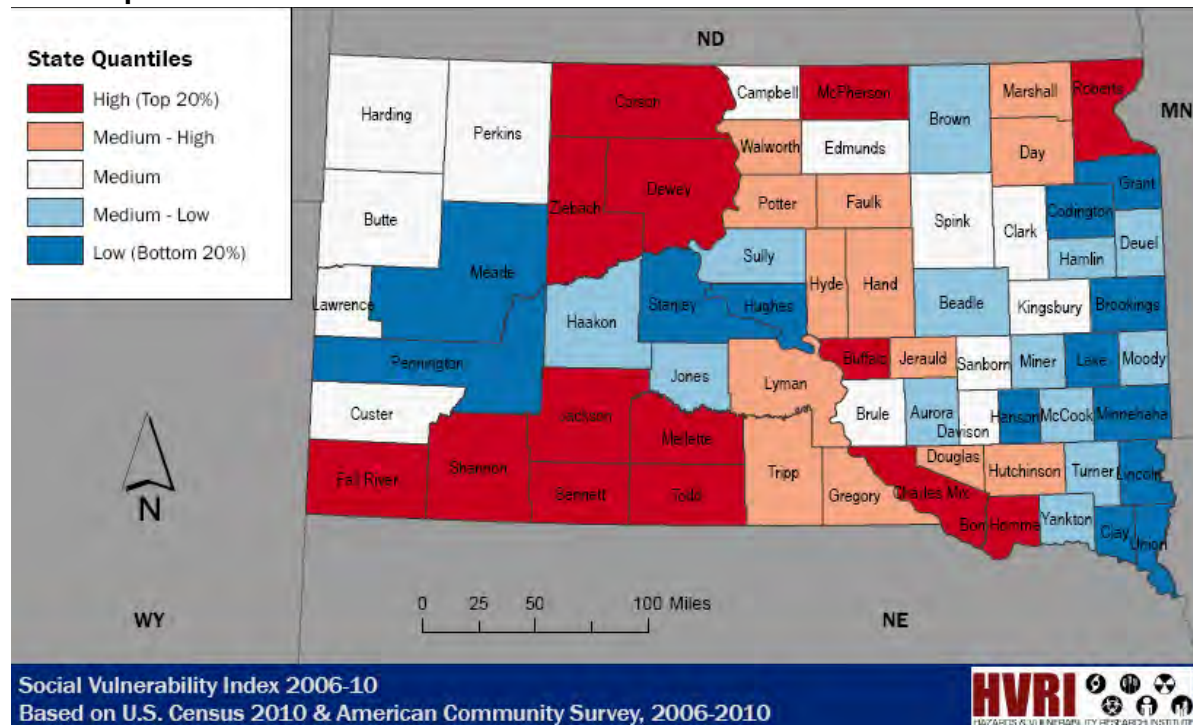
The Social Vulnerability Index (SOVI) developed by the University of South Carolina’s Hazards and Vulnerability Research Institute measures the social vulnerability of U.S. counties nationwide to environmental hazards. The index is a comparative metric that facilitates the examination of the differences in social vulnerability among counties. The index synthesizes and graphically illustrates analysis of 30 socioeconomic variables, which the research literature suggests contribute to a community’s ability or inability to prepare for, respond to, and recover from hazards. The 30 socioeconomic variables are standardized and determined to be either positive or negative. Positive variables are associated with increased vulnerability and negative variables are associated with decreased vulnerability. A higher resulting numerical score indicates greater the social vulnerability and therefore less capability to cope with environmental hazards. Although the SOVI index has been developed to measure social vulnerability to all environmental hazards, it also provides value in assessing the socioeconomic vulnerability of South Dakota Counties to the impacts of drought. The map in **Figure 28** provides a graphic of South Dakota Counties, based on a comparison of their nationwide SOVI index score. The map that follows in **Figure 29** provides a graphic of South Dakota Counties based on comparison with each other.

Figure 28. Social Vulnerability to Environmental Hazards, South Dakota—County Comparison within the Nation



Source: University of South Carolina’s Hazards and Vulnerability Research Institute, SOVI Index, 2006-2010.

Figure 29. Social Vulnerability to Environmental Hazards, South Dakota—County Comparison within the State



Source: University of South Carolina’s Hazards and Vulnerability Research Institute, SOVI Index, 2006-2010.

Economics

Typical drought vulnerabilities to the economy include reduced income, higher unemployment, higher indebtedness, and stunted industry growth.

Reduced Income

During a prolonged drought, even with insurance, farmers struggle to break even. This means there is no money left over to invest. Local businesses as well as big manufacturing companies are hit hard as well since farmers won’t be spending as much and there won’t be as much agricultural products to process and sell.

Since the recent drought in 2012-2013 was relatively short-lived, crop insurance and high prices for the in-demand agricultural products minimized reduction in income.

In the Wildlife-related Recreation and Tourism economic sectors, minimized, sick, or stressed wildlife, increased wildfires, and lack of flora and fauna can reduce the appeal of outdoor activities. Additionally, with a hard hit to the agricultural economy, the population supported by agricultural-related jobs will not have expendable income to spend on these types of leisure activities.

Snowmobiling is a popular winter Sport in South Dakota. Snowmobiling occurs primarily on the 350 mile Black Hills Snowmobile Trails System. Eastern South Dakota also has 1,225 miles of groomed, signed, and maintained snowmobiling trails. One specific study detailed the contribution of snowmobiling to the South Dakota economy. This report detailed that that snowmobiling, is associated with 1,449 jobs in South Dakota. If a drought cycle impacts the winter snowfall amounts in the State, this activity and associated jobs would decline tremendously.²²

Higher Unemployment

Businesses and industries that support agriculture and processing of agricultural goods can experience layoffs as a result of the low yields and lack of products that need to be processed. Similarly, with recreation and tourism in decline, jobs that support those markets decline as well. Again, this type of impact is anticipated only for droughts that have a long duration.

Higher Indebtedness

Higher indebtedness can occur as a result of lower income and higher unemployment as individuals look to loans to supplement income.

Stunted Industry Growth

Industrial growth can be stunted as a result of drought. This can be a result of the lack of water or perceived lack of water needed for certain types of manufacturing as well as a decline of agriculture-related or supported industry.

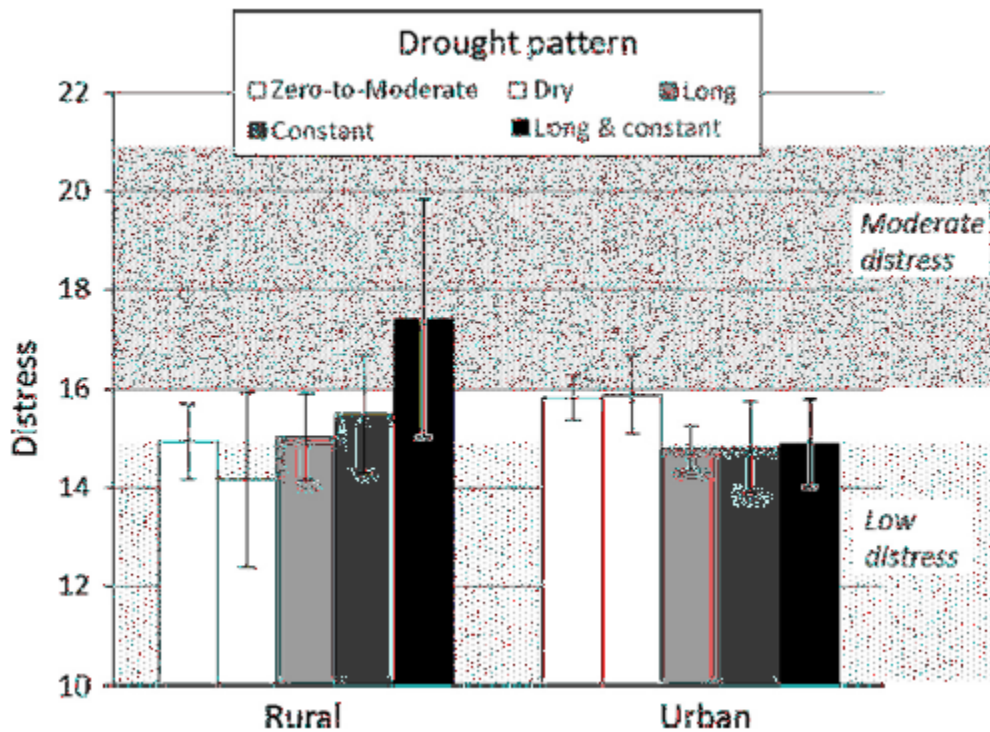
Behavioral Health

The behavioral/mental health impacts of drought are difficult to quantify. Specific relational studies have not been conducted in South Dakota. However, results of a 2013 study in Australia examined this issue (**Figure 30**). Drought was quantified in terms of duration and intensity of relative dryness and drought characteristics associated with poor mental health were identified to identify vulnerability in rural and urban communities. The results showed that, during a seven-year period of major and widespread drought, long and constant drought was associated with increased distress for rural but not urban dwellers.²³

²²South Dakota State Parks, The Economic Impact of the South Dakota Snowmobiling Industry, January 2012, Michael Allgrunn, Ph.D., Beacom School of Business, University of South Dakota, <https://gfp.sd.gov/to-do/snowmobile/docs/snowmobile-economic-impact-study.pdf>

²³ Drought as a Mental Health Exposure, L.V. Obrien, H.L. Berry, C. Coleman, and I.C. Hanigan, Published by Elsevier Inc., 2014

Figure 30. Mean Distress for Rural and Urban participants Experiencing Different Dryness Patterns.



Source: Drought as a Mental Health Exposure, L.V. O'Brien, H.L. Berry, C. Coleman, and I.C. Hanigan, Published by Elsevier Inc., 2014

Depression/Anxiety

In the 1930’s Dust Bowl drought, depression became synonymous with the event as it became known as the “Great Depression”. Although the term was originally intended to describe the economic situation of the time, there is no arguing the mental health-related depression of those impacted by financial crisis.

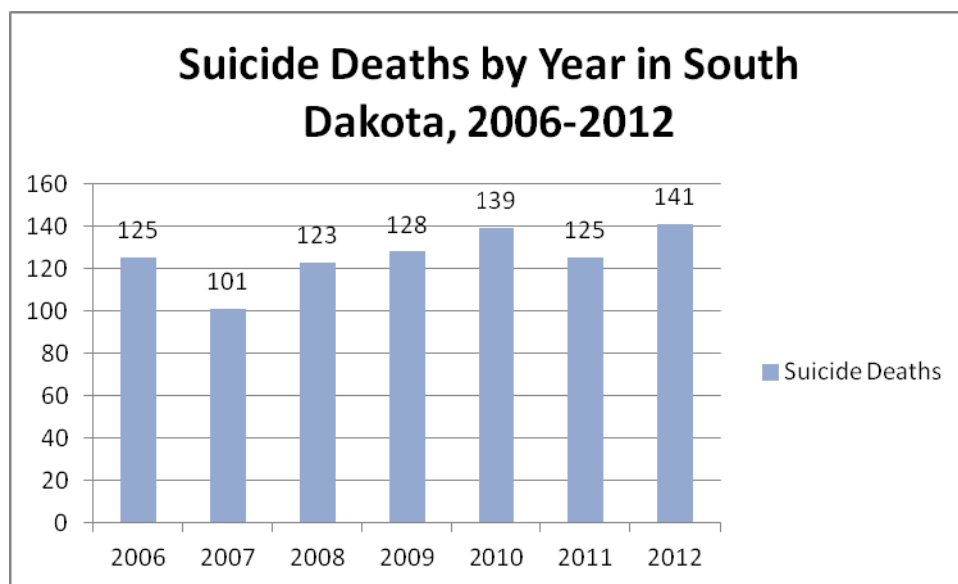
According to a 2007 study, South Dakota was the healthiest state with respect to depression status. A comparative study is not available to determine if the depression status increased during and after the 2012-2013 drought.²⁴

²⁴ An Analysis of Depression Across the States, November 29, 2007, Prepared for Mental Health America by, Thomson Healthcare, Washington, D.C.
http://www2.nami.org/Content/Microsites150/NAMI_Pasco_County/Home138/Whats_New121/Ranking_America_s_Mental_Health_FINAL.pdf

Suicide

In 2011, there were 125 suicide deaths in South Dakota, placing suicide as the ninth leading cause of death in the state. In 2012, the number of suicide deaths rose to 141; an increase of 13 percent, resulting in a national rank of 14 for the State of South Dakota.²⁵ Specific research of any noted causes of suicide deaths in the state has not been done to determine any direct correlation of the increase with drought conditions. **Figure 31** shows the suicide deaths in South Dakota by year from 2006-2012. Although there was a marked increase from 2011 to 2012, 2010 was nearly as high with 139 suicide deaths.

Figure 31. Suicide Deaths by Year in South Dakota, 2006-2012



sources: 2010 south Dakota Vital Statistics Report, South Dakota Department of Health, <http://doh.sd.gov/Statistics/2010Vital/default.aspx> and American Association of Suicidology, prepared by Christopher W. Drapeau, M.A. and John L. McIntosh, Ph.D., 18 October 2014, <http://www.suicidology.org/Portals/14/docs/Resources/FactSheets/2012datapgsv1d.pdf>

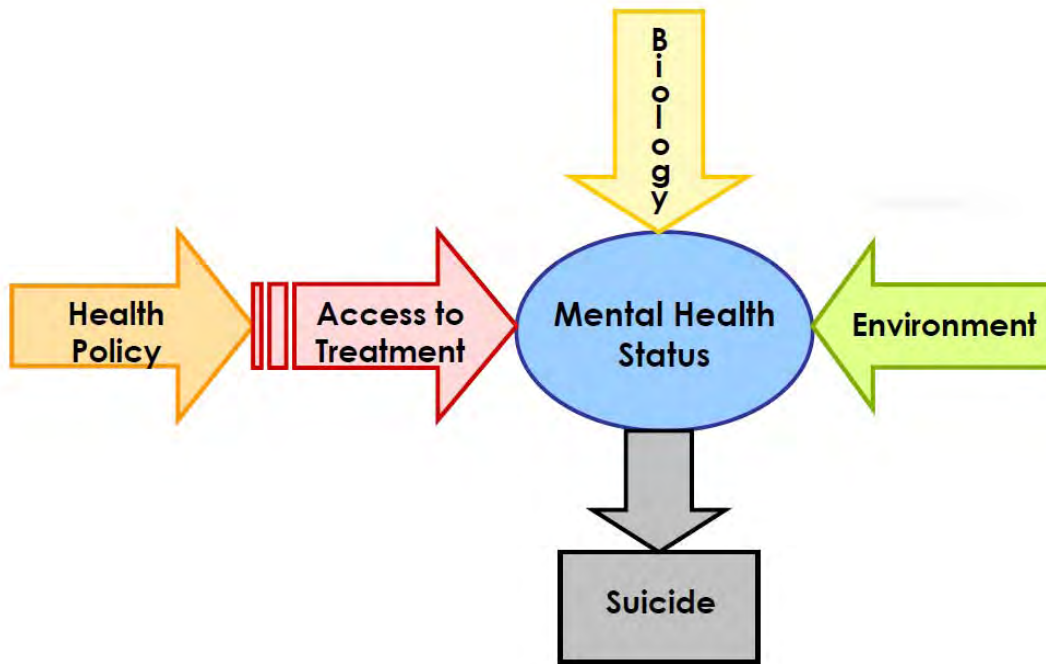
Social scientists have long believed that economic downturns result in higher suicide rates. In his 1897 book *Suicide*, a foundation text in the field of sociology, Emile Durkheim writes "It is a well-known fact that economic crises have an aggravating effect on the suicidal tendency." Contemporary research lends support to Durkheim's assertion. Studies of the great Depression, for instance have found increased suicide among the general population during that period.²⁶

²⁵ American Association of Suicidology, prepared by Christopher W. Drapeau, M.A. and John L. McIntosh, Ph.D., 18 October 2014, <http://www.suicidology.org/Portals/14/docs/Resources/FactSheets/2012datapgsv1d.pdf>

²⁶ Reeves, Aaron; McKee, martin; Stuckler, David, *British Journal of Psychiatry*, 2014, <http://journalistsresource.org/studies/society/public-health/suicides-during-great-recession-united-states-canada-europe#>

In the mid-1980s in Oklahoma, the farm suicide rate was 42/100,000 as compared with an overall suicide rate of 15/100,000. In Kansas the farm suicide rate was 40.27/100,000 in 1985 as compared with an overall suicide rate of 11.5/100,000. Similar high rates of farm/ranch suicide rates were found in Minnesota, Montana, South Dakota, North Dakota, and Wisconsin.²⁷

Mental illness, disability, and suicide are ultimately the result of a combination of biology, environment, and access to and utilization of mental health treatment. Public health policies can influence access and utilization, which in turn may improve mental health status and help to ameliorate the negative consequences of depression and its associated disability (see below).



Source: An Analysis of Depression Across the States, November 29, 2007, Prepared for Mental Health America by, Thomson Healthcare, Washington, D.C.
http://www2.nami.org/Content/Microsites150/NAMI_Pasco_County/Home138/Whats_New121/Ranking_America_s_Mental_Health_FINAL.pdf

Substance Abuse

Substance abuse, in some cases, is a coping mechanism that individuals turn to when they are depressed or anxious. As a result of increased depression and anxiety discussed above, substance abuse can also increase.

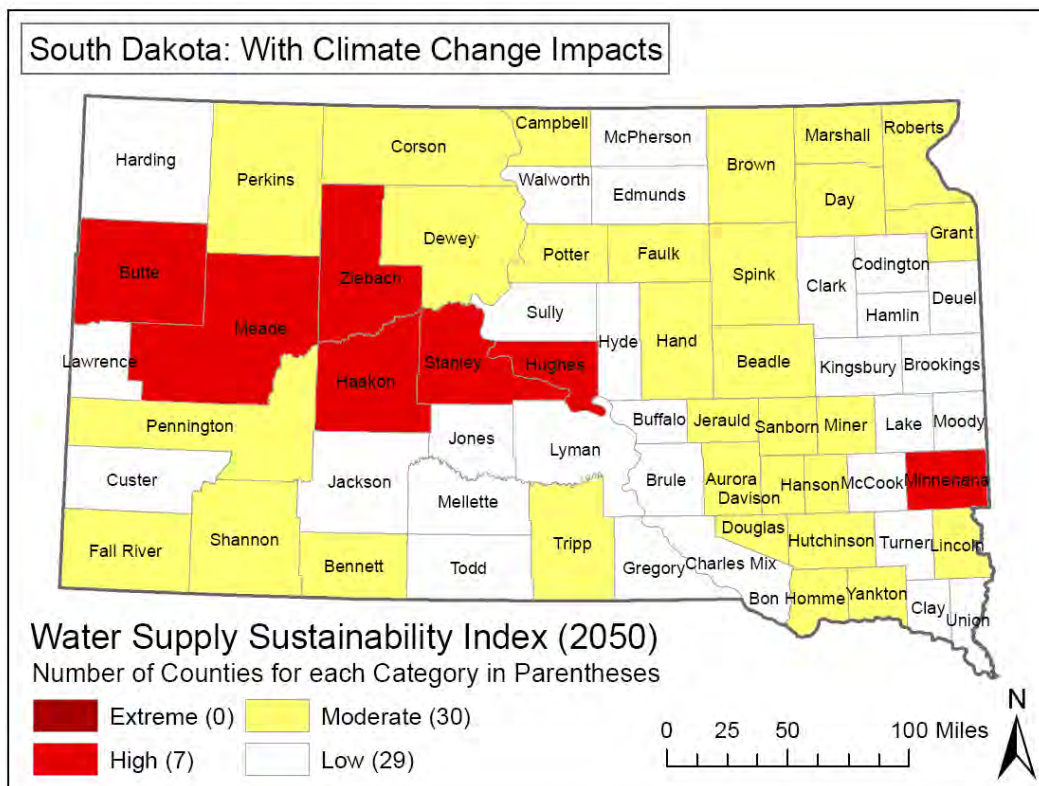
²⁷ Finch, C. (1990, October). Farmers are still killing themselves. Farm Journal. (Available from 230 W. Washington Square, Philadelphia, PA.)

Physical/Public Health

Safe and Sustainable Drinking Water

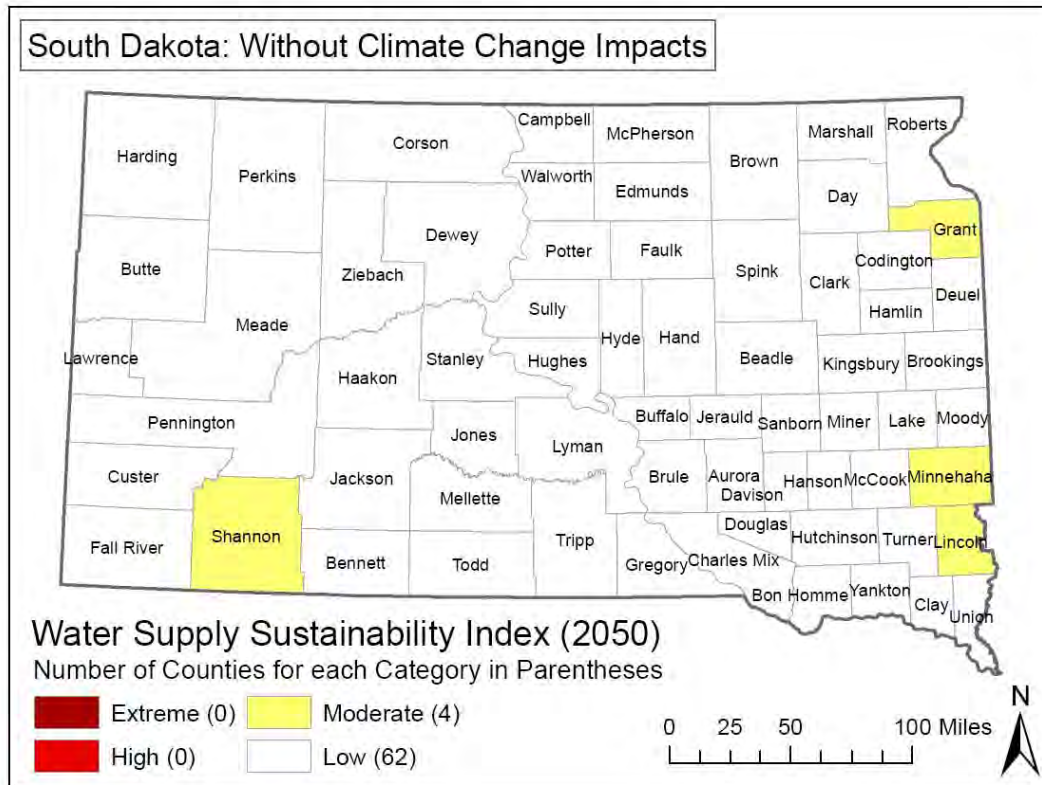
A new analysis, performed for the Natural Resources Defense Council, examined the effects of climate change on water supply and demand in the contiguous United States. The study found that more than 1,100 counties will face higher risks of water shortages by mid-century as a result of climate change. Two of the principal reasons for the projected water constraints are shifts in precipitation and potential evapotranspiration (PET). Climate models project decreases in precipitation in many regions of the U.S., including areas that may currently be described as water short. In South Dakota, these results of this study indicate that about 56% of the state's counties could face higher risks of water shortages by mid-century as a result of increasing potential for drought due to climate change impacts. The maps in **Figure 32** and **Figure 33** below show the water supply sustainability index in South Dakota counties with and without climate change impacts, respectively.

Figure 32. Water Supply Sustainability Index in South Dakota Counties With Climate Change



Source: Natural Resources Defense Council, Climate Change, Water, and Risk: Current Water Demands Are Not Sustainable, July 2010, <http://www.nrdc.org/globalwarming/watersustainability/files/WaterRisk.pdf>

Figure 33. Water Supply Sustainability Index in South Dakota Counties Without Climate Change



Source: Natural Resources Defense Council, Climate Change, Water, and Risk: Current Water Demands Are Not Sustainable, July 2010, <http://www.nrdc.org/globalwarming/watersustainability/files/WaterRisk.pdf>

Other water quality impacts that can occur as a result of drought include:

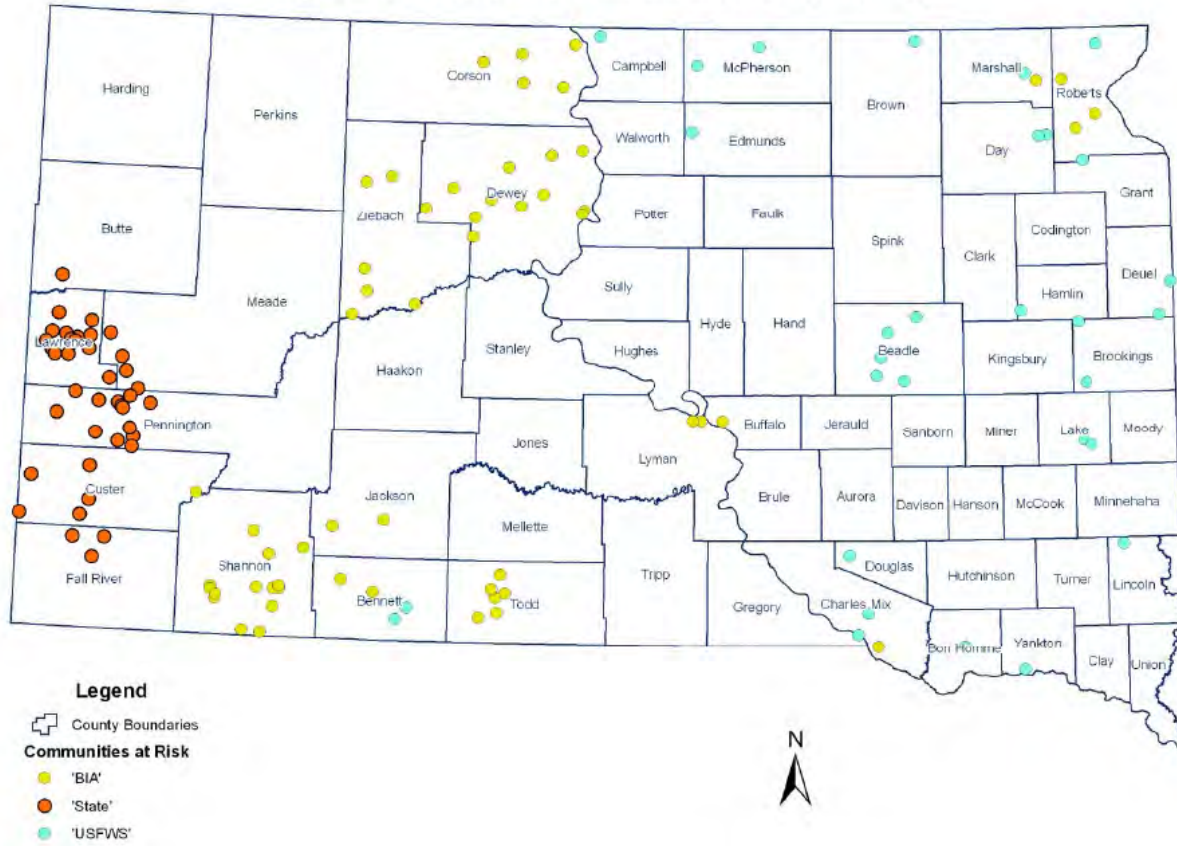
- Impaired water quality resulting from sediment loading and decreased dilution.
- Additional water treatment may be required as municipalities are forced to draw water from lower reservoir levels.
- Decreased reservoir levels and increased temperatures can result in algae blooms

Air Quality

Air born particulate levels can climb when there are extended periods without rain. If levels get too high some residents may experience respiratory complications. Poor air quality can also increase the risk of respiratory infections, such as bacterial pneumonia. In the Dust Bowl of the 1930s, severe drought characterized by substantial clouds of dust and sand caused “dust pneumonia,” an often fatal type of pneumonia caused when dust fills the lungs and inflames

them, resulting in high fever, coughing, chest pain, and difficulty breathing.²⁸ In addition, drought induced wildfires can significantly decrease air quality and lead to respiratory complications. According to the 2013 South Dakota State Hazard Mitigation Plan, there are several areas in the state at increased risk to wildfire (See **Figure 34**). See the Wildfire Sector for more discussion on wildfire risk and drought.

Figure 34. South Dakota Communities at Risk to Wildfire



Source: State of South Dakota Hazard mitigation Plan, September 2013.

Contaminants, Vector-borne Diseases and Other Diseases

Increased bacteria, protozoa, and other contaminants such as chemicals and heavy metals loading in water bodies can pose public health risks for water based recreation. Air quality issues can cause increased incidents of asthma or other respiratory diseases—according to the Natural Resources Defense Council, asthma affects an estimated 18,700 and 43,300 adults in South Dakota. Drought reduces the size of water bodies and can cause them to become stagnant breeding grounds for certain types of mosquitoes. Outbreaks of West Nile virus have occurred

²⁸ Centers for Disease Control and Prevention, Public Health and Drought: *Challenges for the Twenty-First Century*, <http://www.cdc.gov/features/Drought/index.html>

under such conditions. There have been 1,757 cases of West Nile virus reported in South Dakota to the Centers for Disease Control and Prevention between 1999 and 2010.²⁹

Historical Impacts

The University of Nebraska, Lincoln's National Drought Mitigation Center Drought Impact Reporter provides an interface for the public and other sources to report drought impacts. Drought impacts are categorized as follows: agriculture; business and industry; energy; fire; plants and wildlife; relief, response and restrictions; society and public health; tourism and recreation; and water supply and quality. **Figure 35** and **Figure 36** show the number of business and industry impacts and society and public health impacts (respectively) that have been reported by South Dakota on a county basis from January 1, 1980 to April 13, 2014. These results indicate that the greatest number of business and industry impacts have occurred Yankton and Hanson Counties. The greatest number of Society and Public Health impacts has occurred in the north-central counties. There are limitations to this data as it is dependent upon voluntary or media reports, but it does paint an initial picture.

29 Centers for Disease Control and Prevention. West Nile virus Statistics, Surveillance, and Control Archive via Natural Resources Defense Council website, <http://www.nrdc.org/health/climate/sd.asp>

Figure 35. NDMC Reported Business and Industry Drought Impacts (Jan 1980 to April 2015)

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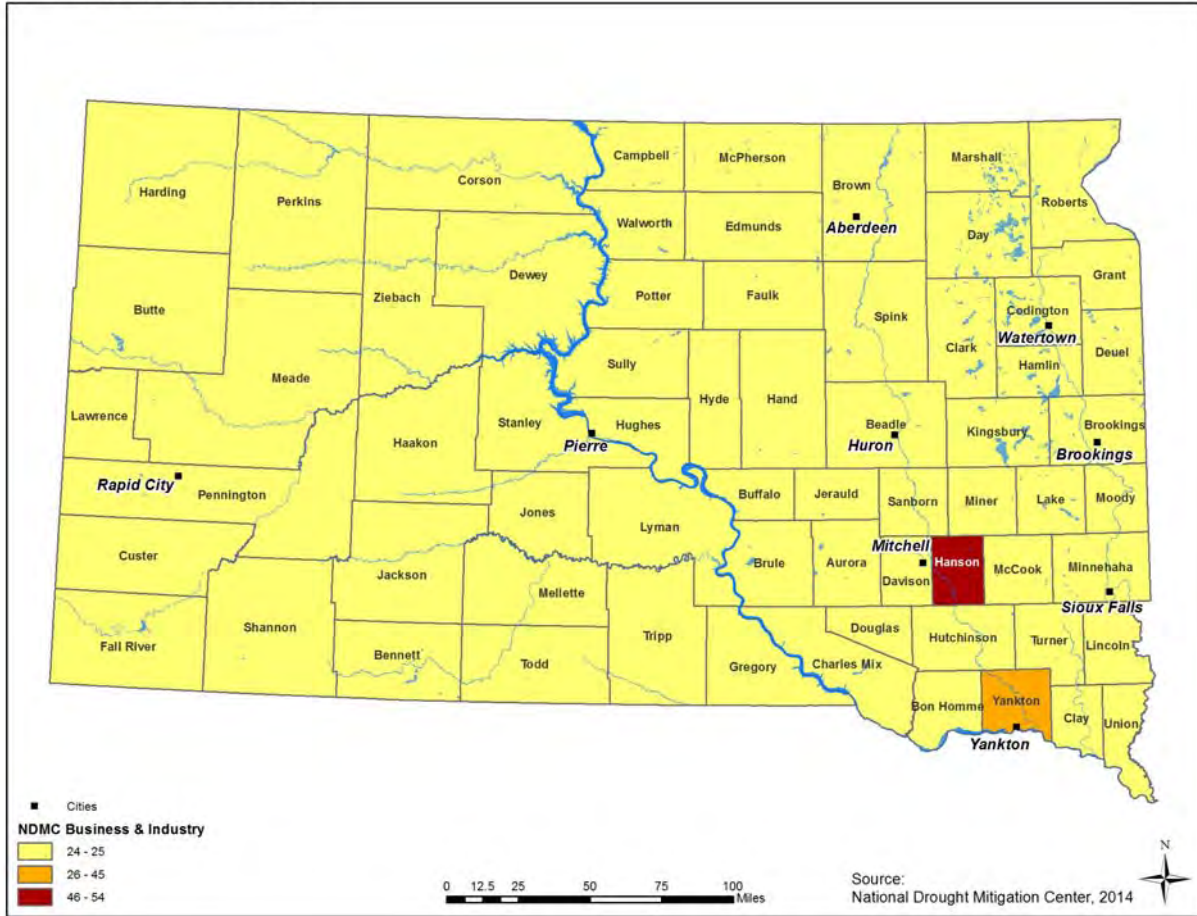
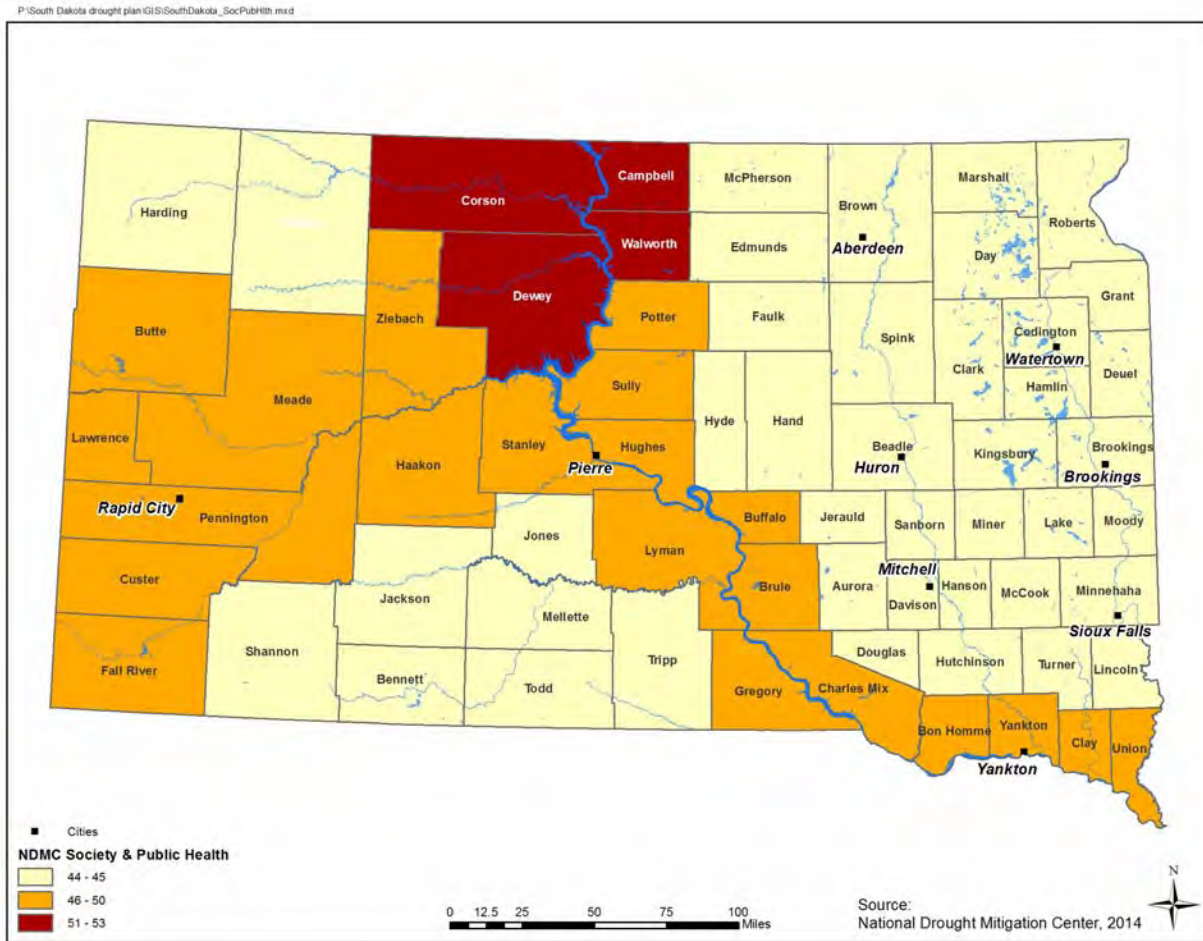


Figure 36. NDMC Reported Society and Public Health Impacts Drought Impacts (Jan 1980 to April 2015)



Specific notable business and industry and society and public health historical impacts are provided below:

- **2014**
 - Large food companies buying up smaller ones in an effort to remain competitive as drought, other factors challenge profitability.
- **2013**
 - Drought, heat, and heavy rainfall contributed to the explosion in the mosquito population in parts of the U.S. in 2013.
 - High hay prices led the International Society for the Protection of Mustangs and Burros in Lantry, South Dakota to give away some of its wild horses and request hay donations.
 - Net farm profit in South Dakota fell nearly 40 percent in 2013
 - Agricultural supplier in Bon Homme County, South Dakota reports profits off by 75 percent; As an agricultural supplier, the drought has affected us more than the farmer and probably more than other retailers such as car dealers. Profit wise we were off 75%,

because once the farmers saw the extent of the drought they stopped buying fertilizer and chemicals because these inputs were not needed to produce a poor crop and collect an insurance check. Insurance, based on high commodity prices, put money in the farmers pockets. They still bought goods like new cars and trucks. If the drought persists this year, the biggest impact will be that the farmers will not have enough feed for their livestock and feed like hay and forage will be high priced to buy.

- *A chef and owner of three restaurants in Sioux Falls and Custer, South Dakota said that drought had the biggest impact on her businesses in 2012. Vegetables did not grow well and forage for buffalo and elk was sparse, prompting her to take elk and buffalo, except for buffalo burgers, off the menu. The food served in these restaurants is from local sources with the animals coming from the Belle Fourche area.*

- **2012**

- *South Dakota's GDP up only 1.9 percent in 2012—Drought took the wind out of South Dakota's economic sails in 2012 as the preliminary estimate of the state's gross domestic product was 1.9 percent, in comparison with an increase of 8.8 percent in 2011, according to the U.S. Bureau of Economic Analysis.*
- *Drought pulled down personal income in South Dakota by 0.2 percent in 2012—Earnings for the farm industry dropped by an estimated 27 percent, compared to 2011, and crop output declined by 18 percent, according to a regional economist with the Bureau of Economic Analysis.*

- **2009:** Shut-off orders issued for junior water rights holders upstream of Angostura and the Belle Fourche reservoirs.

- **2007:** The number of visitors to Rocky Point Recreation Area declined as the water level declined. The reservoir was only 55 % full.

- **2006**

- *Sustained drought conditions have impacted the area's pheasant hunting season The dry conditions led to fewer concentrations of birds, as water and land habitats were reduced. A South Dakota Game, Fish and Parks Conservation officer reported that some hunters bagged fewer birds this season on account of such drought factors.*
- *The first weekend of hunting season revealed some of the impacts of a summer of drought as birds congregated around water holes. There was also less cover for the birds, since little grew well. Some hunters reportedly did not see many birds, while others got their limits. A Game, Fish, and Parks official stated that the number of birds is down from the previous year and that many of the birds are more mature, since the young didn't survive the summer well, and more flighty around hunters because they have survived a previous hunting season.*
- *Nearly half of the 31 boat ramps on Lake Oahe were unusable this year. An ongoing drought has significantly dropped the lake lever, rendering many boat ramps useless.*
- *Dry conditions and several years of low inflows have created low water levels at the Angostura Recreation Area, and this has caused some of the reservoir's docks and boat ramps to close down.*

- **2005**

- *At Pactola Reservoir, low water has made boat launching difficult, and in some places the lake has now dried up, providing a grazing area for cattle. The owner of Pactola Pines Marina notes that the season was fairly good in spite of the drier conditions, while other reservoirs in the Black Hills did not fare quite as well. At Belle Fourche Reservoir (Orman Dam), drought and irrigation demands reduced the lake to 13 % of capacity (from 8,000 acres to less than 2,000 acres), and the public boat ramp is closed. However, fishing has continued at the dam, and an annual fishing tournament is still scheduled. Conditions are similar at Angostura Reservoir near Hot Springs. It is at 46% of capacity, declining from 4,600 to 2,700 acres, and only one ramp is still in operation, but fishing continues.*
- *Drought has caused a loss of \$2.6 million to the recreational fishing industry on the Missouri River and its reservoirs*
- *Extreme drought has lowered reservoirs along the upper Missouri River, exposing ancient villages and artifacts to looters. Among the tribes affected are the Cheyenne River Sioux Tribe, Standing Rock Sioux Tribe, and Three Affiliated Tribes at Fort Berthold in North Dakota. The tribes and the Corps of Engineers are working on setting guidelines for protection of the cultural property along the river and enforcement of those guidelines.*
- *The water in Lake Oahe is so low that the reservoir has literally left the state of North Dakota. From Bismarck to the South Dakota state line, more than 60 miles of the reservoir that was once 5 miles wide are now a narrow river leaving boat ramps stranded a mile or more from the water. Many locals have sold their boats. This winter is the first winter in memory without fishing in the inlet of Beaver Bay.*
- *Water on the Cheyenne River Reservation and surrounding communities is at a critically low level. The Reservation and surrounding areas receive their water supply from the Missouri River, but several years of drought have left the river and reservoirs at critically low levels. The situation is so drastic that 157 new applicants for water have been denied and more than 200 homes that are planned by the Cheyenne River Housing Authority will be denied service by the Mni Waste water system.*
- *The Standing Rock Sioux Tribe had to extend their municipal water intake pipe further into the Missouri River as the water reseeds from the shorelines. Boating docks have been closed and others moved to reach the water.*
- *Sustained drought conditions are impacting the ability of Perkins County families to purchase food and basic supplies. Economic downturn, attributed to the drought's effect on local farming and ranching industries, has caused a strain on county food banks and other provision donation centers.*
- *The Army Corps of Engineers began releasing more water through the Lake Oahe area in the past week, but they forecast that by the end of August, Oahe Reservoir will reach its lowest level on record because of continued lack of rainfall and requirements to maintain downstream flows on the Missouri River. This will leave nearly all boat ramps out of the water. It is also having an economic impact on recreation in the area. A resort*

owner on Lake Oahe just outside of Pollock declared bankruptcy after 4 years of dry weather and lowered watered levels. Cows now roam the area where his boat ramp used to be, and a local fishing guide says he has never seen the river this dry in the 10 years he has been working in the area. He notes that the area is losing many businesses and much money as the number of tourists declines.

- Due to continued drought conditions, the South Dakota Game, Fish, and Parks Department reports that the state has lost approximately \$1 million in pheasant hunter license fees this year. The drought conditions reduced pheasant populations and, corresponding, pheasant hunter numbers across the state*

Factors that Impact Health and Socioeconomic Vulnerability to Drought

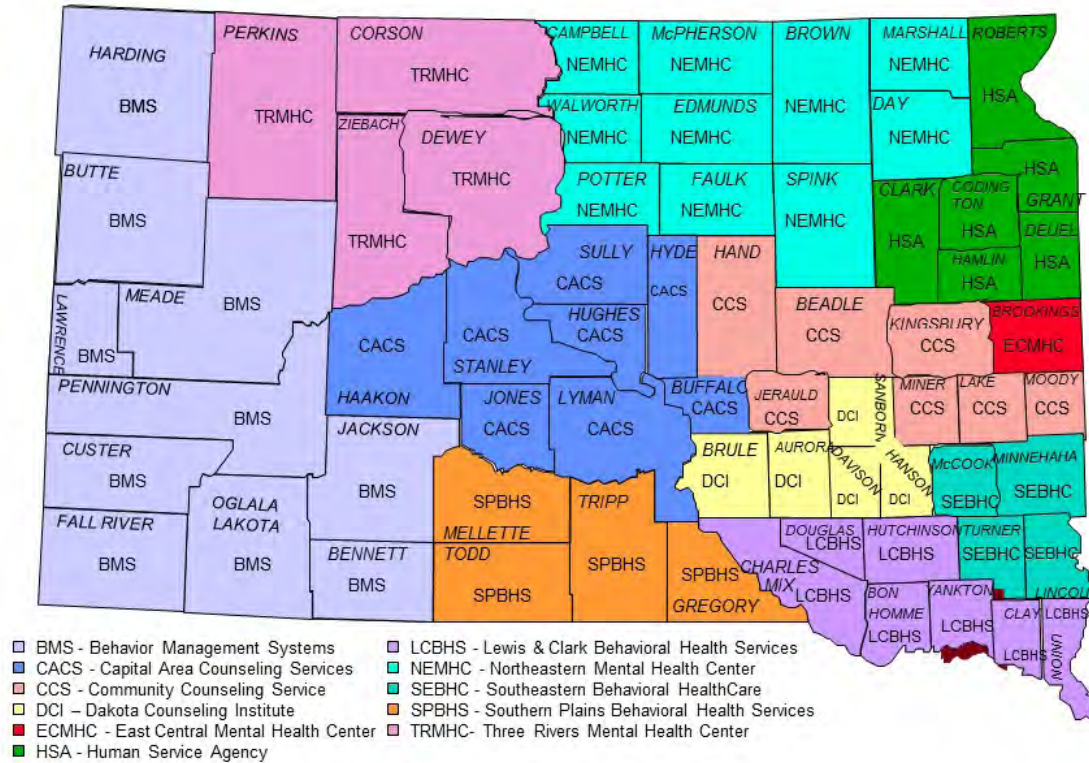
Factors that impact Health and Socioeconomic Vulnerability to Drought include the following:

- Length of Drought
- Existing Economic Health/Vitality
- Economic Diversification
- Availability of Healthcare
- Availability of Mental Health Resources

Tempering this vulnerability to a degree are the mental health resources already in place across the state. **Figure 37** shows the South Dakota Mental health Center Service Areas. Both the Department of Health and Department of Social Services have capabilities to supplement mental health needs as a result of disaster.

Figure 37. South Dakota Mental Health Center Service Areas

South Dakota Mental Health Center Service Areas



Source: South Dakota Department of Health

Estimating Potential Losses

Estimating potential losses as a result of drought impacts to the health and socioeconomic sector and subsectors on statewide or county-specific scale is difficult to quantify due to the lack of data. With the exception of impacts to the agricultural sector of the economy, impacts to the health and socioeconomic sector are not always specifically attributed to drought conditions, even though drought may have been a major factor in the impact. As a result, utilizing statistics from previous impacts to inform loss estimates of future events is not recommended for this sector at this time. Although data limitations prevent estimating potential future losses, as discussed in **Section 3.5.3**, it may be possible to analyze various elements and indicators associated with typical health and socioeconomic impacts of drought across the state to determine those areas of the state that may be most vulnerable.

Summary of Identified Vulnerabilities and Adaptive Capacities

Table 8 Summary of Vulnerabilities and Adaptive Capacities

Public Health and Socioeconomic Subsector	Identified Vulnerabilities	Key Adaptive capacities	
		Existing or Implemented in the Past	Potential Options for Consideration
Economic	<ul style="list-style-type: none"> • Agricultural Losses • Water restrictions and increased unit prices can increase operating costs for industry • Secondary industry impacts due to decline of water-dependent customers, suppliers, or tourists • Potential new industries may be deterred by uncertainty in water supply • Loss of income, unemployment, indebtedness 	<ul style="list-style-type: none"> • Crop Insurance • Promote other tourism activities in the community not dependent on water 	<ul style="list-style-type: none"> • Industry diversification • Coordinate with media to control messages going out • Cooperative alliances and community planning
Behavioral Health	<ul style="list-style-type: none"> • Increased incidence of mental and behavioral health problems (depression, anxiety, and suicide). • Increased substance Abuse 	<ul style="list-style-type: none"> • Mental health screening (Lewis & Clark Behavioral Health) • Free, confidential support hot lines through Agriwellness Inc. that offer advice from financial experts, referrals to mental health providers, and vouchers for therapy sessions 	<ul style="list-style-type: none"> • Increased public awareness about possible drought implications and the signs of behavioral health issues • Increased funding for behavioral health professionals especially in high vulnerability areas
Physical/Public Health	<ul style="list-style-type: none"> • Impaired water quality and air quality impact health • Compromised Food and Nutrition • Increases in illness and disease (asthma) • Increased Vector-borne disease • Potential for stresses to public water supplies due to extended drought 		<ul style="list-style-type: none"> • Increased monitoring and spatial analysis of drought-related impacts • Increased awareness and drought preparation by public agencies • Increased drought management plans at the municipal level to ensure adequate supply

3.5.3 Recommendations

Framework for Future Drought Vulnerability Studies

Future drought vulnerability studies should focus on collection and analysis of various health and socioeconomic factors that can contribute to drought vulnerability. Synthesis of these factors would help more clearly demonstrate those areas of the state that have increased vulnerability with respect to health and socioeconomic impacts. Specific elements for consideration include, but are not limited to:

- Economic dependence on agriculture, tourism, and/or wildlife-related recreation
- High water susceptibility index,
- high poverty levels,
- Elevated wildfire risk
- Lack or gaps in insurance coverage
- Limited Healthcare/Mental Health resources
- High SOVI Index

Recommended Next Steps

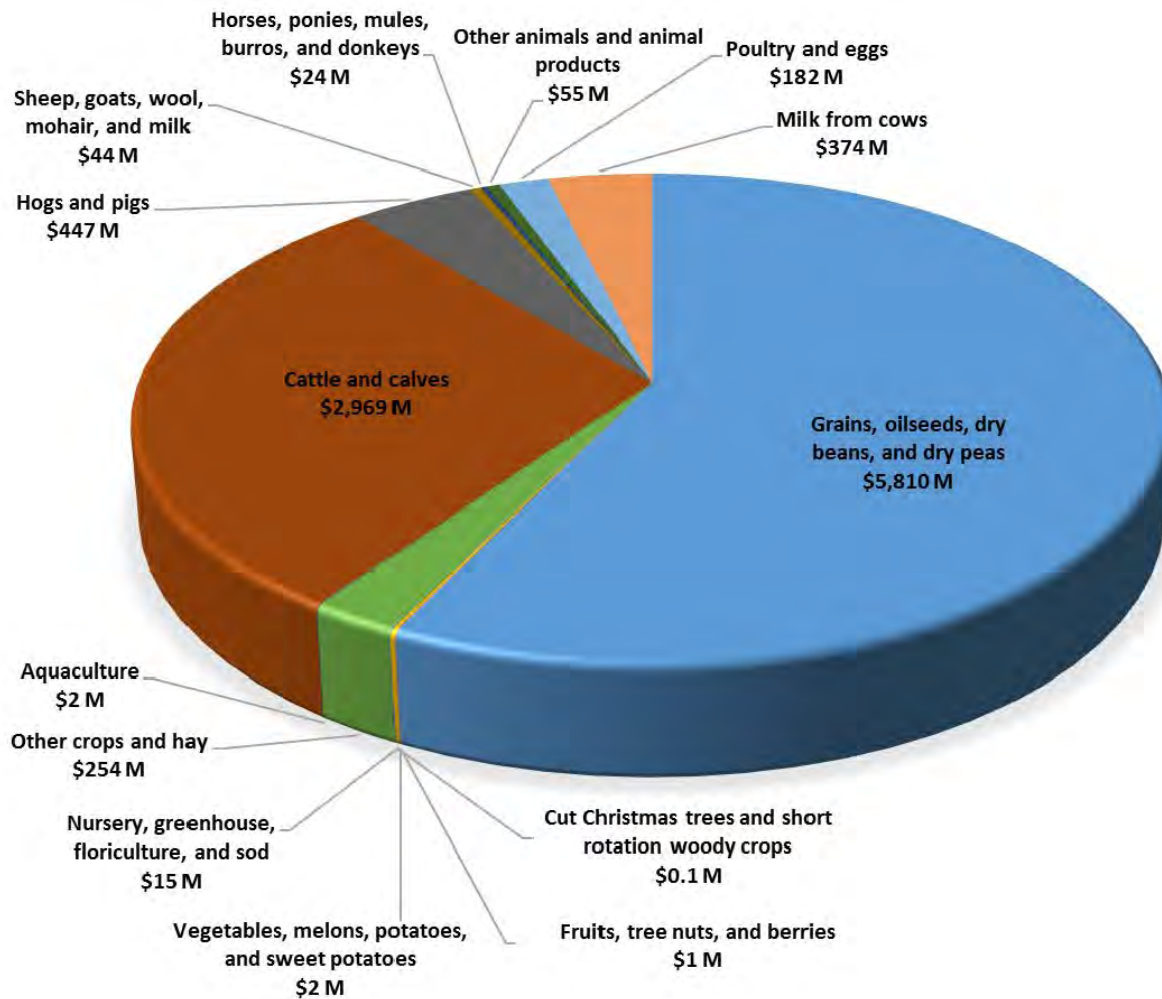
- Economic diversification is a key mitigation strategy for drought. This should occur both on a regional level and in individual business plans.
- Cooperative alliance and community planning that occurs before a drought can greatly increase the efficiency and effectiveness of drought responses.
- Many of the behavioral and public health issues resulting from drought are coordinated by governmental entities. Statewide agencies should increase their understanding of societal impacts of drought and focus on collaborative opportunities to mitigate drought impacts.
- Significant data gathering and additional monitoring are required to spatially characterize social vulnerability.

3.6 Agriculture Sector

3.6.1 Introduction

The Agriculture Sector is significant in South Dakota as some form of agricultural activity is found in every county. The 2012 USDA Census of Agriculture for South Dakota estimates the market value of sold agricultural products to be over \$10 billion annually. **Figure 38** shows how that \$10 billion is broken down between different agricultural groupings. See the health and socioeconomic sector discussion for more details on the economic significance of this sector.

Figure 38. Market Value of Agricultural Products in South Dakota, 2012



Source: 2012 USDA Census of Agriculture for South Dakota

Grains, oilseeds, dry beans and dry peas constitute the largest percentage of the overall agricultural products in South Dakota. This category includes corn, wheat, soybeans, sorghum, barley, rice, and others. Livestock, poultry, and their products collectively contribute over \$4 billion to the Sector. Other sub-sectors identified for this study include crops such as vegetables

and fruits, and the green industry (which consists of nursery, greenhouse, floriculture, and sod). Together these sub-sectors represent the majority of the categories within South Dakota's agricultural industry. Discussion of aquaculture and drought impacts to state-run fish hatcheries, which are expected to be similar to privately-owned hatcheries, is located in the Water Resources and Wildlife sections.

The Drought Task Force identified three subsectors under agriculture:

- Dryland crops
- Irrigated crops
- Livestock

Dryland Crops

Dryland crops, which are entirely dependent on precipitation, are distinguished from irrigated crop for this assessment because they are more susceptible to damage by droughts. The large majority of crops in South Dakota are non-irrigated. Figure 39 shows the concentration by county of dryland crops in South Dakota. Corn is the dominant crop on South Dakota's 17.4 million acres of non-irrigated cropland. Annually, it occupies about one quarter of these acres, which is more than the total of the next four most extensively grown dryland crops (e.g., soybeans, forage, wheat, and alfalfa).³⁰ Livestock producers, located throughout the state, commonly plant annual and perennial forage (dryland) to feed their herd in the winter months.

Irrigated Crops

Irrigated crops are significantly less abundant than dryland crops in South Dakota. Specific types of irrigated crops in the State are largely the same as non-irrigated crops and include corn, alfalfa, forage, soybeans, wheat, hay, oats, dry beans, fruits, and vegetables. Due to the extensive variety of crops grown in South Dakota, specific crop discussion is limited except as it relates to geographic areas of the state.

Figure 39 shows the percentage of total area in each county dedicated to farmland. Geographic distribution of crops by type is shown in **Figure 40**, which illustrates that there is more farmland devoted to row crops in East River than in West River. West River is dominated by grass and pastureland.

³⁰ 2012 USDA Census of Agriculture for South Dakota

Figure 39. Percentage of Total County Area Dedicated to Cropland

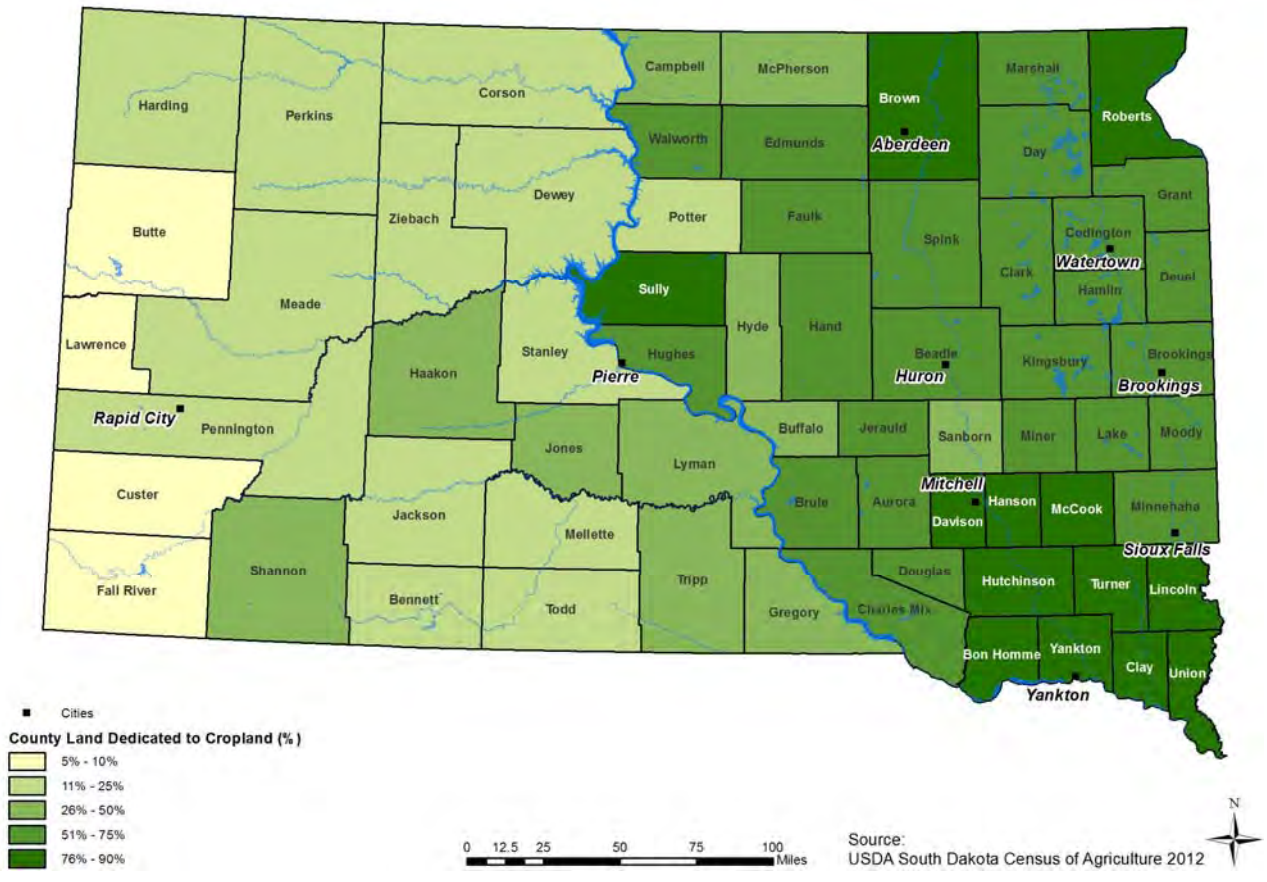
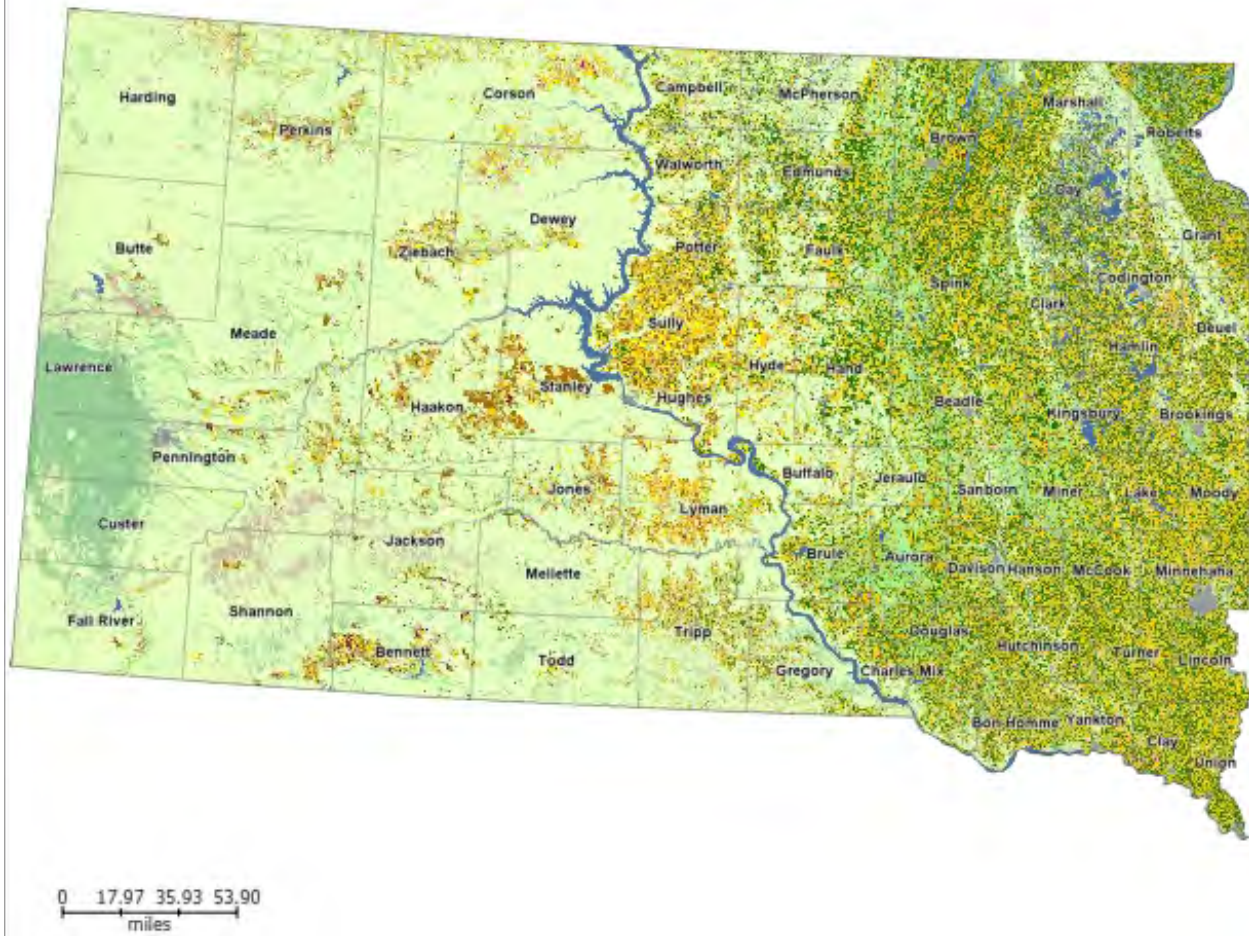


Figure 40. Geographic Distribution of Crops by Type, 2014



Source: USDA

Land Cover Categories
(by decreasing acreage)

AGRICULTURE*

- Grass/Pasture
- Corn
- Soybeans
- Other Hay/Non Alfalfa
- Spring Wheat
- Winter Wheat
- Alfalfa
- Sunflowers
- Fallow/Idle Cropland
- Sorghum

- Oats
- Millet
- Safflower
- Peas
- Barley
- Dbl Crop: WnWht/Com
- NON-AGRICULTURE****
- Open Water
- Evergreen Forest
- Developed/Open Space
- Herbaceous Wetlands
- Shrubland
- Barren

Livestock

For this assessment, discussion of the livestock sub-sector focuses on cattle and calves, although livestock owners in South Dakota do raise other animals (e.g., pigs, sheep, goats, horses, etc.). This focus on cattle is due to the nature of grazing (i.e., drought can severely impact ranchers by limiting forage availability). The cattle and calf industry includes both beef and dairy cows.

The sub-sectors described above were chosen based on their economic impact to the overall agricultural industry and their immediately recognizable vulnerability to drought. Other sub-sectors that are not covered in this report but worth mentioning include:

- Livestock other than cattle, such as hogs, pigs, sheep, goats, poultry, etc. These animals would be impacted by drought but are much smaller in numbers than cattle in South Dakota.
- “Agri-tourism,” which is tourism centered on agricultural attractions, is a small but growing sub-sector within agriculture (see Tourism sector for additional details).

3.6.2 Vulnerability

The following sections discuss aspects of vulnerability to drought in the Agriculture Sector, and cover adaptive capacities used to mitigate the impacts. Agriculture is vulnerable to drought when there is not enough water to sustain crops or livestock. This is largely dependent on relative magnitudes of water supply versus demand that exist in the area.

Agriculture is the dominant water use in South Dakota. While much of the industry relies on precipitation for watering crops, irrigation composes 58% of South Dakota’s total surface and groundwater use. Aquaculture and livestock use a smaller portion of the water with percentages of 8% and 7% respectively.

Since the Agricultural Sector is quite large, different seasons of drought will impact different sub-sectors. **Table 9** below discusses water use and seasonality in the Agricultural Sector.

Table 9 Seasonality and Water Use in the Agricultural Sector

Sub-sector	Season	Water Use
Crops: dryland	<ul style="list-style-type: none"> • Successful crop depends on precipitation and optimal soil temperature. • Corn, the prominent dryland crop in South Dakota, is generally planted on a 2-year rotating basis to allow the soil to accumulate enough moisture to support it. • A lack of soil moisture during dry winters can hinder winter wheat growth (September – April). • Spring wheat growing season is April-June. 	<ul style="list-style-type: none"> • Water is required for adequate soil moisture to germinate and grow. • These crops are entirely dependent on precipitation.
Crops: irrigated	<ul style="list-style-type: none"> • Typically May through August 	<ul style="list-style-type: none"> • Irrigation water is used to supplement natural precipitation and ensure the crop has adequate moisture to grow and produce the desired yield.
Livestock	<ul style="list-style-type: none"> • Cattle in South Dakota may graze on pastureland all year long. 	<ul style="list-style-type: none"> • Animals need clean drinking water and plenty of forage land or pasture. Most cattle ranchers grow their own forage, mainly through dryland practices.

This table demonstrates that impacts from drought are not confined to a single growing season. In addition to being a year-round industry, the Agriculture Sector influences a number of other sectors of the economy and state, namely water resources and socioeconomics.

The sub-sector vulnerability discussions primarily focus on impacts from the 2012-2013 drought due to availability of data. Individual droughts may impact specific sectors differently, and 2012-2013 was especially severe for the agricultural sector.

Dryland Crops

Dryland crops are entirely dependent on precipitation and therefore more susceptible to damage by droughts. Dryland crops are particularly vulnerable to severe, “single season” droughts that deplete soil moisture (McKee et al. 2000). The dryland crops subsector was particularly hard-hit by the 2012-2013 drought. Rangeland and pasture conditions steadily deteriorated throughout the summer until over 80% of pasture was rated as poor or very poor.³¹ The loss of quality rangeland and pasture increased feedlot costs, which were already on the rise due to lack of corn

³¹ From Too Much to Too Little: How the central U.S. drought of 2012 evolved out of one of the most devastating floods on record in 2011, NIDIS, pg. 91.

silage as well. Impacts from the 2002 drought were similar; 78% of pastureland was rated poor or very poor in August 2002.³²

The condition of corn in 2012 followed the same trajectory as pastureland. In late spring the corn crop was expected to be the best in five years. Conditions deteriorated rapidly, and over half of the corn crop was rated poor or very poor by the end of August. Yields were especially low in the southeastern and southcentral parts of the State. Much of the corn was unfit for human consumption and was harvested for silage instead. In spite of this, the low yield per acre meant that the additional silage supply was not enough to meet livestock feed demands created by the lack of viable pastureland. The soybean crop suffered similar impacts. Soybean yields were particularly bad in southeast and south central counties. However, yields were excellent in the north central and northeastern counties that received moderate rainfall at a strategic time in the plants' life cycle. Winter wheat actually benefitted from the mild 2011-2012 winter and warm spring. Soil moisture was high enough for winter wheat to thrive, and the warm weather and the spring further encouraged growth. The 2012 winter wheat harvest was also completed earlier than average, which helped spare the crop from the worst weeks of the drought.

Irrigated Crops

Irrigation can help supplement water available for crops when the soil can't hold enough moisture or when precipitation is too low to meet the water levels needed for crops and livestock. In addition to reduced water quantity due to drought conditions, the quality of irrigation water is a concern, as crops are sensitive to salts and other impurities in the water. South Dakota does not have a large amount of irrigated acreage as a percentage of total cropland. Generally the State relies more on seasonal rains than irrigation, which typically comes from groundwater in South Dakota. However, several counties in the State still have tens of thousands of irrigated acres, and understanding the vulnerability to this subsector is worthwhile.

Irrigated crops are primarily vulnerable to lack of water caused by drought. Because groundwater is the main source of irrigation in South Dakota, irrigated crops are somewhat less vulnerable to a lack of precipitation in the short term. However, in a long-term drought irrigated crops will be vulnerable to depletion of groundwater, which is replenished by precipitation. Figure 13 in the Water Resources section shows the breakdown of irrigation water use (groundwater vs. surface water) by county. The counties that rely more heavily on groundwater will be more susceptible to irrigated crop losses.

Historically, the low benefit to cost ratio of irrigation has deterred South Dakota farmers and ranchers. Most of the time the State is able to rely on precipitation for agricultural water needs, so the need for irrigation is low. Irrigation systems can also be expensive to run, especially during a drought when water supplies are scarce. Many irrigation systems in South Dakota were

³² Diersen, Matthew and Gary Taylor. Examining Economic Impact and Recovery in South Dakota from the 2002 Drought. Department of Economics, South Dakota State University, Brookings, South Dakota, pg. 5.

shut down in 2002 for this reason. However, in 2012 there were over 300 irrigation permit applications, indicating that interest in irrigation is increasing among the State's farmers and ranchers. Depending on the exact circumstances of a given drought, irrigation may be an option for farmers and ranchers, but the State will most likely continue to rely on precipitation to meet its agricultural water needs.

Livestock

Vulnerability to the livestock sub-sector is primarily a function of forage, feed, water, and pastureland availability. When the lands are stressed by drought and the quality of hays and grasses for cattle to graze upon is decreased, ranchers can see sickness and deaths in herds. Decreased water quality is also a concern, as grazing cattle can become sickened if watering holes are contaminated, filled with sediment, or completely dry.

Raising cattle for meat depends on having adequate pasture and feed. The herd is turned out to graze in the summer and frequently turned out to pasture in the winter as well. In severe winter weather they may be brought back to barns or feedlots, where they are fed stored hay and grain. The stored feed is either grown by the rancher or purchased from an outside source, either an in-state farmer or an out-of-state one. The need for supplemental feed means that cattle ranchers are also vulnerable to drought impacting the crop sub-sectors.

Even if feed and silage is available, drought can make it unsafe for consumption. When crop growth is stunted, nitrate levels can reach excessively high levels. This is particularly an issue if a drought begins when pollination is occurring. If affected crops are harvested for silage and fed to livestock in large quantities, the animals can experience nitrate toxicity.³³ Grasslands may recover from drought (and the over-grazing that can result) very slowly, giving invasive weeds and other undesirable species the advantage during droughts over native grassland plants.

Other animals that are housed in feedlots or on small farms generally consume hay and grains purchased from both in- and out-of-state growers and water from various sources. These operations can be secondarily affected by drought in that feed may become more expensive or hard to obtain, and their water supply may become reduced or restricted.

Dairy operations can also suffer when droughts drive up the price of feed and deplete water sources. Organic dairy farms must also graze their cows on pasture at least 120 days of the year per USDA regulations; if pastureland is damaged by drought, organic operations may not be able to satisfy this requirement.

One of the major issues with the 2012-2013 drought was the transition from one climate and weather extreme to another; precipitation and snowpack were so high in 2011 that the Missouri

³³ Lester R. Vough, E. Kim Cassel, and Scott M. Barao. "Nitrate Poisoning of Livestock Causes and Prevention." Extension Extra 4015. South Dakota State University Cooperative Extension Service. 2006.

River flooded throughout the summer. Forage was abundant in the State in 2010 and 2011 as a result of the wet conditions, and droughts elsewhere in the country led South Dakota farmers to ship hay out and sell their stores. When the 2012-2013 drought hit, ranchers and farmers had no feed in storage to meet their own needs. Agricultural operations in the East River in particular were not as used to managing droughts as West River farmers. South Dakota partnered with the Farm Service Agency (FSA) to open up Conservation Reserve Program (CRP) hay and distribute it throughout the state.

While hay distributions can solve one problem, the ranchers may still not have enough water for their livestock. This was the case in 2002 and 2006 when a lack of water was a more pressing issue than lack of forage. Ranchers were forced to sell livestock or haul water, which can be expensive. Figure 14 in the Water Resources section shows which counties have the greatest amount of livestock water use.

Factors that Impact Agricultural Vulnerability to Drought

Agricultural vulnerability to drought is influenced by several factors. These factors may not affect all counties in the same way.

Crop Prices

Corn prices in 2012 were already high before the drought reached its peak due to demand for ethanol, the need for livestock feed, and low production across the Corn Belt. South Dakota farmers planted over 300,000 more acres of corn in 2012 than they did in 2011 to meet these demands.³⁴ In spite of the additional corn acreage, the overall yield in 2012 was lower than previous years due to the severity of the drought's impact on corn. Many farmers did not receive a return on their investment in additional corn crops. These financial issues crippled the livestock industry as well. Combined with a lack of pasture and rangeland, the high price of corn drove farmers and ranchers to cull or sell livestock as feeding them became too expensive.

Heat

Extreme heat can greatly exacerbate the impacts of drought. Both crops and livestock need more water to survive in high heat. Plants require water to dissipate heat as part of the transpiration cycle. Most of the water plants absorb is used for transpiration, rather than growth.³⁵ As temperatures increase, plants require more water for transpiration to cool down. However, heat also encourages evaporation of moisture from the soil. The combination of increased evaporation, greater water needs for transpiration, and the lack of precipitation that characterizes a drought causes plants to overheat until they die.

³⁴ Central U.S. Drought Assessment, pg. 87.

³⁵ Womack, Michelle. Understanding heat effects and transpiration. Caller Times, June 17, 2011. <http://www.caller.com/lifestyle/home-and-garden/understanding-heat-effects-and-transpiration>, accessed April 22, 2015.

Livestock's water needs also increase in high heat. Cattle are less effective than other animals at cooling themselves, and their heat load can actually accumulate over time.³⁶ Drinking water is the quickest way for cattle to cool down. Since water is already in low supply during a drought, providing cattle enough water can be challenging. Cattle grazing in pastures are somewhat less susceptible to the effects of high heat than cattle in feedlots, provided they can find shade and water.

Farming Practices

A lack of crop diversification and crop rotation can make South Dakota's farmers more susceptible to drought. Repeated plantings of one crop on the same fields multiple years in a row can deplete nutrients in the soil and encourage growth of weeds and pests that target specific crops. As a result, crop yields may decrease. These fields are weakened and less able to withstand the impacts of drought.

Erosion is an inherent risk of dryland farming due to the practice of leaving a field fallow. When it rains, the soil is able to replenish its moisture content without any crops to soak up the water. However, the lack of crop cover exposes the soil to wind which blows away the topsoil necessary to dryland farming. A field with eroded topsoil and low soil moisture content will be more vulnerable to drought.

Estimating Potential Losses

Percent Dryland Acreage Out of Total Acreage, 2012

Dryland crops are more vulnerable to drought because they are entirely reliant on precipitation. The percentage of dryland acreage out of total acreage was calculated from data obtained from the 2012 USDA Census of Agriculture for South Dakota. Every county in South Dakota has dryland crops, indicating that the entire State is highly vulnerable to fluctuations in precipitation.

Crop Indemnities Due to Drought, 2000-2014

Crop indemnities related to drought were obtained from the Risk Management Agency for 2000 through 2014. It indicates how much insurance each county received for insured crops during those years, specifically for drought-related damages. The payouts for each crop type were summed to obtain a total indemnity payment per county. The collective data from 2000 through 2014, summarized in **Table 10**, provides a framework for potential average annual damages over a 15-year time period.

³⁶ Dewell, Dr. Grant. Heat Stress in Beef Cattle. College of Veterinary Medicine, Iowa State University. August 2010. <http://vetmed.iastate.edu/vdpam/extension/beef/current-events/heat-stress-beef-cattle>, accessed April 17, 2015.

According to the USDA Risk Management Agency, insured crop losses to farmers in the State of South Dakota from 2000 to 2014 as a result of drought conditions totaled \$2,579,569,105. **Table 10** shows crop insurance paid as a result of drought conditions by year for this 15-year time frame. This shows 2012 as the year with the highest crop losses, followed by 2006 and 2002. Note that this data only applies to insured crops. According to the *2014 South Dakota Crop Insurance Profile Report* issued by the USDA Risk Management Agency, 91 percent of South Dakota's crops were insured in 2014. Some crops such as barley, forage, millet, oats, and rye do not have high insurance coverage rates, and there are other crops that are not insurable, such as field hay. As a result, additional non-quantifiable losses likely occurred. Another limitation of this data is the inability to separate irrigated and dryland crops. It is assumed that the RMA data includes both.

Table 10 Drought Related Insured Crop Indemnities by Year, 2000-2014

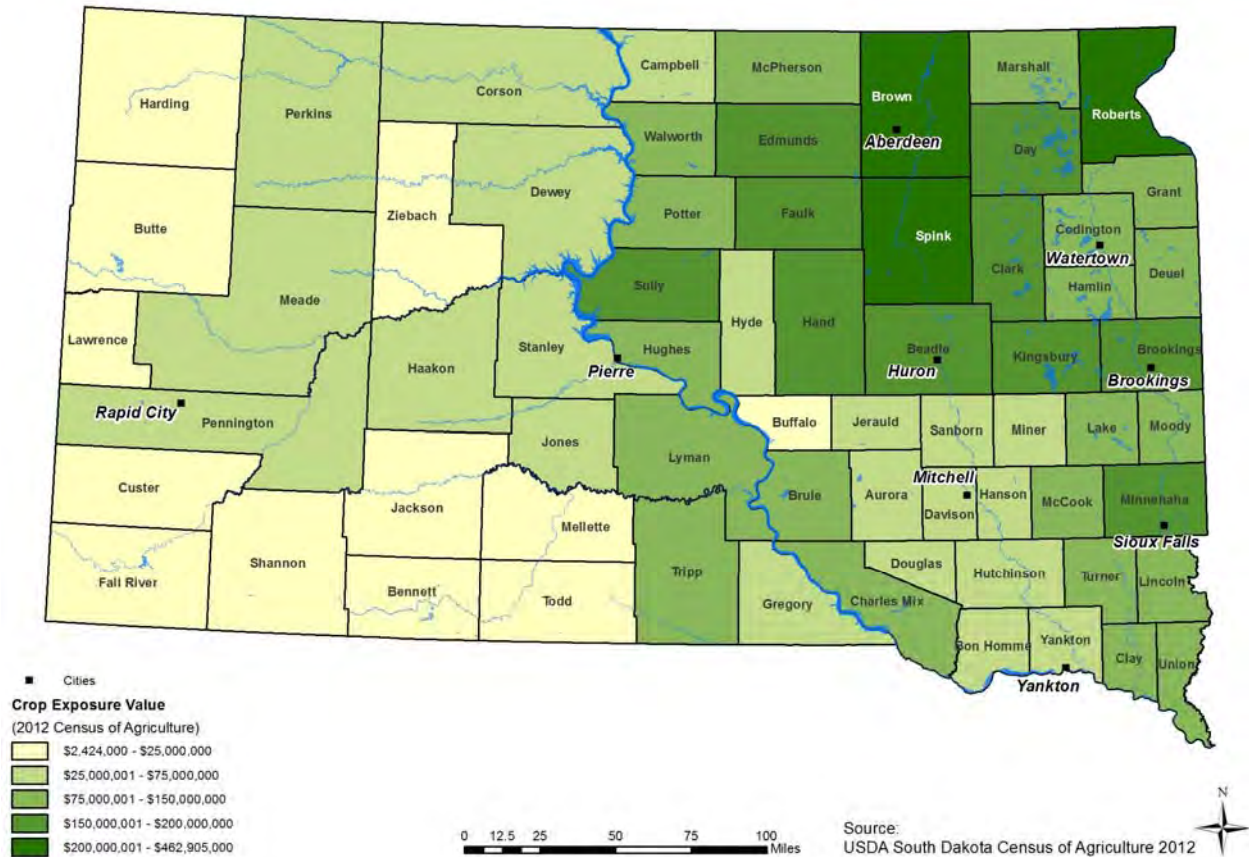
Year	Crop Insurance Paid
2014	\$12,061,217
2013	\$233,296,129
2012	\$972,505,070
2011	\$4,806,272
2010	\$4,988,647
2009	\$11,888,576
2008	\$57,181,952
2007	\$58,271,845
2006	\$417,388,635
2005	\$54,580,926
2004	\$90,983,947
2003	\$139,882,519
2002	\$294,626,257
2001	\$193,745,678
2000	\$33,361,436
Total	\$2,579,569,105

Source: USDA Risk Management Agency, 2015

Typically the most profound impact of drought is to the economy, particularly in South Dakota's agricultural economy. Reduced precipitation may damage crops and reduce the amount of feed available for livestock. Non-irrigated croplands and rangelands are most susceptible to moisture shortages. Irrigated agricultural lands do not feel the effects as quickly, but their yields can also be greatly reduced, particularly if irrigation supplies are rationed. Irrigation is also not widely used in South Dakota. With a market value of over \$10 billion for agricultural products sold,

drought can severely diminish profits for the 31,989 farms and ranches in South Dakota.³⁷ **Figure 41** shows the total market value of crops sold in 2012. The counties with higher values rely more heavily and directly on crops economically. Crop producers can see increased damages and therefore significantly diminished profits caused by drought.

Figure 41. Total Market Value of Crops Sold by County



To determine agricultural areas of the State that are most vulnerable to the impacts of drought, an analysis was completed based on crop exposure as well as the crop loss data based on crop insurance payments. The drought-related crop insurance payments have been extrapolated to estimate damages to insurable crops that are not insured. This is based on the percent of insurable crops that are covered by crop insurance. Ninety-one percent of South Dakota's crops were insured in 2014. The crop exposure value from the 2012 Census of Agriculture is provided as the basis for the development of a loss ratio by county. The loss ratio is the average annualized losses divided by overall crop exposure. The higher the ratio the higher the vulnerability. Average annualized losses were obtained from Risk Management Agency historical crop indemnity data. The 2000-2014 indemnities related to drought were added together and then divided by 15 (for the 15-year time period from 2000 to 2014). Over the past

³⁷ 2012 USDA Census of Agriculture for South Dakota

15 years, insured crop losses in South Dakota due to drought have averaged \$189 million annually.³⁸

Table 11 provides the annualized estimated crop losses by county due to drought. **Figure 42** displays this data in a statewide thematic map. The vulnerability rank is based on the calculated crop damage ratio. **Figure 43** displays this information in a color-coded statewide map. The map indicates a trend of higher vulnerability in the southeastern counties as well as most counties located west of the Missouri River.

Table 11 Crop Vulnerability Analysis to Drought

County Name	Crop Exposure Value (2012 Census of Agriculture)	Drought-Related Crop Insurance Paid (2000-2014)	Crop Damages (extrapolated based on 91% insured in 2014)	Annualized Crop Damages	Crop Damage Ratio (%)	Vulnerability Rank*
Aurora	\$68,196,000	\$60,107,074	\$66,051,730	\$4,403,449	6%	Moderate
Beadle	\$190,063,000	\$92,111,439	\$101,221,362	\$6,748,091	4%	Moderate
Bennett	\$22,270,000	\$17,758,157	\$19,514,458	\$1,300,964	6%	Moderate
Bon Homme	\$41,325,000	\$73,489,666	\$80,757,875	\$5,383,858	13%	Very High
Brookings	\$162,340,000	\$14,051,951	\$15,441,704	\$1,029,447	1%	Low
Brown	\$462,905,000	\$68,329,209	\$75,087,042	\$5,005,803	1%	Low
Brule	\$76,953,000	\$59,487,913	\$65,371,333	\$4,358,089	6%	Moderate
Buffalo	\$22,972,000	\$20,227,215	\$22,227,709	\$1,481,847	6%	Moderate
Butte	\$17,320,000	\$3,737,033	\$4,106,630	\$273,775	2%	Low
Campbell	\$62,126,000	\$28,953,764	\$31,817,323	\$2,121,155	3%	Low
Charles Mix	\$102,917,000	\$111,016,981	\$121,996,682	\$8,133,112	8%	High
Clark	\$159,568,000	\$30,126,654	\$33,106,213	\$2,207,081	1%	Low
Clay	\$79,678,000	\$58,576,644	\$64,369,939	\$4,291,329	5%	Moderate
Codington	\$108,293,000	\$23,376,681	\$25,688,661	\$1,712,577	2%	Low
Corson	\$59,621,000	\$27,898,868	\$30,658,096	\$2,043,873	3%	Low
Custer	\$2,871,000	\$3,257,277	\$3,579,425	\$238,628	8%	High
Davison	\$50,170,000	\$57,768,651	\$63,482,034	\$4,232,136	8%	High
Day	\$158,390,000	\$18,397,556	\$20,217,095	\$1,347,806	1%	Low
Deuel	\$93,232,000	\$10,278,900	\$11,295,495	\$753,033	1%	Low
Dewey	\$29,240,000	\$18,302,602	\$20,112,749	\$1,340,850	5%	Moderate
Douglas	\$41,558,000	\$57,730,389	\$63,439,988	\$4,229,333	10%	Very High
Edmunds	\$186,317,000	\$66,231,491	\$72,781,859	\$4,852,124	3%	Low
Fall River	\$6,474,000	\$8,444,878	\$9,280,086	\$618,672	10%	Very High
Faulk	\$156,409,000	\$48,886,691	\$53,721,639	\$3,581,443	2%	Low
Grant	\$135,881,000	\$18,178,471	\$19,976,341	\$1,331,756	1%	Low
Gregory	\$39,961,000	\$34,859,827	\$38,307,502	\$2,553,833	6%	Moderate
Haakon	\$33,129,000	\$38,890,487	\$42,736,799	\$2,849,120	9%	High
Hamlin	\$124,886,000	\$12,122,384	\$13,321,302	\$888,087	1%	Low
Hand	\$197,905,000	\$60,871,887	\$66,892,183	\$4,459,479	2%	Low
Hanson	\$67,135,000	\$50,813,618	\$55,839,141	\$3,722,609	6%	Moderate

³⁸ 2015 Risk Management Agency data

County Name	Crop Exposure Value (2012 Census of Agriculture)	Drought-Related Crop Insurance Paid (2000-2014)	Crop Damages (extrapolated based on 91% insured in 2014)	Annualized Crop Damages	Crop Damage Ratio (%)	Vulnerability Rank*
Harding	\$17,114,000	\$12,352,443	\$13,574,113	\$904,941	5%	Moderate
Hughes	\$87,163,000	\$51,862,163	\$56,991,388	\$3,799,426	4%	Moderate
Hutchinson	\$71,342,000	\$147,360,051	\$161,934,122	\$10,795,608	15%	Very High
Hyde	\$63,078,000	\$41,078,904	\$45,141,652	\$3,009,443	5%	Moderate
Jackson	\$17,969,000	\$16,808,952	\$18,471,376	\$1,231,425	7%	High
Jerauld	\$62,010,000	\$25,495,565	\$28,017,104	\$1,867,807	3%	Low
Jones	\$40,121,000	\$20,801,602	\$22,858,903	\$1,523,927	4%	Moderate
Kingsbury	\$175,284,000	\$36,624,897	\$40,247,140	\$2,683,143	2%	Low
Lake	\$112,379,000	\$10,578,149	\$11,624,340	\$774,956	1%	Low
Lawrence	\$2,424,000	\$279,496	\$307,138	\$20,476	1%	Low
Lincoln	\$103,441,000	\$79,528,376	\$87,393,820	\$5,826,255	6%	Moderate
Lyman	\$95,031,000	\$59,056,885	\$64,897,676	\$4,326,512	5%	Moderate
Marshall	\$146,118,000	\$14,962,187	\$16,441,964	\$1,096,131	1%	Low
McCook	\$96,689,000	\$65,847,210	\$72,359,572	\$4,823,971	5%	Moderate
McPherson	\$84,627,000	\$38,911,478	\$42,759,866	\$2,850,658	3%	Low
Meade	\$25,425,000	\$26,702,248	\$29,343,130	\$1,956,209	8%	High
Mellette	\$13,929,000	\$7,893,801	\$8,674,507	\$578,300	4%	Moderate
Miner	\$74,947,000	\$27,165,658	\$29,852,371	\$1,990,158	3%	Low
Minnehaha	\$164,228,000	\$39,826,268	\$43,765,130	\$2,917,675	2%	Low
Moody	\$131,252,000	\$8,304,554	\$9,125,884	\$608,392	0%	Low
Pennington	\$29,599,000	\$19,390,759	\$21,308,526	\$1,420,568	5%	Moderate
Perkins	\$43,281,000	\$31,657,712	\$34,788,695	\$2,319,246	5%	Moderate
Potter	\$140,531,000	\$57,310,814	\$62,978,916	\$4,198,594	3%	Low
Roberts	\$200,141,000	\$16,253,489	\$17,860,977	\$1,190,732	1%	Low
Sanborn	\$69,389,000	\$25,796,275	\$28,347,555	\$1,889,837	3%	Low
Shannon	\$8,720,000	\$7,474,476	\$8,213,710	\$547,581	6%	Moderate
Spink	\$334,151,000	\$59,735,881	\$65,643,825	\$4,376,255	1%	Low
Stanley	\$40,815,000	\$42,644,551	\$46,862,143	\$3,124,143	8%	High
Sully	\$186,494,000	\$100,036,938	\$109,930,701	\$7,328,713	4%	Moderate
Todd	\$15,910,000	\$6,432,324	\$7,068,487	\$471,232	3%	Low
Tripp	\$86,671,000	\$46,512,542	\$51,112,684	\$3,407,512	4%	Moderate
Turner	\$100,867,000	\$77,854,625	\$85,554,533	\$5,703,636	6%	Moderate
Union	\$106,501,000	\$46,118,750	\$50,679,945	\$3,378,663	3%	Low
Walworth	\$89,049,000	\$29,051,962	\$31,925,233	\$2,128,349	2%	Low
Yankton	\$56,866,000	\$66,978,827	\$73,603,107	\$4,906,874	9%	High
Ziebach	\$19,261,000	\$20,593,934	\$22,630,696	\$1,508,713	8%	High
Totals	\$6,072,922,000	\$2,579,569,105	\$2,834,691,324	\$188,979,422		

Source: Amec Foster Wheeler based on analysis of data from USDA Risk Management Agency; 2012 USDA Census of Agriculture

* Vulnerability ranking classification based on the following loss ratios: Low (0-3%), Moderate (4-6%), High (7-9%), Very High (10-15%)

Figure 42. Annualized Estimated Crop Economic Losses from Drought, by County 2000-2014

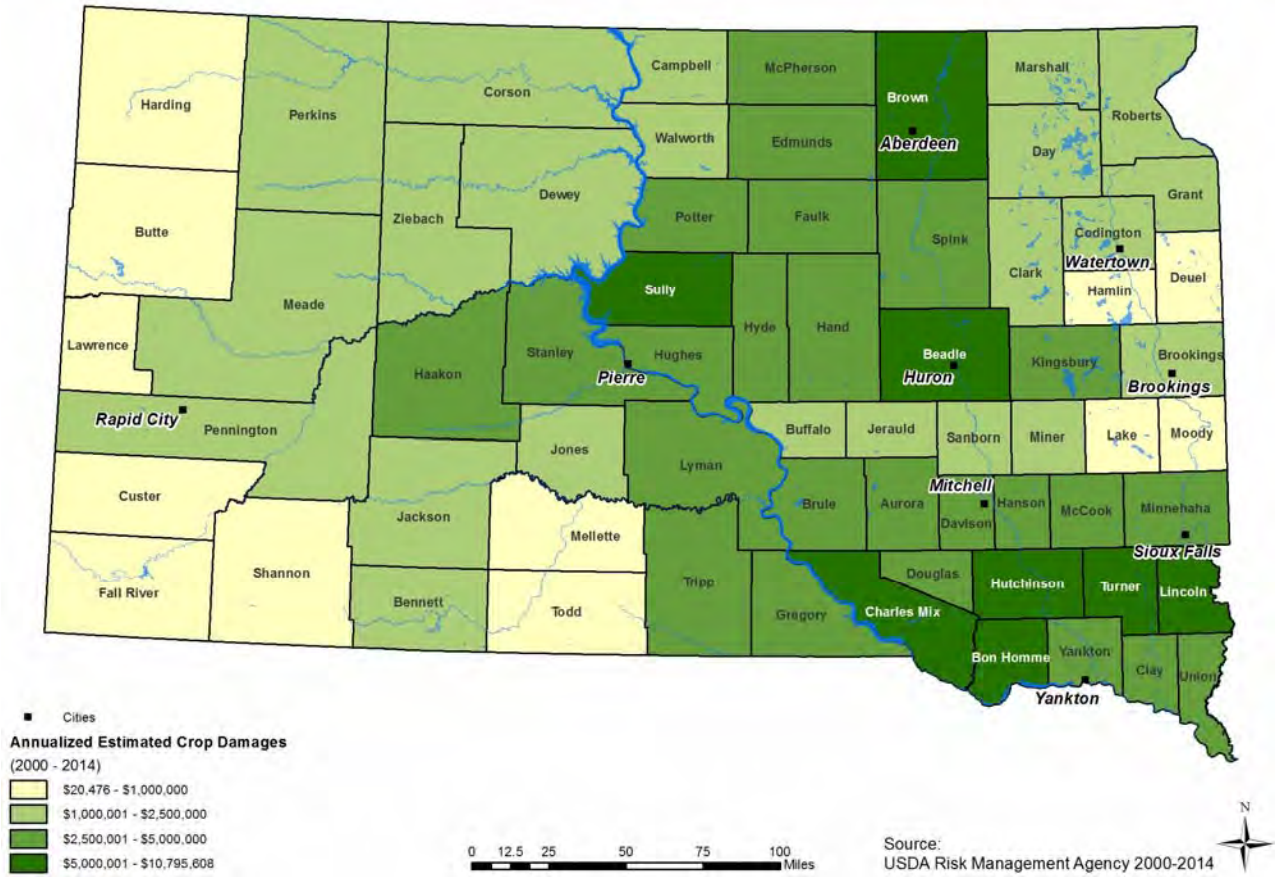
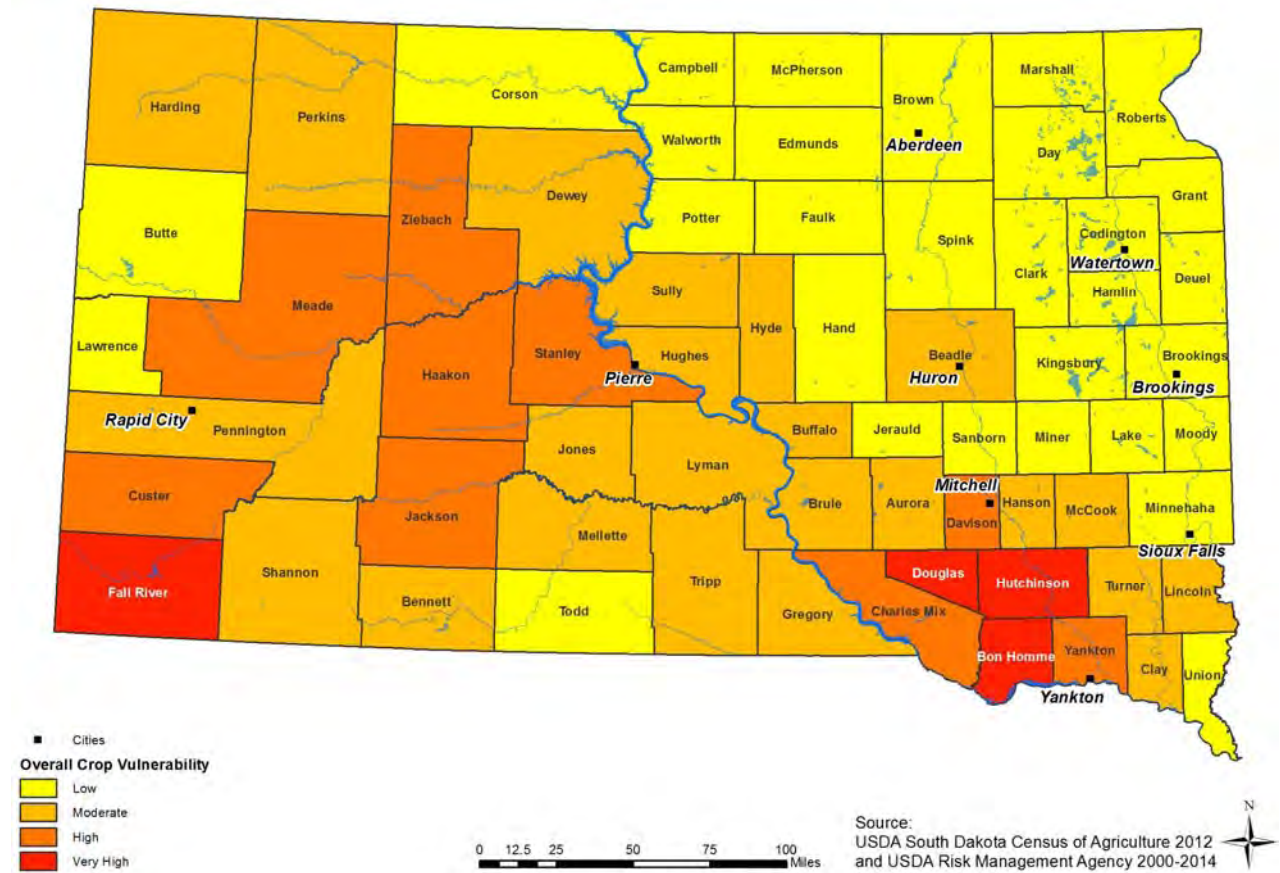


Figure 43. Crop Vulnerability Rank by County - 2000-2014



Crop Subsector Impacts Due to the 2012 Drought

Crop indemnities data for 2012 were separated and analyzed individually to look at how counties were impacted. The 2012 drought was particularly severe for the agricultural sector; thus, it is used to illustrate the potential magnitude of a particularly harsh drought year. According to the *2012 South Dakota Crop Insurance Profile Report* issued by the USDA Risk Management Agency, 82 percent of South Dakota’s crops were insured in 2012. The crop exposure value from the 2012 Census of Agriculture is provided as the basis for a ratio of annualized losses to crop exposure. The vulnerability rank is based on the estimated crop damage ratio.

Table 12 provides the results of this analysis. **Figure 44** illustrates the estimated crop losses by county for 2012. The analysis indicates that the drought was particularly hard on the southeastern counties in the state, an area that typically benefits from highest average annual precipitation. A drought of the same magnitude and extent could cause similar losses unless mitigation measures were implemented. **Figure 45** depicts the spatial distribution of vulnerability ranks across the State.

Table 12 Crop Impact Analysis - 2012 Drought

County Name	Crop Exposure Value (2012 Census of Agriculture)	Drought-Related Crop Insurance Paid (2012)	Estimated Crop Damages (extrapolated based on 82 percent insured in 2012)	Estimated Crop Damage Ratio (%)	Vulnerability Rank*
Aurora	\$68,196,000	\$22,487,488	\$27,423,766	40%	Moderate
Beadle	\$190,063,000	\$22,651,698	\$27,624,022	15%	Low
Bennett	\$22,270,000	\$2,950,855	\$3,598,603	16%	Low
Bon Homme	\$41,325,000	\$56,301,386	\$68,660,227	166%	Very High
Brookings	\$162,340,000	\$5,165,647	\$6,299,570	4%	Low
Brown	\$462,905,000	\$4,898,793	\$5,974,138	1%	Low
Brule	\$76,953,000	\$12,247,681	\$14,936,196	19%	Low
Buffalo	\$22,972,000	\$6,853,531	\$8,357,964	36%	Moderate
Butte	\$17,320,000	\$568,979	\$693,877	4%	Low
Campbell	\$62,126,000	\$1,682,153	\$2,051,406	3%	Low
Charles Mix	\$102,917,000	\$57,673,437	\$70,333,460	68%	High
Clark	\$159,568,000	\$8,418,468	\$10,266,425	6%	Low
Clay	\$79,678,000	\$42,724,148	\$52,102,620	65%	High
Codington	\$108,293,000	\$7,928,684	\$9,669,127	9%	Low
Corson	\$59,621,000	\$4,117,383	\$5,021,199	8%	Low
Custer	\$2,871,000	\$639,062	\$779,344	27%	Moderate
Davison	\$50,170,000	\$30,202,798	\$36,832,681	73%	High
Day	\$158,390,000	\$2,309,734	\$2,816,749	2%	Low
Deuel	\$93,232,000	\$3,513,080	\$4,284,244	5%	Low
Dewey	\$29,240,000	\$1,790,642	\$2,183,710	7%	Low
Douglas	\$41,558,000	\$35,614,040	\$43,431,756	105%	Very High
Edmunds	\$186,317,000	\$3,392,357	\$4,137,021	2%	Low
Fall River	\$6,474,000	\$1,733,280	\$2,113,756	33%	Moderate
Faulk	\$156,409,000	\$3,438,562	\$4,193,369	3%	Low
Grant	\$135,881,000	\$3,225,335	\$3,933,335	3%	Low
Gregory	\$39,961,000	\$15,269,506	\$18,621,348	47%	Moderate
Haakon	\$33,129,000	\$5,376,596	\$6,556,824	20%	Low
Hamlin	\$124,886,000	\$5,754,914	\$7,018,188	6%	Low
Hand	\$197,905,000	\$8,491,045	\$10,354,933	5%	Low
Hanson	\$67,135,000	\$28,949,395	\$35,304,141	53%	High
Harding	\$17,114,000	\$1,844,165	\$2,248,981	13%	Low
Hughes	\$87,163,000	\$6,326,337	\$7,715,045	9%	Low
Hutchinson	\$71,342,000	\$110,221,185	\$134,416,079	188%	Very High
Hyde	\$63,078,000	\$6,185,540	\$7,543,341	12%	Low
Jackson	\$17,969,000	\$1,788,069	\$2,180,572	12%	Low
Jerauld	\$62,010,000	\$5,820,944	\$7,098,713	11%	Low
Jones	\$40,121,000	\$2,830,204	\$3,451,468	9%	Low
Kingsbury	\$175,284,000	\$11,196,898	\$13,654,754	8%	Low
Lake	\$112,379,000	\$4,099,483	\$4,999,370	4%	Low
Lawrence	\$2,424,000	\$83,794	\$102,188	4%	Low
Lincoln	\$103,441,000	\$69,483,031	\$84,735,403	82%	Very High
Lyman	\$95,031,000	\$11,886,312	\$14,495,502	15%	Low
Marshall	\$146,118,000	\$1,355,800	\$1,653,415	1%	Low

County Name	Crop Exposure Value (2012 Census of Agriculture)	Drought-Related Crop Insurance Paid (2012)	Estimated Crop Damages (extrapolated based on 82 percent insured in 2012)	Estimated Crop Damage Ratio (%)	Vulnerability Rank*
McCook	\$96,689,000	\$55,061,780	\$67,148,512	69%	High
McPherson	\$84,627,000	\$4,680,126	\$5,707,470	7%	Low
Meade	\$25,425,000	\$4,752,342	\$5,795,539	23%	Low
Mellette	\$13,929,000	\$1,576,161	\$1,922,147	14%	Low
Miner	\$74,947,000	\$9,130,224	\$11,134,419	15%	Low
Minnehaha	\$164,228,000	\$34,262,035	\$41,782,969	25%	Low
Moody	\$131,252,000	\$3,295,246	\$4,018,593	3%	Low
Pennington	\$29,599,000	\$3,510,029	\$4,280,523	14%	Low
Perkins	\$43,281,000	\$3,412,047	\$4,161,033	10%	Low
Potter	\$140,531,000	\$4,146,112	\$5,056,234	4%	Low
Roberts	\$200,141,000	\$980,815	\$1,196,116	1%	Low
Sanborn	\$69,389,000	\$6,783,953	\$8,273,113	12%	Low
Shannon	\$8,720,000	\$1,340,589	\$1,634,865	19%	Low
Spink	\$334,151,000	\$10,863,591	\$13,248,281	4%	Low
Stanley	\$40,815,000	\$2,123,634	\$2,589,798	6%	Low
Sully	\$186,494,000	\$9,118,654	\$11,120,310	6%	Low
Todd	\$15,910,000	\$1,752,287	\$2,136,935	13%	Low
Tripp	\$86,671,000	\$17,197,692	\$20,972,795	24%	Low
Turner	\$100,867,000	\$67,293,325	\$82,065,030	81%	Very High
Union	\$106,501,000	\$35,673,249	\$43,503,962	41%	Moderate
Walworth	\$89,049,000	\$827,851	\$1,009,574	1%	Low
Yankton	\$56,866,000	\$53,312,537	\$65,015,289	114%	Very High
Ziebach	\$19,261,000	\$1,918,351	\$2,339,453	12%	Low
Totals	\$6,072,922,000	\$972,505,070	\$1,185,981,792		

Source: Amec Foster Wheeler based on analysis of data from USDA Risk Management Agency; 2012 USDA Census of Agriculture

* Vulnerability ranking classification based on the following loss ratios: Low (0-25%), Moderate (26-50%), High (51-75%), Very High (76-100%)

Figure 44. Estimated Crop Economic Losses from 2012 Drought by County

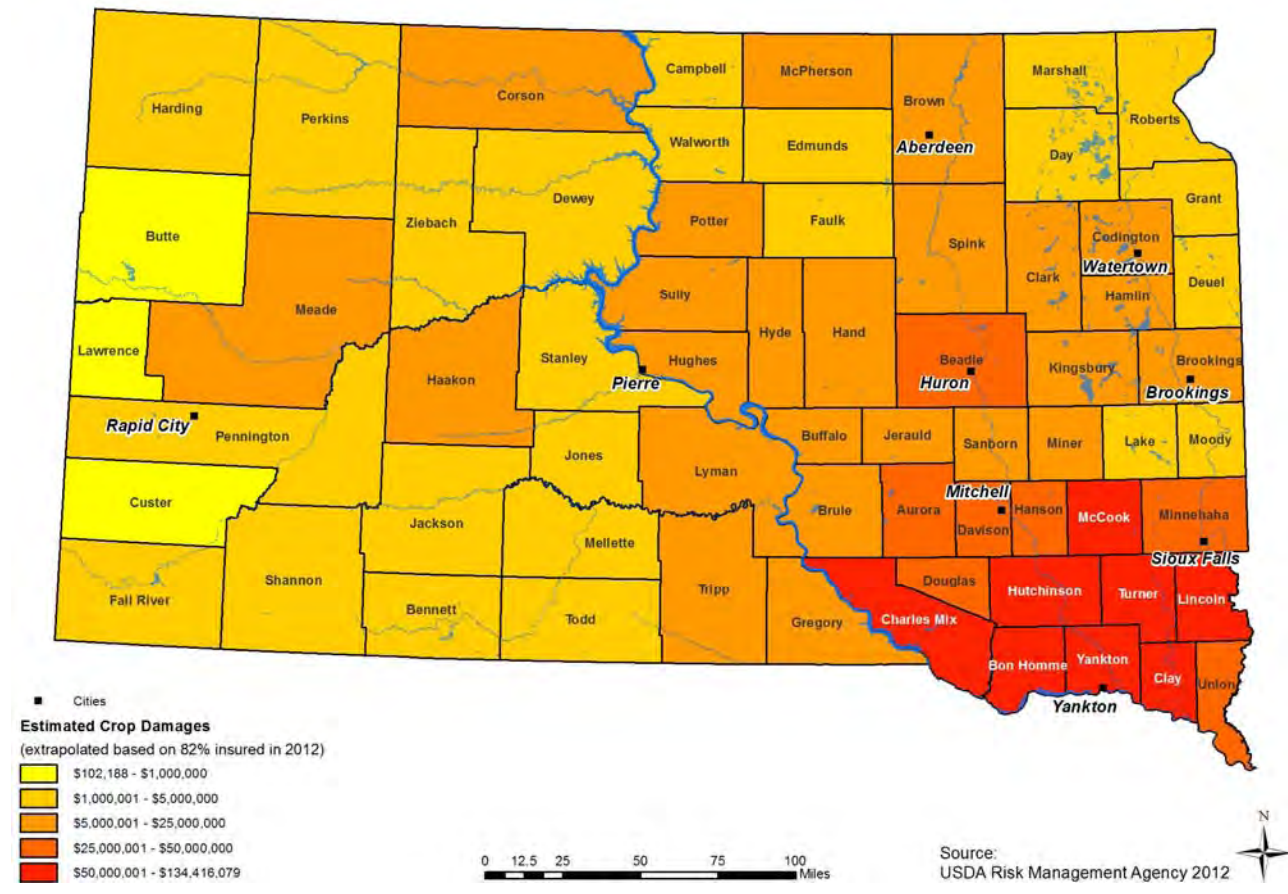
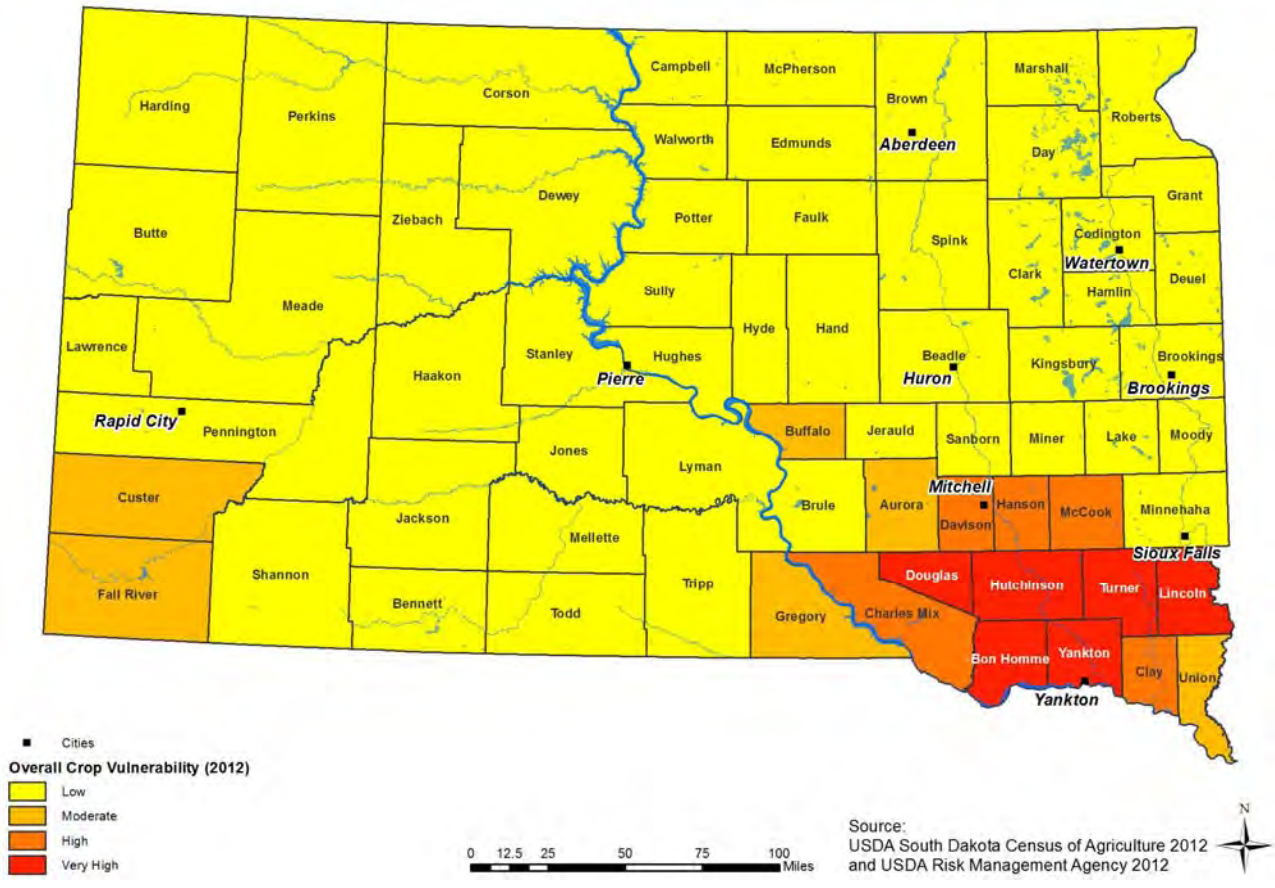


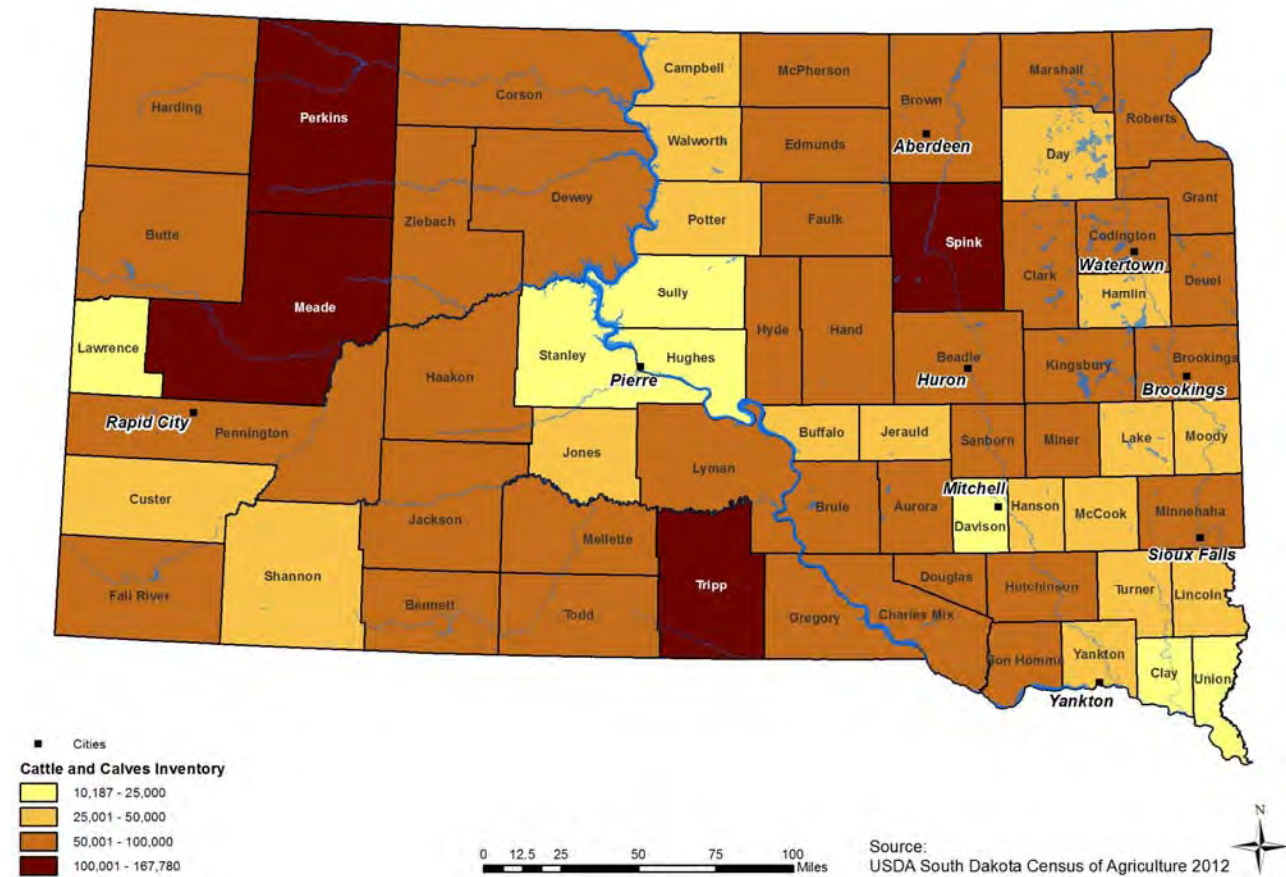
Figure 45. Overall Crop Vulnerability Rank by County – 2012 Drought



Cattle and Calf Head County per County

Counties with higher cattle head counts may be more economically dependent on the local livestock industry and therefore more vulnerable to droughts. The map shown in **Figure 46** illustrates the head count of total cattle per county, including dairy cattle.

Figure 46. Cattle and Calf Head Count per County



Disaster Assistance Outlays for Livestock Losses

Data on FSA disaster assistance program payments were obtained to develop a loss estimate for the livestock subsector. The Livestock Forage Program (LFP) is the only FSA disaster assistance program specific to drought; thus, data from the other programs is not included in this analysis. Since the 2008 Farm Bill, the LFP has been directly tied to the U.S. Drought Monitor drought severity levels, and duration within each severity level.

Table 13 summarizes the FSA’s disaster assistance outlays to South Dakota between 2012 and, 2013, or 2014. South Dakota’s outlays for the 2012 LFP are particularly large at over \$160 million. The LFP “provides compensation to eligible livestock producers that have suffered grazing losses due to drought or fire on land that is native or improved pastureland with permanent vegetative cover or that is planted specifically for grazing.”³⁹ The next highest outlay is the 2013 LFP at \$92 million. These numbers indicate that lack of forage and pastureland for grazing was one of the most costly impacts to the South Dakota livestock industry during the

³⁹ USDA FSA Disaster Assistance Program, <http://www.fsa.usda.gov/programs-and-services/disaster-assistance-program/index>, accessed April 21, 2015.

2012-2013 drought. This issue was exacerbated by South Dakota's sale of surplus feed to other states in 2010 and 2011.

Table 13 Outlays for FSA Disaster Assistance Programs for Livestock in South Dakota - 2012-2013

Program	Outlay Count	Outlay Amount
2012 Livestock Forage Program	12,509	\$162,141,935
2013 Livestock Forage Program	6,426	\$92,028,844

Source: FSA

To determine which areas of the State are most vulnerable to drought impacts on the livestock industry, an analysis was completed based on livestock exposure as well as the LFP outlays from 2012 and 2013. The livestock exposure value from the 2012 Census of Agriculture is provided as the basis for a loss ratio. **Figure 47** shows the total market value of livestock sold in 2012. The counties with higher values rely more heavily and directly on livestock economically. Ranchers and farmers with livestock can see increased damages and therefore significantly diminished profits caused by drought. A vulnerability rank for each county was derived from the ratio of the estimated livestock damage (2012-2013 LFP outlays) to the overall livestock exposure ratio.

Table 14 provides the estimated livestock losses by county for 2012 and 2013 combined.

Figure 48 displays this data in a statewide thematic map. The results of the analysis indicate the greatest impacts and highest loss ratios in the counties west of the Missouri River. Similar losses can be expected in a drought that is similar in magnitude and extent to the 2012-2013 drought. However, as discussed in the previous events section, there is a natural cycle of wet conditions followed by dry conditions. Additionally, the magnitude and extent of dry periods can vary. Average annualized losses specific to drought for livestock were not readily available, thus this analysis represents the impacts of a specific drought as an indicator of vulnerability. Thus this analysis is limited in determining accurate future loss estimates due to the many variables involved.

Figure 47. Total Market Value of Livestock Sold by County in 2012

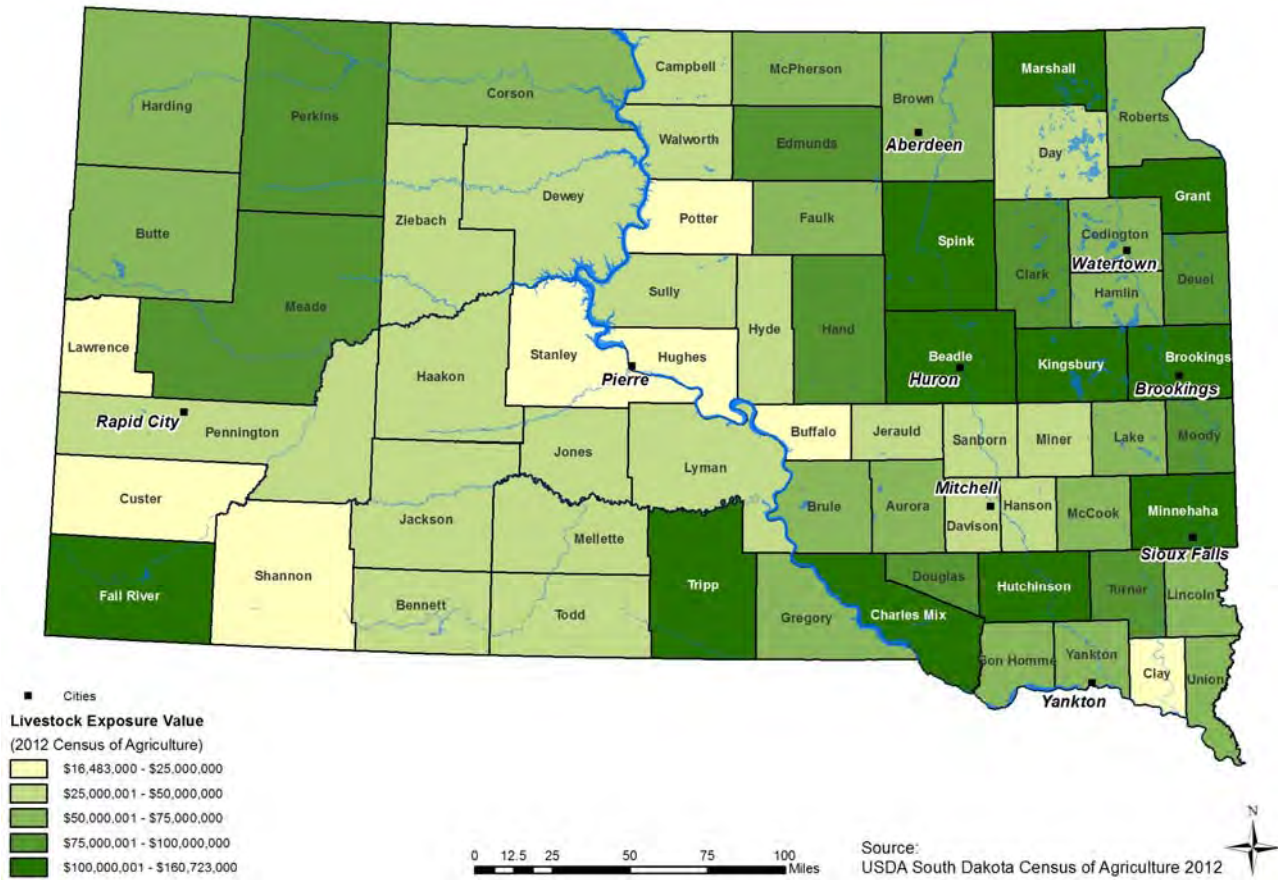


Table 14 Livestock Impact Analysis to 2012-2013 Drought

County Name	Livestock Exposure Value (2012 Census of Agriculture)	FSA Outlays (Total: 2012-2013)	Estimated Livestock Damage Ratio (%)	Vulnerability Rank*
Aurora	\$59,060,000	\$2,404,353	4%	Low
Beadle	\$110,094,000	\$921,117	1%	Low
Bennett	\$39,882,000	\$5,530,433	14%	High
Bon Homme	\$66,534,000	\$2,728,148	4%	Low
Brookings	\$150,193,000	\$1,003,045	1%	Low
Brown	\$57,734,000	\$6,573	0%	Low
Brule	\$73,928,000	\$4,010,129	5%	Low
Buffalo	\$22,678,000	\$1,649,169	7%	Moderate
Butte	\$58,030,000	\$8,189,553	14%	High
Campbell	\$36,756,000	\$0	0%	Low
Charles Mix	\$124,990,000	\$6,217,975	5%	Low
Clark	\$89,807,000	\$42,778	0%	Low
Clay	\$17,149,000	\$615,758	4%	Low
Codington	\$64,118,000	\$1,020,402	2%	Low
Corson	\$57,464,000	\$5,331,749	9%	Moderate
Custer	\$23,143,000	\$3,547,868	15%	High
Davison	\$28,618,000	\$1,098,005	4%	Low
Day	\$31,336,000	\$310,416	1%	Low
Deuel	\$84,521,000	\$1,541,046	2%	Low
Dewey	\$40,026,000	\$11,441,408	29%	Very High
Douglas	\$75,913,000	\$1,147,043	2%	Low
Edmunds	\$85,082,000	\$25,306	0%	Low
Fall River	\$110,384,000	\$10,231,552	9%	Moderate
Faulk	\$59,919,000	\$535,846	1%	Low
Grant	\$104,938,000	\$1,474,589	1%	Low
Gregory	\$54,176,000	\$10,840,703	20%	Very High
Haakon	\$43,989,000	\$12,933,180	29%	Very High
Hamlin	\$63,340,000	\$489,573	1%	Low
Hand	\$86,532,000	\$4,762,981	6%	Moderate
Hanson	\$43,515,000	\$771,457	2%	Low
Harding	\$53,293,000	\$5,529,579	10%	Moderate
Hughes	\$20,178,000	\$1,932,387	10%	Moderate
Hutchinson	\$114,903,000	\$1,988,545	2%	Low
Hyde	\$31,254,000	\$3,403,682	11%	High
Jackson	\$33,943,000	\$9,922,041	29%	Very High
Jerauld	\$37,296,000	\$2,506,747	7%	Moderate
Jones	\$25,130,000	\$5,535,290	22%	Very High
Kingsbury	\$102,976,000	\$1,270,212	1%	Low
Lake	\$56,455,000	\$894,968	2%	Low
Lawrence	\$16,628,000	\$710,520	4%	Low
Lincoln	\$68,824,000	\$329,241	0%	Low
Lyman	\$41,727,000	\$5,868,796	14%	High
Marshall	\$160,723,000	\$90,912	0%	Low
McCook	\$60,276,000	\$841,563	1%	Low
McPherson	\$74,741,000	\$437	0%	Low
Meade	\$91,018,000	\$20,520,999	23%	Very High
Mellette	\$32,282,000	\$8,480,793	26%	Very High
Miner	\$48,748,000	\$1,883,273	4%	Low
Minnehaha	\$106,020,000	\$767,700	1%	Low
Moody	\$83,719,000	\$816,928	1%	Low
Pennington	\$36,148,000	\$9,567,611	26%	Very High

County Name	Livestock Exposure Value (2012 Census of Agriculture)	FSA Outlays (Total: 2012-2013)	Estimated Livestock Damage Ratio (%)	Vulnerability Rank*
Perkins	\$81,738,000	\$11,308,515	14%	High
Potter	\$16,483,000	\$2,533,598	15%	High
Roberts	\$51,030,000	\$19,341	0%	Low
Sanborn	\$49,362,000	\$2,375,034	5%	Low
Shannon	\$23,567,000	\$8,166,643	35%	Very High
Spink	\$113,439,000	\$118,914	0%	Low
Stanley	\$23,215,000	\$5,026,742	22%	Very High
Sully	\$39,085,000	\$2,465,152	6%	Moderate
Todd	\$43,751,000	\$7,048,351	16%	Very High
Tripp	\$142,354,000	\$17,027,067	12%	High
Turner	\$81,315,000	\$1,305,243	2%	Low
Union	\$51,944,000	\$724,794	1%	Low
Walworth	\$28,789,000	\$450,329	2%	Low
Yankton	\$60,560,000	\$2,237,462	4%	Low
Ziebach	\$30,539,000	\$9,679,216	32%	Very High
Totals	\$4,097,302,000	\$254,170,780		

Source: Amec Foster Wheeler based on analysis of data from the FSA and 2012 USDA Census of Agriculture for South Dakota

* Vulnerability ranking classification based on the following loss ratios: Low (0-5%), Moderate (6-10%), High (11-15%) Very High (16-35%)

Figure 48. Estimated Livestock Economic Losses from 2012-2013 Drought by County

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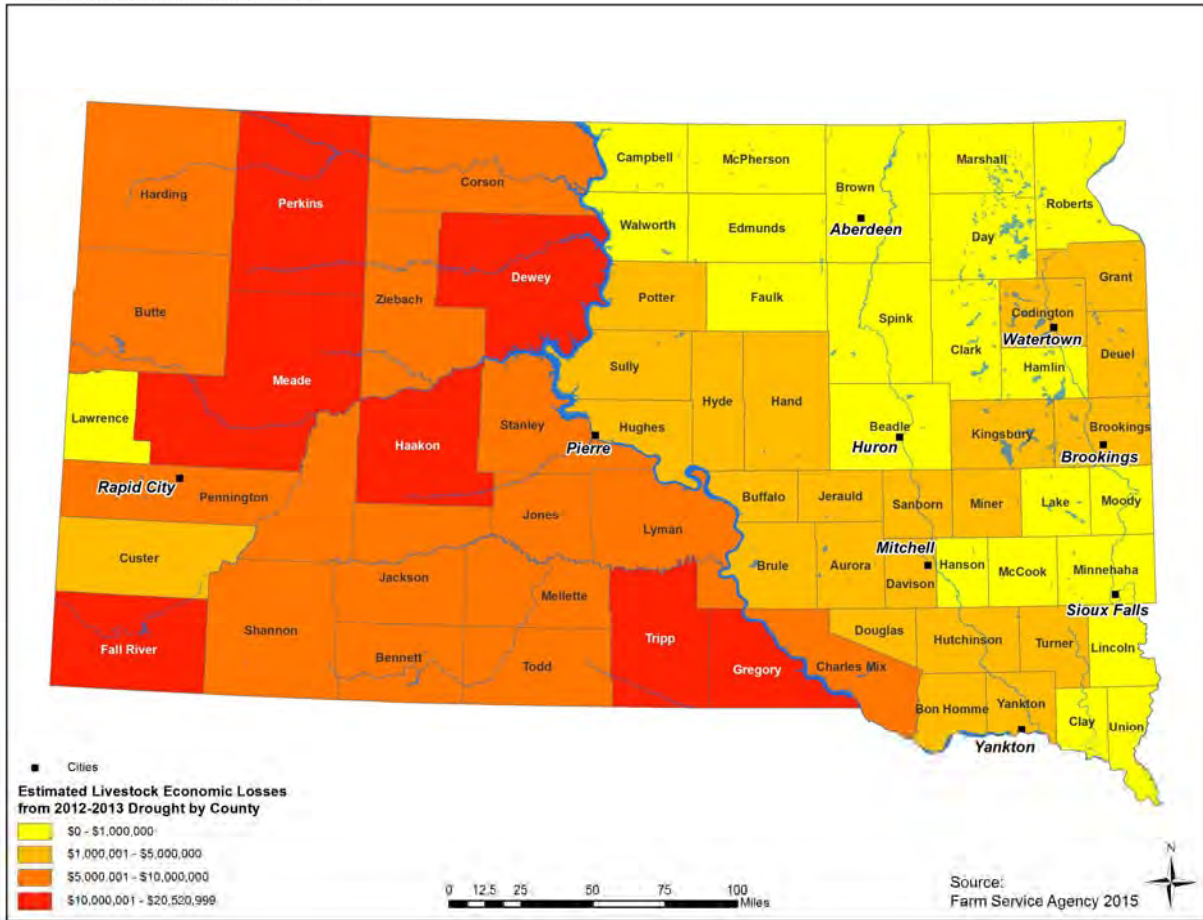
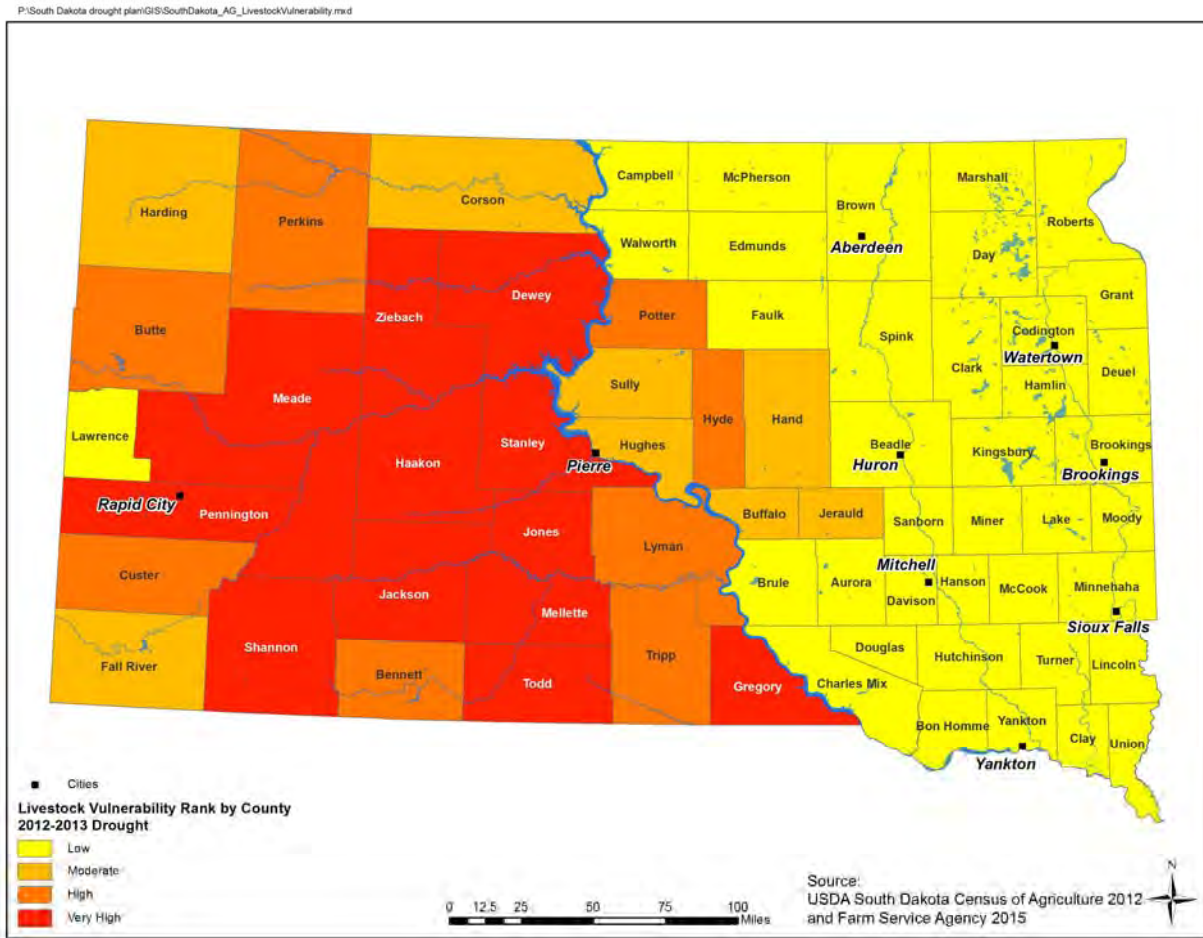


Figure 49. Livestock Vulnerability Rank by County – 2012-2013 Drought



Summary of Economic Impacts

Based on the previous analysis over the past 15 years, insured crop losses in South Dakota due to drought have averaged \$189 million annually. Livestock impacts were estimated at \$162 million for the 2012 drought and \$92 million in the 2013 drought. The economic impacts of drought on agriculture as a major component of South Dakota’s economy is discussed in more detail in the Health/Socioeconomic Sector.

3.6.3 Summary of Identified Vulnerabilities and Adaptive Capacities

Table 15 summarizes the vulnerabilities and existing adaptive capacities associated with the agricultural sector. New adaptive capacities that have been identified through this planning process are also included.

Table 15 Summary of Vulnerabilities and Adaptive Capacities

Agriculture Subsector	Identified Vulnerabilities	Adaptive Capacities	
		Existing or Implemented in the Past	Potential Options for Consideration
Dryland Crops	<ul style="list-style-type: none"> • Dependence on precipitation • Vulnerability to erosion • Farming practices (e.g. repeatedly planting one crop on a field multiple years in a row) 	<ul style="list-style-type: none"> • Crop insurance • Using supplemental irrigation • Crop rotation and best management practices • Create riparian pasture areas through the Game, Fish, and Parks Riparian Pasture Program • Federal disaster assistance programs through the Farm Service Agency <ul style="list-style-type: none"> ○ Noninsured Crop Disaster Assistance Program ○ Tree Assistance Program ○ Emergency Loan Program ○ Disaster Set-Aside Program ○ Emergency Conservation Program 	<ul style="list-style-type: none"> • Using annual crops for forage to supplement perennial forages • Graze winter pastures briefly in early spring to stimulate grass growth • Eliminate or reduce unnecessary tillage • Create windbreaks, or spread straw or mulch over the ground • Diversify agricultural operations to include more drought tolerant crops
Irrigated Crops	<ul style="list-style-type: none"> • Not widely used • Expensive/not cost effective • Dependence on water source • Water quality issues 	<ul style="list-style-type: none"> • Crop insurance • Crop rotation • Federal disaster assistance programs through the Farm Service Agency <ul style="list-style-type: none"> ○ Noninsured Crop Disaster Assistance Program ○ Tree Assistance Program ○ Emergency Loan Program ○ Disaster Set-Aside Program ○ Emergency Conservation Program 	<ul style="list-style-type: none"> • Use subsurface drip irrigation rather than pivot irrigation • Eliminate unnecessary tillage • Diversify agricultural operations to include more drought tolerant crops
Livestock	<ul style="list-style-type: none"> • Feed supplies tied to crop subsector vulnerability • Poor pastureland quality • Depleted water supplies 	<ul style="list-style-type: none"> • Rural water systems to supplement water supplies for livestock • Rotate feeding areas to improve forage utilization during droughts • Federal disaster assistance programs through the Farm Service Agency <ul style="list-style-type: none"> ○ Livestock Forage Disaster Program ○ Livestock Indemnity Program ○ Emergency Assistance for Livestock, Honeybees, and Farm-Raised Fish (ELAP) 	<ul style="list-style-type: none"> • Reduce stocking rate on pastures and rangeland during droughts. Continue reduced stocking measures for at least one year after the drought ends. • Breed drought/high heat-tolerant cattle⁴⁰

⁴⁰ Paschal, Joe C. Breeding Drought (Heat) Tolerant Cattle. American Marketing Services. February 11, 2013. <http://www.amscattle.com/2013/02/breeding-drought-heat-tolerant-cattle/>, accessed April 21, 2015.

3.6.4 Recommendations

Framework for Future Drought Vulnerability Studies

A region's vulnerability to drought varies based on the drought resiliency of the agricultural assets located within the region. For instance, the West River is generally more susceptible to severe drought impacts to livestock than the East River. Additional studies and data collection are necessary to further characterize and, where possible, quantify drought vulnerability in different regions of the State. This section presents a framework for how future regional and State drought vulnerability studies may be conducted to further qualitatively characterize and quantify the vulnerability of the agricultural sector to drought.

A more refined vulnerability framework could consist of the following three steps.

- Step 1 - Identify key indicators or assets that may be used to represent the sensitivity of agriculture to drought within a region. These key indicators would have a significant economic impact on the region, both in terms of market value and employment.
- Step 2 – Collect data necessary to characterize the key indicator under baseline and drought conditions.
- Step 3 – Develop metrics that are indicative of drought severity based on Step #1 and Step #2. For example, a metric could be the area of cropland dedicated to dryland corn in the region. This metric could then be further assigned a weighting factor such as the number of farms or acres that employ crop rotation to restore nutrients to the soil. These metrics may then be summed to develop a single drought index for a particular region.

Data collection is critical to the methodology outlined above. The following table identifies the types of data that can be useful for a drought vulnerability assessment and identifies potential data gaps.

Table 16 Data Collection for Enhancing Vulnerability Assessment

Agriculture Subsector	Data	Notes on Data Availability
Dryland Crops	<ul style="list-style-type: none"> • RMA indemnity data specific to dryland crops • Crop insurance statistics (e.g. percent insured) • Comparison of crop yield per acre between farms that use crop rotation and farms that don't rotate crops • Soil moisture data 	RMA indemnity data readily available
Irrigated Crops	<ul style="list-style-type: none"> • RMA indemnity data specific to irrigated crops • Comparison of crop yield per acre between irrigated farms and dryland farms • Irrigation permit tracking • Compare production cost of irrigated crops to sales to determine benefit vs. cost 	RMA indemnity data readily available
Livestock	<ul style="list-style-type: none"> • Cattle and calf death loss counts related to drought • Livestock weight at time of sale compared to non-drought years • Number of ranches tied into rural water systems 	FSA data has limitations and does not allow tracking loss from drought vs other hazards

Recommended Next Steps

Many of the existing and suggested adaptive capacities listed in **Table 15** and the data needs listed in **Table 7** require a combination of data collection efforts, regional studies, or further consideration/feasibility analysis. Recommendations for additional follow up activities are provided below. These activities will improve the State’s ability to understand the relationship between agriculture and drought and identify adaptive capacities that more effectively address adverse drought impacts.

- Follow-through on next steps identified in the Central U.S. Drought Assessment (2012) report, including:
 - Gathering evapotranspiration data
 - Soil moisture monitoring
 - Local impact reporting
- Encourage farmers and ranchers to create their own drought management plans and share lessons learned/best practices among themselves.
- Maintain or enhance existing adaptive capacity activities noted in **0**; consider additional adaptive capacity alternatives noted and develop related mitigation action strategies.
- Continue to promote and maintain high levels of crop insurance to mitigate economic impacts.
- Continue producing agricultural economic contribution studies at regular intervals to track the impact of drought on the State’s agriculture economy.

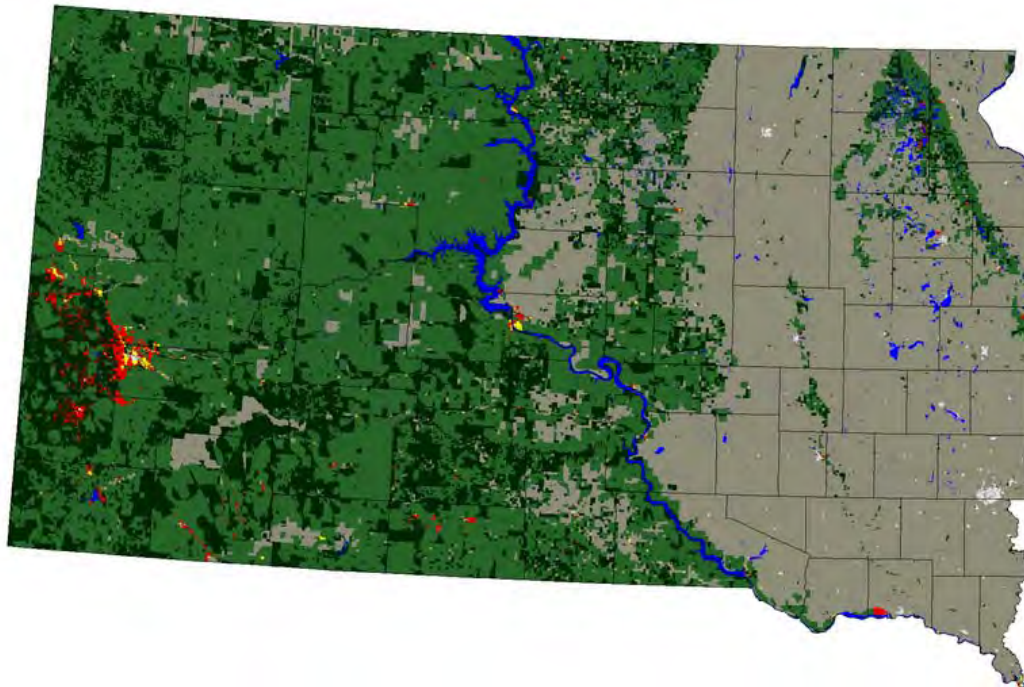
3.7 Wildfire Sector

3.7.1 Introduction

Wildfire is a common secondary impact of drought in South Dakota. Drought alone is not enough to cause wildfires, but does increase wildfire potential, magnitude, and duration. The State's semi-arid climate, highly flammable native vegetation, rugged terrain, and populated wildland-urban interface also contribute to its wildfire hazard. Although wildfires occur throughout the state, the grass and forestland areas west of the Missouri River represent the area most prone to large wildfires. This area remains vulnerable due to the large areas of continuous fuels and the extreme burning conditions that can occur in the area.

Figure 50 illustrates South Dakota's wildland-urban interface (WUI) using 2010 U.S. Census data. The WUI, as illustrated in this figure from the SILVIS Lab at the University of Wisconsin–Madison, is composed of both interface and intermix communities. In both interface and intermix communities, housing must meet or exceed a minimum density of one structure per 40 acres. Intermix communities are places where housing and vegetation intermingle. In intermix, wildland vegetation is continuous, more than 50 percent vegetation, in areas with more than 1 house per 40 acres. Interface communities are areas with housing in the vicinity of contiguous vegetation. Interface areas have more than 1 house per 40 acres, have less than 50 percent vegetation, and are within 1.5 miles of an area (made up of one or more contiguous Census blocks) over 1,325 acres that is more than 75 percent vegetated. The minimum size limit ensures that areas surrounding small urban parks are not classified as interface WUI.

Figure 50. South Dakota's Wildland-Urban Interface



South Dakota

2010 Wildland Urban Interface

WUI

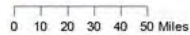
- Interface
- Intermix

Non-WUI Vegetated

- No Housing
- Very Low Density Housing

Non-Vegetated or Agriculture

- Medium and High Density Housing
- Low and Very Low Housing Density
- Water



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WUI 2010 based on the 2010 Census,
 2006 National Land Cover Database (NLCD),
 and the Protected Areas Database version 1.1



Source: SILVIS Lab, Forest Ecology and Management, University of Wisconsin–Madison, 2012

Wildfires can occur year-round in parts of South Dakota, though most fires occur between late spring and fall. The Sioux Falls NWS weather forecast office issues fire danger statements and maps for Rangeland Fire Danger and Red Flag Warnings every day from April 1st to October 31st of each year. Statements and maps are issued as needed during the winter.

The Drought Task Force identified two subsectors under wildfire:

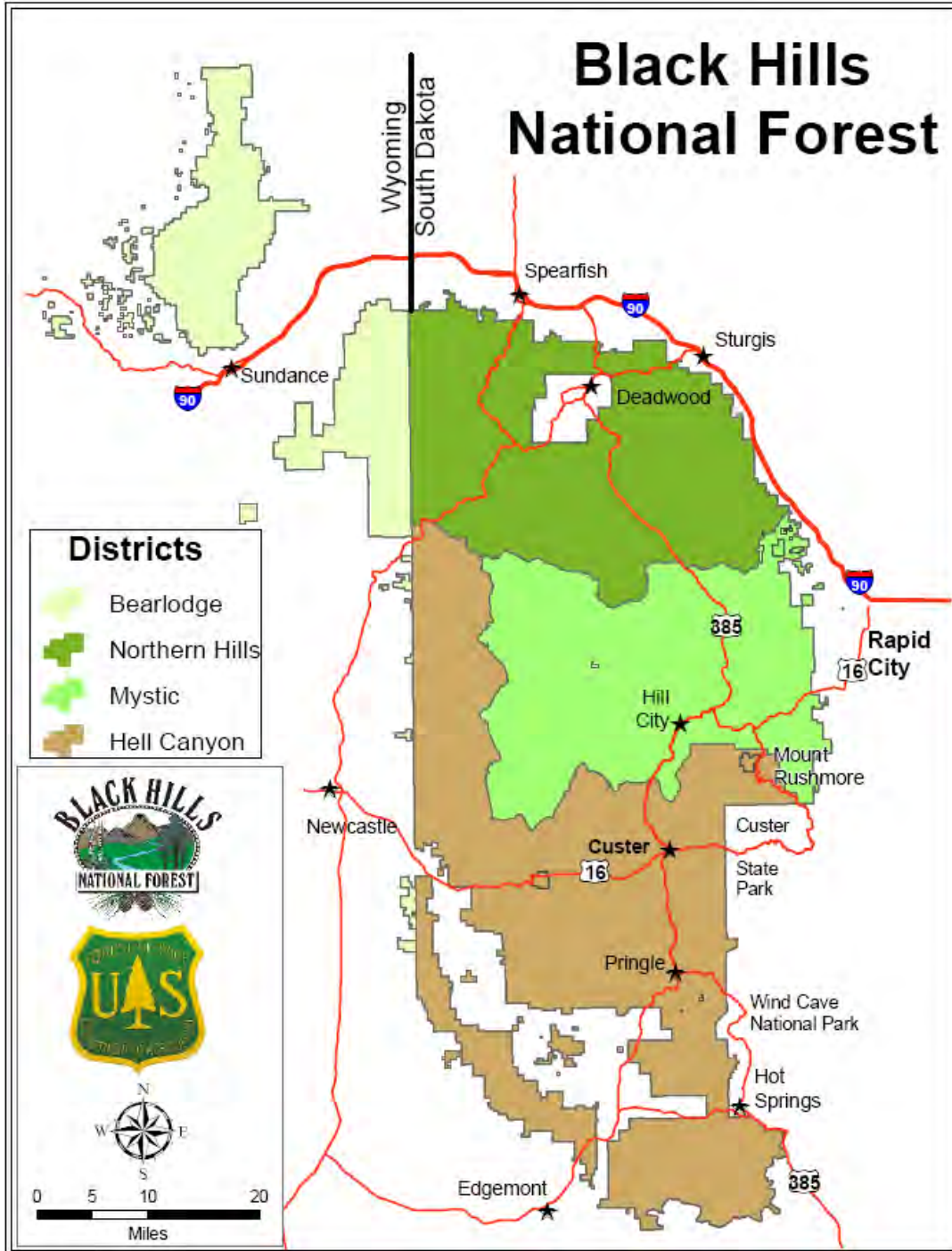
- Forest fires
- Rangeland fires

Forest Fires

Forest fires are distinguished from rangeland fires by the type of vegetation affected. Most of South Dakota’s forest land is made up of coniferous forests located in the Black Hills. The Black Hills National Forest encompasses 1,534,471 acres of land in South Dakota and Wyoming (see Figure 51). Over one million acres of the forest are exclusively in South Dakota (Custer,

Fall River, Lawrence, Meade, and Pennington counties). Of the one million acres, about 80 percent is federally controlled. The remaining 20 percent is controlled by the state and private citizens.

Figure 51. Map of Black Hills National Forest with District Boundaries



Source: U.S. Forest Service, http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5228288.pdf

In addition to the Black Hills National Forest, there are fire-prone smaller forested areas on the Custer National Forest in Harding County, and BIA Trust and tribal lands on the Pine Ridge Reservation of Shannon County (unorganized), and the Rosebud reservation of Todd County (also unorganized). These three counties are in western South Dakota.

The Black Hills area has the highest potential for loss of lives and personal property from wildfire. After years of fire suppression, the landscape of the Black Hills has become a dense forest. High fuel loads, years of drought, and mountain pine beetle infestation have combined to make the area particularly susceptible to wildfire. Between 2000 and 2002, 10 percent of the Black Hills National Forest burned.⁴¹ Other forest types in South Dakota include upland hardwood and bottomland. These forests cover a smaller area of the State compared to coniferous forests, though historical data from the South Dakota Department of Agriculture indicates that wildfires have occurred in these forests.

Rangeland Fires

Rangeland fires occur in areas dominated by grasses rather than large trees. Most of South Dakota's rangeland is located in the western half of the State where pastures are more common than row crops. Drought affects rangeland and grasses in much the same way as forests, drying out vegetation and increasing susceptibility to fire. It is important to note that rangeland fires can occur at any time, and not just when grasses are completely dehydrated. However, a fire may start more easily and spread more quickly in dry conditions.

Another type of fire not covered in this report but worth mentioning is agricultural burning. Agricultural burning is usually done as a land management technique, rather than being a wildfire issue. The State takes note of these fires but doesn't track them along with rangeland and forest fires.

3.7.2 Vulnerability

The following sections discuss aspects of vulnerability to drought in the Wildfire Sector, and cover adaptive capacities used to mitigate the impacts. Metrics used to measure drought conditions and wildfire potential are also discussed, along with historical data to illustrate how previous droughts have impacted wildfire vulnerability.

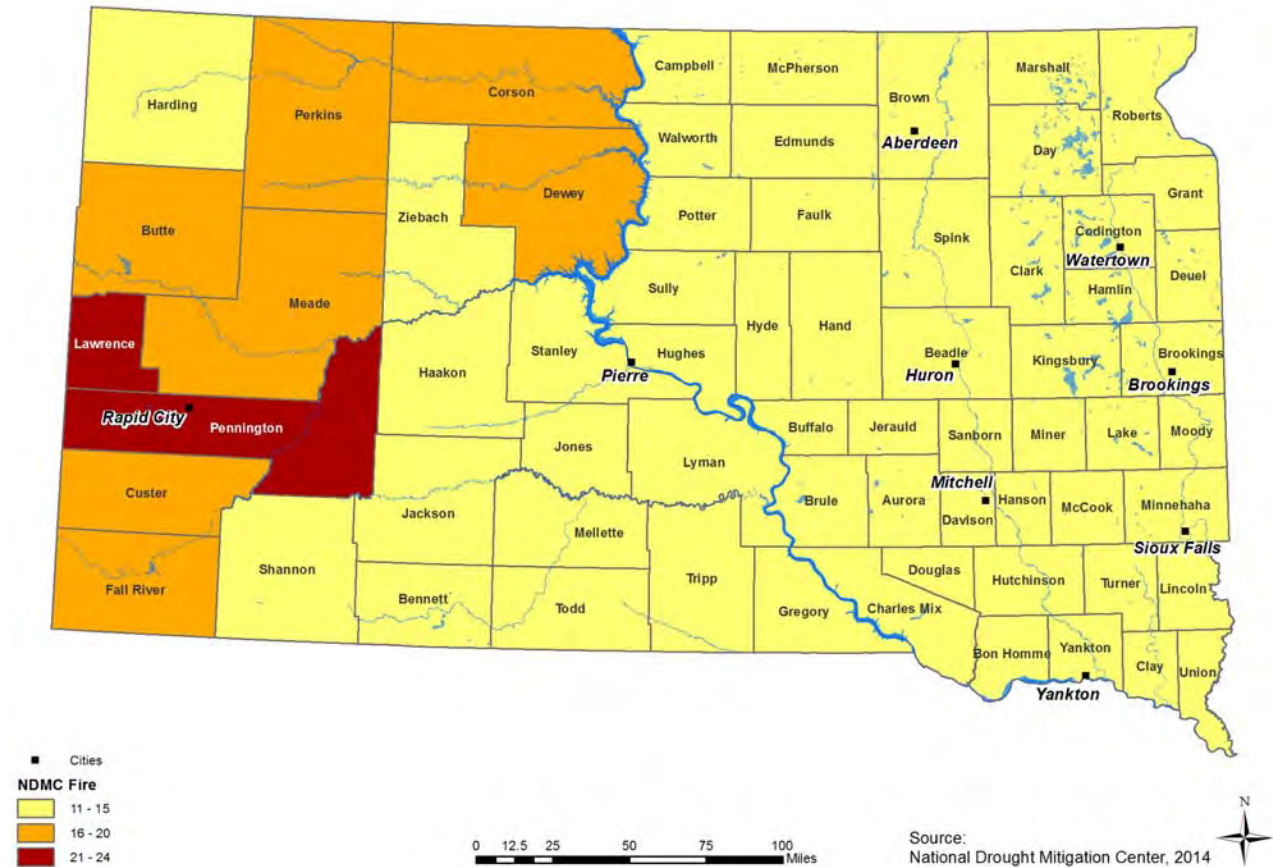
National Drought Mitigation Center Impact Records

South Dakota has experienced a variety of impacts from previous droughts. Wildfire impacts reported to the National Drought Mitigation Center (NDMC) can include enacting or easing burning restrictions, fireworks bans, increased fire risk, occurrence of fire (number of acres burned, number of wildland fires compared to average, people displaced, etc.), state of

⁴¹ U.S. Forest Service, Spearfish, South Dakota, and the Northern Black Hills: Steps to Improve Community Preparedness for Wildfire

emergency during periods of high fire danger, closure of roads or land due to fire occurrence or risk, and expenses to state and county governments of paying firefighters overtime and paying equipment (helicopter) costs.⁴² **Figure 52** shows the number of these impacts reported for each county from January 1, 1980 to April 13, 2015. The greatest number of drought impacts reported to the NDMC occur in counties in West River, namely Lawrence and Pennington counties. The higher number of impacts in these counties can at least partially be attributed to the presence of a major population center (Rapid City) near the WUI.

Figure 52. Number of Reported Wildfire Impacts by County (Drought Impact Reporter 1980-2015)



Soil and Fuels Moisture Metrics

One method of measuring how drought affects fire risk is the Keetch-Byram Drought Index (KBDI). The KBDI was developed in 1968 to assess how fire potential is impacted by drought

⁴² Sources: National Drought Mitigation Center, 2015

conditions, such as moisture deficiency in soils and duff layers.⁴³ The KBDI spans from 0 to 800. The numeric value represents the amount of moisture or precipitation needed to saturate the soil. A higher score indicates more severe drought conditions. According to the National Park Service, “the index’s relationship to fire is that as the index values increase, the vegetation is subject to greater stress because of moisture deficiency. At higher values living plants die and become fuel, and the duff/litter layer becomes more susceptible to fire.”⁴⁴

The Index is broken into four ranges, as follows:

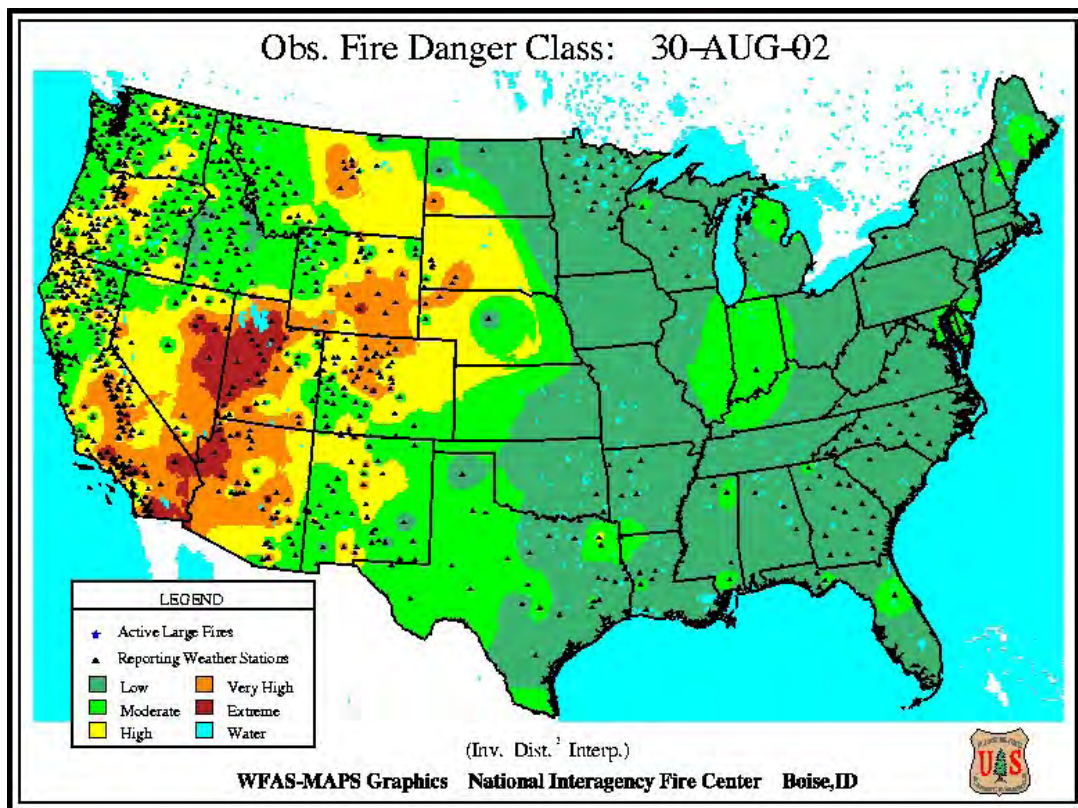
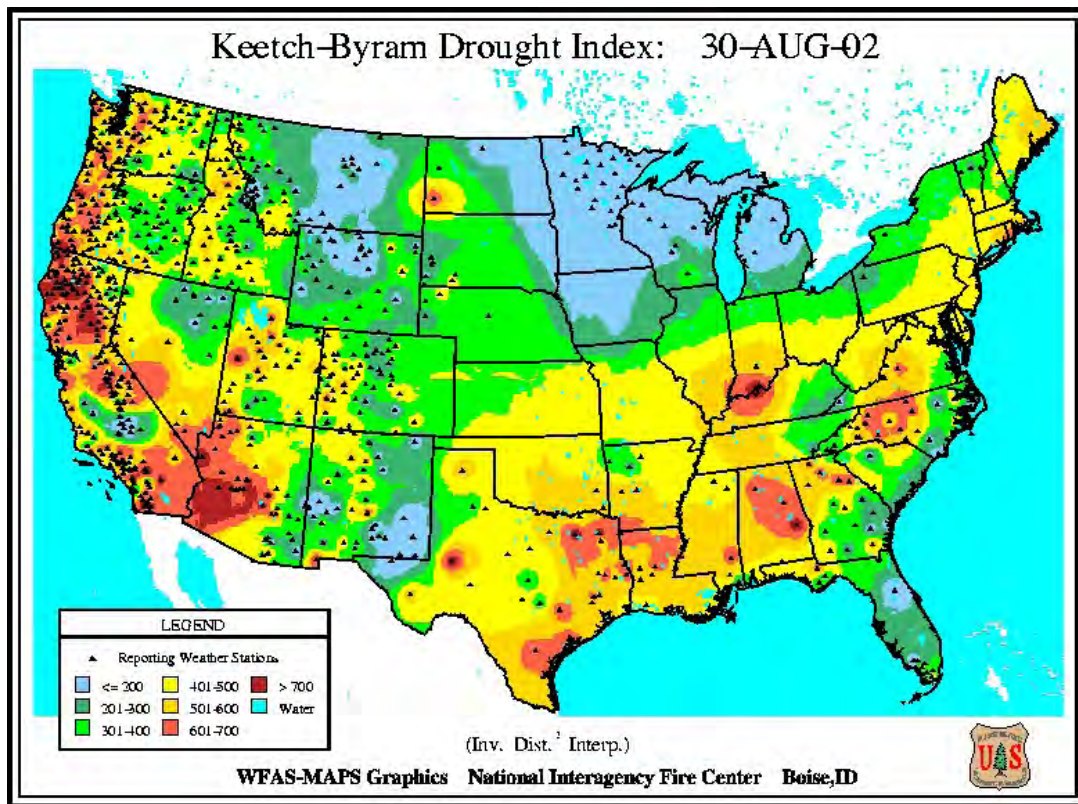
- 0-200: Soil moisture and large class fuel moistures are high and do not contribute to much fire intensity. Typical of spring dormant season following winter precipitation.
- 200-400: Typical of late spring, early growing season. Lower litter and duff layers are drying and beginning to contribute to fire intensity.
- 400-600: Typical of late summer, early fall. Lower litter and duff layers actively contribute to fire intensity and will burn actively.
- 600-800: Often associated with more severe drought with increased wildfire occurrence. Intense, deep burning fires with significant downwind spotting can be expected. Live fuels can also be expected to return actively at these levels.

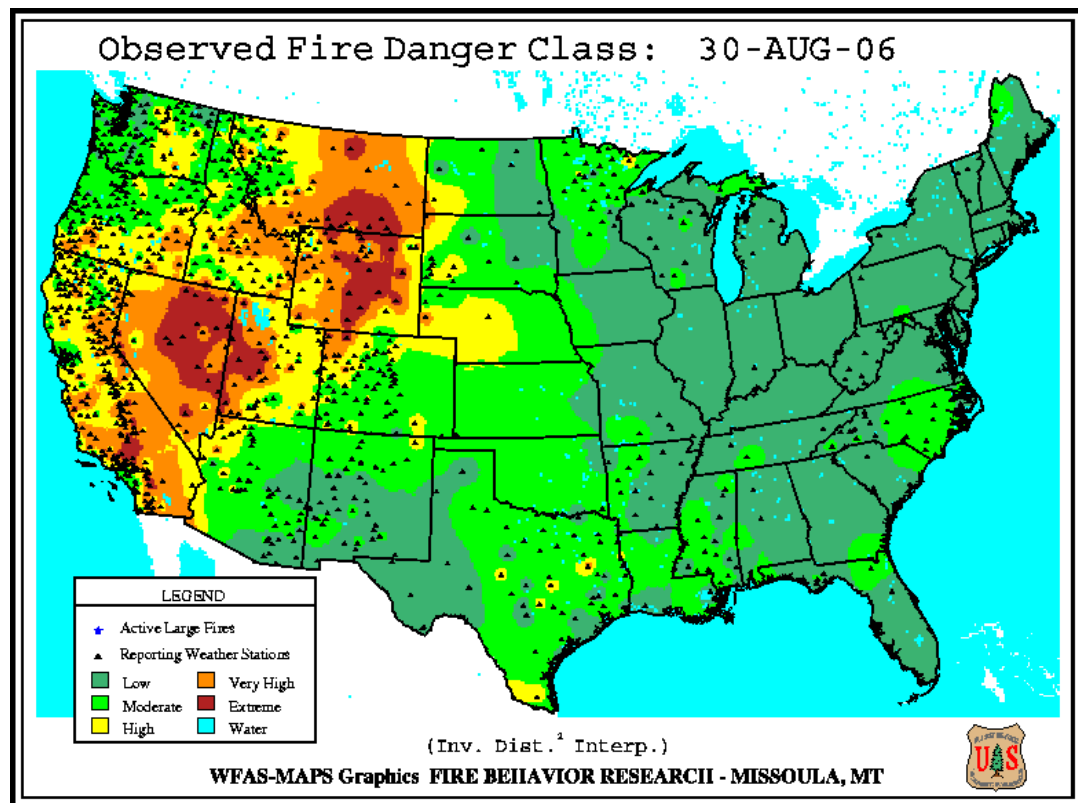
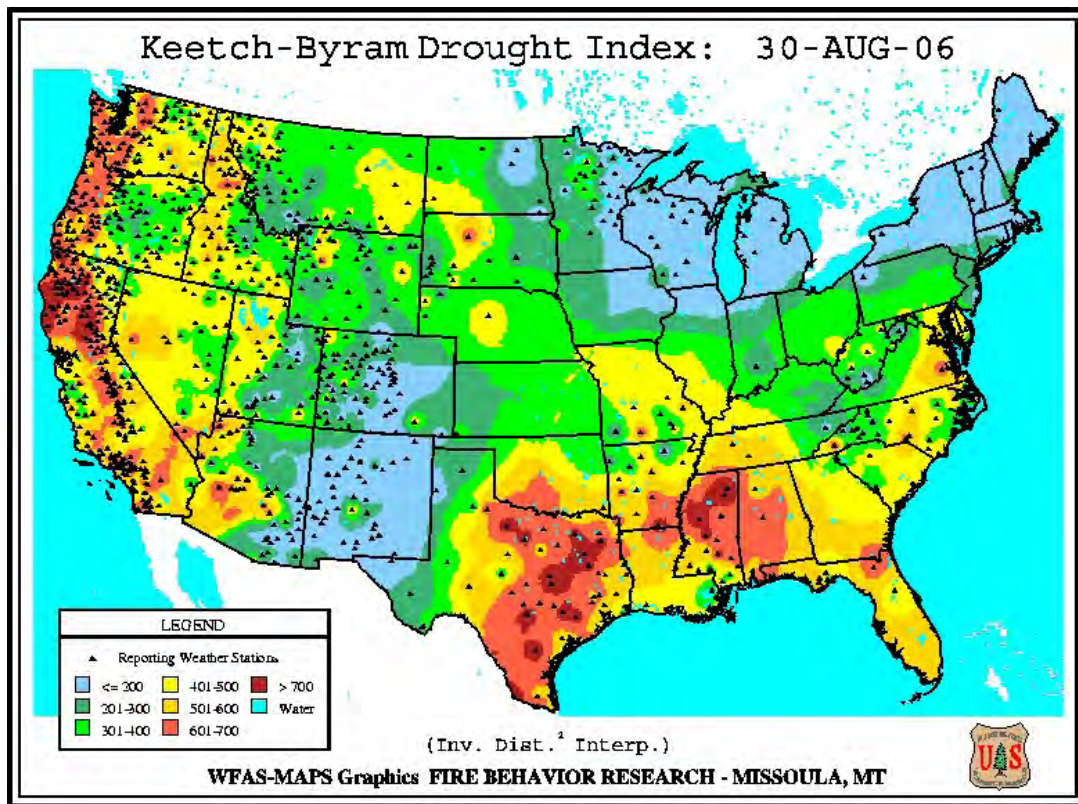
The KBDI is probably most useful as an early warning tool.

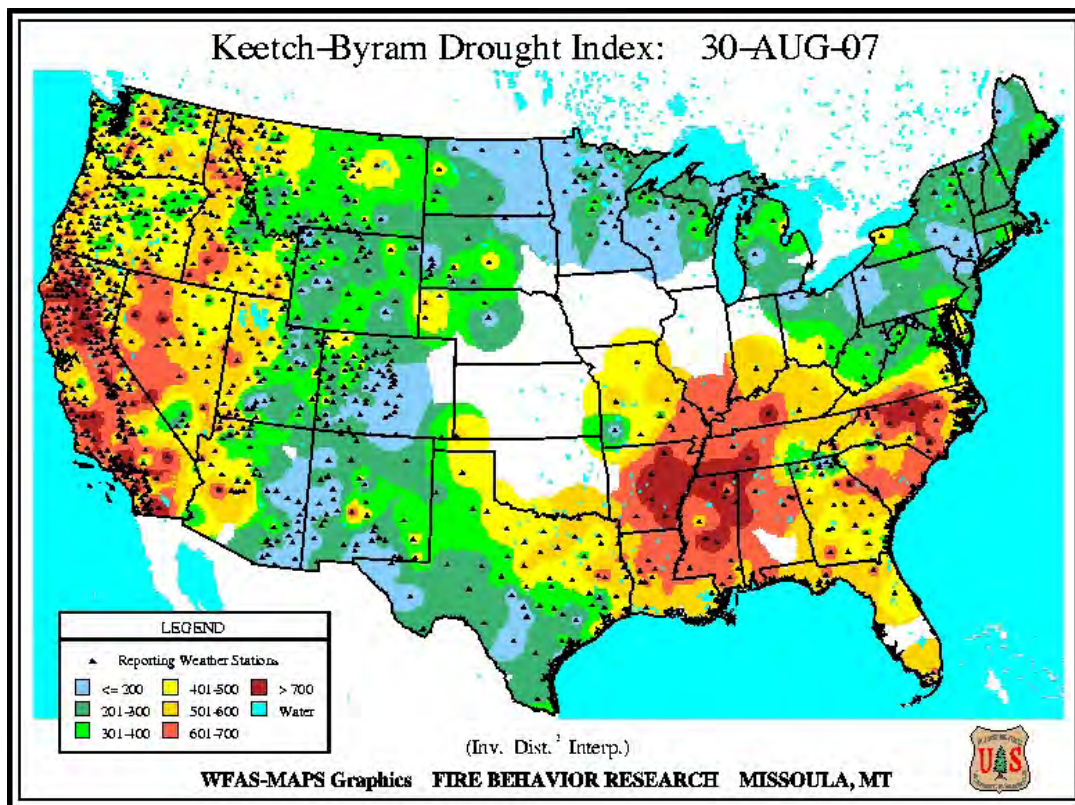
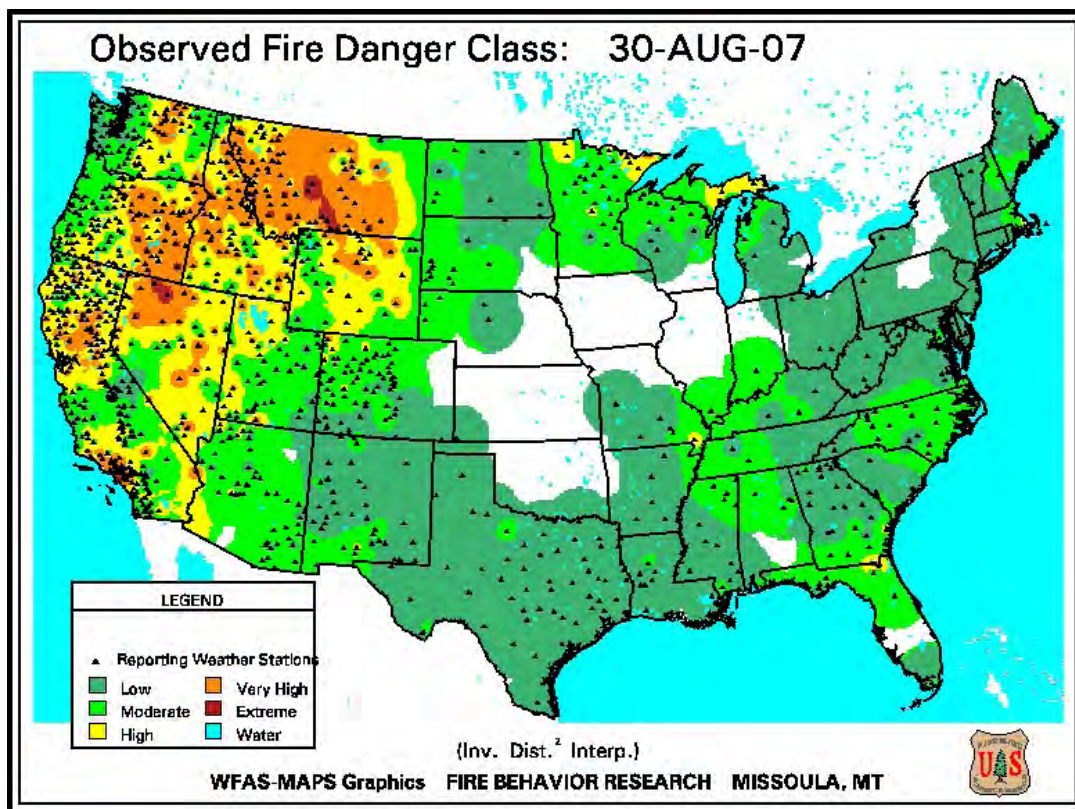
The maps below compare the KBDI to the observed fire danger class for August 30 in 2002, 2006, 2007, and 2012. The fire danger zones do not match up precisely with the KBDI maps; the observed fire danger class takes several factors besides soil moisture into account, such as wind speed, temperature, and fuel types. Dry soil and duff alone are not enough to ignite a fire, but moisture levels can help indicate when fire potential is higher or lower on a given day.

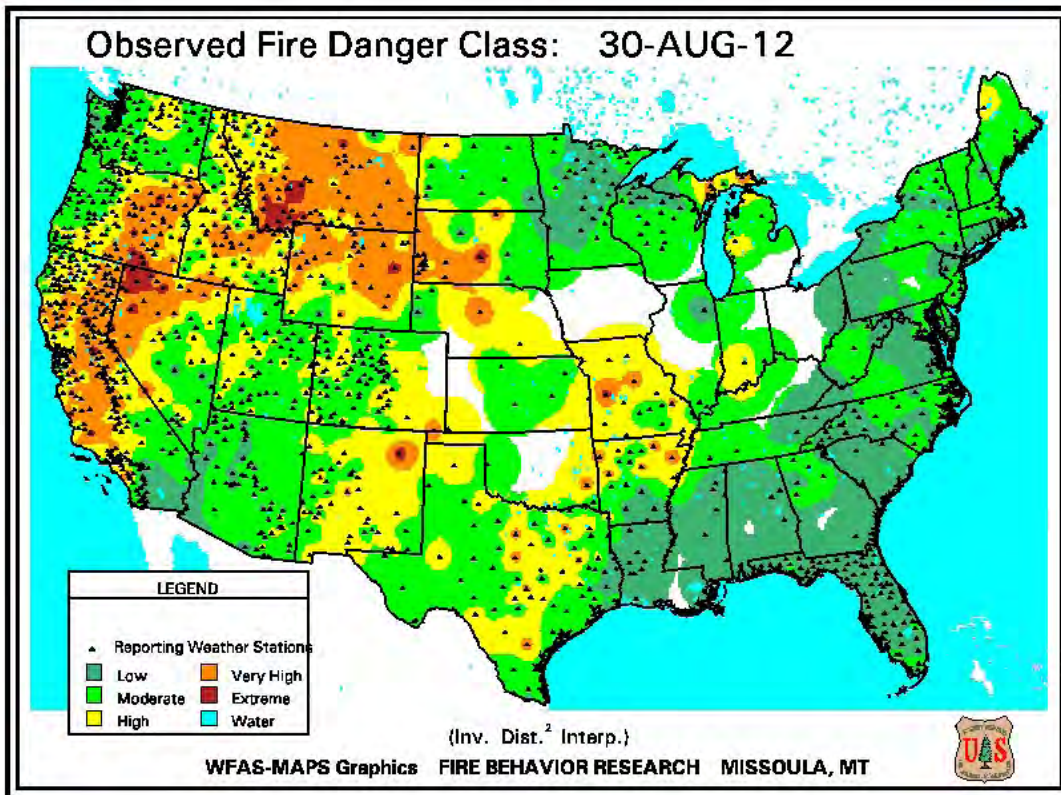
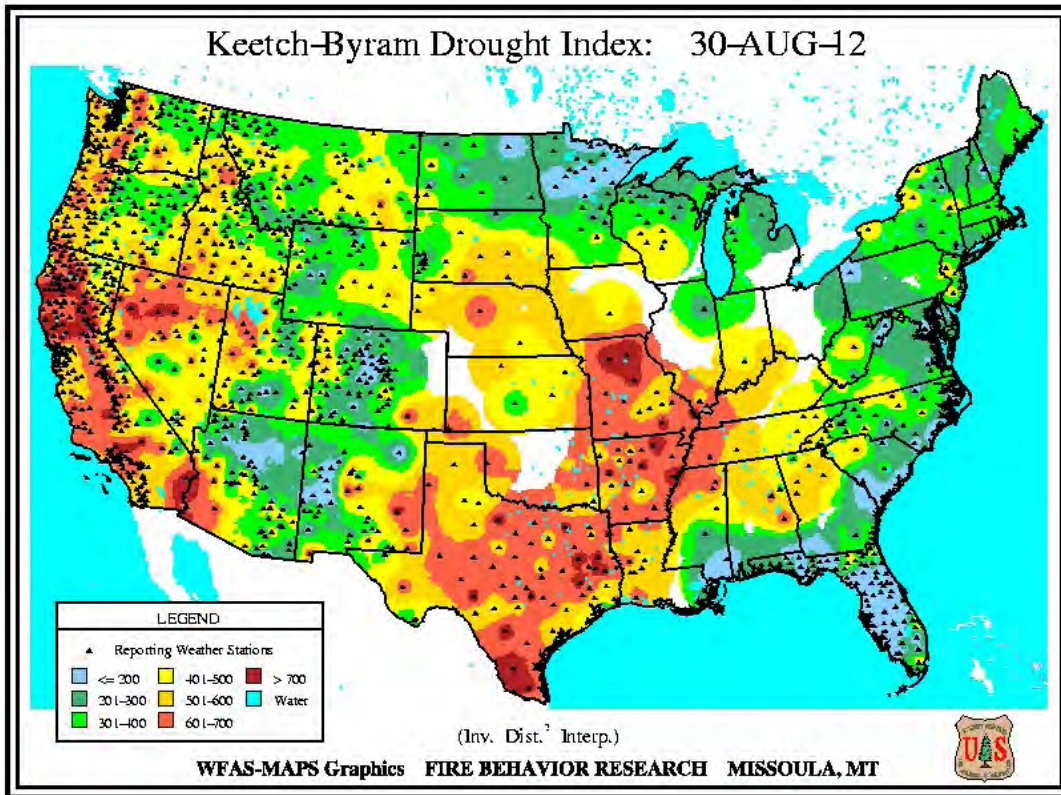
⁴³ Keetch-Byram Drought Index, USFS Wildland Fire Assessment System. <http://www.wfas.net/index.php/keetch-byram-index-moisture--drought-49>, accessed April 29, 2015.

⁴⁴ “Understanding Fire Danger.” National Park Service, U.S. Department of the Interior. <http://www.nps.gov/fire/wildland-fire/learning-center/fire-in-depth/understanding-fire-danger.cfm>, accessed April 29, 2015.









The Normalized Difference Vegetation Index (NDVI) is used to measure vegetation conditions and generate Greenness maps to analyze potential fire risk. Examples from 2006 and 2012 are shown below in **Figures 53** and **54**:

Figure 53. NDVI Greenness Map for August 31, 2006

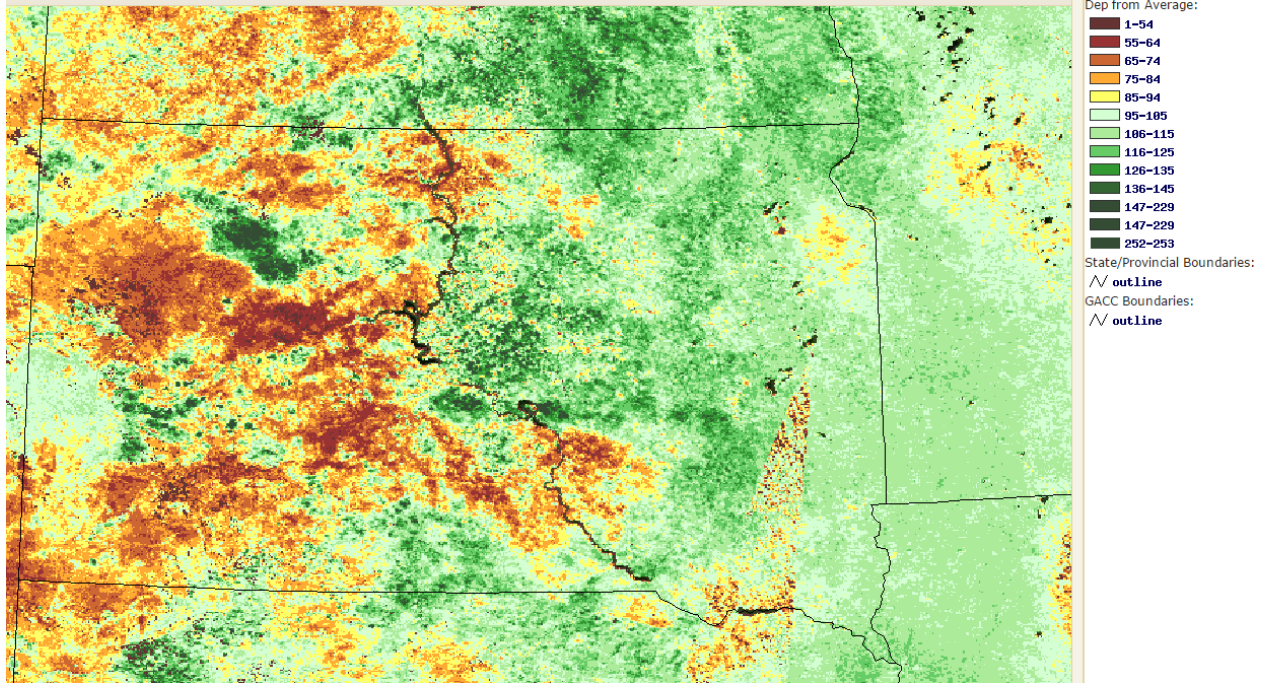
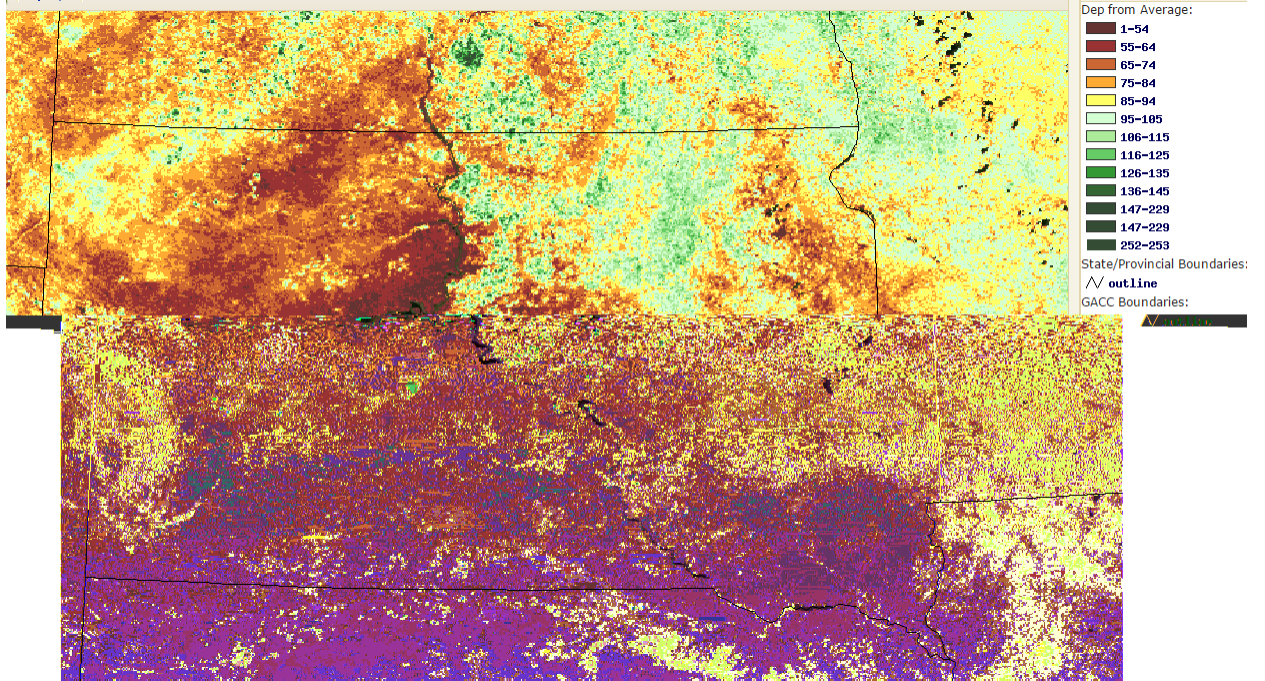


Figure 54. NDVI Greenness Map for August 31, 2012



Forest Fire Historical Data

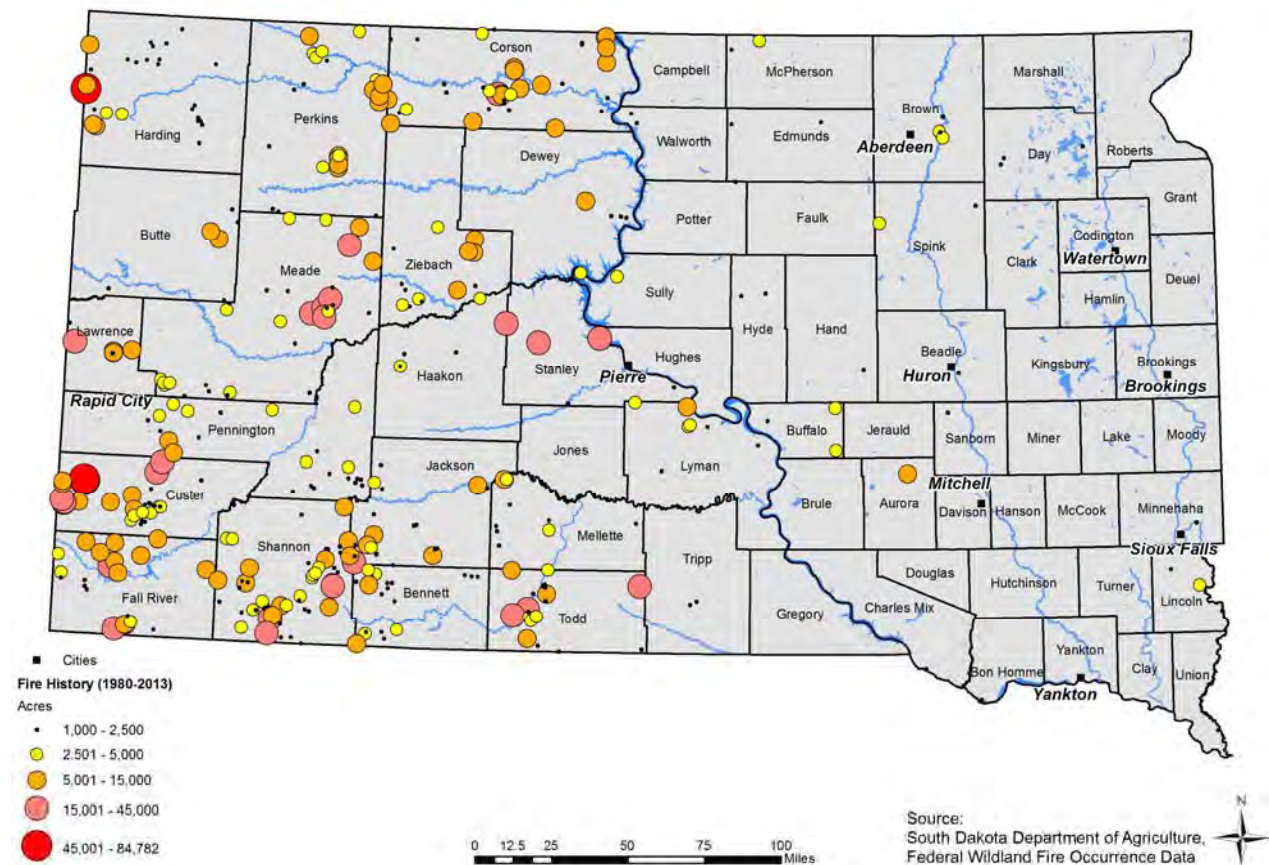
Prior to 2010, years of drought along with extremely low percentages of normal snowpack in the Black Hills created the potential for catastrophic wildfires in South Dakota. One of the most recent extended droughts lasted from 2002 to 2007. Dry conditions eased in 2008 and 2009, and both 2010 and 2011 were wet years, but drought and thus wildfire risk returned in 2012 and again in 2015.

Data on wildfire occurrences was obtained from the South Dakota Department of Agriculture and the Federal Wildland Fire Occurrence Data website:

<http://wildfire.cr.usgs.gov/firehistory/data.html>

The Federal Wildland Fire Occurrence data had records for 182 fires between 1980 and 2013 of 1,000 acres or more in size. These fires burned an estimated total of 1,028,844 acres. The largest of these was the Jasper Fire complex in August 2000, which is profiled in Table 17. The location distribution of the 182 events is depicted in **Figure 55**. Note that this includes both forest and rangeland fires.

Figure 55. South Dakota Fire Occurrences 1,000 Acres or More: 1980-2013



South Dakota received several Fire Management Assistance Declarations for forest fires in the 2000s. The declarations are summarized in **Table 17**. All of these declarations occurred in or near the Black Hills. Many of the largest fires occurred during historical drought periods, including 1988-1992, 2002-2007, and 2012. Declarations were also issued for fires that were smaller in size but threatened populated areas.

Table 17 Fire Management Assistance Declarations for Forest Fires in South Dakota

Date	Comments
August 29, 2012	Wellnitz Fire (FM-5010) The Wellnitz Fire began on August 29 th due to lightning. The fire burned 77,159 acres across Shannon County, South Dakota and into Nebraska. Burned acreage in South Dakota alone was estimated at 28,478. The fire was 100% contained by September 7, 2012.
July 19, 2012	Myrtle Fire (FM-2996) South Dakota received two Fire Management Assistance Declarations in 2012. The Myrtle Fire began on July 19 th , 2012 in Custer County due to human causes. The fire burned 10,080 acres and was 100% contained by July 24 th , 2012.
July 2007	Boxelder Fire (FM-2716) At the time of the state's request, the fire had burned approximately 700 acres and had resulted in the evacuation of 100 residents from the town of Nemo in Lawrence County.
July 2007	Alabaugh Fire (FM-2710) This fire near Hot Springs in Fall River County was started by lightning on July 7 and was contained on July 12. It burned 10,324 acres. The fire killed one man and destroyed 33 homes. It also forced the evacuation of about 600 residents in about 300 homes. Fire suppression costs were estimated at \$2.7 million. A state official said the blaze was the most intense wildfire ever recorded in the Black Hills. Sources: InciWeb, Rapid City Journal, National Public Radio
July 2006	East Ridge Fire (FM-2658) 3,204 acres burned, \$1,973,107 total outlay
July 2005	Skyline #2 Fire (FM-2569) 42 acres burned, total outlay: \$18,975 (FEMA share: \$14,231)
July 2005	Ricco Fire (FM-2565) 3,939 acres burned in Meade County, started by lightning, total outlay: \$573,581 (FEMA share: \$428,064)
April 2005	Camp Five Fire (FM-2557) 775 acres burned. Request for assistance withdrawn because event did not meet fire cost thresholds.
November 2003	Mill Road Fire (FM-2513) About 1,000 acres burned just north of Rapid City. Started by fireworks. Total outlay: \$62,852 (FEMA share: \$45,685)
August 2002	Battle Creek Fire (FM-2458) On August 16, 2002, the Battle Creek Fire ignited on private land near Keystone. High temperatures, low relative humidity, and strong winds created conditions that led to intense fire behavior with long-range spotting. The fire burned actively for four days and burned 12,450 acres (9,120 acres of national forest system lands, 3,330 acres of private lands) before it was fully contained on August 25. Over 600 structures and the town of Keystone were threatened, but thanks to firefighters, losses were limited to three residences near Hayward. Source: U.S. Forest Service, Battle Creek Fire Rapid Assessment (www.fs.fed.us/r2/blackhills/fire/history/battlecreek/index.shtml) Total outlay: \$1.8 million
June–July 2002	Grizzly Gulch Fire (FM-2434) This fire near Deadwood and Lead burned 10,801 acres and destroyed 7 homes and 20 other structures. Source: Jerome Harvey, "Historic Wildfire in the Black Hills" (www.nfpa.org/assets/files/PDF/blackhills.pdf)

Date	Comments
July–August 2001	<p>Elk Mountain #2 Fire (FM-2369) This fire burned mostly in Wyoming, but was complexed with the Roger's Shack fire which burned 11,896 acres in South Dakota in western Custer County. Two single family residential homes were lost. Total outlay: \$293,000</p>
August–September 2000	<p>Jasper Fire (FM-2324) The Jasper Fire was located in Custer County in the Southwest Black Hills. It was the largest fire to occur in the Black Hills in at least a century. The fire started at about 2:30 p.m. on August 24, 2000, and was contained on September 8, 2000. The cause of the fire was arson.</p> <p>The weather was very hot and dry, vegetation moisture was at record low levels, and atmospheric conditions were very unstable. The conditions caused extreme fire behavior and the fire spread rapidly, doubling in size every hour on the day it started. Almost immediately after ignition, the fire spread into the tops of the trees and blowing embers began causing spot fires ahead of the main fire. The fire created its own weather pattern as it burned. Lightning from the storm created by the fire was a big concern. The fire completely blackened some areas, leaving scorched, dead trees and ash-covered ground in its wake. Other areas experienced only a light ground burn. Large areas within the fire perimeter remained green, either lightly burned or completely undamaged.</p> <p>Firefighting efforts continued for a month, and firefighters declared the fire controlled on the evening of September 25, 2000. The Jasper fire burned 83,500 acres and was the largest fire in Black Hills history. It destroyed one summer cabin and three outbuildings, burned acreage at the Jewel Cave National Monument, and threatened more than 100 other structures and the communities of Custer and Hill City. Fire losses included approximately 244 million board feet of timber, 150 miles of range fence, 65 livestock water tanks, 20 miles of range water lines, 17 wildlife water developments, 59 wooden power line structures, and 2,738 feet of above ground telephone line.</p>
August 2000	<p>Flagpole Fire Complex (FM-2319) and The Flagpole fire complex started on August 11, 2000, in Fall River County in southwestern South Dakota. The wildfire was actually three different starts, the Flagpole Mountain, Green Canyon, and Chilson II fires in the southern hills area. The fires were attributed to lightning. The Flagpole Mountain fire burned in ponderosa pine; the Green Canyon fire burned in grass, scrub, and juniper. The terrain was extremely rocky and steep, making access and fire-fighting difficult.</p> <p>Pushed by shifting winds, the Flagpole fire immediately threatened structures, including two homes, and destroyed one outbuilding. The Flagpole and Chilson II fires burned more than 6,000 acres by the evening of August 12. The Flagpole fire threatened 30 homes on the north, south, and east sides of the fire and prompted officials to call for voluntary evacuations in the Shep's Canyon area, where there was only one access road. One residence was lost on the north side of the fire. The fires eventually burned 7,386 acres.</p>
August 15, 1994	<p>Stagebarn Canyon Fire (FM-2109) Stagebarn Canyon near Indian Hills subdivision northwest of Rapid City. Fire started by lightning. 112 acres burned; cost in excess of \$159,000.</p>
September 1990	<p>Swedlund Fire (Cicero Peak fire) (FM-2076) Burned 14,518 acres, approximately 5,000 acres in Custer State Park. Caused by logging equipment.</p>
Jul 25, 1988	<p>Westberry Trail Fire (FM-2068) Suspected arson fire and was located in a subdivision on the western edge of Rapid City. Burned 14 homes and 3,980 acres.</p>
Jul 20, 1987	<p>Battle Mountain Fire (FM-2061) Started by lightning in the game production area, two miles from Hot Springs. Burned 2,200 acres.</p>
July 12, 1985	<p>Seven Sisters and Flint Hills Fire (FM-2056) Lightning caused complex of fires that burned 30,300 acres south and west of Hot Spring in Fall River County.</p>

Date	Comments
July 1975	Custer State Park (FM-2017)
July 1974	Argle & Booms Canyon (FM-2016) Lightning caused fire that burned 4,356 acres north of Hot Springs.

Source: FEMA, South Dakota Department of Agriculture

Rangeland Fire Historical Data

As shown in **Figure 55**, large wildfires also occur outside of the Black Hills. The majority of these fires burn rangeland, pasture, grass, and brush. Some of the most significant rangeland fires are summarized in **Table 18**.

Table 18 Summary of Significant Rangeland Fires in South Dakota, 1871-2012

Date	Comments
August 16, 2012	A wildfire burned grassland in and near the Karl E. Mundt National Wildfire Refuge in southeastern Gregory County South Dakota on August 16 th . No structures were burned. The fire burned 146 acres, including 112 acres on the refuge and 34 acres of private land.
January 9, 2012	Unseasonably warm and dry weather, along with dry and dormant vegetation, provided a setting in which several fires that were started to burn trash and vegetation went out of control in Moody County. The largest was several miles northeast of Flandreau, where the burning of a tree pile spread to grassland. This fire burned about 120 acres, reaching to the eastern border of the county and state. Another fire just northwest of Flandreau, started to burn garbage, burned 4 acres of grassland. No indications of damage amounts were received, but no structures were reported to have burned.
October 4, 2011	Several wildfires broke out in Gregory and Charles Mix counties during the four day period. Warm and dry weather, strong winds, and dry vegetation due to extended dry weather preceding this time contributed to the fires starting and spreading. The fires affected grassland and cropland, including baled hay.
October 5, 2011	The Okcreek fire started in Todd County from a rubble dump site and burned north into Mellette County by late evening, burning 17,501 acres. The fire jumped both US Hwy 18 and State Hwy 44 before being contained. A federal Type II team was ordered by the BIA. The Governor's Office declared a state of disaster for Mellette County.
August 8, 2006	The White Owl fire was started by lightning in the rugged area of the confluence of the Belle Fourche and Cheyenne rivers in Meade County. The fire burned for three days, consuming 21,314 acres of private and BLM lands and required considerable use of hand crews, air tankers and helicopters with a Type III team to assist with containment.
July 15-17, 2006	A complex of wildfires started by lightning burned in Perkins, Meade, Edmunds, Stanley and Corson Counties. The Bowdle fire in Edmunds county burned up 2000 acres and one fire engine. The Black Horse (7,180 acres) and the Wolf (590 acres) started in Perkins County and the Kelley fire (5,033 acres) burned in Meade County on a day with a record dry bulb temp of 120 degrees at Usta, SD on July 15 th . The Stanley county fires burned 1700 acres that time period. At this same time, a complex of lightning fires was burning 21,000 acres in Corson County and Sioux county ND. This activity resulted with OEM creating a "redzone" area to assist local fire department in the affected areas.
September 17, 2000	A complex of lightning caused fires burned approximately 20,000 acres north of Hayes in Stanley County.
October 31, 1999	The Avance fire in Meade County, 7 miles west of Faith, was started by a powerline after a cold front passage of 70 mph winds. The fire burned 12,000 acres in the middle of the night.
October 22, 1992	The New Underwood Fire burned 33,000 acres in a late autumn afternoon SW of Wasta. Started by fireworks.

Date	Comments
November 21, 1962	Burned an area that stretched from Harrold to Highmore (20 miles long) and consumed 30,000 acres of hay and cropland. No loss of life.
September 5, 1947	Three human-caused fires burned into one conflagration that burned an estimated 320,000 acres in Hyde, Sully, Potter, Faulk and Hughes Counties in one day. Estimated \$2,000,000 damage to improvements (1947 dollars). Considerable damage to range and farm land, (Source: WFS agency historical archives and "75 Years of Sully County History" published by the <i>Onida Watchman</i>).
March 1879	This fire burned for at least one week in an area from Brookings County to Union County. The path was over 100 miles long and 20 miles wide.
October 1871	During the week of the Great Chicago fire, a large wildland fire occurred along the Missouri River burning from Springfield to Yankton, burning many structures and farms.

Rangeland fires continued to be an issue after 2012. Drought conditions were reported across South Dakota in early 2015 following a relatively mild winter. In anticipation of a very active fire season, several counties issued burn bans and advised residents to exercise caution.⁴⁵ In spite of these measures, a number of rangeland and grass fires occurred around the time the burn bans were issued. A few grass fires ignited along Interstate 90 between Black Hawk and Deadwood on March 20, 2015.⁴⁶ The Sheep Draw Fire started on March 28, 2015 in Harding County and burned roughly 14,000 acres by April 1, 2015, making it the largest wildfire in South Dakota since 2012. Harding County ranchers were heavily impacted, with some individuals losing between 3,000 and 4,000 acres.⁴⁷ Other smaller fires occurred elsewhere in West River at the same time, including the three square mile Moonshine Fire in Harding County, an eight square mile in Potter County, and a smaller grass fire south of Brandon. The Potter County incident was ignited by a tractor fire.⁴⁸

Factors that Impact Vulnerability to Wildfires Caused by Drought

South Dakota's vulnerability to wildfires caused by drought is influenced by several factors. These factors may not affect all counties in the same way.

Fuels

Fuels in South Dakota are generally conducive to high rates of spread, represented by National Fire Danger Rating System fuel models "G", "L," "K," and "C." Grass predominates in the

⁴⁵ Swan, London. Drought Conditions Throughout South Dakota Prompt Burn Bans. KDLT News. March 28, 2015. <http://www.kdlt.com/news/local-news/drought-conditions-throughout-south-dakota-prompt-burn-bans/32070096>, accessed April 29, 2015.

⁴⁶

⁴⁷ Patrickis, Caroline. Sheep Draw Fire Continues Burning, Largest State Fire Since 2012. News Center 1. April 1, 2015. <http://www.newscenter1.tv/news/local/Sheep-Draw-Fire-Largest-in-the-State-Since-2012-298224661.html>, accessed April 28, 2015.

⁴⁸ Grass fires flare up across South Dakota. Argus Leader. April 2, 2015. <http://www.argusleader.com/story/news/crime/2015/04/02/grass-fires-flare-across-south-dakota/70819620/>, accessed April 29, 2015.

broad valley bottoms. Ponderosa Pine grows on all aspects, and extensive pure forests of Ponderosa grow in the Black Hills. Mixed grass and timber stands occur in many areas depending on aspect.

Fuel density in the Black Hills is greater today than in the past. When wildfires occur in high density fuel loads under dry, warm, and windy conditions, they will frequently develop into uncontrollable crown fires that destroy the forest and any homes within it. Fuel loading is lightest in the southern Black Hills and heaviest in the northern Black Hills.

Topography

The Black Hills are an outcropping of the Rocky Mountains, lying in an ellipse 100 miles long and 50 miles wide along the State's western edge. In the Black Hills, terrain varies from broad, open valleys; rolling topography; mountainous terrain up to 7,242 feet in elevation; and steep, narrow canyons. The topography in the Black Hills is conducive to rapid wildfire spread. Fires spread faster on steep slopes as the heat from the flames is closer to the next fuel source.

Beetle and Insect Infestation

Mountain pine beetle infestations often coincide with drought, which weakens trees. When the beetle population is very low only stressed or weakened trees, such as those struck by lightning, are colonized. However, approximately every ten years the beetle population increases and the beetles begin colonizing healthy as well as stressed trees. These circumstances have been common throughout the Black Hills and have allowed a mountain pine beetle infestation to become epidemic. The Custer State Park area around Harney Peak, and the Norbeck Wildlife Preserve adjacent to Mount Rushmore has extremely high fuel loading due to Mountain Pine Beetle outbreaks. The South Dakota Department of Agriculture (SDDA) reported in 2012 that the mountain pine beetle population had reached epidemic proportions. SDDA published a Black Hills Regional Mountain Pine Beetle Strategy (2012) which proposed mitigation strategies for reducing the population to endemic levels over the course of several years.

Climate and Weather

During the summer months, temperatures are often in the 90s with relative humidity in the teens. Temperatures may climb into the low 100s, though this is rare in South Dakota. The average annual precipitation is approximately 17.5 inches, with the East River generally receiving more precipitation than West River. Some of this precipitation is associated with thunderstorms that bring lightning during the fire season.

Lightning fires burn more acreage than human-caused fires, in part, because 1) multiple lightning fire ignitions often occur at the same time; 2) lightning fires can occur throughout the protection area, while most human-caused fires occur in accessible areas; 3) people often detect and report human-caused fires quickly due to their proximity to inhabited areas; and 4) lightning producing thunderstorms typically occur during the hottest portion of the fire season, while many human-

caused fires start during spring or fall. When combined with drought, these conditions can create devastating wildfires.

Climate change may also affect wildfire risk and magnitude in the future. Longer, hotter summers deplete moisture in soils and vegetation. Beetles and other insects favor drier conditions that weaken trees and make them more vulnerable to infestation. Water supply for vegetation and fire suppression may also decrease as snowpack melts earlier and precipitation declines and evaporates more rapidly. Climate change is also believed to increase the severity of thunderstorms, leading to more lightning strikes that can ignite fires.⁴⁹

Growth and Development Trends

Wildfires destroy hundreds of structures throughout the western United States every year. These fires can and will occur anywhere that humans and their development meet or intermix with wildland fuels. This wildland-urban interface fire problem exists in every state, including South Dakota, and worsens each year. People continue to develop residential properties in fire-prone environments, increasingly exposing themselves and their personal property to the risks of wildfire. An increase in population in the WUI also means more potential ignition sources. People may accidentally start forest or rangeland fires when using farming equipment, camping, or burning trash on their properties.

Estimating Potential Losses

Fire Response Expenditures

Drought can create conditions for more numerous and intense fires that quickly overwhelm local and state capacities for fire suppression. Generally, large wildfires make up a small portion of total fire occurrences in any given year but account for the greatest portion of suppression costs. Expenses can also be driven up by atypically large numbers of moderate or small fires that drain resources. **Table 19** summarizes South Dakota's fire suppression costs from 1994 to 2014. Within that 20-year time period, the highest suppression costs occurred in 2002, 2006, 2007, and 2012; each of these years coincided with a drought. The fire suppression costs for these years was orders of magnitude greater than that of wet years, such as 2010. In addition, in response to the drought year 2006, the South Dakota Legislature passed a law that was enacted to allow the use of the State Fire Suppression Fund to pay for responding and managing large wildfire activity in the prairie regions of the state. This can drive up fire fund expenditures in future years. (Source, SDCL 41-20A-8.)

49 Staudt, Amanda, PhD. Global Warming and Wildfires. National Wildlife Federation. <http://www.nwf.org/Wildlife/Threats-to-Wildlife/Global-Warming/Global-Warming-is-Causing-Extreme-Weather/Wildfires.aspx>, accessed April 30, 2015.

Table 19 State Fire Suppression Costs by Year, 1994-2014

Year	State Fire Suppression Costs
2014	\$454,641
2013	\$893,262
2012*	\$8,493,171
2011	\$1,789,511
2010	\$801,405
2009	\$525,343
2008	\$938,134
2007*	\$7,686,640
2006*	\$6,026,422
2005	\$2,127,925
2004	\$1,009,829
2003	\$1,599,697
2002*	\$9,444,193
2001	\$2,025,028
2000	\$1,510,648
1999	\$191,441
1998	\$135,301
1997	\$149,239
1996	\$307,694
1995	\$258,766
1994	\$389,033
Total	\$46,757,325

Source: South Dakota Department of Agriculture, 2015;

*Drought year

Number and Acreage of Fires in Drought Years vs. Non-Drought Years

Historical fire occurrence data from 1980 to 2014 was analyzed to compare the number and acreage of wildfires in drought years as compared to wet years. **Table 20** indicates that the number and magnitude of fires tended to be higher during droughts. For example, conditions in South Dakota were dry from 1988-1992, 2002-2007, and 2012. Total burned acreage for the dry years is in the hundreds of thousands, compared to wet years such as 2010 when burned acreage was in the low tens of thousands.

Table 20 Number and Acreage of South Dakota Wildfire Events by Year

Year	Number of Fires	Acres Burned
2014	107	5,084
2013	142	857
2012*	2,563	220,842
2011	740	38,685
2010	609	13,448
2009	495	11,372
2008	476	7,089
2007*	808	160,851
2006*	1,388	371,226
2005	781	45,324
2004	437	15,518
2003	710	111,999
2002*	846	179,288
2001	611	124,402
2000	1,348	354,357
1999	879	161,972
1998	208	6,844
1997	69	1,354
1996	69	3,485
1995	56	1,589
1994	201	2,663
1993	44	678
1992*	958	20,367
1991*	815	43,782
1990*	860	11,725
1989*	911	14,779
1988*	1,171	69,512
1987	1,638	52,277
1986	478	3,572
1985	1,229	110,669
1984	651	28,230
1983	950	18,613
1982	403	6,886
1981	1,556	24,537
1980	1,349	42,077
TOTAL	24,365	2,134,714

Source: NCDC, Federal Wildland Fire Occurrence Database, South Dakota Department of Agriculture Division of Wildland Fire Suppression

*Drought year

Exposure, Values at Risk, and Number and Magnitude of Reported Fires by County

An analysis of areas of the State that are most vulnerable to the impacts wildfire was conducted as an estimate of where drought-exacerbated wildfire would have the highest consequences. This analysis was completed based on several factors including the total replacement value of homes in the WUI, the total population in the WUI, the number of housing units, average annual number of historical fires at least 1,000 acres in size, and average annual burned acreage. The

fire occurrence data used in the analysis ranges over a 55-year time span between 1959 and 2014. Each of these factors was assigned a numerical value between 1 and 4, with 1 representing low values and 4 representing high values. The score for each factor was added to obtain a total numerical value for each county. The highest scores indicated the highest vulnerability to wildfire. **Figure 56** and **Table 21** summarize the results of the analysis. Pennington County has the highest overall vulnerability to wildfire. Lawrence, Todd, Fall River, Custer, Meade, and Shannon counties were ranked in the second highest vulnerability category. Corson, Jackson, and Perkins counties were ranked at moderate vulnerability. The data indicated that Aurora and Miner counties did not have any population or structures at risk in the WUI, nor did they have any previous fire occurrences.

Figure 56. Aggregate Wildland Fire Vulnerability

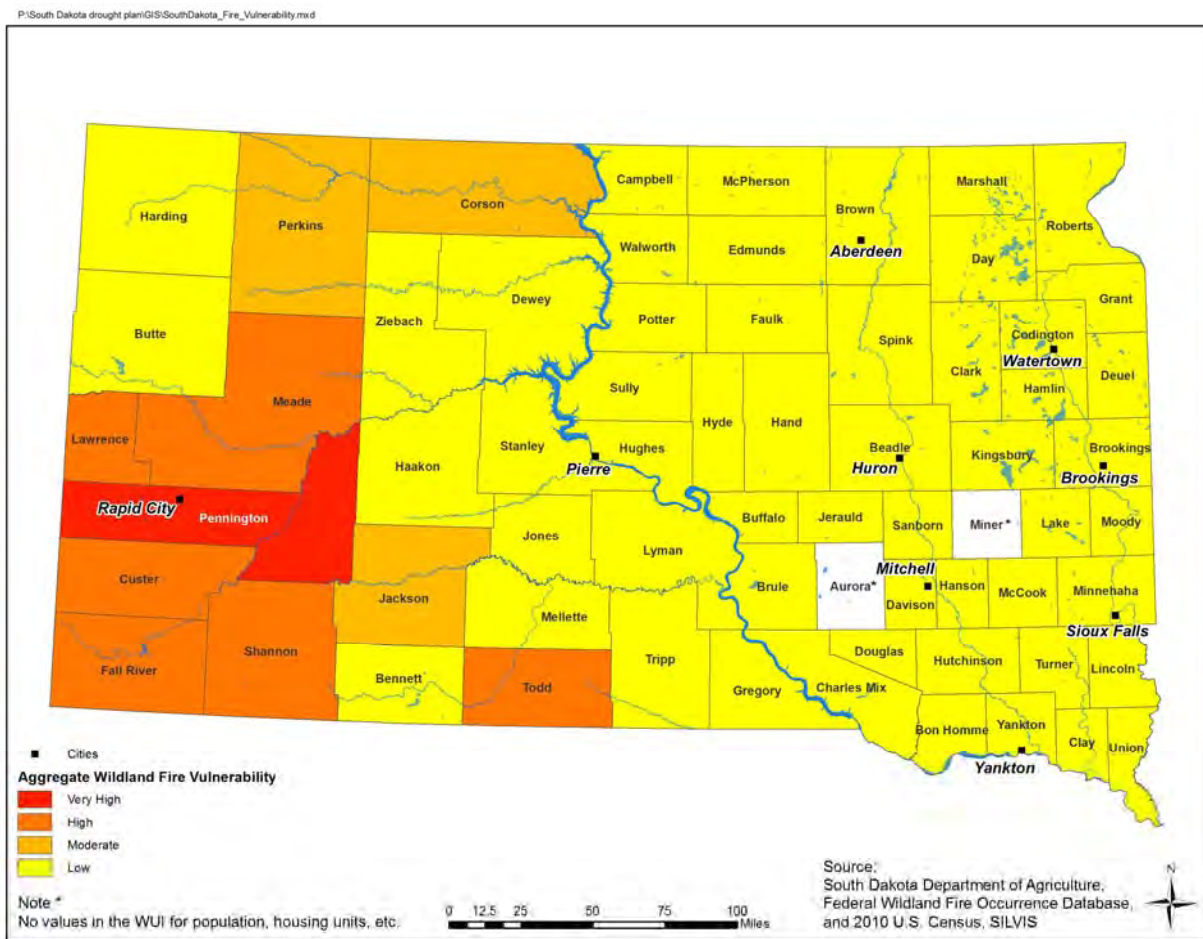


Table 21 Wildfire Vulnerability Analysis to Drought, 1959-2014

County	Total Population in WUI	Total Housing Units in WUI	2010 Census Median Home Value (\$) in WUI	2010 Medium Home Value*Housing Units (\$) in WUI	Contents Replacement Value (\$) in WUI	Total Replacement Value (\$) in WUI	Number of Fires 1,000+ Acres in Size	Average Annual # of Fires 1,000+ Acres in Size	Total Acreage Burned	Average Annual Acreage Burned	Vulnerability Rank
Aurora	-	-	-	-	-	-	-	-	-	-	-
Beadle	138	82	83,400	6,838,800	3,419,400	10,258,200	1	0.02	1,000	18	Low
Bennett	1,669	597	60,200	35,929,818	17,964,909	53,894,727	8	0.15	25,144	457	Low
Bon Homme	851	506	67,700	34,256,200	17,128,100	51,384,300	1	0.02	1,000	18	Low
Brookings	494	282	138,300	39,000,600	19,500,300	58,500,900	0	0.00	0	0	Low
Brown	125	71	115,700	8,214,700	4,107,350	12,322,050	1	0.02	1,000	18	Low
Brule	2,262	1,091	87,300	95,221,556	47,610,778	142,832,335	0	0.00	0	0	Low
Buffalo	1,071	299	67,500	20,182,500	10,091,250	30,273,750	1	0.02	1,453	26	Low
Butte	7,335	3,333	114,300	380,927,373	190,463,687	571,391,060	1	0.02	1,268	23	Low
Campbell	748	554	40,600	22,492,400	11,246,200	33,738,600	1	0.02	13,100	238	Low
Charles Mix	376	199	67,700	13,472,300	6,736,150	20,208,450	1	0.02	1,800	33	Low
Clark	197	104	64,500	6,708,000	3,354,000	10,062,000	0	0.00	0	0	Low
Clay	100	54	116,900	6,312,600	3,156,300	9,468,900	0	0.00	0	0	Low
Codington	828	361	131,000	47,291,000	23,645,500	70,936,500	0	0.00	0	0	Low
Corson	2,054	741	45,900	34,011,900	17,005,950	51,017,850	14	0.25	75,272	1,369	Moderate
Custer	6,340	3,578	160,700	574,984,600	287,492,300	862,476,900	30	0.55	242,363	4,407	High
Davison	661	277	108,800	30,137,600	15,068,800	45,206,400	0	0.00	0	0	Low
Day	742	894	64,800	57,919,128	28,959,564	86,878,692	1	0.02	1,435	26	Low
Deuel	444	193	87,200	16,812,339	8,406,170	25,218,509	0	0.00	0	0	Low
Dewey	3,284	1,187	56,900	67,540,300	33,770,150	101,310,450	2	0.04	16,317	297	Low
Douglas	10	4	58,300	233,200	116,600	349,800	0	0.00	0	0	Low
Edmunds	618	324	70,300	22,777,200	11,388,600	34,165,800	1	0.02	2,000	36	Low
Fall River	5,264	3,174	86,800	275,503,200	137,751,600	413,254,800	25	0.45	168,245	3,059	High
Faulk	788	485	51,300	24,880,500	12,440,250	37,320,750	0	0.00	0	0	Low
Grant	233	121	99,800	12,123,280	6,061,640	18,184,920	0	0.00	0	0	Low
Gregory	2,278	1,407	56,100	78,921,613	39,460,807	118,382,420	0	0.00	0	0	Low
Haakon	1,013	558	74,800	41,738,400	20,869,200	62,607,600	0	0.00	0	0	Low
Hamlin	173	76	83,700	6,361,200	3,180,600	9,541,800	0	0.00	0	0	Low
Hand	98	72	74,900	5,392,800	2,696,400	8,089,200	0	0.00	0	0	Low
Hanson	77	24	87,300	2,095,200	1,047,600	3,142,800	0	0.00	0	0	Low

County	Total Population in WUI	Total Housing Units in WUI	2010 Census Median Home Value (\$) in WUI	2010 Medium Home Value*Housing Units (\$) in WUI	Contents Replacement Value (\$) in WUI	Total Replacement Value (\$) in WUI	Number of Fires 1,000+ Acres in Size	Average Annual # of Fires 1,000+ Acres in Size	Total Acreage Burned	Average Annual Acreage Burned	Vulnerability Rank
Harding	385	261	67,000	17,487,000	8,743,500	26,230,500	6	0.11	23,736	432	Low
Hughes	14,059	6,485	133,200	863,839,923	431,919,962	1,295,759,885	0	0.00	0	0	Low
Hutchinson	22	14	68,700	961,800	480,900	1,442,700	0	0.00	0	0	Low
Hyde	776	385	66,600	25,641,000	12,820,500	38,461,500	0	0.00	0	0	Low
Jackson	1,791	660	54,600	36,036,000	18,018,000	54,054,000	11	0.20	41,966	763	Moderate
Jerauld	71	43	62,200	2,674,600	1,337,300	4,011,900	0	0.00	0	0	Low
Jones	629	373	75,000	27,975,000	13,987,500	41,962,500	2	0.04	8,450	154	Low
Kingsbury	82	59	70,300	4,147,700	2,073,850	6,221,550	0	0.00	0	0	Low
Lake	203	80	108,800	8,704,000	4,352,000	13,056,000	0	0.00	0	0	Low
Lawrence	20,958	11,355	155,100	1,761,160,500	880,580,250	2,641,740,750	4	0.07	27,701	504	High
Lincoln	101	53	169,700	8,994,100	4,497,050	13,491,150	0	0.00	0	0	Low
Lyman	2,280	1,034	64,900	67,106,600	33,553,300	100,659,900	3	0.05	6,590	120	Low
Marshall	205	472	81,700	38,562,400	19,281,200	57,843,600	0	0.00	0	0	Low
McCook	50	19	91,900	1,746,100	873,050	2,619,150	0	0.00	0	0	Low
McPherson	824	653	45,100	29,450,300	14,725,150	44,175,450	0	0.00	0	0	Low
Meade	20,512	9,013	145,800	1,314,095,400	657,047,700	1,971,143,100	11	0.20	76,351	1,388	High
Mellette	1,200	465	49,800	23,157,000	11,578,500	34,735,500	8	0.15	24,589	447	Low
Miner	-	-	-	-	-	-	-	-	-	-	-
Minnehaha	899	329	144,900	47,672,100	23,836,050	71,508,150	0	0.00	0	0	Low
Moody	66	26	102,800	2,672,800	1,336,400	4,009,200	0	0.00	0	0	Low
Pennington	78,815	34,905	149,700	5,225,253,054	2,612,626,527	7,837,879,581	21	0.38	99,428	1,808	Very High
Perkins	19	11	50,800	558,800	279,400	838,200	12	0.22	45,082	820	Moderate
Potter	502	516	55,600	28,681,869	14,340,935	43,022,804	0	0.00	0	0	Low
Roberts	964	415	73,200	30,378,000	15,189,000	45,567,000	0	0.00	0	0	Low
Sanborn	104	52	62,700	3,260,400	1,630,200	4,890,600	0	0.00	0	0	Low
Shannon	8,334	2,054	18,600	38,204,400	19,102,200	57,306,600	41	0.75	185,522	3,373	High
Spink	119	53	62,700	3,323,100	1,661,550	4,984,650	0	0.00	0	0	Low
Stanley	2,161	995	113,700	113,131,500	56,565,750	169,697,250	3	0.05	28,985	527	Low
Sully	153	88	72,200	6,353,600	3,176,800	9,530,400	0	0.00	0	0	Low
Todd	5,898	1,862	53,800	100,175,600	50,087,800	150,263,400	19	0.35	143,522	2,609	High
Tripp	1,313	707	69,400	49,093,265	24,546,633	73,639,898	0	0.00	0	0	Low
Turner	47	18	85,600	1,540,800	770,400	2,311,200	0	0.00	0	0	Low

County	Total Population in WUI	Total Housing Units in WUI	2010 Census Median Home Value (\$) in WUI	2010 Medium Home Value*Housing Units (\$) in WUI	Contents Replacement Value (\$) in WUI	Total Replacement Value (\$) in WUI	Number of Fires 1,000+ Acres in Size	Average Annual # of Fires 1,000+ Acres in Size	Total Acreage Burned	Average Annual Acreage Burned	Vulnerability Rank
Union	2,392	1,059	132,200	140,049,081	70,024,541	210,073,622	0	0.00	0	0	Low
Walworth	4,528	2,525	62,500	157,791,465	78,895,732	236,687,197	1	0.02	2,500	45	Low
Yankton	752	388	115,500	44,814,000	22,407,000	67,221,000	0	0.00	0	0	Low
Ziebach	1,176	304	62,200	18,903,145	9,451,573	28,354,718	7	0.13	20,999	382	Low

Source: Amec Foster Wheeler based on analysis of data from the South Dakota Department of Agriculture, Federal Wildland Fire Occurrence Data and 2010 U.S. Census

Summary of Economic Impacts

Based on the previous analysis over the past 20 years, fire suppression costs in South Dakota have averaged \$2,337,867 million annually. Drought has undoubtedly exacerbated the magnitude and frequency of fires in the State, leading to higher fire suppression costs. Wildfire also impacts tourism revenue and can have a more direct impact on visitation than drought alone. This is discussed in more detail in the Tourism Sector.

3.7.3 Summary of Identified Vulnerabilities and Adaptive Capacities

Table 22 summarizes the vulnerabilities and existing adaptive capacities associated with the wildfire sector. New adaptive capacities that have been identified through this planning process are also included.

Table 22 Summary of Vulnerabilities and Adaptive Capacities

Wildfire Subsector	Identified Vulnerabilities	Adaptive Capacities	
		Existing or Implemented in the Past	Potential Options for Consideration
Forest Fires	<ul style="list-style-type: none"> • Plentiful fuel loads in Black Hills • Climate change exacerbates fire potential and intensity • West River is typically drier than East River and more susceptible to drought-caused wildfires 	<ul style="list-style-type: none"> • Enact county or statewide burning restrictions as needed • Issue controlled burning permits • Limit fireworks displays • Prescribed burns • Weed control • Create fire breaks and defensible space • Develop wood utilization projects to reduce fire hazards around structures • Training fire management personnel • Complete, update, and implement CWPPs for each county • Continue publicizing and implementing fire hazard and fuels mitigation cost-share program • Banned Exploding Targets within the Black Hills Fire Protection District 	<ul style="list-style-type: none"> • Build biomass plants to utilize dead trees and wood waste • Cross-train fire management personnel in forest and rangeland fire response and suppression • Have local fire departments develop WUI mitigation programs • Fire Prevention Program
Rangeland Fires	<ul style="list-style-type: none"> • West River is typically drier than East River and more susceptible to drought-caused wildfires • Grass fires spread quickly, even if the fuel is not completely dry 	<ul style="list-style-type: none"> • Enact county or statewide burning restrictions as needed • Issue controlled burning permits • Limit fireworks displays • Prescribed burns • Weed control • Perform proper maintenance on combines and tractors to prevent sparking • Graze livestock on rangeland to thin fuels • Create fire breaks and defensible space • Training fire management personnel • Complete, update, and implement CWPPs for each county • Plant drought-resistant grasses • Continue publicizing fire hazard and fuels mitigation cost-share program • Built network of Single Engine Airtanker bases in Hot Springs, Lemmon, Pierre SD, along with bases in Valentine, Chadron and Alliance NE. 	<ul style="list-style-type: none"> • Cross-train fire management personnel in forest and rangeland fire response and suppression • Educate farmers and ranchers about importance of farm equipment maintenance and what to do if a tractor or combine fire ignites • Encourage farmers/ranchers and government agencies to share their fire action plans, especially when their lands border one another • Identify water supplies and other resources on farms and ranches that could be used during fire response and suppression activities • Build a SEAT base at Mobridge. • Enact "Redzone" areas to assist local VFD's in suppressing prairie fires in drought years.

3.7.4 Recommendations

Framework for Future Drought Vulnerability Studies

A region's vulnerability to drought varies based on several factors. For instance, the West River is generally more susceptible to drought-related wildfires than the East River due to fuels, topography, and climate. Additional studies and data collection are necessary to further characterize and, where possible, quantify drought-caused wildfire vulnerability in different regions of the State. This section presents a framework for how future regional and State drought vulnerability studies may be conducted to further qualitatively characterize and quantify the vulnerability of the agricultural sector to drought.

A more refined vulnerability framework could consist of the following three steps.

- Step 1 - Identify key indicators or assets that may be used to represent the sensitivity of wildfire to drought within a region. These key indicators might include the number of people living in the WUI, structural values in the WUI, economic assets at risk (e.g., recreational and tourist attractions), sensitive wildlife habitat, etc.
- Step 2 – Collect data necessary to characterize the key indicator under baseline and drought conditions.
- Step 3 – Develop metrics that are indicative of drought severity based on Step #1 and Step #2. For example, a metric could be the number or value of structures located in the WUI. This metric could then be further assigned a weighting factor such as the number or value of critical facilities among those structures. These metrics may then be summed to develop a single drought index for a particular region.

Data collection is critical to the methodology outlined above. The following table identifies the types of data that can be useful for a drought vulnerability assessment and identifies potential data gaps.

Table 23 Data Collection for Enhancing Vulnerability Assessment

Wildfire Subsector	Data	Notes on Data Availability
Forest Fire	<ul style="list-style-type: none"> • Soil moisture data • Forest health/beetle kill data • Fire cause data • Fire size and duration data • Fire suppression costs data • Drought declarations that include wildfire impacts • Climate change data focusing on lack of precipitation, temperature, and lightning strike frequency • Data on historic fire patterns 	Various data exists including: NCDC, Federal Wildland Fire Occurrence Database, South Dakota Department of Agriculture Division of Wildland Fire Suppression NFIRS database
Rangeland Fire	<ul style="list-style-type: none"> • Soil moisture data • Fire cause data • Fire size and duration data • Fire suppression costs data • Drought declarations that include wildfire impacts • Climate change data focusing on lack of precipitation, temperature, and lightning strike frequency • Data on historic fire patterns 	Various data exists including: NCDC, Federal Wildland Fire Occurrence Database, South Dakota Department of Agriculture Division of Wildland Fire Suppression NFIRS database

Recommended Next Steps

Many of the existing and suggested adaptive capacities listed in **Table 22** and the data needs listed in **Table 23** require a combination of data collection efforts, regional studies, or further consideration/feasibility analysis. Recommendations for additional follow up activities are provided below. These activities will improve the State’s ability to understand the relationship between wildfire and drought and identify adaptive capacities that more effectively address adverse drought impacts.

- Continue to develop or update CWPPs for all counties in South Dakota.
- Continue to implement wildfire mitigation actions identified in CWPPs.
- Continue issuing daily Rangeland Fire Danger and Red Flag Warning statements from April through October.
- Develop climate change studies that forecast drought patterns in South Dakota.
- Pursue training for fire management personnel.
- Produce public drought management plans that emphasize fire safety during droughts.
- Investigate effect of pine beetles on wildfire potential in South Dakota.

3.8 Wildlife Sector

3.8.1 Introduction to the Wildlife Sector

South Dakota contains a diversity of wildlife and ecosystems, all of which can be negatively impacted by drought. The wildlife sector encompasses land-based and aquatic wild species and the habitat in which they live. Within South Dakota, the Department of Game, Fish & Parks (GFP) is responsible for managing wildlife resources.

While it is not possible to assign monetary value to South Dakota's wildlife and natural environment, it is important to acknowledge the role it plays in the state's economy. According to the GFP, 54% of South Dakotans participate in wildlife-associated recreation. In 2006 hunting and fishing generated a combined \$350 million in retail sales and \$162 million in hunting- and fishing-related salaries, wages, and income within South Dakota. In addition, wildlife watchers in South Dakota were estimated to have spent \$183 million in trip expenditures and equipment costs in 2006⁵⁰.

As well as being an important component of the State's economy, the presence of wildlife and undeveloped habitat imparts an intangible benefit to the residents of and visitors to South Dakota. The success of all other sectors discussed in this drought vulnerability assessment is linked to environmental quality to varying degrees. For example, tourism is directly linked to wildlife and natural habitat due to the popularity of hunting, fishing, and wildlife watching cited above. Health and socioeconomics are tied to the environment: multiple studies have shown the majority of South Dakota residents feel that it is important to conserve and protect as much fish and wildlife habitat as possible⁵¹, and outdoor recreation has been shown to have physical and mental benefits⁵². Many South Dakota residents also feel that healthy fish and wildlife populations are important to the economy and well-being of residents.⁵³

Wildlife is a broad category that encompasses many different species and habitats. For purposes of this study, the following aquatic and terrestrial categories are used for the evaluation of drought vulnerability. These categories of wildlife assets were recommended by the GFP.

Aquatic Wildlife Assets

- Fisheries resources - includes wild species of fish, fish reared in state-run fish hatcheries, and the hatchery facilities

⁵⁰ GFP, 2006 – reference <http://gfp.sd.gov/agency/information/economic-impact.aspx>.

⁵¹ GFP Division of Wildlife-Habitat Section, 2008; GFP Larry Gigliotti, Wildlife Values and Beliefs of South Dakota Residents, 2004

⁵² Kent State University 2007 <http://einside.kent.edu/?type=art&id=82928>; Godbey 2009

⁵³ Private land habitat plan summary, p. 1

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- Fishing habitat and access - fishing habitat including lakes, reservoirs, and streams and human access to such locations

Terrestrial Wildlife Assets

- Wildlife resources - small and large game species that the GFP actively tracks, manages, and oversees for hunting, viewing, and other recreational purposes
- Wildlife habitat and access – forests, grasslands, croplands and other types of land use where specific terrestrial species are located

Aquatic Wildlife Assets

Fishing resources, habitat and access are different in the western portion of the State as compared to the eastern portion. The Missouri River essentially divides these two portions. On the east side, the Prairie Pothole Region provides habitat for waterfowl and other migratory birds. Fishing access here is largely focused on boat and shore fishing in natural lakes. West of the Missouri River, fly fishing for trout in cold-water streams in the Black Hills is prevalent, as is boat and shore fishing in streams and reservoirs. Trout are found in streams and reservoirs in the Black Hills region and other popular fish species are found throughout the State.

The Missouri River traverses the State from north to south and supports a large variety of aquatic and riparian life along the river corridor. There are four U.S. Army Corps of Engineers dams on the Missouri River that form four reservoirs: Oahe Dam (Lake Oahe), Big Bend Dam (Lake Sharpe), Fort Randall Dam (Lake Francis Case), and Gavins Point Dam (Lewis and Clark Lake). The GFP maintains recreation areas along these reservoirs. Fishing access along the Missouri occurs from GFP access points at the four reservoirs and along the river banks.

Figure 57 shows the location of the major water features (lakes, streams, rivers, reservoirs) and State hatcheries that provide habitat for aquatic wildlife.

Figure 57. Fisheries Resources and Access: Streams, Lakes, Reservoirs and State Fish Hatcheries

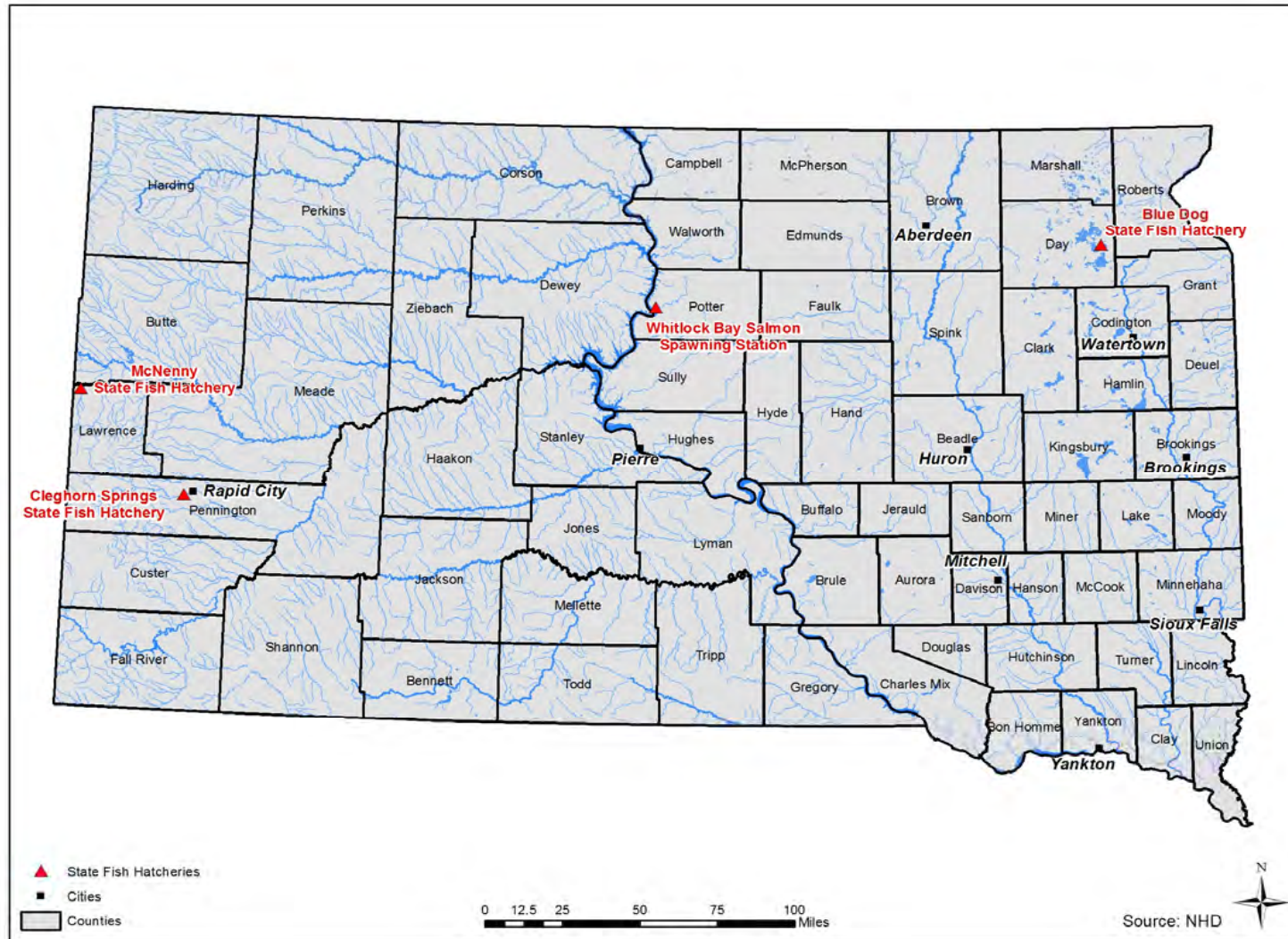


Table 24 provides information on the where these aquatic assets are located. The most popular fish species from a recreational perspective include:⁵⁴

- Trout – located in approximately 800 miles of stream and 22 reservoirs in the Black Hills area⁵⁵. Most streams contain self-sustaining wild populations of brown and brook trout. Little or no reproduction takes place in reservoirs, making annual stocking necessary for reservoirs. Less than 10% of the stream mileage in the Black Hills is stocked.⁵⁶ Rainbow trout are primarily stocked in reservoirs.
- Walleye – The most-preferred game fish species in the State. They are prevalent throughout the state especially in Missouri River reservoirs, natural lakes in eastern South Dakota, and Bureau of Reclamation reservoirs in western South Dakota⁵⁷.
- Yellow perch – widespread throughout the state with principal fisheries existing in eastern SD glacial lakes and wetlands, small prairie reservoirs, Sheridan and Deerfield Lakes in the Black Hills⁵⁸.
- Bass – Smallmouth bass are present in Lake Francis Case, Lake Sharpe, and the Prairie Lakes (natural lakes in the northeastern corner of the State). Eastern SD natural lakes, and prairie stock dams and small impoundments support the majority of largemouth bass fishing opportunity.
- Catfish – abundant in Lake Oahe and throughout the Missouri River system and in western South Dakota Bureau of Reclamation reservoirs⁵⁹. Widespread in larger streams, lakes, and rivers of South Dakota, and is the predominant sport fish in turbid rivers where larger individuals occupy pools.⁶⁰

⁵⁴ From John Lott, see email of 3/27/15.

⁵⁵ Black Hills of South Dakota Fishing Guide, South Dakota Department of Game, Fish and Parks (see BHFishingGuide_lores.pdf).

⁵⁶ Black Hills of South Dakota Fishing Guide, South Dakota Department of Game, Fish and Parks (see BHFishingGuide_lores.pdf).

⁵⁷ <http://gfp.sd.gov/fishing-boating/tacklebox/lake-surveys/lake-oahe/oahe-walleye.aspx>

⁵⁸ Black Hills of South Dakota Fishing Guide, South Dakota Department of Game, Fish and Parks (see BHFishingGuide_lores.pdf).

⁵⁹ <http://gfp.sd.gov/fishing-boating/tacklebox/lake-surveys/lake-oahe/oahe-catfish.aspx>

⁶⁰ Guide to the Fishes of South Dakota. South Dakota GFP. (GuidetoCommonFishes-lores.pdf)

Table 24 Geographic Region and Seasonal Access to Aquatic Wildlife Assets

Wildlife Asset	Geographic Region	Seasonal Access
Fisheries resources		
Cold water fish / trout	Black Hills streams and lakes ⁶¹	Fishing season is year round spring through fall, but wintertime habitat for mature fish can be a limiting factor to species proliferation. Lower wintertime stream flows can decrease available habitat for adult fish ⁶² . High water temperatures can also be a limiting factor in summer, particularly in dryer years.
Warm water fish / walleye, yellow perch, bass, catfish	Lakes and reservoirs	Fishing season is year-round. Wintertime habitat in lakes and reservoirs is less of a concern than the streams.
Fishing habitat and access		
Streams	Mainly in the Black Hills	Access to Black Hills streams is primarily in spring through fall but many streams are fishable year round. In the winter, some access roads are closed ⁶³ .
Reservoirs/lakes	Throughout the State. Largest reservoirs/lakes are located on the Missouri River corridor.	Year-round access to lakes and reservoirs is maintained by GFP.

Terrestrial Wildlife Assets

South Dakota offers a variety of habitats for terrestrial wildlife species including private lands consisting of cultivated croplands, pastures and grasslands, and conservation habitat acres, public grazing lands, national forests and State owned lands. Cultivated and uncultivated acres provide substantial habitat a variety of terrestrial wildlife. Land used for cultivated crops, such as corn and soybeans, provides habitat for different species than uncultivated grassland and pasture. Grassland and pasture provides habitat for mule deer, while corn fields near the Missouri River can provide habitat for quail and pheasant⁶⁴. In general, most of the uncultivated grassland and pasture occurs in the western half of the State and cultivated corn, soybeans and non-alfalfa hay dominate the agricultural landscape east of the Missouri River. Uncultivated grassland and pasture comprises the majority of agricultural lands comprising almost half of the agricultural land use in 2014. ⁶⁵ This is followed by corn, soybeans and non-hay alfalfa comprising 31% of agricultural land use. The remaining 20% of agricultural land use is made up of crops such as

⁶¹ Dakota Angler & Outfitter – Fly Shop of the Black Hills. “Fly Fishing in the Black hills”. Accessed 4/6/2015. 2013. <http://www.flyfishsd.com/black-hills-fishing/>

⁶² From the Colorado Drought Vulnerability Assessment (Annex B, p. 170/340).

⁶³ Communication with Wanda Goodman

⁶⁴ Sdwildlife brochure, see PDF in Wildlife folder.

⁶⁵ CropScape – Cropland Data Layer. USDA National Agricultural Statistics Service. 2014. <http://nassgeodata.gmu.edu/CropScape/>

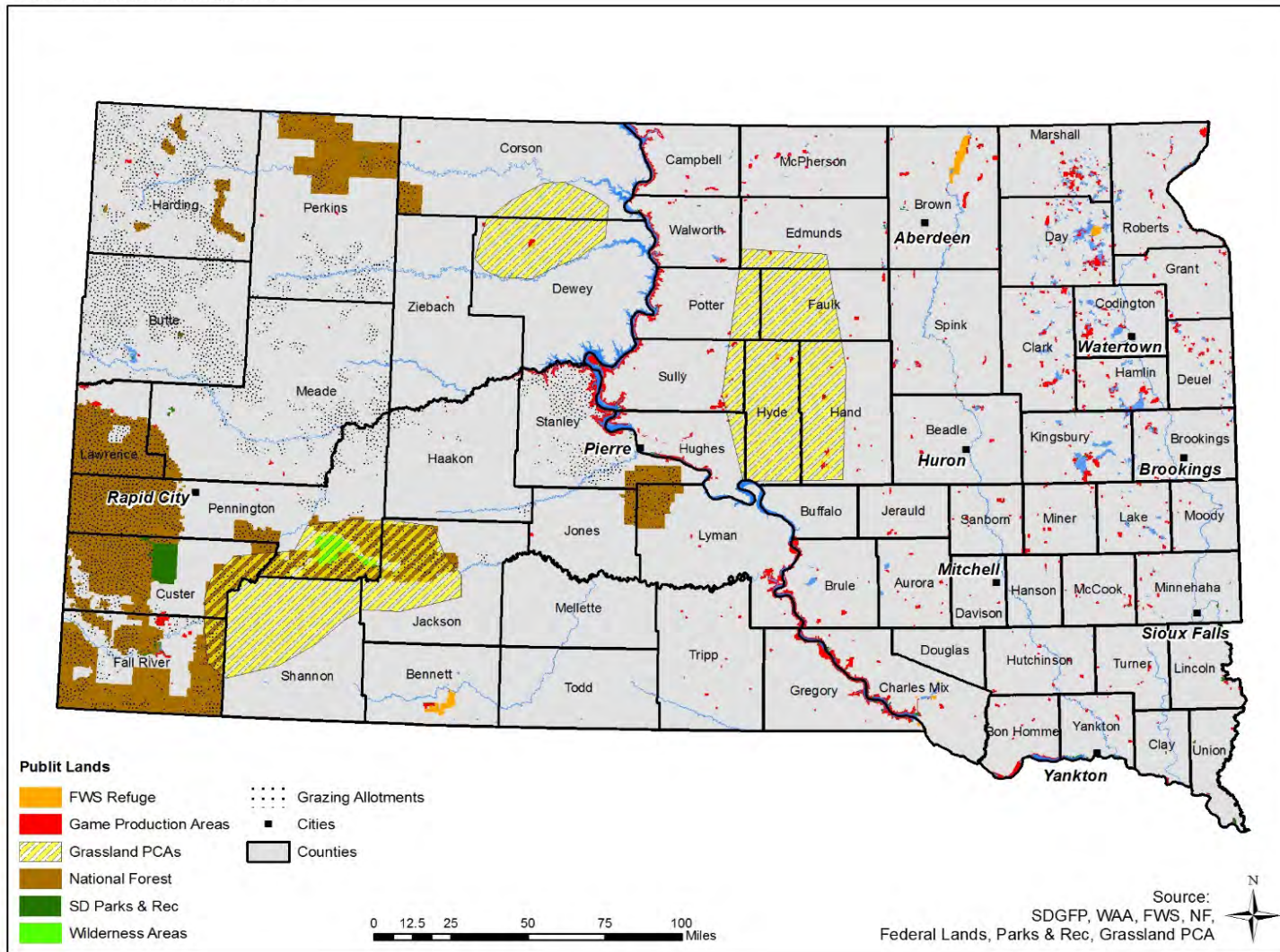
spring and winter wheat, alfalfa, and non-crop land uses like open water, developed land, and wetlands.

South Dakota has also reserved a significant amount public land to support livestock grazing and other wildlife. These lands are shown in **Figure 58**. Grassland Priority Conservation Areas (PCAs) are areas of importance in three nations, Canada, the United States, and Mexico, due to their ecological significance and threatened nature⁶⁶. South Dakota has three Grassland PCAs. The presence of these conservation areas is a positive indicator for wildlife adaptability, as it identifies grassland habitat that may be protected from development, farming, or grazing in the future.

The USFS also manages grazing allotment land in National Forests within South Dakota. There are four national forests in South Dakota: Nebraska National Forest, Black Hills National Forest, Custer National Forest, and Dakota Prairie Grasslands National Forest. South Dakota has 125 state parks, distributed throughout the State. The largest state park by far is Custer State Park in Custer County, at 70,780 acres. Four more state parks are between 1,000 and 1,500 acres, and the rest are between 5 and 980 acres in size. Hughes County has the highest number of state parks with 12 parks, followed by Gregory County (9), Charles Mix and Walworth Counties (7), Stanley County (6), and Sully County (5). All other counties have four or fewer state parks.

⁶⁶ USGS Science Base-Catalog. "North America Grassland PCAs 2010." Updated 7/17/14. Accessed 3/26/2015.

Figure 58. Federal and State Reserved Lands for Wildlife



The most popular terrestrial game species for hunting in South Dakota include the following:

- Pheasant – located statewide but primary focus in eastern South Dakota and the counties adjacent to the west side of the Missouri River.
- White-tailed and mule deer – white-tailed deer are found statewide, and mule deer are found primarily west of the Missouri River and a handful of counties in eastern South Dakota.
- Elk – located primarily in the Black Hills region with a few counties in the prairie.
- Waterfowl – located statewide with more of an emphasis in eastern and central South Dakota.

Table 25 Geographic Region and Seasonal Access to Terrestrial Wildlife Assets

Wildlife Assets	Geographic Location	Seasonal Access
Wildlife resources		
Pheasant	Central and eastern South Dakota	October through first weekend in January ⁶⁷
White-tailed deer	Statewide	Deer are susceptible to EHD throughout the summer. Epidemics end at the first frost of the year ⁶⁸ .
Mule deer	West of Missouri River and a few counties in eastern South Dakota	Hunting seasons vary by year and location.
Elk	Primarily in the Black Hills region and in Butte, Bennett, and Gregory counties ⁶⁹ .	Hunting seasons vary by year and by location. In general the season runs September through December ⁷⁰ .
Waterfowl	Located statewide, but northeastern South Dakota is a critical region for migratory waterfowl ⁷¹ .	Migration and nesting season is in the spring ⁷² . Hunting season is generally October through January.
Wildlife habitat and access		
Cultivated crops	Statewide eastern dominant	
Uncultivated crops	Statewide western dominant	
National Forests and Parks	See Figure 58	Year round although access to some locations can be limited in the winter
State Parks	See Figure 58	Year round.
Public grazing lands	See Figure 58	

3.8.2 Vulnerability Assessment of the Wildlife Sector

Considerations when addressing drought vulnerability specific to the wildlife sector include:

- What criteria will be used to characterize the current condition of the habitat or species relative to a particular “baseline” condition?
- What is the hydrologic regime and is there significant riparian presence?
- How do changes in climate and precipitation patterns impact the region?

⁶⁷ Communication with Wanda Goodman

⁶⁸ GFP. Epizootic Hemorrhagic Disease and Bluetongue in South Dakota 2013. Accessed 4/9/2015. Downloaded from <http://gfp.sd.gov/wildlife/diseases/docs/EHDBluetongueSD.pdf>

⁶⁹ GFP. “Big Game: Elk”. Accessed 4/9/2015. <http://gfp.sd.gov/hunting/big-game/elk/>

⁷⁰ South Dakota State News. “2014 Elk Seasons Set.” Accessed 4/9/2015. <http://news.sd.gov/newsitem.aspx?id=15975>

⁷¹ Ducks Unlimited. “Prairie Pothole Region.” Accessed 4/9/2015. No date on website. <http://www.ducks.org/conservation/where-we-work/prairie-pothole-region>.

⁷² Ducks Unlimited. “Prairie Pothole Region.” Accessed 4/9/2015. No date on website. <http://www.ducks.org/conservation/where-we-work/prairie-pothole-region>.

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- How is wildlife stress characterized?

Some proxy measurements to establish a baseline for wildlife well-being could be stream flows, average minimum and maximum stream temperatures, presence of undeveloped land, and average hunting and fishing license sales. Stream flows significantly above or below the average could signal potential vulnerability to aquatic species because it forces them to adapt quickly to conditions they are unaccustomed to. Departures from average temperatures could signal stresses to both land- and aquatic-based species, as very low or very high temperatures can make it more difficult to regulate body temperature and can reduce the availability of food and water sources. A decrease in undeveloped land can signal potential wildlife encroachment issues, or loss of cover for vulnerable species. Finally, hunting or fishing license sales can be a lagging indicator of the overall health and abundance of a particular species.

The considerations discussed above are not commonly quantified in published literature specific to drought, can be very specific to individual species and populations, and is beyond the scope of this study. This section provides a qualitative overview on factors that contribute to the vulnerability of wildlife species to drought. Information is also provided on historical drought impacts both specific to wildlife and experienced by the GFP, whom is responsible for managing many of the wildlife assets in South Dakota.

Historical Drought Impacts

Historical impacts to wildlife from drought in South Dakota have not been widely documented. Based on communication with the GFP, drought impacts fall into three main categories: impacts to species and habitat, changes in revenue, and changes in expenditures. Drought conditions often result in staff members becoming busier addressing issues specific to drought, e.g. enzootic hemorrhagic disease (EHD) outbreaks and prairie dog encroachment, and the GFP annual budget is reduced due to a decrease in hunting, fishing, and boating license sales. Fishing access becomes limited as lake levels drop and stream flows decrease. Wildlife habitat becomes degraded or reduced due to wildfires, demand for grazing and haying acreage, and reduction in cover.

Specific examples of historical drought impacts on wildlife, as observed by GFP staff, are listed below:

- In extended drought, boat ramps are affected and staff spends more time and resources maintaining lake access. In some situations, boat ramps may need to be closed or low level boat ramps must be added. This impacts fishing access for the public and the GFP annual budget.
- When drought causes lower lake levels and impacts boat ramps, fewer people come to boat, which reduces park entrance license sales, camping revenue, and fishing license sales.
- Outbreaks of EHD, an often-fatal virus contracted by deer, are common during droughts. Drought accelerates the annual spread of EHD by creating the conditions where a high level

of midges that carry the virus can persist. EHD is more prevalent in drought conditions, causing staff to spend more time responding to calls regarding dead or dying deer. Staff spends more time handling EHD calls, reducing their availability for other assignments. In some instances, GFP will engage in on-the-ground monitoring to further assess the severity of the outbreak to help in making management decisions that ultimately impact hunting license sales.

- GFP refunded deer hunting licenses in 2012 and removed from sale licenses that had not yet been distributed. The reduction in deer numbers from a severe EHD outbreak has a lasting effect of reduced licenses over several years.
- During drought years, and instances of multiple years of drought, forage and grass conditions are stressed and in a deteriorated state. Prairie dog complaints typically rise under those conditions because the prairie dogs are in competition with livestock for forage, and because prairie dogs and mounds are more visible in drought conditions compared to years when grass is taller and in better condition. GFP expenditures for prairie dog control rise due to the elevated number of requests from landowners.
- Reduction in small game hunting licenses sold as game bird production falls, habitat is removed, and landowners deny access to private lands out of wildland fire fears.
- Reduction in fishing licenses sold due to decreased fishery quality associated with low water levels in lakes and low flow in Black Hills streams.
- The reach of Spring Creek in the Black Hills below Sheridan Lake may dry up or become too warm to support trout in dry years⁷³. The entire reach of French Creek and streams in the Battle Creek watershed similarly experience low flows and warm temperatures in dry years.
- In the event of severe drought in the Prairie Pothole Region, waterfowl (particularly duck) numbers will be reduced.
- Pheasant numbers may be reduced in the event of severe drought in the eastern and south-central part of the State.
- The GFP gets a portion of its revenue from hunting and fishing license sales. Drought can reduce the number of licenses sold, which can reduce the GFP's operating budget.⁷⁴

The National Drought Mitigation Center's Drought Impact Reporter provides an interface for the public to report drought impacts specifically related to plants and wildlife, among others.

Figure 59 shows the number of plant and wildlife drought impacts that have been reported by South Dakota on a county basis from January 1, 1980 to April 13, 2014. These results indicate

⁷³ Black Hills Fishing Guide (BHFishingGuide_lore.pdf)

⁷⁴ Currently the GFP does not track license sales in a way that makes the sales data easy to access or analyze patterns in drought years vs non-drought years. Tracking these data would allow for an economic analysis of drought impacts to the GFP.

that the greatest number of reported impacts have occurred in the Black Hills area of Custer and Pennington counties with over 30 impacts reported. The majority of other impacts have been reported in the northwest portion of the State and in three counties near the southeast border. There are limitations to this data as it is dependent upon voluntary or media reports, but it does paint an initial picture.

Figure 59. NDMC Reported Plant and Wildlife Drought Impacts (Jan 1980 to April 2015)

Typical impacts reported to the NDMC might include: loss of biodiversity of plants or wildlife; loss of trees from rural or urban, landscapes, shelterbelts, or wooded conservation areas; reduction and degradation of fish and wildlife habitat; lack of feed and drinking water; greater mortality due to increased contact with agricultural producers, as animals seek food from farms and producers are less tolerant of the intrusion; disease; increased vulnerability to predation (from species concentrated near water); migration and concentration (loss of wildlife in some areas and too much wildlife in others); increased stress on endangered species; salinity levels affecting wildlife; wildlife encroaching into urban areas; and loss of wetlands.⁷⁵

⁷⁵ South Dakota Hazard Mitigation Team. 2013. State of South Dakota Hazard Mitigation Plan.

Factors that Impact Wildlife Vulnerability to Drought

Wildlife vulnerability to drought is complex and depends on a multitude of interrelated factors. Specific regions in South Dakota are more vulnerable than others depending on the drought resiliency of wildlife species present in the region, the level of legal wildlife protection, administration of water rights, land management, susceptibility to wildfire and capabilities of wildlife managers within the region.

Habitat Protection and Land Management

One of the factors that can influence an area's vulnerability is the level in which the area is legally protected and how it is managed. Land and water-based species are impacted by drought in two basic ways: reductions in food and water and degradation of habitat quality and coverage.

Human development and management of lands can intensify the impact that drought has on wildlife habitat. Competition between municipal, industrial, and agricultural users can also further degrade an area that is already experiencing negative impacts due to drought. The presence of national forests and state parks in a county increases the adaptive capacity of the wildlife. These lands are owned by the Federal and State governments where private development on the lands are limited and human activities on the lands are regulated to preserve the wildlife assets. The presence of grazing allotment land can be both a benefit and a vulnerability for the wildlife in the area. Grazing can be beneficial to the grassland by enhancing growth and vigor of some plant species while reducing or eliminating unwanted plant species. However, a defined grazing allotment can mean habitat reductions during drought is likely, posing a vulnerability to the wildlife living there.

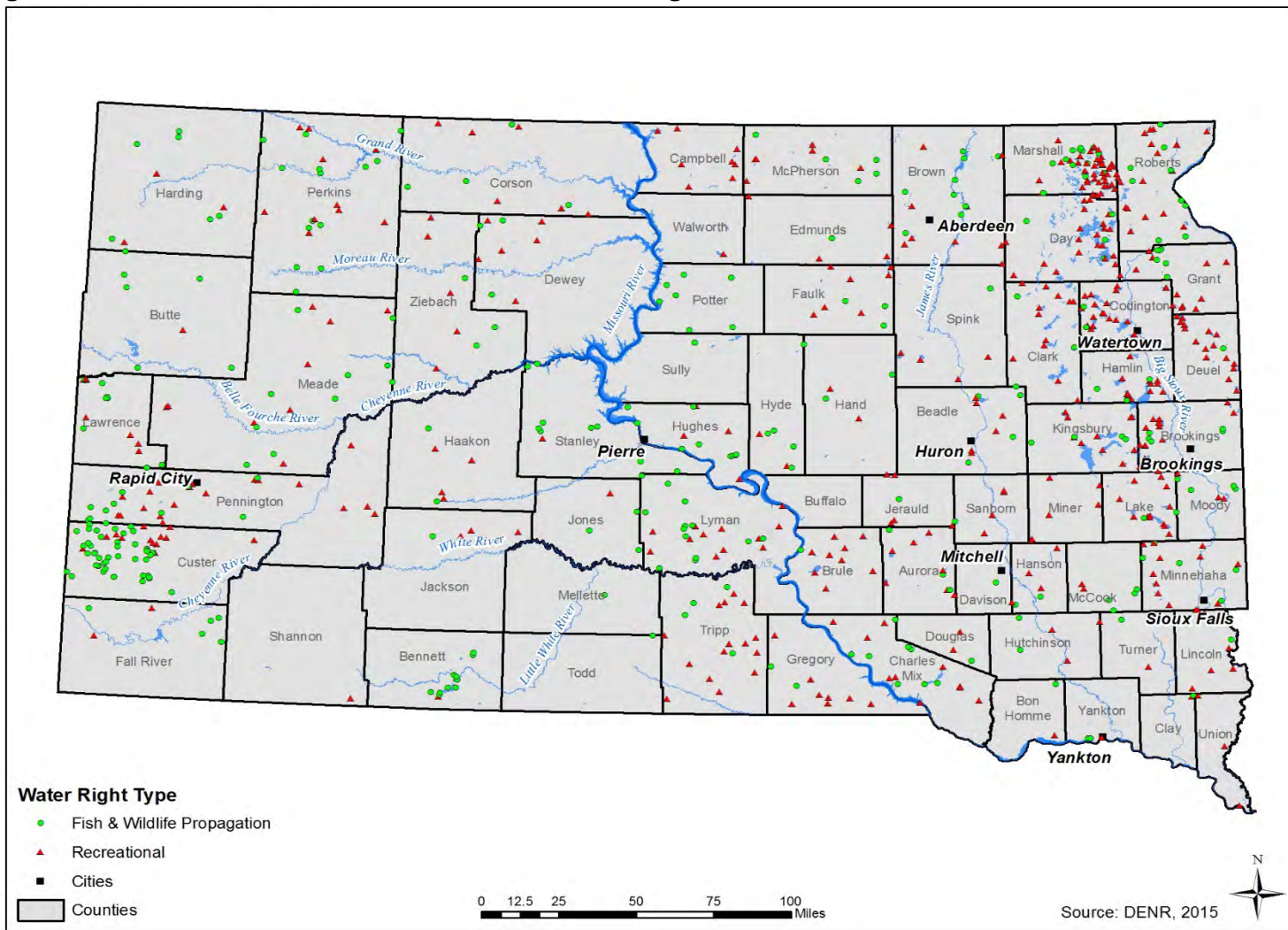
In aquatic habitats, stream flows are often lower during dry periods and levels in lakes and reservoirs can decline. This can reduce the quality and amount of habitat available to aquatic species. Furthermore, reduced flows and declining water storage in lakes and reservoirs can have negative impacts on water quality. Temperatures may increase, algae blooms can occur reducing dissolved oxygen in the water and harmful water contaminants can be concentrated if stream flows are reduced to low levels. Cold-water fish in streams in the Black Hills region rely on cold water for survival and are especially vulnerable to drought. Fishery resources and access in the eastern half of the State and along the Missouri River have not historically suffered the same level of impact given that there is generally larger quantities of water and the fish are warm water species. Low water levels of lakes and small impoundments make these waters more susceptible to winterkill and summerkill caused by low oxygen levels.

Administration of Water Rights

South Dakota's water rights system provides protections environmental and recreational protections by enabling water users to own water rights for recreation and environmental and fish propagation purposes. **Figure 60** shows the location of the environmental and fish propagation and recreation water right licenses within the State. These water rights specify instream flows

(CFS) that need to be maintained as well as the amount of water (acre-feet) reserved for reservoir storage purposes. The level of protection these rights can offer during a drought depends on the priority of the water rights, especially for river and stream aquatic resources. Some of these rights are relatively junior and do not provide significant protections while others are senior in priority and provide substantial protection. According to South Dakota water law, water bodies on State owned property have a priority date of when South Dakota was granted statehood. Many of these senior water rights are owned by the GFP and provide significant protection during dry periods. See Section 3.6.2 for additional details on how water rights are administered.

Figure 60. Recreational and Environmental Water Right Licenses



In terrestrial environments, drought can reduce vegetative coverage which provides an important food source and habitat coverage for the ecosystem. Although areas may be legally protected from drought, certain land management practices necessary to meet competing human needs can further stress terrestrial habitats. State-owned Game Production Areas have haying and grazing as part of the annual maintenance of these properties and under extreme drought conditions are often requested as an additional forage source. CRP acres can be released for emergency haying and grazing in a drought, which can reduce the quality of habitat available for wild species like pheasants and deer. Animal mobility can also be aided or harmed by land use and human activities that either encourage, discourage, or prevent the migration of wildlife. Migration is essential to some species (i.e. grazing animals) during drought periods to ensure an adequate food supply.

Susceptibility to Disease and Parasites

Many land-based animals are impacted by food supply reductions and reduction of cover during drought. This can lead to greater susceptibility to disease, parasites, expansion into areas of human development, and decreased birth rates. During the 2012-2013 drought, the pheasant population was impacted due to reduced cover and food sources, and the deer population was reduced due to EHD.

Wildfire Potential

Drought significantly increases the risk and intensity of wildfire. Dry vegetation is more susceptible to sparking through human intent or accident, farm machinery, lightning, etc. Drier conditions can also encourage beetle and insect infestations that kill trees, creating an even greater supply of combustible fuels. Wildfire negatively impacts aquatic and terrestrial wildlife. Runoff from wildfires can significantly degrade water quality and aquatic habitat, whereas burned areas can destroy terrestrial habitat. It may take decades for certain forests to return to their former state. For more information on wildfire see Section 3.7.

Capabilities of Wildlife Management

The GFP earns over 50% of its annual revenue from resident and non-resident licensing fees. As discussed above, drought reduces GFP's annual revenue stream from the reduction in hunting, fishing and boating licensee sales and in park passes. In addition, special programs must be implemented to address drought such as monitoring of wildfires, increased prairie dog management and increased management of deer suffering from EHD. These programs increase management expenditures and increase demands on staff time. The increased expenditures and reduced revenue limits GFP's capabilities to fully address wildlife impacts.

Fish Hatcheries. The GFP also manages three fish hatcheries and one spawning station, shown on **Figure 57**. These hatcheries have variable vulnerabilities to drought. The Blue Dog Hatchery, in Day County, uses typically 55% groundwater and 45% lake water over the course of a year. The groundwater source is not heavily used as of 2015. In 33 years of operation, this hatchery has not seen a major impact on their water sources due to drought. On the other hand, flooding

has caused many issues. The Cleghorn Springs Hatchery, in Pennington County, relies on water from the Madison Aquifer. Aquifer water comes near the surface, is collected in a gallery, and is pumped to the hatchery building and outside rearing units. The water is aerated and oxygenated due to low oxygen levels and high level of dissolved nitrogen gas. The hatchery, spills production rearing and excess water to Rapid Creek through a pipeline. In moderate to severe drought, the hatchery reduces the amount of water it spills to Rapid Creek, but fish production is minimally affected. McNenny Hatchery, in Lawrence County, also gets its water supply from the Madison Aquifer. This hatchery has three artesian wells that provide a stable supply of water. In past droughts the water flow has been somewhat reduced but not to the point of impacting fish production⁷⁶. The salmon spawning station is located at Whitlock Bay near Gettysburg on Lake Oahe, in Potter County. Of these four facilities, the spawning station is most affected by drought as the fish ladder needs to be lengthened and the pumps moved further out into the lake as water levels decline⁷⁷.

Estimating Potential Losses

Aquatic and terrestrial losses associated with drought are inherently difficult to quantify on a monetary scale. As to date, there is not a standardized means to assign monetary costs to environmental attributes nor to the economic losses associated with drought. Additional studies could be conducted to estimate monetary costs associated with the vulnerabilities shown in **Table 26**.

One measurable estimate of potential loss from drought is the impact on GFP revenues as a result of reduced hunting license sales in drought years. In 2013, there were 20% fewer small game hunting licenses purchased than in 2012 which resulted in a \$2 million decrease in revenue.⁷⁸ Fewer deer and antelope licenses were also purchased which resulted in economic losses to the GFP. In regions that are managed by the GFP, monetary impacts to wildlife management could be further assessed by collecting data on GFP's expenditures and revenue streams during drought. Such expenditures and revenues will vary depending on the geographic area.

3.8.3 Summary of Identified Vulnerabilities and Adaptive Capacities

Table 26 summarizes the vulnerabilities and existing adaptive capacities associated with the wildlife sectors. New adaptive capacities that have been identified through this planning process are also included.

⁷⁶ Personal communication with Will Sayler, Fisheries Program Administrator.

⁷⁷ Personal communication with John Lott, Aquatic Resources Chief.

⁷⁸ South Dakota Department of Game, Fish and Parks Wildlife Division 2013 Annual Report, pg. 8.

Table 26 Summary of Vulnerabilities and Adaptive Capacities

Wildlife Asset	Identified Vulnerabilities	Adaptive Capacities	
		Existing or Implemented in the Past	Potential Options for Consideration
Aquatic Wildlife Assets			
Fisheries resources	<ul style="list-style-type: none"> • Reduced trout abundance due to lower stream flows and higher water temperature. • Fish kills in reservoirs due to lower lake levels and higher temperatures, and/or algae blooms • State Fish Hatcheries may be impacted due to lower inflows; i.e. fewer fish able to be supported, or low spawning success 	<ul style="list-style-type: none"> • Relocate populations • Restock impacted areas after drought • Voluntary angling restrictions during afternoons in summer months • Voluntary angling closures 	<ul style="list-style-type: none"> • Improve monitoring of baseline conditions (conditions in normal years)
Fishing habitat and access	<ul style="list-style-type: none"> • Degradation of aquatic habitat • Boat ramps become unusable if water levels drop too far • Need to construct new boat ramps • Reduced number of fishing licenses during drought • Smaller streams (i.e. in the Black Hills) may have significantly less flows or go dry • Ephemeral streams may remain dry during the whole year 	<ul style="list-style-type: none"> • Modify fisheries management to address drought • Advertise water-based recreation that doesn't involve boating (i.e. open more swimming beaches) • Environmental and recreational water rights can provide protection depending on seniority 	<ul style="list-style-type: none"> • Include boat ramp construction money into the annual budget • Develop drought reserve funds for use in a drought (i.e. funds for the construction of new boat ramps) • Lease flows from senior water right holders to maintain flows in the stream

Wildlife Asset	Identified Vulnerabilities	Adaptive Capacities	
		Existing or Implemented in the Past	Potential Options for Consideration
Terrestrial Wildlife Assets			
Wildlife resources	<ul style="list-style-type: none"> • Over-winter forage conditions are impacted by summer drought, causing increased mortality in large game • Wildlife (i.e. prairie dogs) encroaching on private land • Decreased forage and insects • Prevalence of disease during droughts (i.e. EHD is more prevalent in deer populations) • Increased mortality rate in species (i.e. pheasant & ungluates) • Lower big-game and small game license sales • More wildlife (especially young animals) can succumb to starvation, disease, parasites, and predation • Hibernation, migration, and breeding patterns can be thrown off by lack of food/water and changing weather patterns • Wildlife enter populated areas in search of food and water, potentially resulting in more conflicts between humans and wildlife and even between livestock and wildlife. 	<ul style="list-style-type: none"> • GFP manages the elk population as established in the elk management plan • Adjust license sales by species type to reduce or increase harvest overall mortality • Study the correlation between severe winter weather and mule deer survival and recruitment • Manage hunting licenses 	
Wildlife habitat and access	<ul style="list-style-type: none"> • Degradation of terrestrial habitat • Release of CRP acres to emergency haying reduces habitat for wildlife • State-owned Game Production Areas released to haying and grazing • Private landowners deny access to hunters out of fire fears • Dry-up of wetlands in the Prairie Pothole Region which is an important habitat for waterfowl • Increased risk of wildfire • Cottonwoods planted to provide bald eagle habitat don't survive tough droughts 	<ul style="list-style-type: none"> • GFP puts out news releases to warn hunters and wildlife viewers of dry conditions, precautions to take, and actions they can take if they spot a fire while in the field • Landscape-scale wildfire mitigation efforts • Conservation of wetland area through conservation easements and habitat improvements • Adjust license sales by species type to increase harvest to reduce impact on forage. 	

3.8.4 Recommendations

Framework for Future Drought Vulnerability Studies

South Dakota has a diverse portfolio of aquatic and terrestrial wildlife assets. Drought impacts each of these assets in a very complex, interrelated manner. A region's vulnerability to drought varies based on the drought resiliency of the wildlife species located within the region, how the water resources within the region respond to drought and on the variety of other factors discussed in Section 3.6.2. For instance, aquatic habitat along the Missouri corridor in the central portion of the State may be less vulnerable to drought relative to other aquatic habitats in drier more arid regions of western South Dakota. Additional studies and data collection are necessary to further characterize and, where possible, quantify drought vulnerability in different regions of the State. This section presents a framework for how future regional and State drought vulnerability studies may be conducted to further qualitatively characterize and quantify the vulnerability of the wildlife sector to drought.

A more refined vulnerability framework could consist of the following three steps.

- Step 1 - Identify key indicator species and/or habitat that may be used to represent the sensitivity of wildlife to drought within a region. These key indicator species/habitat would generally play a critical role in the ecosystem, be prevalent within the region and a sufficient amount of data has been collected in both normal (baseline) and drought conditions on the specie/habitat.
- Step 2 – Collect data necessary to characterize the species/habitat under baseline and drought conditions.
- Step 3 – Develop metrics that are indicative of drought severity based on Step #1 and Step #2. For example, a metric could be the area of grassland (acres) per the average number of estimated deer in a designated region. These metrics may be further assigned a weighting factor and summed to develop a single drought index for a particular region.

Data collection is critical to the methodology outlined above. The following **Table 27** identifies the types of data that can be useful for a drought vulnerability assessment and identifies potential data gaps.

Table 27 Data Collection Needs for Enhancing Vulnerability Assessment

Wildlife Asset	Data	Notes on Data Availability
Aquatic Wildlife Assets		
Fisheries resources	<ul style="list-style-type: none"> • Endangered species • Species critical for recreational purposes • Spatial data on indicator habitat • Optimum flows & temperature for indicator species • Other relevant water quality data • Presence of invasive fish species (if applicable) • Presence of species prone to disease • Level of protection (i.e. endangered species) 	
Fishing habitat and access	<ul style="list-style-type: none"> • Reservoir levels • Water quality conditions • Flow data • Invasive and natural species • Groundwater interaction • Spatial data on key habitats (i.e. spawning area) • Spatial data on endangered species habitat • Features critical to survival (fish ladders) • Habitat protections (i.e. environmental water rights) • Key recreational features (i.e.: boat ramps) 	
Terrestrial Wildlife Assets		
Wildlife resources	<ul style="list-style-type: none"> • Endangered species • Species critical for recreational purposes (i.e. hunting) • Spatial data on indicator habitat • Presence of species prone to disease • Level of protection (i.e. endangered species) 	
Wildlife habitat and access	<ul style="list-style-type: none"> • Protected lands (conservation easements) • Invasive and natural species • Spatial data on key habitats (i.e. breeding areas) • Spatial data on endangered species habitat • Features critical to survival • Key recreational features (i.e.: campgrounds) • Susceptibility to wildfire 	
Wildlife Management	<ul style="list-style-type: none"> • Annual revenue sources and amounts received • Annual expenditures • Challenges experienced during drought • Staff time expended in normal vs drought years 	

Recommended Next Steps

Many of the existing and suggested adaptive capacities listed in **Table 26** and the data needs listed in **Table 27** require a combination of data collection efforts, regional studies, or further consideration/feasibility analysis. Recommendations for additional follow up activities are provided below. These activities will improve the State's ability to understand the relationship between wildlife and drought and identify adaptive capacities that more effectively address adverse drought impacts.

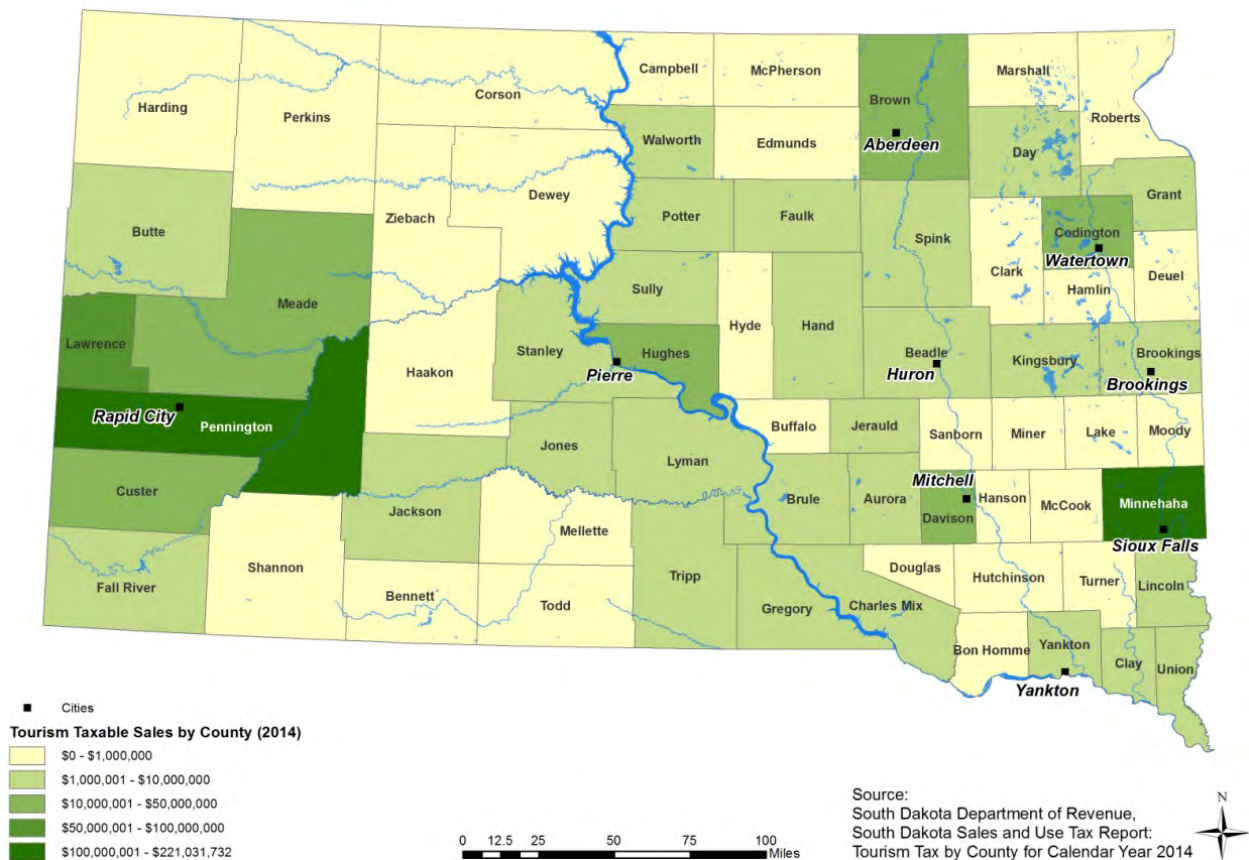
- Maintain or enhance existing adaptive capacity activities noted in **0**; Consider additional adaptive capacity alternatives noted and develop related mitigation action strategies.
- Identify regions in the State where pilot studies can be conducted comparing pre-determined baseline metrics in normal years relative to drought years. Such metrics may be developed using data such as stream flows, average minimum and maximum stream temperatures, presence of undeveloped land, and average hunting and fishing license sales, etc.
- Annually collect monetary data on GFP's revenue sources and itemized expenditures. Compare this information between normal and drought years to identify drought revenue impacts to the agency and how adjustments may be made to further improve the GFP's ability to manage wildlife impacts during dry years and operate under revenue shortfalls.
- Obtain additional spatial data that would be useful in characterizing wildlife vulnerability on a regional level. This may include spatial data of all CRP lands, conservation easements and wildlife habitat types throughout the State.
- Conduct or sponsor ecological studies on the drought vulnerability of key indicator species (i.e. game or endangered species).

3.9 Tourism Sector

3.9.1 Introduction to the Tourism Sector

Tourism is an important industry in South Dakota. According to the Calendar Year 2014 Sales and Use Tax Report, taxable sales related to tourism totaled over \$700 Million.⁷⁹ The Black Hills and Badlands region (nearby cities include Custer, Deadwood, Keystone, and Spearfish) generates the most tourism revenue, followed by the Southeast region (Yankton, Mitchell and Sioux Falls), the Glacial Lakes and Prairies region (Aberdeen, Brookings, and Watertown), and finally the Missouri River region (Pierre) See **Figure 61** for a representation of tourism taxable sales by county in 2014.

Figure 61. South Dakota Tourism Taxable Sales by County, 2014



⁷⁹ South Dakota Department of Revenue, South Dakota Sales and Use Tax Report, Tourism Tax by County, Calendar year 2014, http://dor.sd.gov/Taxes/Business_Taxes/Statistics/2014/PDFs/Calendar%20Year/CY2014County%20Tourism.pdf

Activities and attractions that contribute to the tourism sector in South Dakota include the following:

- Outdoor Recreation
- Popular Attractions
- Events

Outdoor Recreation

Tourism encompasses a variety of recreational activities throughout the State. Many of these activities are in the outdoors and depend upon healthy wildlife ecosystems. Many of the wildlife drought impacts and vulnerabilities discussed in the Wildlife Sector are also relevant to tourism. This section cross references drought wildlife vulnerabilities when they are relevant to outdoor recreation.

Outdoor recreational activities that play a part in tourist activities include:

- Fishing
- Hunting
- Wildlife viewing
- Camping/Hiking
- Biking
- Horseback Riding
- Rock Climbing
- Motorcycling
- Archaeology / Paleontology
- Golfing
- Boating
- Skiing
- Snowmobiling

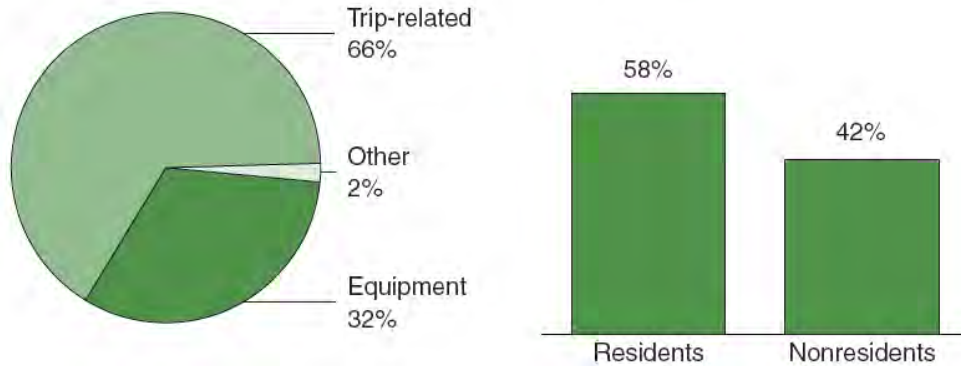
Fishing

According to a 2011 report, fishing-related expenditures in South Dakota totaled \$203 Million. Out of 268,000 total anglers that year, 58% were residents and 42% were non-residents.

Figure 62. Fishing Expenditures and Anglers by Residence, 2011

Fishing Expenditures in South Dakota
(Total: \$203 million)

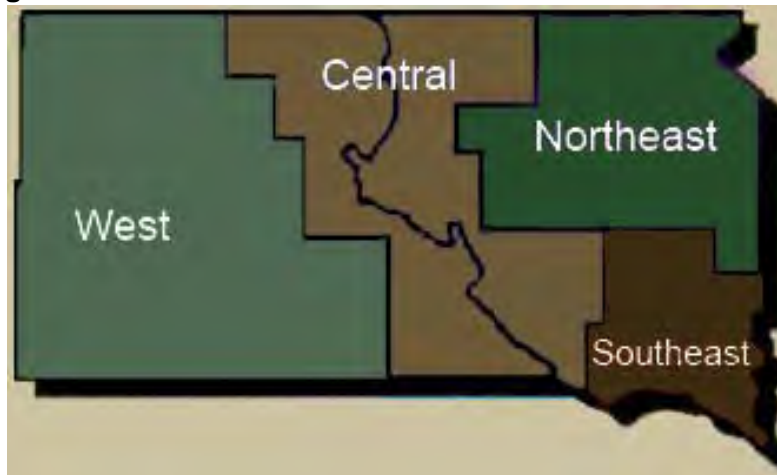
Percent of Anglers by Residence
(Total: 268 thousand participants)



Source: U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. *2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation*.

Fishing opportunities in South Dakota are best described by region as the types of fish and fishing techniques vary, depending on the water resources in each region.⁸⁰ The South Dakota Game, Fish and Parks Department has divided the state into four regions: West, Central, Northeast, and Southeast (see **Figure 63**). See the wildlife Section 3.8 discussion for more details on fishery resources by region.

Figure 63. Regions in South Dakota



Source: South Dakota Game, Fish & Parks Department Website, <http://gfp.sd.gov/state-parks/find-a-park/default.aspx>

Western Region—Black Hills, Badlands and Lakes Region: This region comprises nearly a third of the state. Within the Black Hills are 14 mountain lakes and more than 400 miles of

⁸⁰ Travel South Dakota website, <https://www.travelsouthdakota.com/things-to-do/recreation/fishing/>

meandering streams containing brook, brown and rainbow trout. On the surrounding prairie, reservoirs and ranch stock dams also provide opportunities for anglers. More than 50,000 stock dams are abundant with largemouth bass, northern pike, and a variety of panfish.

There are seven State Parks/Recreation areas in the Western Region indicated as providing recreational fishing opportunities: These include: Angostura Recreation Area, Bear Butte State park, Custer State park, Rocky Point Recreation Area, Roughlock Falls Nature Area, Shadehill Recreation, and Sheps Canyon Recreation Area.

Central Region—Missouri River Region: Four massive dams on the Missouri River, completed in the early 1960s created more than 900 square miles of open water and 3,000 miles of shoreline. The reservoirs include Lake Oahe, Lake Sharpe, Lake Francis Case, and Lewis and Clark Lake. In this region, there are also many smaller prairie stock dams from one to 100 acres. Walleye are the most abundant and popular fish in the Missouri River reservoirs. Chinook Salmon can also be fished on Lake Oahe. Other fish species available are northern pike, smallmouth bass, white bass, channel catfish, and paddlefish.

There are 22 State Parks/Recreation areas in the Central Region indicated as providing recreational fishing opportunities: Burke Lake Recreation Area, Buryanek Recreation Area, Cow Creek Recreation Area, Farm Island Recreation Area, Indian Creek Recreation Area, LaFramboise Island Nature Area, Lake Hiddenwood Recreation Area, Little Moreau Recreation Area, North Point Recreation Area, North Wheeler Recreation Area, Oahe Downstream Recreation Area, Okobojo Point Recreation Area, Pease Creek Recreation Area, Platte Creek Recreation Area, Randall Creek Recreation Area, Revheim Bay Recreation Area, Snake Creek Recreation Area, Spring Creek Recreation Area, Swan Creek Recreation Area, West Bend Recreation Area, West Pollock Recreation Area, and West Whitlock Recreation Area

Northeast Region—Glacial Lakes and Prairies Region: Scouring and scraping of glaciers created glacial bowls which have become more than 120 glacial lakes in the northeastern part of the state. The lakes range in size from several acres to more than 17,000 acres. Included in this region are 16 state parks and recreation areas, plus several municipal and private campgrounds. Many of the glacial lakes remain undeveloped and some are on private land. But, there are resorts on some of the larger lakes. Glacial lakes that are fished frequently throughout the year include Blue Dog, Enemy Swim, Lake Thompson, Lynn, Roy, rush, and Waubay Lakes. Walleye is the most predominate fish species in the northeast. Other fish species include largemouth and smallmouth bass, perch, bass, bullheads, bluegills, and pike.

The 16 State Parks/Recreation areas in this region include: Fisher Grove Recreation Area, Fort Sisseton Historic State Park, Hartford Beach State Park, Lake Cochrane Recreation Area, Lake Herman State Park, Lake Louise Recreation Area, Lake Poinsett Recreation Area, Lake Thompson Recreation Area, Mina Lake Recreation Area, Oakwood Lakes State Park, Pelican Lake Recreation Area, Pickerel Lake Recreation Area, Richmond Lake Recreation Area, Roy Lake State Park, Sandy Shore Recreation Area, and Walker's Point Recreation Area.

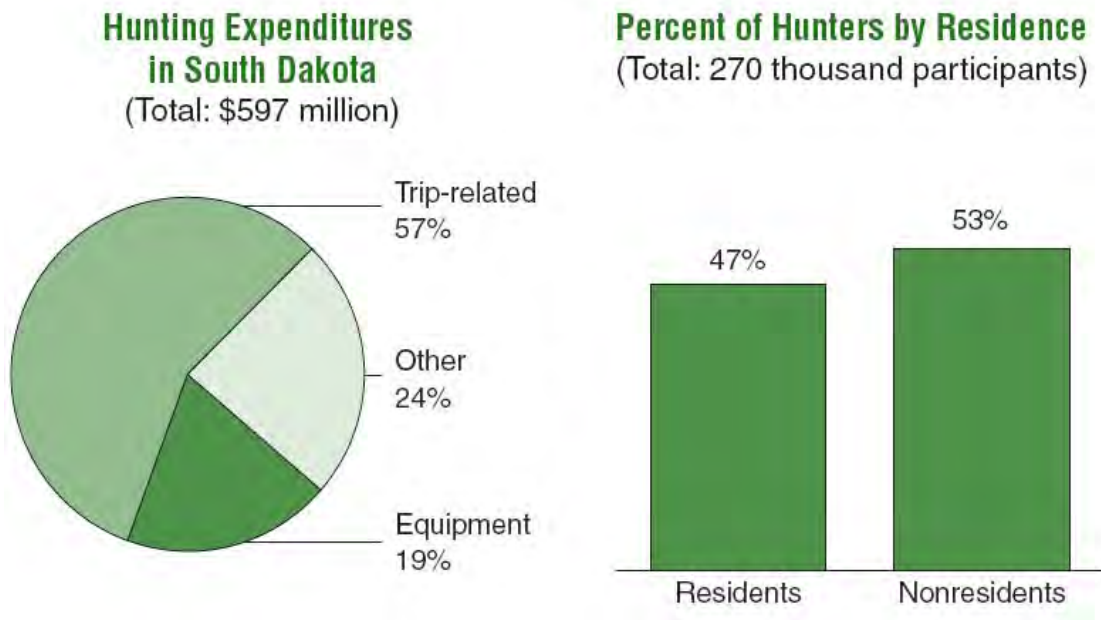
Southeast Region—Prairies Region: More than 175 fishing lakes (glacial and man-made) are available ranging in size from three to 29,000 acres. There are three major rivers in the Southeast Region: the Big Sioux River, James, and Missouri River, which includes Lewis and Clark Lake, a 30-mile long Missouri River reservoir. Walleye and bass are the two most prevalent fish species in this region. Northern pike and bullheads can also be found in Southeast Region waters.

There are nine State Parks/Recreation areas in the Southeast Region indicated as providing recreational fishing opportunities: These include: Big Sioux Recreation Area, Chief White Crane Recreation Area, Lake Alvin Recreation Area, Lake Vermillion Recreation Area, Lewis and Clark Recreation Area, Newton Hills State Park, Palisades State Park, Pierson Ranch Recreation Area, and Springfield Recreation Area.

Hunting

According to a 2011 report, hunting-related expenditures in South Dakota totaled \$597 Million. Out of 270,000 total hunting participants that year, 47% were residents and 53% were non-residents.

Figure 64. Hunting Expenditures and Hunters by Residence, 2011



Source: U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. *2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation*.

The most popular terrestrial game species for hunting in South Dakota and the associated regions include the following:

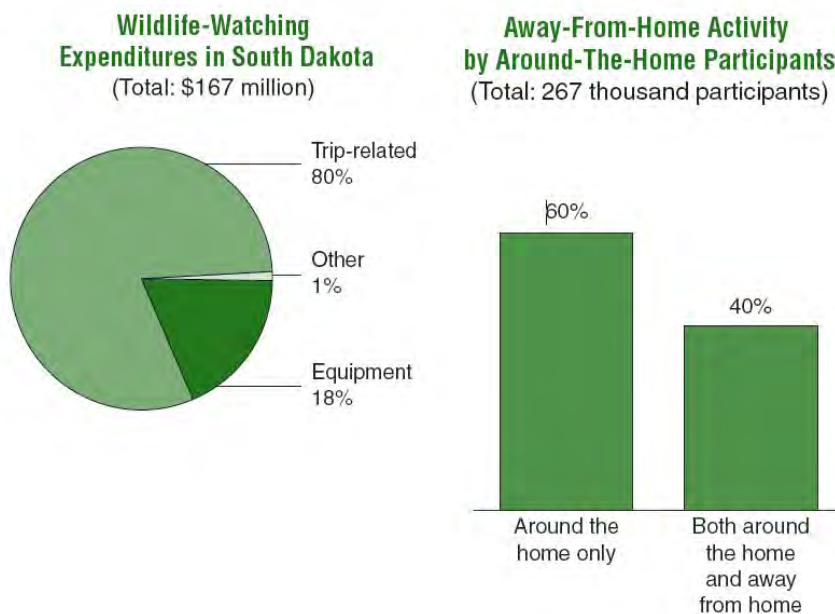
- Pheasant – located statewide but primary focus in eastern South Dakota and the counties adjacent to the west side of the Missouri River.
- White-tailed and mule deer – white-tailed deer are found statewide, and mule deer are found primarily west of the Missouri River and a handful of counties in eastern South Dakota.
- Elk – located primarily in the Black Hills region with a few counties in the prairie.
- Waterfowl – located statewide with more of an emphasis in eastern and central South Dakota.

See the wildlife sector discussion for more details on game resources by region.

Wildlife Viewing

According to a 2011 report, wildlife watchers spent \$167 Million on wildlife watching activities. Out of 267,000 total wildlife watchers, 60% viewed wildlife around the home only and 40% viewed wildlife both around the home and away from home, see **Figure 65**.

Figure 65. Wildlife-Watching Expenditures and Around the Home / Away from Home Participants, 2011



Source: U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. *2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation*.

Bird-watching: South Dakota, situated squarely in the middle of where eastern and western North American avifaunas (bird regions) meet, is home to nearly 400 species of birds. Some of the best places to enjoy birding are in the state park and recreation areas of the state. A few

mentioned on the state tourism website include Newton Hills, Hartford Beach, and Union Grove State Parks and Farm Island Recreation Area.

Camping/Hiking

Out of South Dakota's 63 State Parks and Recreation areas (see **Figure 66**), 52 of them offer camping and hiking opportunities.

Figure 66. South Dakota's State Parks



Source: South Dakota Game Fish & Parks Department, <http://gfp.sd.gov/state-parks/find-a-park/default.aspx>

Biking

The International Mountain Bicycling Association (IMBA) awarded the State one of only two ‘A’ grades for its mountain biking trails. Popular biking trails in the state include:

- George S. Mickelson Trail
- State Park Trails
- Black Hills National Forest Trails
- Sioux Falls Greenway
- Yankton Biking Trail
- Spearfish Canyon⁸¹

Horseback Riding

South Dakota's varied terrain and scenic trails are favorable for every type of horseback riding, from open prairies to rugged, winding trails. Several parks and recreation areas designate trails for horseback riding, including Custer State Park, Badlands National Park, Lewis and Clark Recreation Area, Sica Hollow State Park and Bear Butte State Park.⁸²

Rock Climbing

Most of South Dakota’s best climbing areas are concentrated in the west in the Black Hills. The southern part of the Hills is home to the Needles, one of the last bastions of traditional runout face climbing in the U.S., as well as the granite sport routes near Mount Rushmore national Memorial. The northern part of the hills near Spearfish is laced with limestone canyons, many of which have been developed as sport areas. In the eastern part of the State, Palisades State park northeast of Sioux Falls contains a fair number of quartzite cliffs.⁸³

Motorcycling

Home to the annual Sturgis Motorcycle Rally, South Dakota is a popular destination for motorcycling enthusiasts across the state. Some of the most popular areas for riding include: the Black Hills, Lincoln County, and Minnehaha.⁸⁴ Also many scenic drives across the state that we promote to motorcycle enthusiasts. (Oyate Trail, Native American Scenic Byway, many scenic drives in the Hills, etc.). Motorcyclists often comment on the good quality of our highways for riding.

⁸¹ Travel South Dakota website, <https://www.travelsouthdakota.com/things-to-do/recreation/biking/biking-biking-trails>

⁸² Travel South Dakota, <https://www.travelsouthdakota.com/things-to-do/recreation/horseback-riding>

⁸³ Rock Climbing.com, http://www.rockclimbing.com/routes/North_America/United_States/South_Dakota/

⁸⁴South Dakota Rides, www.southdakotarides.com

Archaeology / Paleontology

The Mammoth Site of Hot Springs is an active paleontological dig site, which boasts the largest concentration of mammoth remains in the world, including 58 Columbian and three Woolly mammoths. Also the Prehistoric Indian Village in Mitchell where visitors can watch excavation in progress at various times of the year. There are other ways visitors can learn more and even get involved in archaeology and paleontology. Here's a link to our 2014 guide: <https://travelsd.s3.amazonaws.com/archaeologypaleontology2014.pdf>

Golfing

South Dakota has 132 golf courses. The cities with the most golf courses included Rapid City, Sioux Falls, Aberdeen, Huron, Brandon, Brookings, Dakota Dunes, Delmont, Fort Pierre, and Mitchell.⁸⁵

Boating

South Dakota has acres of lakes and miles of rivers that are popular for various types of boating including: sail boating, canoeing and kayaking, and motorized watercraft.

Sail boating: Sailing in South Dakota is popular on the Missouri River reservoirs and other large lakes in the State.

Canoeing and Kayaking: The rivers and lakes in South Dakota provide canoeists and kayakers with excellent opportunities to enjoy the outdoors. Some South Dakota streams are passable year-round, while others offer seasonal floating only after snowmelt or rain in spring and early summer. The Cheyenne, Battle Creek at Hermosa, Beaver Creek near Buffalo Gap, Belle Fourche, Lake Creek, James and Bad Rivers are accessible during seasonal flows, while the White, Moreau and Little Missouri Rivers provide year-round access.

Many South Dakota State Parks also have lakes with easy access, including: Angostura Recreation Area, Bear Butte State Park, Burke Lake Recreation area, Custer State Park, and Shadehill Recreation Area.⁸⁶

Motorized Watercraft: The following South Dakota lakes allow motorized watercraft: Angostura Reservoir, Belle Fourche Reservoir, Pactola Lake, Sheridan Lake, Shadehill Reservoir, Lake Oahe, Lake Sharp, Lake Andes, Lake Byron, Lake Kampeska, Pelican Lake, Lake Poinsett, Lake Thompson, Lake Traverse, and Big Stone Lake.⁸⁷

⁸⁵ Golfink, <http://www.golfink.com/golf-courses/state.aspx?state=SD>

⁸⁶ Canoeing & Kayaking in South Dakota, South Dakota Department of Game, Fish, and Parks, <http://gfp.sd.gov/to-do/docs/canoe-kayak-sd.pdf>

⁸⁷ Invertsports, <http://www.invertsports.com/south-dakota-lakes>

Skiing

The main ski areas in South Dakota include Great Bear Recreation Park, a downhill skiing, snowboarding, and cross country ski area in Sioux Falls, and two ski resorts close to Deadwood and Lead.

Snowmobiling

Snowmobiling is a popular winter Sport in South Dakota. Snowmobiling occurs primarily on the 350 mile Black Hills Snowmobile Trails System. Eastern South Dakota also has 1,225 miles of groomed, signed, and maintained snowmobiling trails. One specific study detailed the contribution of snowmobiling to the South Dakota economy. This report detailed that that snowmobiling, is associated with 1,449 jobs in South Dakota and generates approximately \$131.6 Million in annual economic impact to South Dakota. If a drought cycle impacts the winter snowfall amounts in the State, this activity and associated jobs and economic could decline tremendously.⁸⁸

Popular Attractions

The most popular tourist attractions in South Dakota include: Mount Rushmore National Memorial, Badlands National Park, Crazy Horse Memorial, Historic Deadwood, Jewel Cave National Monument, Custer State Park, Wind Cave National Park, the Corn Palace, the Missouri River, National Parks, State Parks, National Forest, and FWS Refuges.

Events

Specific events and/or celebrations can also be a tourist draw. A few events that draw large numbers from residents and non-residents include: Fort Pierre's Fourth of July Celebration, Sisseton Wahpeton Oyate Wacipi Pow wow, Sturgis Motorcycle Rally, Custer State Park Buffalo Roundup. Other large events across the state that draw thousands of visitors include JazzFest, the Belle Fourche Roundup Rodeo, Hills Alive, LifeLight, Days of '76 in Deadwood, Kool Deadwood Nites, Hot Harley Nights, and the Black Hills Powwow.

Sturgis Motorcycle Rally: This event is an American motorcycle rally held annually in Sturgis, South Dakota usually during the first full week of August. It began in 1938 and was originally held for stunts and races, but has evolved into being a meeting for motorcycle enthusiasts from around the world. It brings significant income to the citizens of Sturgis.

Native American Pow Wows: Pow Wows are the Native American people's way of meeting together to join in dancing, singing, visiting, renewing old friendships, and making new ones.

⁸⁸South Dakota State Parks, The Economic Impact of the South Dakota Snowmobiling Industry, January 2012, Michael Allgrunn, Ph.D., Beacom School of Business, University of South Dakota, <https://gfp.sd.gov/to-do/snowmobile/docs/snowmobile-economic-impact-study.pdf>

Each year, there are approximately 60 Pow Wows across the state, including the Sisseton Wahpeton Oyate Wacipi Powwow which is the longest running powwow in the State of South Dakota. It is traditionally held in July.

Custer State park Buffalo Roundup: At this annual event traditionally held in September, cowboys and cowgirls roundup and drive the herd of approximately 1,300 buffalo.⁸⁹

3.9.2 Vulnerability Assessment of the Tourism Sector

Concerning vulnerability to drought, tourist activities in South Dakota can be classified as follows:

- Water-Dependent Tourist Activities
- Water-Related Tourist Activities
- Non Water-related Tourist Activities

Water-Dependent Tourist Activities

Several of the Outdoor Recreation tourist activities fall into this category including: fishing, boating, golfing, skiing, and snowmobiling. For these activities, inadequate water as a result of drought or water with diminished quality can directly impact these activities.

If a prolonged drought impacts stream and reservoir levels, fish can be stressed and the overall abundance of fish can be impacted. In addition, as has been seen in the past, access to boat docks and boat intake areas can be impacted by receding water levels. For anglers that fish from boats, this can make this activity impossible in some cases.

As with access for fishing boats, other boating activities, such as sail boating, and motorized boating can be directly impacted if docks are closed or inaccessible as a result of drought.

Golfing is susceptible to drought due to the necessity to keep the golf courses irrigated. Depending on the severity of the drought or the efficiency of irrigation systems impacts may be limited to course-owner's watering expenses. However, if the drought is severe enough that water restrictions are imposed, course owners may be prohibited from watering, depending on the nature/authority of the restrictions, and result in further economic impacts.

If the drought conditions affect winter snowfall amounts, both skiing and snowmobiling activities can be diminished or infeasible depending on the severity.

⁸⁹ South Dakota Game, Fish and Parks Website, <http://gfp.sd.gov/state-parks/directory/custer/events/buffalo-roundup/>.

Water-Related Tourist Activities

Many of the remaining Outdoor Recreation tourist activities fall into this category such as: hunting, wildlife viewing, camping/hiking, biking, horseback riding, rock climbing, motorcycling, and archaeology / paleontology. For these activities, part of the draw is related to the beauty of the landscape offered by the flora and fauna. Hunting and wildlife viewing are particularly affected if the health or abundance of wildlife is diminished as a result of drought.

The GFP earns over 50% of its annual revenue from resident and non-resident licensing fees. Drought can reduce GFP's annual revenue stream from the reduction in hunting, fishing and boating licensee sales and in park passes. See the wildlife sector for additional discussion on impacts to GFP staffing due to increased management activities during drought.

In addition to Outdoor Recreation tourist activities, some of the Attractions and Tourist Events can be affected by lack of water. For example, loss of certain colors of corn from drought affects murals at Corn Palace and the Fourth of July Celebrations, such as the large one in Fort Pierre, can be impacted if drought conditions have made fireworks too dangerous.

Non Water-Related Tourist Activities

The remaining tourist events in the Attractions and Events categories are not typically directly impacted by drought. For example, visits to Mount Rushmore are not generally impacted by drought cycles. Although these activities are not directly impacted by drought, wildfires that often accompany drought cycles may deter visitors from these activities as well.

Interviews were conducted with tourism sector representatives on the State's Drought Task Force. In speaking with representatives of the South Dakota Department of Tourism and Economic Activity, the general impression was that tourism revenue as a whole has not been impacted by drought in the past. Of primary concern during a drought is the increased potential for wildfires, which is discussed further below.

Historical Drought Impacts

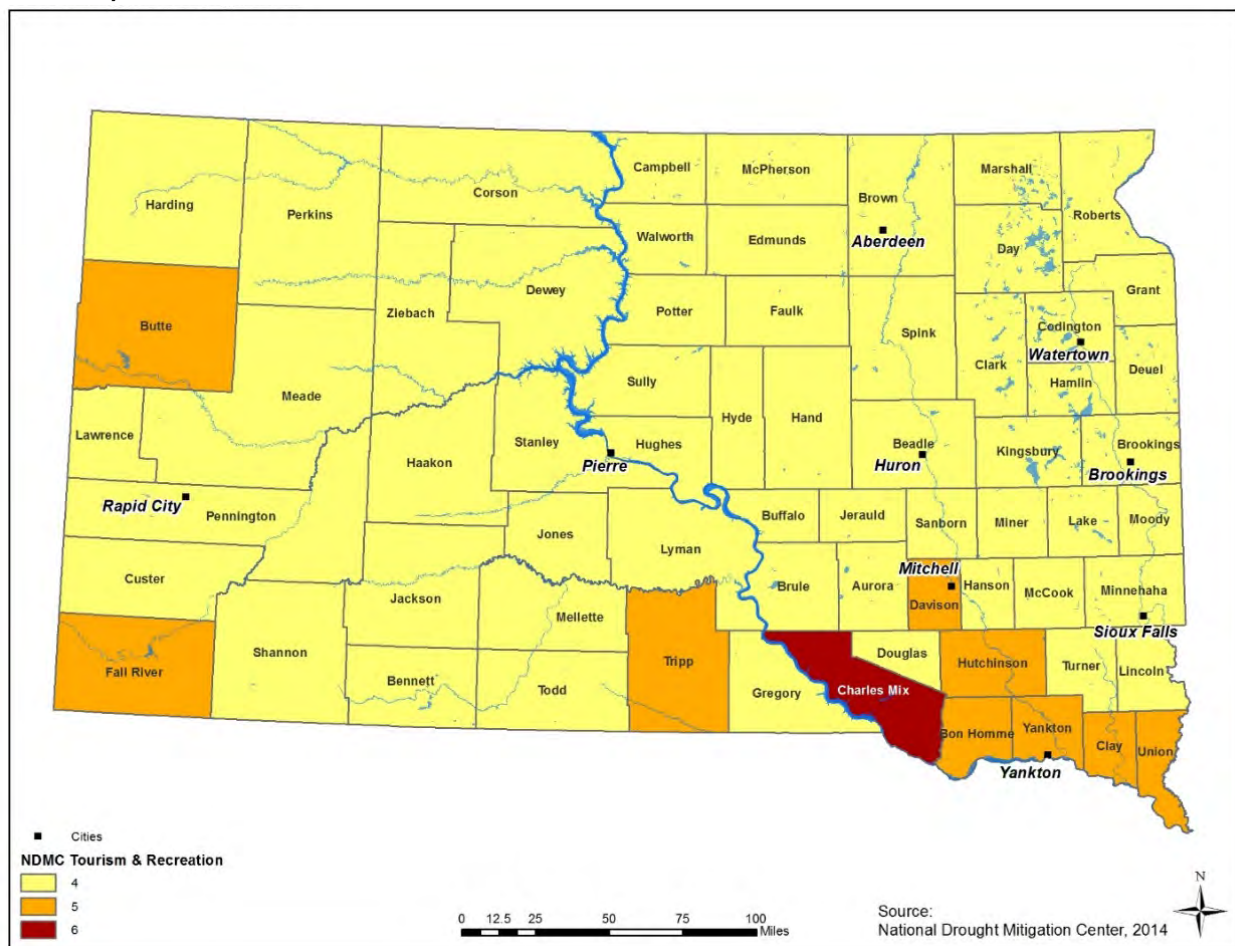
Historical impacts to tourism from drought in South Dakota have not been widely documented.

According to the Department of Tourism, tourism in South Dakota has not historically been impacted by drought, but the state has adapted its messaging during times of drought and wildfire. In recent years, wildfires have been the biggest threat to the tourism industry. Wildfires create a marketing problem as tourism can decrease if people get the impression that more areas within the state are burning than actually are. The most recent drought in South Dakota was in 2012, a year that also experienced a number of wildfires. However, there was no loss to tourism due to drought that year, and in fact there was a slight increase in tourism revenue overall. In the drought of 2012-2013 the Department of Tourism re-focused its advertising message to highlight areas of the state that were not experiencing wildfires. Another example of the Department of

Tourism re-focusing its message is with pheasants, whose populations were impacted in the 2012-2013 drought. Rather than focus on pheasant hunting messages, the Department of Tourism broadened the message. The slogan changed from “South Dakota #1 in Pheasants” to “South Dakota there’s no place like it”.⁹⁰

The University of Nebraska, Lincoln’s National Drought Mitigation Center Drought Impact Reporter provides an interface for the public and other sources to report drought impacts. Drought impacts are categorized as follows: agriculture; business and industry; energy; fire; plants and wildlife; relief, response and restrictions; society and public health; tourism and recreation; and water supply and quality. **Figure 67** shows the number of tourism impacts that have been reported for South Dakota on a county basis from January 1, 1980 to April 13, 2014. These results indicate that the greatest number of tourism impacts have occurred in Charles Mix County. The South East region in general had the most reported impacts. There are limitations to this data as it is dependent upon voluntary or media reports, but it does paint an initial picture.

Figure 67. DMC Reported Tourism and Recreation Drought Impacts (Jan 1980 to April 2015)



⁹⁰ Personal communication with Wanda Goodman Dept. of Tourism.

Additional specific tourism-related drought impacts from the Drought Impact Reporter are provided below:

- **2013**
 - *January – Skier visits during the 2011-2012 winter fell to 51 million, 16 percent lower than the previous winter, as meager snowfall led to poor skiing conditions. The 2011-2012 winter was the driest in the last 20 years.*
 - *Summer – The level of Angostura Reservoir was down due to drought. However, this had a positive impact for Breakers Beach Club because there was more beach available for visitors with the reservoir at just 70 percent of capacity.*
- **2012**
 - *August – Drought damage to the colored corn used to create Corn Palace murals in Mitchell led palace officials to exclude four corn colors, blue, calico, orange, and light brown.*

Additional specific examples of historical drought impacts on tourism-related activities are included in the Wildlife Sector and Health and Socioeconomic Sector.

Factors that Impact Tourism Vulnerability to Drought

Assessing the Tourism sector vulnerability to drought is complex and hindered by a lack of quantitative data at the county level. Tourism sector impacts are largely economic and depends on a multitude of interrelated factors. Considerations when assessing drought vulnerability specific to the tourism sector include:

- Economic dependence on tourism at a regional level
- Lack of economic diversity at a municipal or county level
- Length of drought
- Time of year impacted by drought
- Wildfires associated with drought (location/severity)
- Locations most impacted by drought
- Imposed water restrictions

Economic Dependence on Tourism at a Regional Level

Specific regions in South Dakota are potentially more vulnerable than others depending on the level of impact to wildlife and associated recreational activities, administration of water rights, susceptibility to wildfire and capabilities of wildlife managers within the region and the economic dependence of tourism within a region. Regional vulnerabilities are discussed here in qualitative terms. The Western Region attracts the most tourism revenue of the four regions and is also has the most economic dependence on tourism.

Western Region—Black Hills, Badlands: The Black Hills and Badlands region of South Dakota region covers Harding, Perkins, Butte, Meade, Ziebach, Lawrence, Haakon, Pennington, Jackson, Jones, Custer, Fall River, Shannon, Bennett, Mellette, and Todd counties. Major cities include Spearfish, Deadwood, Rapid City, Keystone, and Custer. Of these cities, Keystone, Custer and Deadwood could be considered more dependent on tourism revenue, while Rapid City and Spearfish would be considered less dependent on tourism revenue⁹¹. The entire Black Hills and Badlands region in general is a draw for tourists and many of the cities and towns discussed below are more appropriately lumped together in one big region. That is, many of the potential drought impacts are common among all the cities.

Keystone is the entrance to Mt. Rushmore and the Black Hills. The bulk of its visitation is in the spring through fall, although it is open year-round. Wildfires caused in part by drought could negatively impact tourism in Keystone, but the city is minimally dependent on water-based tourism revenue.

Deadwood is a year-round destination for gambling, western history, and winter sports. Like Keystone, a wildfire caused in part by drought could negatively impact tourism to Deadwood. A drought occurring in the winter months would negatively impact their snowmobiling and skiing industry.

Custer is the entrance to Custer State Park, the largest state park in South Dakota. Their slogan is “minutes from outdoor adventure”, which highlights their reliance on the health of the natural environment. Camping in the state park is a major attraction, as is hiking, horseback riding, and fishing. A wildfire caused in part by drought could negatively impact tourism in Custer and the adjacent state park. A drought occurring in the summer could cause decreased stream flows or even cause some streams to dry up, as has happened in past droughts. This would have a negative impact on the fishing industry. A wintertime drought could cause a reduction in the mature fish population by decreasing stream flows, which would have a lagging negative impact on the spring through fall fishing season.

Rapid City is the second largest city in South Dakota⁹² and has many attractions beyond the Black Hills outdoors activities of its smaller neighbors. It can be impacted by drought in the same way as the other cities in the Black Hills region, but it is a larger city with a wide variety of economic industries and therefore less economically vulnerable.

Spearfish bills itself as “a paradise for outdoor recreation”. The town is located just outside of the Spearfish Canyon Scenic Byway, which is promoted heavily by the Department of Tourism year-round, but especially in the fall when leaves are changing. Fishing is a popular activity in the spring through fall, and snowmobiling is big in the winter. Thus, Spearfish tourism could be impacted by drought in ways similar to other towns in the Black Hills region with fishing and

⁹¹ Personal communication with Wanda Goodman at SD Dept. of Tourism (see email of 4-3-15).

⁹² http://en.wikipedia.org/wiki/List_of_cities_in_South_Dakota

snowmobiling industries. Hunting for big game, specifically deer, elk, and turkeys, is another outdoor activity. Wildfires caused in part by drought have the potential to impact any of these activities in Spearfish.

In the Black Hills and Badlands region, the main impacts caused by drought are:

- Decreased tourism due to wildfires caused in part by drought.
- Decreased fishing revenue due to lower stream flows.
- Decreased hunting revenue if severe and/or long-lasting drought causes a reduction in game population.
- Impact to winter sports tourism if wintertime drought causes reduced snowfall.
- Impacts to camping include forced closure of campsites and surrounding forest due to wildfires and risk of wildfires and/or hazard trees; both conditions exacerbated by drought.

Central Region—Missouri River/Great Lakes: The central region of South Dakota encompasses the Missouri River Valley, the Oahe, Francis Case and Sharpe reservoirs, the urban areas of Winner, Fort Thompson, North Eagle Butte, Mobridge and the state capital of Pierre, plus a large number of recreation and camping areas. Boating, birding and fishing are all popular tourism activities in the region that can be negatively impacted by droughts. Decreased stream flows can decrease the stock of the walleye, chinook salmon, northern pike, smallmouth bass, white bass, channel catfish, tiger muskie, and paddlefish, which then reduces the demand for fishing and fishing related tourism activities (camping, outfitting, food/beverage, lodging, etc.).

The region does host a number of festivals and events that are themed around local history and culture (like the Oahe Music and Arts Festival) but many of the larger events are centered on water and water based activities (such as the South Dakota Walleye Classic and the Mobridge Ice Fishing Tournament). This region is susceptible to drought-related fluctuations on the Missouri River system, which can have substantial economic impacts if boat ramps and lake access is affected.

Northeast Region—Glacial Lakes and Prairies Region: This region, populated by the cities and towns of Aberdeen, Redfield, Brookings, Watertown, Sisseton and Milbank, is best known for pheasant hunting, but also hosts a number of other attractions including gaming and viticulture. In addition, there are 16 state parks that draw visitors for camping, fishing and boating.

In general, the Northeast Region is less dependent on water related tourism than the Central Region but could be susceptible to impacts from drought on the pheasant population. A growing fishing industry around lakes in this region could suffer during a long term drought.

Southeast Region—Prairies Region: Fishing, pheasant hunting and hiking are also popular activities in the Southeast towns of Yankton, Sioux Falls, Wagner, Mitchell and Madison. Wildfires caused by droughts can lead to closures of the many state parks and recreation areas lowering the number of visitors to the region.

The water related activities (fishing, boating, swimming, etc.) are also vulnerable to droughts for the aforementioned reasons.

Estimating Potential Losses

Estimating potential drought losses to the Tourism sector at a regional or county level is limited by data availability. One measure of loss potential is to review losses to state agency revenue from drought-related conditions. In 2013 the Game, Fish, and Parks Department reported 20% fewer small game hunting licenses purchased than in 2012. This impact alone resulted in an approximate \$2 million decrease in revenue. According to the 2011 report on the economic contribution of hunting in the State, the overall contribution was \$597 million. If a 20% reduction occurs to the total economic contribution of this one tourist activity that could mean a drop of nearly \$120 Million in tourism revenues. If the same losses are experienced in the fishing and wildlife sectors, that could mean an additional loss of \$75 million.

Similarly, skier visits during the 2011-2012 winter fell to 51 million, 16 percent lower than the previous winter, as meager snowfall led to poor skiing conditions.

The historical reduction of small game hunting licenses and skier visits in drought years indicates that water-dependent and water-associated recreation activities are definitely decreased during drought years. Additional data is not available to accurately estimate potential losses that could occur related to decreases in other tourist activities in the State

3.9.3 Summary of Identified Vulnerabilities and Adaptive Capacities

Table 28 summarizes the vulnerabilities and existing adaptive capacities associated with the recreation sector. Potential adaptive capacities that have been identified through this planning process are also included.

Table 28 Summary of Vulnerabilities and Adaptive Capacities

Tourist Activities	Identified Vulnerabilities	Adaptive Capacities	
		Existing or Implemented in the Past	Potential Options for Consideration
All	<ul style="list-style-type: none"> Public perception of wildfires degrading enjoyment of tourist activities. Lack of economic diversity 	<ul style="list-style-type: none"> Targeted messaging to reassure the public of quality of visits 	
Fishing/boating	<ul style="list-style-type: none"> Low water levels Smaller streams (i.e. in the Black Hills) may have significantly less flow or go dry Ephemeral streams may 	<ul style="list-style-type: none"> Administration of water rights (see below) Lease flows from senior water right holders to maintain flows in the stream 	<ul style="list-style-type: none"> Advertise water-based recreation that doesn't involve boating (i.e. open more swimming beaches Modify boating season length

Tourist Activities	Identified Vulnerabilities	Adaptive Capacities	
		Existing or Implemented in the Past	Potential Options for Consideration
	remain dry during the whole year		
Boating/fishing access	<ul style="list-style-type: none"> • Reduced access • Boat ramps become unusable if water levels drop too far • Need to construct new boat ramps 	<ul style="list-style-type: none"> • Relocate ramps • Include boat ramp construction/extension money into the annual budget • Develop drought reserve funds for use in a drought (i.e. funds for the construction of new boat ramps) • Communicate to the public which ramps are open and which are not 	
Fishing	<ul style="list-style-type: none"> • Degradation of aquatic habitat Reduction in fishing licenses during drought 	<ul style="list-style-type: none"> • Modify wildlife management to address drought 	
Various Outdoor Recreation	<ul style="list-style-type: none"> • Fire restrictions resulting in less interest in camping/hiking/horseback riding, etc. 	<ul style="list-style-type: none"> • Work with PR firms and media to control message, emphasize the positive. • Provide information to public through media and tourism outreach to notify visitors of areas not impacted 	
Skiing/Snowboarding	<ul style="list-style-type: none"> • Decline in skier/snowboarding visits due to lack of snow 	<ul style="list-style-type: none"> • Snowmaking • Work with PR firms and media to control message, emphasize the positive 	<ul style="list-style-type: none"> • Work with PR firms and media to control message, emphasize the positive • Ski resorts can market other winter recreation activities
Golfing	<ul style="list-style-type: none"> • Watering restrictions for golf courses 		<ul style="list-style-type: none"> • Increase irrigation efficiency by changing irrigation methods or timing (ex. water at night). • Increase use of xeriscaping and drought resistant grasses

Summaries of some specific adaptive capacities/capabilities that help mitigate the impacts of drought on tourism are provided below:

Administration of Water Rights

South Dakota’s water rights system provides environmental and recreational protections by enabling water users to own water rights for recreation and environmental and fish propagation purposes. **Figure 68** shows the location of the environmental and fish propagation and

recreation water right licenses within the State. These water rights specify instream flows (CFS) that need to be maintained as well as the amount of water (acre-feet) reserved for reservoir storage purposes. The level of protection these rights can offer during a drought depends on the priority of the water rights. Some of these rights are relatively junior and do not provide significant protections while others are senior in priority and provide substantial protection. According to South Dakota water law, water bodies on state-owned property have a priority date of when South Dakota was granted statehood. Many of these senior water rights are owned by the GFP and provide significant protection during dry periods. See Section 3.4.1 for additional details on how water rights are administered.

Figure 68. Recreational and Environmental Water Right Licenses

3.9.4 Recommendations

Framework for Future Drought Vulnerability Studies

The results of this analysis did not yield a high level of vulnerability in the tourism sector. This is largely based on qualitative information. Future vulnerability analyses could attempt to quantify actual impacts. The vulnerability framework could consist of the following steps.

- Step 1 - Identify indicator tourist industries that may be used to represent the sensitivity of tourism to drought within a region. These indicator industries would generally be prominent in the region being evaluated and a sufficient amount of data has been collected in both normal (baseline) and drought conditions on the particular industry.
- Step 2 – Collect data necessary to characterize the industry under baseline and drought conditions. This could include tracking visitation data. A table could be generated to allow analysis of number of visitors each year to see if there was a trend of decreased visitors in dry years. In regions that are managed by the GFP, monetary impacts to recreational management could be assessed by collecting data on GFP’s expenditures and revenue streams during drought. Such expenditures and revenues will vary depending on the geographic area.
- Step 3 – Develop metrics that are indicative of drought severity based on Step #1 and Step #2. For example, metrics could be 1) admittance rates and revenue from state and national parks during non-drought and drought years or 2) the number and value of hunting/fishing licenses, ski passes purchased during non-drought and drought years. These metrics may be further assigned a weighting factor and summed to develop a single drought index for a particular region.

Data collection is critical to the methodology outlined above. The following **Table 29** identifies the types of data that can be useful for a drought vulnerability assessment and identifies potential data gaps.

Table 29 Data Collection for the Tourism Sector

Tourist Activity	Data	Notes on Data Availability
Water Dependent	<ul style="list-style-type: none"> • County-level data providing annual contribution to the economy for specific tourism activities • County-level data providing annual participant numbers for specific tourism activities • Targeted county-level data on specific sales such as boat sales, fishing license sales, snowmobile sales to determine trends • Aggregate activities on a regional basis • Determine factors that impact vulnerability for specific tourism activities such as length of drought, time of year, associated wildfires, etc. • Identify key indicators of reduction in tourism such as restaurant sales, fuel sales and analyze against drought cycles. • Data on excess funds spent during drought years to mitigate losses such as relocating boat docks, watering golf courses 	<p>The economic impact report from IHS Global Insight includes county-level data on economic impact. The data is general though, and not specific to water-dependent activities</p>
Water- Related	<ul style="list-style-type: none"> • County-level data providing annual contribution to the economy for specific tourism activities • County-level data providing annual participant numbers for specific tourism activities • Targeted county-level data on specific sales such as hunting license sales • Annual visitors to State Parks, National Parks, etc. • Aggregate activities on a regional basis • Determine factors that impact vulnerability for specific tourism activities such as length of drought, time of year, associated wildfires, etc. • Identify key indicators of reduction in tourism such as restaurant sales, fuel sales and analyze against drought cycles. 	<p>Visitation counts for National Parks, Wildlife Refuges and National Forests can generally be obtained by request to the agency.</p>
Non Water-Related	<ul style="list-style-type: none"> • County-level data providing annual participant numbers for specific tourist destinations • Aggregate activities on a regional basis • Determine factors that impact vulnerability for specific tourism activities • Identify key indicators of reduction in tourism such as hotel room sales, restaurant sales, fuel sales and analyze against drought cycles • County-level data on events that typically draw tourists such as number of events, number of participants, revenue generated 	<p>These sources may provide information: Tourism Promotion Tax, BBB Tax, Taxable Sales and the Deadwood Gaming Handle</p>

Recommended Next Steps

- Continued use of targeted/timely/coordinated Public Relations messaging is a key mitigation strategy for reductions in tourism as a result of drought.
- Diversification in the types of activities that might be impacted by drought. For example, if drought impacts winter activities such as skiing and snowmobiling, market other winter time tourism that is not impacted by the drought; or market hiking activities if fishing/fishing access/boating is hampered.
- Significant data gathering and additional monitoring are required to spatially characterize the potential impacts of drought on tourism across the State.

4 MITIGATION STRATEGY

4.1 Hazard Mitigation Goals

This chapter focuses on the State's drought hazard mitigation strategy. It is divided into four parts:

- Drought Mitigation Goals
- State Drought Mitigation Capability Assessment
- Mitigation Actions
- Funding Sources

4.1.1 Description of Drought Mitigation Goals

This section describes the goals of the Drought Mitigation Plan and the process used to identify the goals. Goals are broad based and describe the overall direction that the State will take to reduce drought impacts. Some goals have more specific objectives associated with them. The actions describe in more detail the activities or projects used to support the accomplishment of the goals. Actions are meant to be implemented and can be tracked over time as a measure of meeting the Plan goals.

To develop the Plan goals the DTF reviewed the goals from related planning mechanisms including the State HMP. The DTF was provided a worksheet with the HMP goals and goals from another state's drought plan, the Colorado Drought Mitigation and Response Plan. The DTF felt that the majority of the goals and objectives from the Colorado plan were comprehensive and applicable to South Dakota and elected to develop similar goals with a few modifications.

The goals of the South Dakota Drought Mitigation Plan are listed below, in no particular order. Objectives for goals 5 and 6 are also included.

1. Improve water availability monitoring and drought impact/vulnerability assessment
2. Increase public awareness and education
3. Enhance mechanisms to provide water supplies to areas of shortage during droughts
4. Reduce water demand and encourage water conservation
5. Reduce drought impacts to South Dakota's economy, people, state assets, cultural resources, and environment
 - Reduce losses to natural resources (i.e., forest and watershed health)
 - Reduce impacts to cultural resources (i.e., historical/tribal)
 - Reduce agricultural losses
 - Reduce losses to critical facilities, utilities, and infrastructure
 - Reduce economic losses to recreation and tourism

6. Continue to maintain and enhance intergovernmental and interagency stakeholder coordination
 - Coordinate and provide technical assistance for state, local, tribal, federal, and watershed planning efforts
7. Evaluate changes in drought frequency and severity related to climate change as a planning issue, and incorporate into the South Dakota Hazard Mitigation Plan and other relevant plans

4.2 State Drought Mitigation Capability Assessment

4.2.1 Introduction

A drought mitigation capability assessment was conducted as part of the Plan development process. Per the DMA 2000 the state mitigation strategy must include a discussion of the State's pre- and post-disaster hazard management policies, programs, and capabilities to mitigate the hazards in the area, including an evaluation of state laws, regulations, policies, and programs related to drought mitigation as well as to development in drought-prone areas, and a discussion of state funding capabilities for hazard mitigation projects. This entailed a development of a capabilities matrix and worksheet for the DTF to provide input on pre and post disaster programs and policies that contribute directly or indirectly to reducing drought losses. The worksheet also allowed the DTF to provide information on funding opportunities for risk reduction, community resiliency, and mitigation activities. The results of this process are incorporated in the Plan in the following subsections.

4.2.2 Pre- and Post-Disaster Hazard Policies, Programs and Funding

State laws and regulations that provide authority to various agencies for pre-disaster programs are included in the current South Dakota State Hazard Mitigation Plan. In several cases the capabilities are both pre- and post-disaster.

Many of the members of the DTF have specific pre- and post-disaster programs, policies and funding available for drought. These are summarized in **Table 30** below:

Table 30 – Summary of Drought Specific Capabilities by Sector and Task Force Agency

Agency	Pre-Disaster Programs	Post-Disaster Programs	Pre Disaster Policies	Post Disaster Policies	Pre Disaster Funding	Post Disaster Funding
South Dakota Drought Task Force	<ul style="list-style-type: none"> Provides information to agricultural producers to assist in making sound crop rotation decisions 	<ul style="list-style-type: none"> Monitors emerging drought conditions Meets more frequently during times of drought to assess impacts and coordinate relief efforts 				
Agriculture Sector						
Department of Agriculture	<ul style="list-style-type: none"> Administers campaigns on drought through the DTF, extension, service and producer groups 		<ul style="list-style-type: none"> Promotes insurance to cover damages incurred by natural hazards Supplemental irrigation Encourages agricultural modifications to lessen the impacts of drought including crop rotation, drought resistant crops, no till, etc. 	<ul style="list-style-type: none"> Promotes feeding area rotation to improve forage utilization during droughts 		<ul style="list-style-type: none"> Assists in administering federal disaster assistance programs through the Farm Service Agency

Agency	Pre-Disaster Programs	Post-Disaster Programs	Pre Disaster Policies	Post Disaster Policies	Pre Disaster Funding	Post Disaster Funding
Water Resources Sector						
South Dakota State University - State Climatologist	<ul style="list-style-type: none"> Provides drought monitoring and weather information to inform decisions regarding drought 			<ul style="list-style-type: none"> Provides drought monitoring and weather information to inform decisions regarding drought 		
Department of Environment and Natural Resources	<ul style="list-style-type: none"> Ground water monitoring Lake level monitoring Promote municipal water conservation efforts 		<ul style="list-style-type: none"> Grants permits for water rights for both surface and groundwater Restricts development to fully appropriated surface water and ground water systems Enforces environmental and recreational water rights 	<ul style="list-style-type: none"> Administers surface water restrictions 	<ul style="list-style-type: none"> Administers loans and grants through the board of water and natural resources to the public water system to enhance water supply 	
Wildlife Sector						
Department of Game, Fish and Parks		<ul style="list-style-type: none"> Relocation of boat ramps based on water level 	<ul style="list-style-type: none"> Modify wildlife management to address drought issues Can issue fewer hunting licenses and target issued licenses by species type to reduce overall mortality 			

Agency	Pre-Disaster Programs	Post-Disaster Programs	Pre Disaster Policies	Post Disaster Policies	Pre Disaster Funding	Post Disaster Funding
Tourism Sector						
Office of the Governor	<ul style="list-style-type: none"> Public service announcements (PSAs) to promote tourism and recreation Basic public information campaign on drought related issues 					<ul style="list-style-type: none"> Governor's declaration (disaster funding)
Department of Tourism		<ul style="list-style-type: none"> Promote tourism opportunities that are less reliant on water Target messaging to reassure the public on quality of visits 				
Health and Socioeconomic Sector						
Department of Health		<ul style="list-style-type: none"> Support hotlines for mental health therapy and financial assistance Mental health assessment and treatment 				
Department of Social Services	<ul style="list-style-type: none"> Provides training and support individuals who have or deal with mental illness through the national alliance on mental illness Provides support through the disaster technical assistance center to deliver effective mental health and substance abuse response to disasters 	<ul style="list-style-type: none"> Substance abuse assessment and treatment 			<ul style="list-style-type: none"> Services for substance abuse and mental health Funding for training through Helpline Center and Front Porch Coalition on Mental Health First Aid 	<ul style="list-style-type: none"> Services for substance abuse and mental health

Agency	Pre-Disaster Programs	Post-Disaster Programs	Pre Disaster Policies	Pre Disaster Funding	Post Disaster Funding
Health and Socioeconomic Sector					
Department of Military	<ul style="list-style-type: none"> • Build and maintain drought based websites 	<ul style="list-style-type: none"> • Build and maintain additional forms with adequate planning time 			
Department of Public Safety - Office of Emergency Management	<ul style="list-style-type: none"> • Promotes all hazard mitigation, public outreach and participation 	<ul style="list-style-type: none"> • Coordinates disaster emergency relief 		<ul style="list-style-type: none"> • Administers FEMA pre disaster mitigation grant assistance 	<ul style="list-style-type: none"> • Administers FEMA hazard mitigation grant program
Wildland Fire Sector					
Department of Agriculture - Division of Wildland Fire	<ul style="list-style-type: none"> • Prescribed burns • Complete, update and implement CWPPs for each county • Fire breaks and defensible space • Fire prevention program • Fuels mitigation for private land • Provides fire management training for personnel 	<ul style="list-style-type: none"> • Rehab of fire suppression activities 	<ul style="list-style-type: none"> • Pre-position resources based on hazard sensitivity • Governor's pre-identification of areas of fire concern (Red zone) • Mutual aid agreements with neighbor agencies • Burn bans 	<ul style="list-style-type: none"> • Continue publicizing fire hazard and fuels mitigation cost share program • Severity funding • Fuels mitigation for private land 	<ul style="list-style-type: none"> • Administers the fire management assistance grant (FMAG)
Department of Public Safety - Office of State Fire Marshall	<ul style="list-style-type: none"> • Promotes all hazard mitigation • Public outreach and participation 		<ul style="list-style-type: none"> • Enacts county or statewide burning restrictions as needed • Limits displays of fireworks • Issues controlled burning permits as needed 		

4.3 Mitigation Actions

Per the DMA requirements the state mitigation strategy must identify, evaluate, and prioritize cost effective, environmentally sound, and technically feasible mitigation actions and activities the State is considering, and an explanation of how each activity contributes to the overall mitigation strategy. Local input should also be included when available. The mitigation actions must take into consideration the vulnerability and capability assessment, and are intended to address areas of high vulnerability or where capabilities should be strengthened.

4.3.1 Identification of Actions under Consideration

Table 31 identifies the actions under consideration by the South Dakota DTF. The following recommendations represent the collaborative efforts of the DTF. The projects are listed under the primary goal they are designed to help achieve, as an indication of how each action contributes to the overall mitigation strategy. Some actions help meet more than one goal, as indicated in the “Primary and Related Goal” column. A summary discussion of progress made toward implementing the action is included in the table under the “Status, Implementation, and Funding Comments” column.

Many of the recommendations can be implemented in the short term which is defined as the next five year update cycle; others must be viewed as long-term measures, and some will be implemented during drought cycles. The actions are prioritized and sorted by **High**, **Medium** and **Low** (see Section 4.3.3 for a discussion of the prioritization process). In general the timeline of implementation is reflected in the prioritization: High- target implementation within three years; Medium – within three to six years; Low - within ten years or as needed.

Table 31 Actions Under Consideration

Action ID	Priority	Recommended Action	Primary and Related Goal	Lead/Partner Agency	Status, Implementation and Funding Comments
Goal 1: Improve Water Availability Monitoring and Drought Impact/Vulnerability Assessment					
1.1	M	Expand the state's stream gauging network	1	DENR, Chief Engineer	
1.2	H	Update and refine aquifer mapping to better quantify volume and location of water resources	1	DENR, State Geologist	
1.3	M	Develop data assessment for drought impacts to tourism, including data on hotel occupancy and the tourism promotion tax; could also include Deadwood gaming handle	1	Department of Tourism	
1.4	H	Increase or maintain surveillance and monitoring activities for drought-specific public health issues (e.g. West Nile surveillance, private well testing for water quality)	1	Division of Behavioral Health	
1.5	H	Provide guidance to state agencies on data collection in order to track drought impacts from year to year	1	Drought Task Force	
1.6	H	Convene the Drought Task Force annually to discuss data collection per each sector to enhance future versions of the drought plan	1	Drought Task Force	
1.7	M	Continue to maintain the Drought Task Force website	1	BIT/ Task Force	
1.8	H	Increase weather and climate monitoring and expand manual/automated data network on precipitation, hydrology, soil moisture/infiltration to support drought assessment	1	SDSU Extension; NWS; USGS; NRCS; DENR; FSA; SDDA	
1.9	H	Increase monitoring and assessment of impacts related to economics, losses, and human factors	1	State Climate Office & other SDSU departments	
1.10	L	Develop business impact assessment to determine how businesses (i.e. seed/fertilizer/equipment dealers, truckers, grain elevators, livestock auctions, etc.) are affected during drought	1	USDA, SBA and GOEP Loans	

Action ID	Priority	Recommended Action	Primary and Related Goal	Lead/Partner Agency	Status, Implementation and Funding Comments
Goal 2: Increase Public Awareness and Education					
2.1	M	Educate producers on technical assistance available through SDDA Resource Conservation and Forestry Division	2	SDDA Resource Conservation and Forestry Division	
2.2	H	Create and keep current a web-based State burn ban map	2	SDDA Wildland Fire Division	
2.3	H	Create "Drought Tools" website for South Dakota	2	BIT/DTF	
2.4	M	Disseminate public information on water use during droughts through schools and public service announcements	2	DENR	
2.5	H	Coordinate communication for in-state and out-of-state tourists, including social media, email databases and tourism industry partners	2	Department of Tourism	
2.6	H	Continue to use marketing and messaging during droughts	2	Department of Tourism	
2.7	M	Dissemination of public health information on diseases related to poor air and water quality and vector-borne illnesses	2	Division of Behavioral Health	
2.8	H	Create public awareness campaigns that various agencies can use for water conservation, fire prevention, etc.	2	Drought Task Force	
2.9	M	Coordinate drought messaging on social media across agencies	2	Drought Task Force	
2.10	H	Educate producers on production modifications available to lessen drought impacts	2	SDDA and SDSU Extension	
2.11	H	Disseminate public outreach, awareness, and education on fire mitigation	2	SDDA Wildland Fire	
2.12	H	Increase awareness and education for drought planning ranchers	2	SDSU Extension, Farm Credit Services, SDDA, NIDIS	

Action ID	Priority	Recommended Action	Primary and Related Goal	Lead/Partner Agency	Status, Implementation and Funding Comments
2.13	H	Disseminate public awareness and information (e.g. brochures, fliers, PSAs, social media)	2	SDSU Extension, State OEM, NIDIS	
Goal 3: Enhance Mechanisms to Provide Water Supplies to Areas of Shortage During Droughts					
3.1	H	Encourage development of drought-resistant rural water systems	3	SDDA	
3.2	H	Develop instream flow protections	3	DENR, Chief Engineer	
3.3	L	Secure water rights for fish and wildlife conservation	3	Game, Fish and Parks	
3.4	M	Pre-position water resources to support fire suppression activities	3	SDDA Wildland Fire	
Goal 4: Reduce Water Demand and Encourage Water Conservation					
4.1	L	Promote catching water in cisterns in the southwestern part of South Dakota	4	DENR	
4.2	H	Create tax credit incentives for efficient water use	4	SD Legislature	
4.3	H	Develop more efficient irrigation systems	4	SDDA and SDSU Extension	
4.4	M	Develop livestock water system for less reliance on ponds	4	SDDA and SDSU Extension	
4.5	M	Promote water-friendly landscaping and planting of drought-resistant lawns	4	SDDA and SDSU Extension	

Action ID	Priority	Recommended Action	Primary and Related Goal	Lead/Partner Agency	Status, Implementation and Funding Comments
Goal 5: Reduce Drought Impacts to South Dakota's Economy, People, State Assets, Cultural Resources and Environment					
5.1	M	Implement long-term restoration of grasslands	5	SDDA	
5.2	M	Develop strategies for mental health and substance abuse agencies to ensure referrals are made to providers in the areas that are impacted	5	Division of Behavioral Health	
5.3	H	Develop strategies to assist behavioral health providers if they become overwhelmed or need assistance from other providers of the Division of Behavioral Health	5	Division of Behavioral Health	
5.4	L	Enhance habitats	5	Game, Fish and Wildlife	
5.5	L	Enhance outreach outside of the Black Hills fire district for mitigating damages in rural areas; potential capabilities of reducing agricultural losses due to fire	5	SDDA Wildland Fire	
5.5	L	Enhance outreach outside of the Black Hills fire district for mitigating damages in rural areas; potential capabilities of reducing agricultural losses due to fire	5	SDDA Wildland Fire	
Goal 6: Continue to Maintain and Enhance Intergovernmental and Interagency Stakeholder Coordination					
6.1	H	Increase outreach and interaction with local, tribal, and federal agencies	6	Drought Task Force	
6.2	M	Provide the drought plan to local and tribal governments to encourage the development of water conservation plans	6	Drought Task Force	
6.3	H	Engage tribal entities more closely in the drought planning and mitigation process	6	NIDIS, State Climate Office, Tribal Relations	

Action ID	Priority	Recommended Action	Primary and Related Goal	Lead/Partner Agency	Status, Implementation and Funding Comments
6.4	M	Encourage local communities to think about creation of drought mitigation plan	6	State OEM	
6.5	M	Encourage counties to participate in county/state fire suppression agreements to assist counties when fires occur in county jurisdictions	6	SDDA Wildland Fire	
6.6	H	Encourage counties to increase support of local volunteer fire departments to prepare/fund suppression activities	6	SDDA Wildland Fire	
6.7	H	Encourage local level drought planning and increase community/local level drought planning assistance and identify leaders at local level (i.e. create Drought Ready Communities)	6	SDSU Extension, State OEM, NIDIS	
6.8	H	Increase NIDIS interactions and planning efforts	6	State Climate Office	
6.9	H	Encourage tribal representatives to coordinate with local planning personnel for joint initiative development and increase data sharing	6	Tribal Relations, OEM	
Goal 7: Evaluate Changes in Drought Frequency and Severity					
7.1	M	Create studies on drought frequencies and future changes	7	State Climate Office; Various SDSU Departments	

4.3.2 Evaluation and Selection of Actions and Activities

During the 2015 Plan development the DTF members were asked to generate ideas for actions to be included in the Plan. At the mitigation strategy meeting in May 2015, DTF members were provided with several lists of typical drought hazard mitigation actions or alternatives. One of these was a compendium of tools typically used by states to mitigate drought, based on information from the National Drought Mitigation Center’s website. In addition to these handouts, a presentation at the meeting on the detailed vulnerability assessment included recommendations for “adaptive capacities” that could mitigate impacts to the various sectors. These suggested recommendations are captured in Chapter 3 Vulnerability Assessment by sector and were provided to the DTF sector leads in advance of the meeting for consideration during the mitigation strategy development.

The following general categories of state-level approaches to drought mitigation were considered:

- Administrative
- Emergency services
- Financial
- Monitoring and prediction
- Natural resource protection
- Projects to reduce impacts to state assets
- Public education
- Regulatory
- Structural projects
- Studies, publications, planning efforts
- Technical assistance
- Training and exercises

A facilitated discussion took place at the meeting to examine and analyze the alternatives. With an understanding of the alternatives and progress on existing actions, a brainstorming session was conducted to generate a list of preferred mitigation actions. DTF members wrote project ideas on sticky notes. These were posted on flip charts organized by vulnerability sector. The result was over 40 new project ideas that help to meet the identified goals. New actions identified through this process are indicated in **Table 32**. Some actions that were similar in nature were combined.

4.3.3 Prioritization of Actions and Activities

Once the mitigation actions were identified, the DTF members were provided with several sets of decision-making tools, including FEMA’s recommended criteria, STAPLE/E (which considers social, technical, administrative, political, legal, economic, and environmental constraints and benefits).

- Social: Does the measure treat people fairly?
- Technical: Will it work? (Does it solve the problem? Is it feasible?)
- Administrative: Is there capacity to implement and manage the project?
- Political: Who are the stakeholders? Did they get to participate? Is there public support? Is political leadership willing to support the project?
- Legal: Does your organization have the authority to implement? Is it legal? Are there liability implications?
- Economic: Is it cost-beneficial? Is there funding? Does it contribute to the local economy or economic development? Does it reduce direct property losses or indirect economic losses?
- Environmental: Does it comply with environmental regulations or have adverse environmental impacts?

Other criteria used to recommend what actions might be more important, more effective, or more likely to be implemented than another included:

- Does action address areas with the highest risk (from Vulnerability Assessment)?
- Does action protect state assets or infrastructure?
- Does action improve the State capability to manage and implement mitigation (from Capability Assessment)?

The action identification and prioritization process is the first step in laying-out, in broad terms, what needs to be done to minimize the impact of the drought hazard in the State. Some of the actions can be accomplished with minimal cost or integrated into the work plans of the lead agency. While cost-effectiveness is required for FEMA funding of projects, many of the projects identified are non-structural and thus difficult to quantify cost-effectiveness. The detailed engineering studies, implementation costs, and benefit-cost analysis of specific projects will come at future points in the process, when and where applicable.

4.4 Funding Sources

The State's mitigation strategy includes an identification of existing and potential sources of federal, state, local or private funding to implement mitigation activities. South Dakota uses a variety of sources to fund state and local drought mitigation activities that are described in the next section.

4.4.1 Identification of Existing Federal, State, Local Funding Sources

There are multiple federal avenues under which the State of South Dakota could be eligible for funding for drought-related mitigation projects. The State, through OEM, has instituted an effective and comprehensive all-hazard mitigation program. Through a variety of programs, and the wise use of available federal and state funds, the State has been successful in mitigating areas against the devastating effects of drought and other hazards. As of the writing of this Plan, FEMA's Hazard Mitigation Assistance programs are the primary sources of funding for South

Dakota’s mitigation activities. These grants include the Pre-Disaster Mitigation (PDM) program and Hazard Mitigation Grant Program (HMGP). Additional information on existing funding sources available for mitigation projects is found in Section 4.9 of the State’s Hazard Mitigation Plan.

A sample of drought-related federal grant and loan programs that could be used for mitigation related activities are shown in **Table 32**.

Table 32 Federal Drought Mitigation Funding Sources Available in South Dakota

PROGRAM	GRANT/LOAN FUNDS AVAILABLE	USES/REQUIREMENTS	AGENCY
Water2025 Challenge Grant Program for Western States	Up to \$250,000	Projects that can be completed within 24 months and that reduce conflicts through water conservation, efficiency, and markets	USBR
Water Conservation Field Services Program	Up to \$25,000	Funds projects that improve water use efficiency and improve water management practices	USBR
U.S. Economic Development Administration Grant (EDA)	No limit (subject to federal appropriation)	Water and wastewater	EDA
Hydrologic Research Grants	Up to \$125,000	To conduct joint research and development on pressing surface water hydrology issues common to national, regional, local operational offices. Eligible applicants are federally recognized agencies of state or local governments, quasi-public institutions such as water supply or power companies, hydrologic consultants and companies involved in using and developing hydrologic forecasts.	NOAA
Natural Resources Conservation Service – Emergency Watershed Protection Program	-Funding available through the Simplified Acquisition Procedures (SAP) ranges from \$25K to \$100K -Funded through contracts between project sponsors and the NRCS. There are no grants. The NRCS pays 75% of the costs.	Installing/repairing conservation measures to control flooding and prevent soil erosion. Generally, more than one individual should benefit from the project. Public or private landowners or others who have a legal interest or responsibility for the values threatened by the watershed emergency	NRCS –Initial contacts should be made with NRCS county offices when an emergency exists.
Rural Development (U.S. Department Of Agriculture)	Subject to federal appropriation	Water, wastewater & stormwater projects	USDA

PROGRAM	GRANT/LOAN FUNDS AVAILABLE	USES/REQUIREMENTS	AGENCY
Watershed Processes and Water Resources	\$100,000	Sponsors research that address two areas: (1) understanding fundamental watershed processes; and (2) developing appropriate technology and management practices for improving the effective use of water (consumptive and non-consumptive) and protecting or improving water quality for agriculture and forestry production	USDA
National Research Initiative Standard Research (Part T): Watershed Processes and Water Resources	\$500,000	Innovative research in understanding fundamental processes that affect the quality and quantity of water resources at diverse spatial and temporal scales, ways on improving water resource management in agriculture, forested, and rangeland watersheds, and developing appropriate technology to reach those goals.	USDA
Emergency Community Water Assistance Grants	\$150,000 to \$500,000	Available to rural communities with populations over 10,000 people with a median household income less than \$65,900. Provides assistance to communities who have experienced a decline in quantity or quality of drinking water as a result of an emergency including drought.	USDA
USDA Rural Development 502 Direct Housing Loan Program	-Loans limited by individual county mortgage limits -Most counties have loan limit of \$108,317	Available for wells and water connections – Applicants must be very low income, owner/occupant, unable to obtain conventional credit, and in rural communities and areas	USDA Rural Development offices in South Dakota
National Rural Water Association (NRWA) Revolving Loan Fund	\$100,000 or 75% of the total project (whichever is less)	Provides loans for pre-development costs associated with water and wastewater projects and for existing systems in need of small-scale capital improvements.	USDA Rural Utilities Service
Pre-Disaster Mitigation Program	Variable	Provides funds to states, territories, tribal governments, and communities for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event.	FEMA
Emergency Management Performance Grant	Variable	Advances three national priorities: Implementing the National Incident Management System (NIMS), expanding regional collaboration and strengthening planning priorities.	FEMA

State Sources

State sources of funding that could be used to fund drought mitigation related activities are noted in the following table. A wide variety of projects that could be considered drought mitigation are eligible for funding through the Consolidated Water Facilities Construction Program, the Drinking Water State Revolving Fund Program, and Clean Water State Revolving Fund program (under the water conservation eligibilities). The Water and Waste Funding Program does not earmark funds for drought mitigation projects or actively search for these type of projects. If an eligible project sponsor approached the department to fund a drought mitigation project, staff would work with the sponsor to determine which of the funding programs would be the best fit and assist them through the application process.

Table 33 State Drought Mitigation Funding Sources Available in South Dakota

PROGRAM	GRANT/LOAN FUNDS AVAILABLE	USES/REQUIREMENTS	AGENCY
Water and Waste Funding	Variable	Grants and loans are available for infrastructure projects that include drinking water and watershed restoration	DENR - Division of Financial and Technical Assistance
Drinking Water State Revolving Fund	Interest rates and terms are 2.25% for up to 10 years or 3.0% for 11-20 years	Funds projects that improve water use efficiency and improve water management practices	DENR - Division of Financial and Technical Assistance
State Water Plan	Variable	Large costly water projects that are seeking significant state cost share participation must be identified on the State Water Resources Management System portion of the State Water Plan.	DENR - Division of Financial and Technical Assistance
Small Community Planning Grants		Communities of 2,500 or less can receive a Small Community Planning Grant to assist in the preparation of a preliminary engineering report or facilities plans.	DENR - Division of Financial and Technical Assistance

Local Sources

Local governments actively pursue grant opportunities through federal and state agencies and use general funds or in-kind services to meet the local match requirement. Local communities are constantly seeking sources of funding to maintain programs and install or upgrade water systems. Unfortunately, funds for these types of projects are limited and the need strongly outweighs the availability. Even if communities get startup funds, continuation of programs creates new financial needs on already very tight budgets with competing demands. Despite this, South Dakota communities have made great strides and progress in prevention and preparedness activities and continue to do more each year by taking advantage of limited opportunities.

4.4.2 Sources of Funding Used to Implement Previous Drought Mitigation Activities

The initial development of this Drought Mitigation Plan was funded through a FEMA Pre Disaster Mitigation planning grant initially awarded to OEM in 2014. The funding allowed a planning consultant to be utilized for the planning process facilitation, vulnerability assessment research, and plan development.

5 PLAN MAINTENANCE PROCESS

5.1 *Monitoring, Evaluation and Updating the Plan*

Implementation and maintenance of the Plan is critical to the overall success of hazard mitigation planning. This section describes the State's system for monitoring implementation of mitigation actions and reviewing progress toward meeting Plan goals, and any changes in the system since the previously approved Plan.

5.1.1 Method and Schedule for Monitoring Plan

OEM and the Department of Agriculture is charged with the overall responsibility for Plan monitoring and evaluation, with assistance from the DTF. OEM and the Department of Agriculture, in their capacity as support agencies to the DTF, are responsible for coordination and leadership of the DTF. The responsibilities for monitoring and evaluating the Plan include the following:

- Communicating the schedule and activities for Plan updating and maintenance to the DTF
- Facilitating meetings of the DTF
- Assisting other agencies with the implementation of mitigation actions
- Coordinating with agencies between DTF meetings
- Coordinating and conducting outreach to other stakeholders or interested parties and the public
- Obtaining local mitigation Plan data to be used in Plan update cycles
- Conducting all Plan evaluation and monitoring activities that are not otherwise assigned to another agency
- Monitoring, capturing, and communicating mitigation success stories
- Documenting and incorporating the findings of the evaluation and monitoring analyses into the next edition of the Drought Mitigation Plan
- Updating the DTF on grant funds available or dispersed for actions
- Engaging and maintaining the interest of the agencies participating on the DTF
- Monitoring progress of local drought and water efficiency plan development and providing technical and financial assistance

As participants of the DTF, state agencies have the following responsibilities for Plan monitoring and evaluation:

- Participating in meetings of the DTF
- Leading the implementation of their agency's respective mitigation action(s)
- Providing progress reports on their agency's respective mitigation action(s)
- Monitoring and documenting disasters of significance to state agencies and providing this information to OEM and the Department of Agriculture
- Suggesting Plan revisions to reflect changes in priorities, regulations, policies, or procedures

- Taking action as needed to effectively monitor and evaluate the agency's role in the planning process

OEM will keep the DTF abreast of changes or opportunities with FEMA mitigation grants or policies.

The DTF will convene at least once yearly, ideally in the Fall. The Fall meeting will focus on the progress made on mitigation actions, with status reports discussed by the respective agency so that progress can be noted in the OEM annual report that is published at the beginning of the next calendar year. This meeting will also be used to discuss any lessons learned from response to drought conditions that may have been present during the year. These meetings also will help to ensure that staffs remain up to date on the activities related to the Mitigation Plan and the response procedures.

5.1.2 Method and Schedule for Evaluating and Updating the Plan

Updates to state hazard mitigation plans are required by the DMA every five years. In addition, the Drought Mitigation Plan should be evaluated after significant droughts. The Drought Mitigation Plan should align with the update schedule of the State HMP. Updates to the Plan should align with the latest DMA 2000 planning requirements. The next update of the South Dakota HMP will need to be reapproved by FEMA in 2019. OEM and the DTF will aim to complete the update to allow enough time for OEM to sync it with the HMP and submit to FEMA. The Plan will need to be approved by OEM and the DTF by September 2019. The Plan will be readopted by the Governor as part of the overall South Dakota HMP.

OEM will coordinate with the DTF on the schedule and specific needs for the State Hazard Mitigation Plan update. Funding needs for the next update cycle should be identified and pursued so that the necessary resources are in place in advance of the update year. At the Fall DTF meeting prior to the update year OEM will issue a schedule for the Drought Mitigation Plan update. This schedule will establish a timeline for the following (and other activities as needed):

- Plan update meetings
- Determining involvement and activities of newly participating state agencies (as well as changes in existing ones), including assessment of vulnerabilities, analysis of programs and policies, and identification of new mitigation actions
- Updating the status of mitigation actions identified in the 2015 Plan
- Contracting consultant assistance, as necessary

5.2 Monitoring Progress of Mitigation Activities

5.2.1 Reviewing Progress on Achieving Goals in Mitigation Strategy

Progress towards achieving this Plan’s goals will be checked annually and discussed at the annual meeting of the DTF mentioned previously. During the DTF meetings, the lead agencies will deliver a progress report on their mitigation actions. The progress will be recorded in detail during each Plan update process. All of the proposed actions listed in **Table 31** in Section 4 support one or more of the seven goals described in Section 4.1. As the progress on these recommended actions is tracked, progress on achieving the seven goals will also be monitored and summarized in the next update. If any of the goals are not receiving adequate attention, it will become apparent as the table is periodically updated. It is recommended that this table be updated at least annually, and new projects/initiatives be added as they are developed.

**SOUTH DAKOTA
DROUGHT MITIGATION PLAN
2015**

**APPENDIX A - Planning Process
Documentation**

South Dakota Drought Mitigation Plan

Drought Task Force Meeting #1 – Kickoff

September 3, 2014

10:00am – 12:30 pm

**State Emergency Operations Center
Auditorium
Pierre, SD**

AGENDA

1. Introductions
2. Discussion of Objectives and Schedule for the Plan Development
 - 2.1. Project Approach
 - 2.2. Vulnerability Assessment Approach
 - 2.3. Mitigation Strategy Development
 - 2.4. Schedule and Meetings
3. The Role of the Drought Task Force
4. Other Stakeholders Involvement
 - 4.1. NIDIS and NDMC
5. Public and Stakeholder Workshops
6. Drought Vulnerability Data Collection Needs
7. Next Steps
8. Questions and Answers/Adjourn

South Dakota Drought Mitigation Plan

Drought Task Force Meeting #2 – Vulnerability Assessment Workshop

December 11, 2014

9:00am – 12:00 pm

**State Emergency Operations Center
EOC Classroom
Pierre, SD**

AGENDA

1. Introductions
2. Recap of Objectives and Schedule for the Plan Development and Progress to Date
3. Drought Task Force Membership update
4. Public and Stakeholder Involvement Recommendations
5. Drought Vulnerability Assessment Work Session
 - 5.1. Drought impacts and adaptive capacity by Sector
 - 5.2. Preliminary findings
 - 5.3. Adaptive capacity
 - 5.4. Data gaps identification
6. Next Steps
7. Questions and Answers/Adjourn

South Dakota Drought Mitigation Plan

Drought Task Force Meeting #3 – Mitigation Strategy Development

**May 7, 2015
9:00am – 12:00 pm**

**State Emergency Operations Center
EOC Classroom A/B
Pierre, SD**

AGENDA

1. Introductions
2. Planning Process Review
3. Drought Vulnerability Assessment - Sector Findings
4. Drought Capability Assessment
5. Drought Mitigation Plan Goals Development
6. Review Types of Drought Mitigation/Adaptive Capacity Actions
7. Discuss Criteria for Mitigation Action Selection and Prioritization
8. Brainstorming Session/Development of Mitigation Actions
9. Prioritize Mitigation Actions
10. Discuss Plan Implementation and Maintenance
11. Public/stakeholder Involvement
12. Next Steps
13. Questions and Answers/Adjourn

Drought Mitigation Action Worksheet

Name of Department/Agency: _____

Use this to record potential mitigation projects (1 page per project) identified during the planning process. Provide as much detail as possible and use additional pages as necessary. Complete and return to Amec Foster Wheeler by **May 28th, 2015**.

Mitigation Project Title	
Project Description, Issue/Background	
Lead Agency and Title of Lead Person	
Partners/Support Agencies	
Priority (High, Medium, Low)	
Potential Funding	
Schedule	

Prepared by: _____ Phone: _____ Email: _____	Please return worksheets by mail, email, or fax to: to: Jeff Brislawn jeff.brislawn@amecfw.com 1002 Walnut St, Suite 200 Boulder CO, 80302 Tel 303-443-7839 Fax 303-442-0616
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South Dakota Drought Mitigation Plan Development Fact Sheet

Background

The State of South Dakota is in the process of developing a Drought Mitigation Plan. The plan is being prepared in coordination with the State's Drought Task Force, which is comprised of various state agencies and co-chaired by the Departments of Agriculture and Department of Public Safety, Office of Emergency Management. The Drought Task Force is charged with coordinating the exchange of drought information related to the agriculture, health and other societal effects, tourism, water resources, wildland fire, and wildlife sectors. The state is utilizing a consulting firm, Amec Foster Wheeler, to prepare the plan and analyze drought vulnerability by sector. The plan will include a stakeholder process with input from a wide array of state and federal agencies and experts.

Purpose

Drought can be defined as an extended shortfall of precipitation that results in water supplies inadequate to meet the requirements of people and the environment. The entire state of South Dakota is susceptible to drought and was recently impacted by severe drought during 2012. Based on historical records notable droughts have occurred somewhere in the state about every 12 years, which is equivalent of an 8% annual chance. Losses, especially to agribusiness, are assumed to exceed millions of dollars during drought years.

This project will result in the development of a South Dakota Drought Mitigation Plan (Drought Plan) which will consist of two main components): 1) a vulnerability assessment for the state; 2) a plan to mitigate those identified risks & vulnerabilities. The plan development approach follows a process similar to the FEMA four phase state hazard mitigation planning process that includes:

1. Organize Resources
2. Assess Risks
3. Develop a Mitigation Plan
4. Implement the Plan and Monitor Progress

The planning process began in August 2014 and is anticipated to be completed during the summer of 2015.

Please take a short online survey by following this link:
https://www.surveymonkey.com/s/SD_DroughtMitigationPlan

The Drought Mitigation Plan will:

- Include a sector-based vulnerability assessment for 6 sectors including:
 - Agriculture
 - Health/Socioeconomic
 - Tourism
 - Water Resources
 - Wildland Fire
 - Wildlife
- Develop a statewide strategy to reduce the impacts of future droughts
- Serve as a hazard specific annex for the State of South Dakota's Hazard Mitigation Plan
- Include collaboration with the National Integrated Drought Information System (NIDIS) and National Drought Mitigation Center and various stakeholders
- Provide a resource for local drought planning.

Opportunities for Input

Public and stakeholder input is invited and welcomed. In addition to the survey a draft will be made available for public and stakeholder review in fall 2015.

For more information on the plan and opportunities for input contact:

Jason Bauder, OEM Deputy Director
605-773-3231
jason.bauder@state.sd.us

Formulating the Drought Mitigation Strategy

Goals, Objectives, and Actions

Goals, objectives, and mitigation actions should be based on the information revealed in the Risk Assessment. Definitions and actions are provided below:

Goals are general guidelines that explain what you want to achieve. Goals are defined before considering how to accomplish them so that the goals are not dependent on the means of achievement. They are usually broad policy-type statements and represent long term global visions such as:

- Reduce exposure to drought-related losses
- Reduce the impact of drought to the citizens of the state
- Provide protection for natural resources from drought impacts
- Maintain and enhance existing mitigation measures
- Increase public awareness of vulnerability to drought and support and demand for drought mitigation

Objectives define strategies or implementation steps to attain the identified goals. Unlike goals, objectives are specific and measurable, such as:

- Support practices that reduce drought losses and impacts
- Improve drought monitoring capabilities

Mitigation Actions are specific actions that help you achieve your goals and objectives. Some examples include:

- Provide technical assistance and guidance for local-level drought mitigation plans
- Develop a systematic method to collect and assess drought impacts as they emerge
- Promote a water efficiency workshop for agriculture

Goals from Related Plans

It is also important to integrate the mitigation strategy with goals in other existing planning mechanisms to ensure consistency, efficiency, and effectiveness, which is also useful in identifying funding opportunities. The goals from the 2013 South Dakota Hazard Mitigation Plan are listed below, along with the objectives relevant to drought. The goals from the 2013 Colorado Drought Mitigation and Response Plan are also listed below to provide an example from a drought-specific mitigation plan.

South Dakota Hazard Mitigation Plan, 2013

1. Reduce injuries and loss of life from hazards.
 - Maintain and improve public health and safety outreach activities/programs.
2. Reduce damage to existing and future structures within hazard areas.
 - Reduce the number of structures lost by wildfires.
3. Reduce the losses to critical facilities, utilities, and infrastructure from hazards.
 - Reduce negative impacts to water supply and sewage treatment systems.
4. Reduce impacts to the economy, the environment, and cultural resources from hazards.
 - Reduce losses to natural resources (i.e., forest and watershed health).
 - Reduce impacts to cultural resources (i.e., historical/tribal).
 - Reduce agricultural losses.
 - Reduce economic losses to recreation and tourism.
5. Support and assist local/tribal mitigation capabilities and efforts.
 - Encourage locals to participate in risk reduction measures.

Colorado Drought Mitigation and Response Plan, 2013

1. Improve water availability monitoring and drought impact assessment
2. Increase public awareness and education
3. Enhance mechanisms to provide water supplies to areas of shortage during droughts
4. Coordinate and provide technical assistance for state, local, and watershed planning efforts
5. Reduce water demand/encourage conservation
6. Reduce drought impacts to Colorado's economy, people, state assets, and environment
7. Develop intergovernmental and interagency stakeholder coordination
8. Evaluate potential impacts from climate change

Group Goals and Objectives Update/Development

The purpose of this process is to develop goals and objectives and come to a team decision, or consensus, on revisions to them. **List below suggested revisions or additions to the goals and objectives of South Dakota’s Drought Mitigation Plan.** You can refer to the South Dakota State Hazard Mitigation Plan goals listed previously and you may reword them to be more relevant to drought or add new ones. For any new goals suggest one or more objectives to accomplish that goal. Return to Jeff Brislaw (jeff.brislaw@amecfw.com or fax to 303-442-0616).

Goal 1:

Objectives:

Goal 2:

Objectives:

Goal 3:

Objectives:

Goal 4:

Objectives

Survey Questions for South Dakota Drought Mitigation Plan

7-7-15

Background: The State of South Dakota is developing a Drought Mitigation Plan in 2015 under the guidance of the State Drought Task Force. The purpose of this survey is to collect information from the public and stakeholders to better understand drought vulnerabilities within the state as well as solicit input on needs to best mitigate, or reduce, the impacts of drought. Please complete this survey by August 31, 2015. Hardcopies of the survey can be faxed to 303-442-0616 or scanned and emailed to jeff.brislawn@amecfw.com.

1) Please specify the county in which you are located.

▪ _____

2) Select affiliation

- Member of the Public
- Private Industry
- Nonprofit
- Government – Local
- Government – State
- Government – Federal
- Tribal

3) Specify if you are associated with any of the following sectors that could be impacted by drought:

- Recreation and Tourism
- Agriculture – Crops
- Agriculture – Livestock
- Agricultural Industry – Other
- Water Provider (rural water, municipal, etc.)
- Wildland fire suppression
- Wildlife management
- General public
- Other:

4) Were you adversely affected by the 2012-2013 drought?

- Yes
- No

5) During the 2012-2013 drought which impacts did you most frequently experience? Please rank them according to level of impact with high, medium or low or N/A.

- Loss of income
- Crop loss
- Lack of water for livestock
- Lack of water for domestic, municipal and industrial uses
- Increased number of wildfires
- More severe wildfires
- Decreased water quality
- Decreased groundwater availability or a drop in groundwater levels
- Decreased surface water availability or a drop in surface water levels
- Poor hunting or fishing quality

- Fewer/poorer quality recreational opportunities (e.g., boating, snowmobiling, etc.)
 - Reduction in recreation or tourism-based revenue
 - Reduction in agri-business revenue
 - Depression, anxiety, or other behavioral health issue (survey results are anonymous)
 - Other: _____
-

6) How would you characterize the drought vulnerability of your organization and/or county in 2012-2013 compared to previous droughts? Select the option that most accurately reflects your current situation.

- Our organization/county was more susceptible to drought impacts in 2012-2013 than in previous droughts because the supply/storage situation was more severe.
- Our organization/county was less susceptible to drought impacts in 2012-2013 than in previous droughts because the supply/storage situation was less severe.
- Our organization's/county's susceptibility to drought impacts was about the same in 2012-2013 as in previous droughts.
- The supply/storage situation in 2012-2013 and in previous droughts was very similar. However, our organization/county is less susceptible to drought impacts than in earlier droughts because we have applied the lessons learned from other droughts and are better prepared for mitigating drought.
- Unsure
- N/A

7) Please list up to three projects implemented by you, your organization, county, or other state or federal agency over the past five years that you consider the most worthwhile for reducing drought impacts.

- _____
- _____
- _____
- N/A

8) What projects would help you, your organization, or your county reduce impacts from future droughts? Place a check next to the types of mitigation actions that would be most desired.

- Public education and outreach
- Wildfire mitigation
- Improving awareness of/participation in federal aid programs
- Economic diversification
- Increased behavioral/mental health resources
- Developing local or organizational -level drought mitigation plans
- Diversification of water supplies
- Workshops/information on agricultural best practices
- Workshops/information on water efficiency/conservation practices

- Increased crop insurance
- Improved drought monitoring/early warning
- Other: _____

9) How likely are you to improve your personal level of drought preparedness following the 2012-2013 event?

- Not likely, what we have is sufficient
- Not likely, what we have is not sufficient but resources are limited
- Somewhat likely
- Likely, it is part of our long range planning but we haven't implemented any activities yet
- Likely, and the process is underway

10) Is there sufficient funding to support drought planning within your organization or county? Select one option.

- Yes, there is sufficient funding from local resources
- Yes, there is sufficient funding with State and Federal financial assistance
- No, additional State and Federal financial assistance is needed.
- Unknown

11) Are you interested in receiving future correspondence from SDOEM reading the 2015 South Dakota Drought Mitigation Plan? If yes, please provide an email address below.

- Yes (email: _____)
- No

12) Please provide any remaining comments here:

Mitigating Drought

Mitigation Tools for States

The document presents various drought mitigation and response tools that U.S. states have employed. This document is adapted by Amec Foster Wheeler from the National Drought Mitigation Center's (NDMC) webpage for the South Dakota Drought Task Force as reference material for the development of the 2015 South Dakota Drought Mitigation Plan. The mitigation options are categorized according to 11 impact sectors (Water Availability, Municipal Water, Water Shortage/Conservation Activities, Agricultural Industry, Public Information and Education, Fish/Wildlife Preservation, Health, Commerce and Tourism/Economy, Wildfire Protection/Forestry/Public Lands, Energy, and Social), based on a survey result by Najarian (2000). The tools listed here are not specific recommendations but intended to give planners an idea of the available options. Some tools may be inappropriate in some areas or may already be in use.

Other sources of drought mitigation ideas include:

NDMC Drought Management Database: <http://drought.unl.edu/droughtmanagement/Home.aspx>
Includes an online searchable database containing a collection of information about what has been tried in responding to and preparing for drought in the United States categorized by sector.

NDMC Drought Planning Processes: <http://drought.unl.edu/Planning/PlanningProcesses.aspx>

FEMA Mitigation Ideas: <https://www.fema.gov/media-library/assets/documents/30627>

Water Availability

Mitigation programs

- Encourage/enforce development of local drought plans
- Enact policy to assure equitable water distribution/water metering
- Assess need for policy change regarding drought
- Identify resource deficiencies/availabilities
- Implement actions to reduce occurrence of water supply emergencies
- Research hydrologic process/climate change/predicting drought
- Conduct water rights adjudications
- Establish groundwater monitoring network/control withdrawal
- Prepare stockpile of pipes, pumps, etc.
- Weather modification
- Analyze long-term or residual impacts of drought
- Encourage long-term drought management planning in river basins
- Collect and map geographic information
- Draft policy to require water use reporting

- Grants/loans to promote development of efficient use of water
- Include “water shortage criteria” for drought years in all projects
- Provide list of water-moving equipment
- Develop state agency-level operating procedures for drought response
- Create drought fund to support programs
- Create drought advisory board for legislative input and plan update
- Develop guidelines for drought plan development
- Require surface water applicants to submit plan for alternate water supply
- Clarify state law regarding sale of water
- Clarify state law on changes in water rights
- Established statewide contingency plan
- Forest management with intent of optimizing water supply yield and water quality goals

Water rights/legal agreement related programs

- Water Exchanges
- Water Transfers
- Substitute Water Supply Planning
- Interruptible Supplies
- Dry Year Lease
- Other Leases
- Operating Agreements
- Water supply bank/allocation system
- Water Conservation Easements
- Use of Instream Flow programs

Impact assessment actions

- Evaluate drought conditions/assess water supply/needs
- Provide/analyze data
- Reporting
- Provide technical information, including gaps
- Review/update procedures
- Climate analysis/long-range forecasts
- Enhance data collection and forecasting
- Make projections for several scenarios

Response programs

- Augment water supplies/identify alternative sources
- Provide information and technical assistance
- Expedite water transfers/issue emergency permits during drought
- Inventory/review/modify project operations
- Mediate water conflicts
- Coordinate with river basin/lake plan

- Clarify water rights to allow water regulation/modification
- Ensure implementation of public utilities local drought plans
- Identify resource deficiencies/availabilities
- Provide grants/loans for water-related projects
- Water purchases, including water banks
- Appropriation permit suspensions/water use restrictions
- Communicate with states experiencing similar problems
- Develop drought legislation
- Oppose new diversions during drought
- Identify or recommend response actions based on conditions/triggers
- Reduced snowmaking

Municipal Water

Mitigation programs

- Assist in developing local response plans/activities
- Investigate/offer alternate water supplies/tech assistance
- Develop program for services to small water systems in drought
- Evaluate local vulnerabilities to water shortage
- Evaluate potable and non-potable water reuse options
- Provide strategies for mitigating drought impacts
- Develop additional wastewater storage
- Develop funding for services to small water systems in drought
- Plan for “worst case” situations

Impact assessment actions

- Assess drought-related impacts
- Develop water supply assessment
- Assess need for federal programs/drought declaration
- Reporting
- Analysis of municipal firefighting capabilities
- Direct data to response agencies/local jurisdictions
- Protocol for outreach/coordination/information gathering in impacted areas
- Determine extent and effectiveness of previous mitigation for event
- Assessment of needs
- List problem areas

Response programs

- Assist communities under long-term water stress
- Emergency funding
- Water use restrictions
- Information/technical assistance for public water/wastewater treatment

- Construct wells/transport water to political subdivisions
- Coordinate with National Guard/private industry for material support
- Identify sources of assistance/resources
- Technical assistance in distribution of water to communities/first aid
- Grants for public water and wastewater treatment/improvement
- Institute water pricing/rate adjustments
- Intensify leakage control efforts/water metering
- Volunteer for local response actions
- Recommend response levels and activities
- Industrial process modification
- Limit installation of new water use permits to new customers
- Use of non-potable water to meet certain requirements
- Water Management Team to implement community activities
- Distribute fire service guide to fire stations
- Establish start-up/shut down for assessment and response
- Process and review all relief project applications
- Review applications for exemption of restrictions

Water Shortage/Conservation Activities

Mitigation programs

- Develop and disseminate water conservation materials
- Response/conservation planning assistance
- Technical assistance
- Resource conservation and development program
- Conserve water on state lands/give shortage criteria
- Encourage use of drought-resistant vegetation
- Develop model water conservation/water efficiency program
- Provide incentives for water conservation
- Assess conservation measures
- Develop partnership with power utilities to encourage conservation
- Develop water conservation partnership with adjacent state
- Install water-saving devices
- Implement water metering program
- List industrial users/suppliers for development of conservation partnership

Response programs

- Promote/enforce conservation practices
- Prepare/distribute education materials
- Limit serving water in restaurants to raise public awareness
- Identify alternate water supplies
- Publish emergency publication about water
- Call town meeting/elicite community support

- Funds for drought-related impacts
- Develop long-range water conservation goals

Agricultural Industry

Mitigation programs

- Provide insurance against unavoidable loss
- Encourage alternate water supplies/delivery
- Increase water delivery efficiency (smart irrigation scheduling, lining ditches)
- Funds for improved water use efficiency
- Volunteer irrigation water scheduling program
- Evaluate need for irrigation, including supplemental
- Program for grazing strategies/range land management
- Provide technical assistance
- Research to minimize impacts
- Computer information networks
- Coordinate preparedness activities
- Develop fire and insect programs
- Develop irrigation district drought plans
- Draft policy to modify irrigation districts
- Education on soil and water conservation best practices for agriculture
- Education for riparian streambank protection
- Evaluate riparian land regarding water rights

Impact assessment actions

- Assess severity/cost of impacts
- Collect and evaluate impact data
- Report, maintain data and records
- Analyze/assess needs
- Identify sources of assistance
- Recommend response levels and activities
- Make projections for several scenarios
- Survey and monitor animal health and care
- Estimate costs of activities
- Keep inventory of programs and responsibilities
- Improve assessment of impacts

Response programs

- Emergency funding (loans, grants, credits, etc.)
- Technical assistance/program coordination
- Recommend response levels/activities to minimize impacts
- Assist livestock owners/feed distribution

- Construct wells/transport water to farmers and ranchers
- Community coordination/education
- Disease/pest/predator control
- Determine needs/aid in rehabilitation
- Hay bank/hotline
- Irrigation reduction/alteration
- Production adjustment programs/crop rotation
- Forest resource evaluation
- Data collecting/analysis
- Develop supplemental natural resources employment opportunities
- Develop support services hotline
- Emergency control guidelines for wildlife species on crop or range land
- Emergency food stamp allotments
- Fire control
- Increase storage of surface waters/rehabilitate reservoirs
- Program to apply livestock sale income to next year's income tax
- Use reclaimed water for irrigation
- Water supply safety test
- Drought property tax programs for farmers
- Emergency irrigation permits

Public Information and Education

Mitigation programs

- Local information and education programs
- PSAs and press releases, magazine articles, bulletins, social media
- Conduct workshops: conserving water/managing drought impacts
- Develop partnership with public utilities for information dissemination
- Encourage private/public utilities to support media announcements
- Inventory relief programs
- Establish drought information/natural hazard mitigation center

Response programs

- Develop and disseminate drought-related information
- Press release regarding drought areas/conditions
- Education/awareness programs
- Public service announcements (PSAs) to encourage efficient water use during drought and counteract negative reaction to drought
- Public hearings regarding restrictions

Fish/Wildlife Preservation

Mitigation programs

- Enact policy to increase/protect instream flows/wetlands
- Help develop drought plans to minimize fish and wildlife impacts
- Identify sensitive facilities or habitats/improve security of water supply
- Program to enhance and protect fish habitat during low flows
- Cost-share improvements in fisheries/habitat
- Develop alternative water supplies for lakes and streams
- Develop mitigation and response alternatives
- Investigate effects of alternative hunting seasons
- Monitor stream dewatering/fish habitats and effects of streamflow
- Develop regional drought monitoring/action reporting system

Impact assessment actions

- Estimate short- and long-term losses to public land/assess impacts
- Recommend/estimate costs of implementing programs
- Reporting
- Evaluate impact on water rights/water releases
- Assess alternatives to instream flow
- Assess fish/fishery resources
- Assessment of needs
- Determine susceptibility to dewatering
- Establish intergovernmental dialogue regarding wildlife
- Identify major vulnerable areas of concern
- Monitor water quality to determine effects on fish and wildlife

Response programs

- Activate instream rights/programs to allow instream flows
- Implement drought assistance programs
- Grants/loans
- Modify hunting season/fishing regulations
- Actions to reduce depravation of livestock forage/water quality
- Identify resources uses/needs
- Prevent fish harvesting exploitation/fish loss due to diversions
- Disseminate funds from sale of fishing and hunting licenses
- Employ agriculture to enhance status of nongame species of fish
- Encourage use of permanent, less destructive water diversions
- Install temporary gauges to monitor streamflow
- Modify hatchery water delivery system to solve water quality problems
- Provide food and water for drought-stressed wildlife
- Recommend response levels and activities

- Request voluntary reduction of pollutant to minimize wastewater
- Set priorities/new compliance dates for environmental regulations
- Temporarily halt fish stocking programs/hatchery production
- Use fish from hatcheries to stock habitats

Health

Mitigation programs

- Develop mitigation strategies for areas lacking mental health services
- Develop program to reduce health effects of blowing dust

Impact assessment actions

- Determine water quality/water quality standards
- Assessment of health problems/needs
- Assess water restriction measures on community health
- Increase monitoring of food processors
- Reporting
- Survey private water supplies

Response programs

- Drinking water safety
- Release drought-related health advisories
- Water shortage response plans for health departments/utilities
- Address drought-related issues
- Enact policy to ensure water quality standards
- Provide increased preventive/direct health services
- Provide list of ice manufacturers
- Recommend response levels and activities

Social

Mitigation programs

- Develop social counseling and support program

Impact assessment actions

- Assess drought socio-economic impacts

Response programs

- General drought assistance programs

- Family/unemployment counseling services
- Distribute surplus food to disaster victims
- Emergency funding
- Emergency temporary housing
- Legal advice and assistance

Commerce and Tourism/Economy

Mitigation programs

- Prepare applications for supplemental employment
- Provide training for private fish/wildlife-based enterprises
- Pursue emergency income projects for drought areas
- Recommend mitigation strategies

Impact assessment actions

- Identify and project economic/employment impacts, monitor conditions
- Identify commercial and industrial problem areas/impacts
- Assess visitation data, sales tax, employment, and lodging receipts
- Recommend/estimate costs of implementing programs
- Assessment of needs
- Aggregate data from other sectors
- Assess impacts on secondary business
- Reporting

Response programs

- Coordinated press releases
- Appropriate funding/programs for employment, local businesses
- Expedite federal loans/emergency funding to business communities
- Public information regarding tourism
- Authorize purchases without competitive bidding
- Emergency transportation/supply needs
- Implement drought assistance programs
- Provide emergency licensing/tax assistance
- Assist communities in designing economic and community projects
- Assist in financial record keeping
- Investigate fraud in distribution of commodities
- Recommend response levels and activities
- Respond to needs of migrant workers
- Review/modify regulations governing financial institutions
- Unemployment insurance programs
- Extend boat ramps and docks in recreational areas

Wildfire Protection/Forestry/Public Lands

Mitigation programs

- Fire management and mitigation planning
- Fire management to reduce vulnerability to public lands
- Alternatives to reduce competitive land use
- Develop plans to limit forest access during drought
- Employ managed and prescribed fires
- Fire safety programs
- Identify forest lands for wastewater application
- Provide technical assistance for planning and preparedness

Impact assessment actions

- Assess severity of impacts
- Collect and evaluate impact data
- Inventory fire protection resources
- Report, maintain data and records
- Identify sources of assistance
- Estimate costs of activities
- Make projections for several scenarios
- Identify major vulnerable areas of concern

Response programs

- Wildfire suppression
- Wildfire prevention
- Forest/public land closures
- Ban open fires/other restriction policies
- Ban fireworks displays
- Modify project operations/land management practices
- Interagency coordination
- Manage range depletion/modify grazing schedules on public lands
- Recommend response levels and activities
- Wildfire detection/monitoring
- Provide information/equipment to restore river basin and roads
- Wildfire readiness
- Identify potential fire hazard areas
- Implement general drought assistance programs
- Provide technical assistance
- Provide funds for wildfire suppression
- Retard runoff/prevent erosion
- Secure water sources for fighting fires

South Dakota Drought Mitigation Plan Development 2014 Participant Worksheet *Stakeholder and Public Involvement Recommendations*

Return worksheet by November 7th, 2014 to : Jeff Brislawn Amec project manager Amec Environment and Infrastructure Inc. 1002 Walnut St, Suite 200, Boulder, CO 80302 Ph (303)820-4654; Fax (303) 442-0616; jeff.brislawn@amec.com	Completed by: Name: Agency: Contact:
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Suggestions for Stakeholder Involvement -

The following is a list of membership of the Drought Task Force who will participate as the core planning team:

State Agencies

- Office of the Governor
- Department of Agriculture
 - Division of Wildland Fire
- Department of Environment and Natural Resources
- Department of Game, Fish and Parks
- Department of Health
- Department of Military
- Department of Public Safety
 - Office of Emergency Management
 - Office of State Fire Marshal
- South Dakota State University
 - State Climatologist
- Department of Social Services
- Department of Tourism
- Department of Tribal Affairs
- Bureau of Information and Telecommunication

The following is a list of suggested stakeholders. Stakeholders will be more peripherally involved, but given an opportunity to comment on the plan during its development, and may have information that may be relevant to the plan.

- NOAA– National Integrated Drought Information System (NIDIS)
- NDMC - National Drought Mitigation Center
- Farmers Union
- Water Development Districts
- Rural Water Systems Associations
- Town and Township Associations
- Municipal League
- County Associations
- Universities

Please add suggestions for additional stakeholders here; provide specific contacts for additional stakeholders (or those within the above organizations):

Public Involvement and Outreach:

Please suggest any upcoming opportunities where the drought plan can be promoted to increase awareness and interest in the project. This could be an existing forum such as a meeting or conference. Note specific upcoming meetings and dates that you may be aware of. Suggested examples include:

- Watershed group meetings
- County Commissioner's organization meetings
- County Conservation District organizational meetings
- Farm Bureau organization meetings (typically meet in Nov-Winter timeframe)
- Agricultural interest group meetings

In your opinion what is the best way to engage the public and stakeholders in the planning process? Rank in numerical order with 1 being most effective.

___ **Specific workshops/meetings on the drought plan**

___ **Online surveys**

___ **Flyers and outreach at targeted stakeholder meetings**

___ **Other:**

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APPENDIX B – Public Participation Plan

South Dakota Drought Mitigation Plan Development 2015 Stakeholder and Public Participation Plan

**Prepared by
Amec Foster Wheeler
based on input from the South Dakota Drought Task Force**

Purposes of the Stakeholder and Public Participation Plan

The basic purpose for a stakeholder and public participation plan is to provide for a meaningful process through which South Dakota's citizens, public officials, and stakeholder groups may effectively participate in the development of the Drought Mitigation Plan. This plan will be developed based upon the understanding that citizens and stakeholders are the source of tremendous creativity, and that their creativity and input will produce better planning decisions. Stakeholders and public participation throughout the planning process is regarded as an essential strategy for developing a plan with public buy-in.

A wide variety of public participation methods, representing distinct purposes, will be employed to provide for broad public participation. These purposes of public participation are as follows:

- Awareness - to share information and to promote awareness of planning process, including ways the public and stakeholders can participate
- Education - to educate citizens and groups and help them make more informed choices
- Input - to provide citizens and groups with opportunities to inject ideas into the planning process
- Interaction - to exchange views and ideas
- Partnership - to involve citizens and stakeholders in the plan development process

Objectives of the Stakeholder and Public Participation Plan

1. To build public and stakeholder support and awareness of the Drought Mitigation Plan.
2. Recognizing that there are many levels of public and stakeholder participation, to provide for an effective mix of participation opportunities that meet the above bulleted purposes.

State Government Public Outreach/Stakeholder Involvement Responsibilities in Mitigation Planning

The requirements related to public/stakeholder involvement in state hazard mitigation plans according to the Disaster Mitigation Act of 2000 are listed below:

Disaster Mitigation Act Requirement §201.4(b): The [State] mitigation planning process should include coordination with other State agencies, appropriate Federal agencies, interested groups,

and be integrated to the extent possible with other ongoing State planning efforts as well as other FEMA mitigation programs and initiatives.

The following is a list of membership of the Drought Task Force who will participate as the core planning team:

State Agencies

- Office of the Governor
- Department of Agriculture
 - Division of Wildland Fire
- Department of Environment and Natural Resources
- Department of Game, Fish and Parks
- Department of Health
- Department of Military
- Department of Public Safety
 - Office of Emergency Management
 - Office of State Fire Marshal
- South Dakota State University
 - State Climatologist
- Department of Social Services
- Department of Tourism
- Department of Tribal Affairs
- Bureau of Information and Telecommunication

Federal Agencies

- NOAA– NIDIS
- USDA - NRCS

Other

- National Drought Mitigation Center

Stakeholders

The following is a list of suggested stakeholders. Stakeholders will be more peripherally involved, but given an opportunity to comment on the plan during its development, and may have information that may be relevant to the plan.

Other State Agencies

- SD Geological Survey
- SD Dept of Social Services Division of Economic Assistance
- Department of Labor and Regulation

Other Federal Agencies

- NWS
- USDA -
 - Animal and Plant Inspection Service
 - FSA
 - Risk Management Agency
 - Forest Service
 - Rural Development
- US Army Corp of Engineers
- USGS – SD Water Science Center
- USDOJ
 - National Park Service
 - Fish and Wildlife Service
 - Bureau of Indian Affairs
 - Bureau of Reclamation
- FEMA

Local Government

- County Emergency Managers
- South Dakota Municipal League
- SD Association of Counties and Townships
- SD Emergency Management Association

Wildland Fire

- SD Firefighters Association

Agricultural Organizations

- SD Farm Bureau
- SD Stockgrowers
- SD Cattlemen’s Association
- SD Conservation Commission
- SD Dairy Producers
- SD Sheepgrowers
- SD Corn
- SD Soybean
- SD Wheat Commission
- SD Pork Producers
- SD State University – Extension

Other Organizations

- Midwest Assistance Program (MAP)
- Planning and Development Districts
- Rural Community Assistance Corporation (RCAC)
- South Dakota Association of Rural Water Systems
- SD Association of Cooperatives
- Water Development Districts (7)
- Western States Governor's Association
- Universities

Public Involvement and Outreach Opportunities

A combination of outreach methods will be used during the plan's revision. This is based on input received through a Stakeholders and Public Involvement Recommendations worksheet circulated among the Drought Task Force. This may include:

- Developing a fact sheet flyer that can be posted online and distributed at various meetings/forums
- Developing an online survey to target input from various stakeholder groups and the public
- Hosting a meeting or series of workshops to discuss the plan with stakeholders and the public
- Allowing a stakeholder and public review and comment period

Possible Meetings/Forums

The following is a list of possible meetings or forums that could be used to raise awareness about the Drought Plan, either at speaking opportunities or distribution of the fact sheet.

Possible meetings/forums/outreach opportunities	Specifics/Timeframe	Agency
Commodity group meetings	<ul style="list-style-type: none"> Cattlemen's Association Convention – Dec 3-4, 2014 Aberdeen Dec 8-10, 2015 Pierre SD Soybean Association Ag Outlook Conference, Dec 11, 2014 Sioux Falls, Dec 10, 2015 Sioux Falls, Corn Annual Meeting, Sioux Falls Jan 17, 2015 	Dept of Ag
Agricultural interest group meetings	<ul style="list-style-type: none"> Ag Horizons –December 1-2, 2015 	Dept of Ag
County Emergency Managers	<ul style="list-style-type: none"> Quarterly regional meetings with county emergency managers SD Emergency Management Association 	SD OEM
OEM and DPS Facebook and Twitter accounts	<ul style="list-style-type: none"> Periodic updates 	SD DPS/OEM
Firefighters	<ul style="list-style-type: none"> Annual SD Fire Chiefs Association Dec 4-6, 2015 	SD DPS
Water conferences	<ul style="list-style-type: none"> 2015 Western South Dakota Hydrology Meeting Spring; April 15, Rapid City Eastern South Dakota Water Conference SDSU – Oct 29, 2014; Oct 28, 2015 Brookings USACE meetings – 4/30/2015 	DENR
Other –	<ul style="list-style-type: none"> South Dakota Weather Broadcasters meeting Universities – extension and research communities; early in semester 	State Climate Office
Regional workshops	<ul style="list-style-type: none"> Develop workshops in specific regions about the Drought Plan 	SD OEM State Climate Office

Implementation

The following table of implementation steps identified specific outreach activities that occurred with the development of the plan.

Drought Mitigation and Response Plan Stakeholder and Public Participation Plan Implementation – 2014-2015

Timeframe	Stakeholder and Public Participation Activities	Highlights/Outcome
June 2015	Developed backgrounder on plan for distribution	
Jul-Aug 2015	Deployed Public Input Survey	1,450 Responses Summary in Appendix D
Sept-Oct	Posted draft plan for public review	25 responses

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APPENDIX C - References

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APPENDIX D – Public Input Survey Results

Public Input Survey Results (Draft 9-2-2015)

As part of the planning and public engagement process of the South Dakota Drought Mitigation Plan, a 12 question web-based and hardcopy survey was created. The purpose of the survey was to collect information from the public and stakeholders to better understand drought vulnerabilities within the state as well as solicit input on needs to best mitigate, or reduce, the impacts of drought. The online survey opened on 7/6/2015 and closed on 8/31/2015. The link to the survey was distributed via email to members of the Drought Task Force, who were encouraged to broadcast the link far and wide through their constituent networks. The constituent networks were identified in the Stakeholder and Public Participation Plan (Appendix B). A total of 1,450 responses were collected, with at least one response from each county.

The following charts and graphs summarize the data collected from this effort.

Question 1: Please specify the county in which you are located

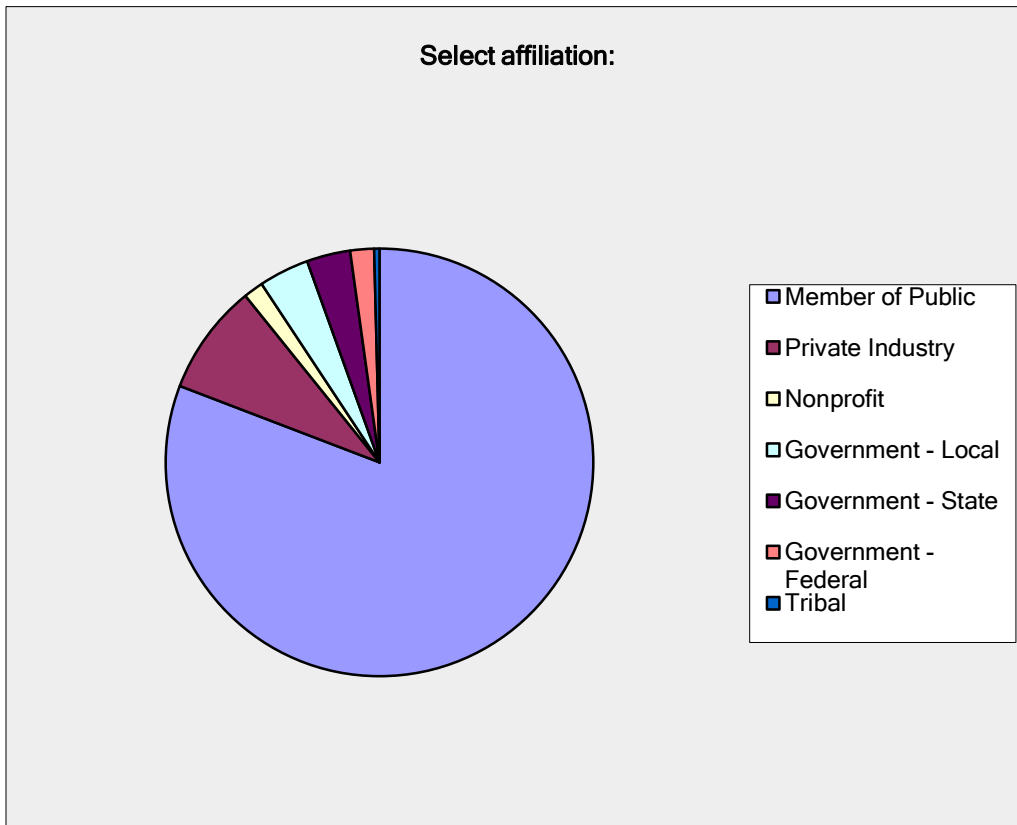
Answer Options	Response Percent	Response Count
Pennington County	11.9%	169
Minnehaha County	10.2%	144
Hughes County	5.6%	80
Brookings County	4.7%	67
Brown County	4.7%	67
Lawrence County	3.5%	50
Codington County	3.1%	44
Lincoln County	3.1%	44
Meade County	2.6%	37
Union County	2.5%	35
Yankton County	2.2%	31
Beadle County	2.0%	28
Custer County	2.0%	28
Davison County	1.9%	27
Kingsbury County	1.6%	22
Lake County	1.6%	22
Roberts County	1.6%	22
Spink County	1.5%	21
Charles Mix County	1.3%	19
Day County	1.3%	19
Grant County	1.3%	19
Turner County	1.3%	19
Aurora County	1.3%	18
Walworth County	1.3%	18
Fall River County	1.2%	17
Brule County	1.1%	16
Clay County	1.1%	16
Gregory County	1.1%	16
Hutchinson County	1.1%	16
Hamlin County	1.1%	15

Question 1 (Continued): Please specify the county in which you are located

Hand County	1.1%	15
McCook County	1.1%	15
Stanley County	1.1%	15
Clark County	1.0%	14
Marshall County	0.9%	13
Perkins County	0.9%	13
Potter County	0.9%	13
Tripp County	0.9%	13
Edmunds County	0.8%	11
Sanborn County	0.8%	11
Deuel County	0.7%	10
McPherson County	0.7%	10
Moody County	0.7%	10
Butte County	0.6%	9
Miner County	0.6%	9
Faulk County	0.6%	8
Bon Homme County	0.5%	7
Campbell County	0.5%	7
Douglas County	0.5%	7
Lyman County	0.5%	7
Corson County	0.4%	6
Sully County	0.4%	6
Hanson County	0.4%	5
Harding County	0.4%	5
Hyde County	0.4%	5
Buffalo County	0.2%	3
Dewey County	0.2%	3
Haakon County	0.2%	3
Jackson County	0.2%	3
Mellette County	0.2%	3
Todd County	0.2%	3
Bennett County	0.1%	2
Jerauld County	0.1%	2
Jones County	0.1%	2
Oglala Lakota (formerly Shannon) County	0.1%	1
Ziebach County	0.1%	1
<i>Answered Question</i>		<i>1416</i>
<i>Skipped Question</i>		<i>29</i>

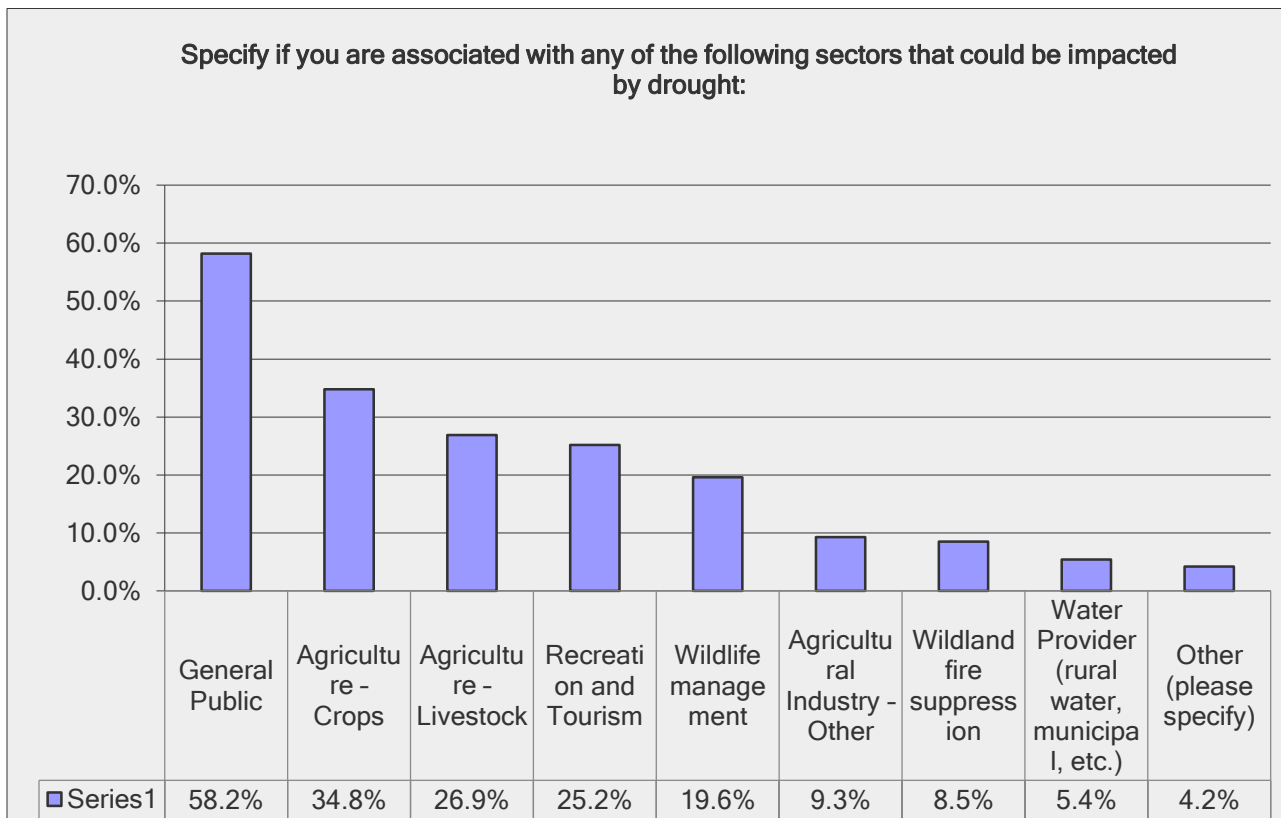
Question 2: Select affiliation

Answer Options	Response Percent	Response Count
Member of Public	80.9%	1153
Private Industry	8.4%	119
Nonprofit	1.5%	21
Government - Local	3.8%	54
Government - State	3.3%	47
Government - Federal	1.8%	26
Tribal	0.4%	5
<i>answered question</i>		1425
<i>skipped question</i>		20



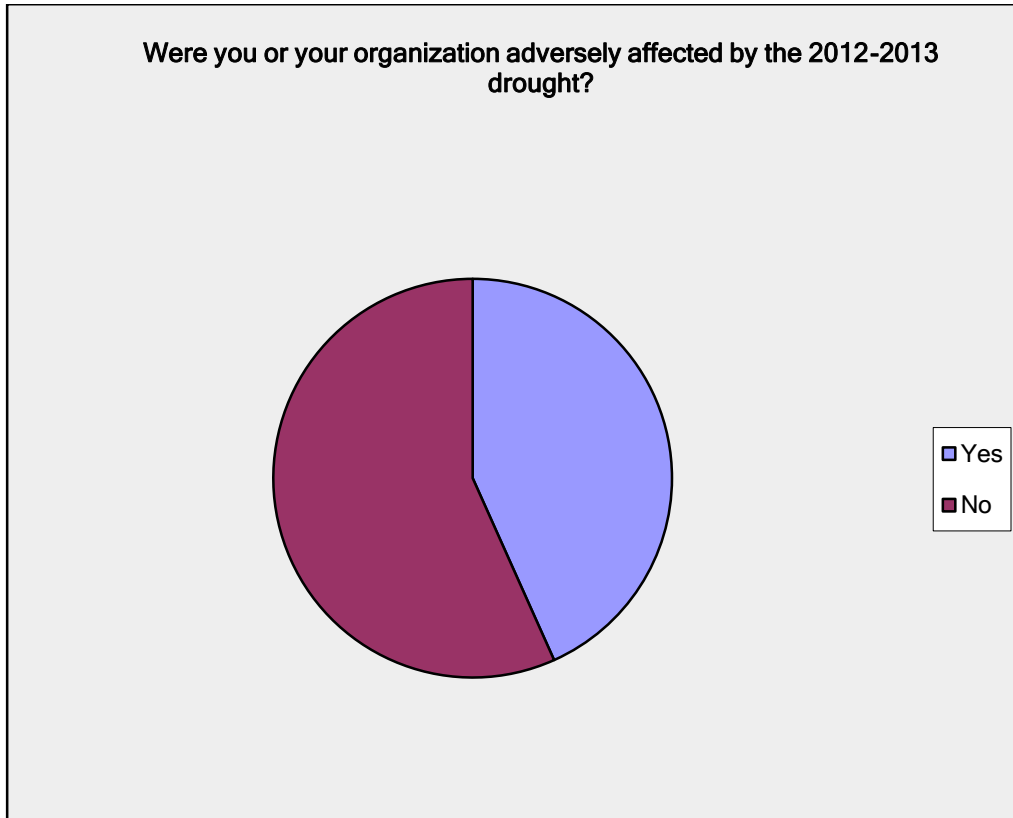
Question 3: Specify if you are associated with any of the following sectors that could be impacted by drought

Answer Options	Response Percent	Response Count
General Public	58.2%	792
Agriculture - Crops	34.8%	473
Agriculture - Livestock	26.9%	366
Recreation and Tourism	25.2%	343
Wildlife management	19.6%	267
Agricultural Industry - Other	9.3%	127
Wildland fire suppression	8.5%	116
Water Provider (rural water, municipal, etc.)	5.4%	74
Other (please specify)	4.2%	57
	<i>answered question</i>	1360
	<i>skipped question</i>	85



Question 4: Were you or your organization adversely affected by the 2012-2013 drought?

Answer Options	Response Percent	Response Count
Yes	43.3%	589
No	56.7%	771
<i>answered question</i>		1360
<i>skipped question</i>		85



Question 5: During the 2012-2013 drought which impacts did you most frequently experience? Please rank them according to level of impact.

Listed highest average ranking to lowest average ranking

Answer Options	Low (1)	Medium (2)	High (3)	N/A (0)	Rating Average	Response Count
Poor hunting or fishing quality	235	393	340	119	2.11	1087
Decreased surface water availability or a drop in surface water levels	188	251	246	317	2.08	1002
Crop loss	170	182	137	526	1.93	1015
Fewer/poorer quality recreational opportunities (e.g., boating, snowmobiling, etc.)	272	321	209	219	1.92	1021
Reduction in agri-business revenue	173	174	113	512	1.87	972
Increased number of wildfires	217	163	122	468	1.81	970
Lack of water for livestock	187	121	100	565	1.79	973
Decreased groundwater availability or a drop in groundwater levels	257	202	103	404	1.73	966
Loss of income	257	204	95	456	1.71	1012
More severe wildfires	230	108	104	504	1.71	946
Decreased water quality	255	149	106	449	1.71	959
Reduction in recreation or tourism-based revenue	226	110	56	555	1.57	947
Depression, anxiety, or other behavioral health issue (survey results are anonymous)	260	123	60	522	1.55	965
Lack of water for domestic, municipal and industrial uses	271	110	40	542	1.45	963
Other						34

Question 5 (Continued): During the 2012-2013 drought which impacts did you most frequently experience? Please rank them according to level of impact

Other responses

Date	'Other' responses
Aug 27, 2015 10:24 AM	o
Aug 25, 2015 1:37 PM	Fewer pheasants
Aug 24, 2015 10:26 PM	We did not have a drought in our area
Aug 24, 2015 1:37 PM	alergies from dust
Aug 24, 2015 11:24 AM	killed trees in our game management areas
Aug 23, 2015 1:57 PM	lack of pasture and grass for cattle lack of feed and necessary cost for herd maintaince
Aug 23, 2015 12:15 AM	I didn't live in SD during this period.
Aug 22, 2015 10:27 PM	Water from tile drained to adjacent landowner, reduced habitat
Aug 22, 2015 8:25 PM	No runoff, no stockdams, needed to use rural water, our dams are still dry 2015. 2012-13 the deer were using the automatic wateres and drinking our of the dog dish. We also had more coons and possum around the house than before
Aug 22, 2015 10:06 AM	planted crp grass it did not come up to dry
Aug 22, 2015 3:35 AM	during the "2012-2013" so called "drought" I most frequently experienced the state & government stealing my money witch had horable impact's on me.. you idiots belong in a nut house!
Aug 22, 2015 2:47 AM	Farm crops and wildlife was the primary impact
Aug 21, 2015 9:37 PM	Loss of wildlife habitat and forage
Aug 21, 2015 7:49 PM	Severe road dust
Aug 21, 2015 5:54 PM	The plan needs to include the shut down of unnesecary high water usage operation such as Fracking, Insitu Leech, Precious metal mining and Ethanol plants during extended droughts of over a year to replentish our aquifers.
Aug 21, 2015 4:19 PM	We got very busy as an information source and conveyor of information & resources. We were more affected indirectly by these types of things.
Aug 21, 2015 2:01 PM	Had to reduce cattle herd about 25%
Aug 21, 2015 5:22 AM	Hunting food plots Failed completely
Aug 21, 2015 4:31 AM	Diminished wildlife numbers
Aug 21, 2015 3:08 AM	loss of several trees
Aug 21, 2015 2:13 AM	drought bolstered advance of pine bark beetles by weakening trees. lost many trees on my property
Aug 20, 2015 7:32 PM	Drought resistant weeds became a real problem!
Aug 20, 2015 5:44 PM	I was not living in the state for the drought period.
Aug 20, 2015 4:45 PM	Not significantly impacted, but I had to water my yard more often because of the drought.
Aug 20, 2015 4:10 PM	Loss of waterfowl habitat. Many of the sloughs and smaller water areas the ducks use dried up and still have not filled up.
Aug 20, 2015 3:54 PM	concern for my own water and concern for the farmers and ranchers
Aug 20, 2015 3:17 PM	I feed horses and the quacity and quantity of hay was poor, price was high.
Aug 20, 2015 3:14 PM	Less water results in lower crop yields there for higher prices at the grocery stores.

Question 5 (Continued): During the 2012-2013 drought which impacts did you most frequently experience? Please rank them according to level of impact

Date	'Other' responses
Aug 20, 2015 3:10 PM	Increase in cost of water for domestic use. High.
Aug 20, 2015 3:04 PM	Another dust bowl would ruin us all...university closed, apartments vacated
Aug 20, 2015 2:43 PM	risk of fire while working in road ditch right of way or working in private easement
Aug 20, 2015 2:32 PM	Did not know about the drought in here in the Black Hills
Aug 20, 2015 2:14 PM	Overgrazed pasture problems & subsequent loss of habitat for wildlife (pheasants, etc).
Aug 20, 2015 1:58 PM	I was not a resident of South Dakota until 2014

Question 6: How would you characterize the drought vulnerability of your organization and/or county in 2012-2013 compared to previous droughts? Select the option that most accurately reflects your current situation.

Answer Options	Response Percent	Response Count
Unsure	35.9%	404
Our organization's/county's susceptibility to drought impacts was about the same in 2012-2013 as in previous droughts.	23.7%	267
N/A	18.3%	206
Our organization/county was less susceptible to drought impacts in 2012-2013 than in previous droughts because the supply/storage situation was less severe.	8.9%	100
Our organization/county was more susceptible to drought impacts in 2012-2013 than in previous droughts because the supply/storage situation was more severe.	6.7%	76
The supply/storage situation in 2012-2013 and in previous droughts was very similar. However, our organization/county is less susceptible to drought impacts than in earlier droughts because we have applied the lessons learned from other droughts and are better prepared for mitigating drought.	6.5%	73
<i>Answered question</i>	1126	
<i>Skipped question</i>	319	

Question 7: Please list up to three projects implemented by you, your organization, county, or other state or federal agency over the past five years that you consider the most worthwhile for reducing drought impacts.

Project 1	Project 2	Project 3
storing rain water	improveing irrigation availity	increaseing water storage
CRP creation	prescribed burns	Juniper removal
rotational grazing	rural water-wells in pastures	
Lewis and Clark rural water hook up	New water tower	
Increased free-board (depths) of surface water storage available on critical sites for dust suppression	Overall reduction of mine haul road lengths that require frequent dust suppression	
irrigation expansion	irrigation efficiency modifications	rural water availability
habitate needs to be more protected		
Purchased new water tender for fire suppression	Added pivot irrigation systems	
pipd a deep well [365 ft] to our house and stock tanks in case our shallow [30 ft] but better well dried up.		
Grazing systems	Crp	Dams
no till farming	crp	crep
restore wetlands	remove all drainage tiles	three crop rotation
more water efficient corn hybrids	advances in forage sorghum crosses	
collect water moisture from barn/house roofs		
keep dams near full		
Better management practices in regard to burning		
remove trees around springs		
Water lines	Improvement in reservior	controlled grazing
None		
tree planting	weed controle	grass seeding
no till		
signed up for the CREP Program		
limited till farming practices	# acres in CRP	disaster relief programs
controlled releases from main stream dams in drought		
n/a		
Retention and maintentace of native grassland areas owned	Establishing a National Wildlife Protect area	
CRP		
Installing rural water tanks to pastures instead of relying solely on dugouts and stockdams		

Question 7 (Continued): Please list up to three projects implemented by you, your organization, county, or other state or federal agency over the past five years that you consider the most worthwhile for reducing drought impacts.

Project 1	Project 2	Project 3
Low flow toilets, help in replacement costs	watering restrictions on lawns	
less tillage of farm land	dugouts had been cleaned out	
livestock pipelines	wildlife water facilities	
added larger water tanks at feedlot	dug more stock dams	
hails canyon 3 detention ponds for holding water	built bigger wetlands on last leg of the hartland expresway	hwy 18 smithwick turnoff to Oelrichs expanded wetlands
Rural water	More CRP	Better weed control on state and federal lands
Installed irrigation	grid sampling of soils	adding nutrients for improved production thru drought or excess moisture
Reduced the herd.	Put more water lines in.	
Having access to rural water to farms and pastures.	Haying CRP acres	
Use less wter		
water projects		
increase water shed	dugout projects	small storage dams
Changed grazing practices	Tried to reduce dependency on rural water	Rural water system trying to upgrade their system
xeriscaping	water conservation with lawn watering in Rapid City	education
no till farming	livestock watering lines to pastures	dugout/dams
improved spring	waterline developed from other well	
N/A	N/A	N/A
Harvesting Less Game	na	na
rotational grazing	put in more dams to hold water	expanded our operations over a larger area
Put in irrigation pivot	artesian well in pasture	
water lines	grazing management	
you can't make it rain or change the weather		
The city obtains municipal water from the Missouri River		
Not eliminating wet areas- no tiling		
watering restrictions		
No lawn watering	Water recycling (dehumidification)	
Rotaional grazing with shared water sources	added more private pipeline for livestock water	installed energy free waterers, that also cut water waste.

Question 7 (Continued): Please list up to three projects implemented by you, your organization, county, or other state or federal agency over the past five years that you consider the most worthwhile for reducing drought impacts.

Project 1	Project 2	Project 3
No lawn watering	drought resistant gardening	
grazing rotation	rural water installation	
manage herd size		
flood control ditch was raised		
use restrictions	more efficient equipment	less waste
Wetland Reserve Program		
pasture pipeline cost-share		
Water retention in reservoirs, wetlands, and canals	Water/soil conservation in farming practices	Utilizing subsurface irrigation to maintain healthy crops and maximize water efficiency
water releases from lake Oaha		
no till farming methods		
built damn	no til	cover crops
No-till or minimum tillage	Rotational grazing	Constructing dams and waterways
provide water for stock dams		
Home water use restrictionscampaign	Reduced outflows from area reservoirs	Fire safety campains
Purchased grass fire suppression equipment	Lowering Grazing density/stocking rate on pasture	Stockpiling feed/hay
ripping out drain tile.	ripping out drain tile	ripping out drain tile
No-till	Less grazing pressure	Better water quality abilities
Establishing water tanks for the wildlife	Notill farming	Digging out a stock dam to hold more water
Irrigation practices	Seed varieties	Farming practices
watering with soaker hoses	using extra compost to hold moisture	planting plants that require less water
forest thinning		
Drought plan		
Drip lines for irritation		
helping with water supply for wildlife and livestock		
rotational grazing	water pipelines	grants for wells and materials to go with it
Larger storage ponds on property		
Any program to restore/preserve native wetlands		

Question 7 (Continued): Please list up to three projects implemented by you, your organization, county, or other state or federal agency over the past five years that you consider the most worthwhile for reducing drought impacts.

Project 1	Project 2	Project 3
Talking to public land agencies and their drought management plans, or mostly lack thereof		
Wetlands		
change in watering habits		
none	none	none
sandlake	richmond	mina
fixing stock dams	reduced tillage	built up hay reserve
Eliminate drain tiles	Enforce wetlands protection	increase availability of boat launches
planting drought resistant crops	water storage	
low flow shower/faucet devices		
installation of crop land irrigation systems	specialty crop irrigation available	adequate livestock water source(s)
Pipe lines for livestock	Sold livestock	
Dought resistant plants	Low/No water landscaping	Re-capture and reused roof run off
Conservation Farm Strips	Water Developement	
Pine beetle mitigation	Complete removal of all pine infested trees	
change of lawn cover	change in grass cropping	more efficient sprinklers
putting rural water in our pastures	implementing soil health practices	
reduced avail. of hunting licenses for big game.	N/A	N/A
Reducing water use earlier, before mandatory reductions.	Using weather and climate long-range forecasts and trends to anticipate drought (drought early warning system).	Developing Missouri River basin NIDIS pilot for a regional drought early warning system.
Na	Na	Na
GFP should purchase and develop more wetland	USFWS should buy more habitat	More CRP
Limiting water usage ie. watering yards,etc		
Less lawn watering	More sparing use of water around the house	
water restrictionist		
Observation Well Network	Increased Irrigation Efficiency	Suspendable Groundwater Permits
Water rationing for domestic uses - watering lawns!	Well drilling	
State Drought task force		
No till	Conservation tillage	

Question 7 (Continued): Please list up to three projects implemented by you, your organization, county, or other state or federal agency over the past five years that you consider the most worthwhile for reducing drought impacts.

Project 1	Project 2	Project 3
detention, settling ponds		
NOT changing water rights/permitting for ag irr		
Limit The tile draining		
no till		
None	None	None
improved water storage capacity	looping project	user conservation
better agronomic practices	better crop insurance	
irragation		
water truck	tracktor and disc in field while harvesting	
better equipped to fight wildfire		
100% no till planting	Installation of watering facilities on all pastures	Rotational grazing on pastures
cleanout of pasture dugout	repaire of dams	
select good seed	tillage management	
being able to hay CRP or set aside acres	allowing grazing of CRP or set aside acres	subsidizing the livestock producers for pasture loss
buying up water rights for Pactola Lake	water restristions	
More hay storage	Better pumps on wells	
no till practice	rotational grazing	put in additional water sources
Stream buffer strips with easements on big Sioux to keep cattle out of streams	Water tank program piped to keep cattle from watering and excreting in rivers	Increased predator control needed for pheasant populations to grow in brigs/kings bury county, a lot of pothole cover but no pheasants.
supplement surface water supply with ground water	secure adequate hay supply early on	bolster hay supply with other forages and grains
no-till	Up graded fire equipment	
let my turf die	let my landscape die	
No till farm practices	CRP conservation	
replace grass with rock	hydroponic garden vs ground	
repaired stock dam		
Federal assistance financially		
none	none	none
Notill		
built a dam	in processs of cleaning down trees and grass out of creek for better flow	
web water for farms	web water for cattle,crop spraying	allowed to buy hay from crp,or graze crp

Question 7 (Continued): Please list up to three projects implemented by you, your organization, county, or other state or federal agency over the past five years that you consider the most worthwhile for reducing drought impacts.

Project 1	Project 2	Project 3
Cleaning out dugouts, deepening ponds, adding ponds	Adding rural water, more lines and watering tanks	Raising pheasant chicks, reducing hunters and bird take
FARMING PRACTICES	DUG WATER HOLE FOR WILDLIFE	
No field tilling	Keeping CPR areas in tact, no mowing and no removal from program	Try to capture snow to fill wetlands.
clean dam out		
Pipelines to pastures	No till	Surplus feed
manage water storage better	help trees resist disease(beetles) bolstered by drought	
water in my plants	mow in my yard	takin a bath
Rain Barrel	Water Conservation methods	low cultivation of gardens
Conservation		
na	na	na
Carry over more hay	Culllll cows more severely	
no til farming practices	careful hybrid selection	tile drainage / water management systems
bought water hauling truck	kept all our hay, never sold any	
Increased depth in fire management team roster	No till plantings	
Putting water lines through pastures instead of relying on stock dams.	cross fencing pastures to utilize the water lines	I am a no-til farmer
As a firefighter we are better trained and equipped.	Rural water is a blessing in our fire protection area.	
Piped water	Rotate graze	Sell some livestock
work against the global warmest alarmest	vote republican	pray since nature is unchangable
My daughters live near Johnson Siding. I help and encourage them to keep several birdbaths filled with clean water. Not only do the smaller birds have a dependable source of drinking water, but also the turkeys and deer.		
water tiling laws		
N/A		
We rolled all the natural waterways/creeks in the fields flat and got rid of them.	Our second project was to drill some more wells in those fields that we got rid of natural creeks in and started to irrigate.	Wait none of these projects had a positive effect, in fact these things were illegal and had a very negative effect on local wildlife.

Question 7 (Continued): Please list up to three projects implemented by you, your organization, county, or other state or federal agency over the past five years that you consider the most worthwhile for reducing drought impacts.

Project 1	Project 2	Project 3
Absolutely none!!!!!!!!!!		
lewis and clark	lewis and clark	lewis and clark
Beetle redction		
Cleaned Dugouts	piped in rural water to multiple locations	bigger stock tanks
no till		
no till farming practices		
CRP acres increase	wetland	wildlife land
Decrease water use	Conserve at home	Restrict yard watering
none		
none		
Previous year hay on hand.	Previous years grassland forage utilization levels	Proper stocking rates I.e. Livestock number to land base acreage
preservation of upland potholes and sloughs	valley water retention	
None		
Controlled release of Pactola dam	Water storage	Implementation of wild plants and low maintenance lawn care
better weed and pest control	upgraded stockdams and wells	
don't know		
PLANTING OF DROUGHT RESISTANCE CROPS	NO TILL FARMING	
I implemented landscaping methods that required little or no water	Implemented water water restrictions during the drought within city limits.	County restricted outdoor burning for extended periods until moisture levels returned to normal.
Already do minimum till on my farm if it doesn't rain there is nothing more to do but have good insurance and wait for rain to return I have had way above rainfall since 2012 and am in good shape till the next dry spell comes a plan can't prevent the next drought		
stockdams dug on our property and cleaned out		
Wetland development		

Question 7 (Continued): Please list up to three projects implemented by you, your organization, county, or other state or federal agency over the past five years that you consider the most worthwhile for reducing drought impacts.

Project 1	Project 2	Project 3
Less lawn watering	Collected available rain water for plants	NA
drip irrigation		
stockpile feed		
USA livestock indemnity programs	Haying crep grounds	Drilling wells
the coe not draining the river	fighting the coe and their dumbass management	the south having water so the coe would not drain the water
na		
Pasture divisions allowing more flexibility in cattle management	Water developments	Improving cattle management by establishing rotation systems to improve the resilience of the rangeland resource
low stocking rates of livestock	pipelines and range wells	trying to carry over hay stocks in normal and above normal years
Farm bill	Pasture rotations	Hay storage
Pasture Water Pipeline Project	Cross Fencing	
increased private water basin leases	purchase of water basins	
none		
new pivits	more pivits	stock dam
Installing more water hydrants	Rebuilding/repairing dam structures	
Cut expenses	No new projects	
wildland fire prevention		
Added stock pond	More no till	
Stock dam dredging		
Crp acts as a snow fence	thinning dead trees	gravel fire breams
Ground cover management enhancements	Tree belt additions	
EQIP	haying CRP	
not aware of any projects		
planting sweet corn for selling	Food plots for hunting deer, and pheasants	wet lands are so severely reduced that waterfowl hunting is at an all time low in our area.
Big Sioux River WQ Project		
Open the haying of CRP acres		
no till farming	Missouri River management of Corps	conservation measures made by self
No tilling land	Built a stock dam for wildlife	
clean dams out		

Question 7 (Continued): Please list up to three projects implemented by you, your organization, county, or other state or federal agency over the past five years that you consider the most worthwhile for reducing drought impacts.

Project 1	Project 2	Project 3
providing gov't assistance to dig wells- allows cattle to utilize entire pasture	selling cattle to reduce chances of over-grazing	gov't assistance drought relief program allowed us to recoup losses incurred by extremely high hay prices
Stop overgrazing public lands	Limit cultivation of marginal land	Planting more food plots
we provided water guzzlers for nesting Pheasants and other wildlife on our property		
Reduced tillage	Subsurface drainage projects only(reduce runoff)	
reducing forest cover in Black Hills area	reducing total fuel loads in Black Hills area	
water conservation		
Stop the conversion of grasslands to row crops.	Enrolled wetlands into the WRP.	
Installing pipeline and tanks	Implemented prescribed grazing	Implemented a drought management plan
Improved Gusslers		
Water restrictions	Better water reclamation	informing the public about water saving ideas. to include appliances, to landscaping, rain barrels, ect..
Land owners from Iowa tiling land	More CRP land put aside	
construction of small dams (similar to effect of beaver dam) in creeks to enable drafting of water for fire suppression		
rural water system	local fire response equipment	
Water restrictions when necessary.		
DOT has stepped up on Wetland mitigation		
Canyon lake bypass	Valve on sheridan lake outlet	Stream reconstrucion below pactola
restricted water use to domestic purposes - no car washing or lawn watering.		
better prepared finacialy	better drought tolerant hybrids	increased fire water supply tanks
Tank for livestock in pasture.		
Installed rainwater tanks	dug stock ponds deeper	
no till farming	planting of tree stands	
Reduce personal consumption/water usage.	Reduce business consumption/water usage.	Limit increased number of water users to sustainable numbers.

Question 7 (Continued): Please list up to three projects implemented by you, your organization, county, or other state or federal agency over the past five years that you consider the most worthwhile for reducing drought impacts.

Project 1	Project 2	Project 3
protect our wetland base with wetlands protection laws - no net loss of wetlands	maintain adequate cover for wildlife during drought times - not all grass needs to be hayed or mowed.	increase grasslands to compensate for recent losses to grow corn for ethanol
farm programs	cash reserves	
Putting in rural water taps in pastures	Increased rural water availability in area with larger supply lines	
Adjusting manpower to needs	reduce equipment purchases or replacement	suspend building projects
Cleaned out dugout		
Water conservation and wise use	Well management	Operational changes
low water use corn hybrids		
erosion control	taking away habitat	drainage and tiling
water fisheries	deer loses	reduced water fowl hunting
No till where it is possible	Crop residue left where possible	Trre plantings
Private Well drilling	Stock dam repairs	
Added tree lines. Shelter belt		
Prayed for rain	let grass grow longer	chopped more weeds to give grass more moisture
water storage by dams		
Municipal water supplies from the Missouri River	Reducing phosphorous fed algie on lakes	Soil conservation practices especially on tilled ground
piped livestock water	rotational grazing	
HAYING CRP		
ground storage ponds		
no disc farming		
In town watering conservation, watering alternate days.		
Thining trees		
low till land		
Rural water		
James river water district		
No till planting	Cover crop planting	Minimum tillage planting
Improved ground water storage, ie - dams		
We doug our fish ponds deeper	we made more fish ponds	
Built cross fencing to control grazing by cattle	Reduced number of cow/ calf pair counts	Controled grazing, to permit grass to re-seed naturally
Crop insurance	Ethanol	
moved to water saving appliances and toilet fixtures	set up rain barrels to catch water for use in garden	
Some No-Till planting	Dam's constructed in waterways	CSP on farm ground to enhance wildlife production

Question 7 (Continued): Please list up to three projects implemented by you, your organization, county, or other state or federal agency over the past five years that you consider the most worthwhile for reducing drought impacts.

Project 1	Project 2	Project 3
decreased watering my yard		
Eliminate Farmers Drain Tile	Increase CRP	Increase Wetlands
Drilled new well with more storage capability.	Make dam larger for more storage	Pray!
better crop insurance		
Covered hay storage		
Proper grass management	Creation of multipl water sources	
Lewis & Clark water project	increased storage	
Open crp production acres	Livestock pasture payment	Nrcs water line
Maintain water levels in pactola		
Prescribed fires in the Black Hills to increase water yield and ground water recharge	Reduction in cattle grazing to improve water quality and plant health and vigor	New county regulations governing septic systems.
not sure		
monitoring of center pivots / tiling	removal of small ponds/areas for ag use	creation of dams and/or water holding areas
planting of tree belts	irrigation system improvements	crop selection
drought resistant seed	water development programs	
Water development	reduce livestock earlier in drought	
Crp		
tillage practices		
Reduce nonessential watering.		
water userestriction		
Water conservation.	Reduction of areas watered.	
CRP	CREP	Walk-In Areas
planting grass instead of crops		
rainwater collection systems	Create more lakes...dam every stream and river many times	Dam up the James river make a huge lake: wildlife, agriculture, recreation all win
Trees	Fishing pond	
no till	rotational grazing	
Plankinton FD purchase of new brush/grass fire truck		
Notill	more efficient use of our water	
Odd even lawn watering schedule	Lewis and Clark water project	
farming practices	better seed stocks	
Installation of rain barrels	planting drought tolerant plants	
Creation of many small impoundments such as those funded by the James River Water Development District	Creation of an irrigation system in Charles Mix county	
wetland protection	riparian zone protection	grazing management
water use conservation	increased conservation acres/reduction of crop acres	natural grass preservation

Question 7 (Continued): Please list up to three projects implemented by you, your organization, county, or other state or federal agency over the past five years that you consider the most worthwhile for reducing drought impacts.

Project 1	Project 2	Project 3
More piped water to tanks	More acres of grass to extend grazing	
water quality	recreation opportunities	quality of the environment
Rural Water pipelines		
No till farming	CRP	
wells	pipelines	
Additional Idle land for habitat		
small dams created	setting up rotational/managed grazing systems	restoring wetlands
Written drought plan for livestock grazing	management-intensive grazing	Feed stockpile
do work in areas, where dry vegetation is not as tall	keep all trucks, crews, & equipment equipped with fire protection	keep exhaust and exhaust systems in working order and maintained
Reduced the release of water in SD dams to downstream transportation / barge traffic.		
Lewis & Clark Pipeline	use of satellite imagery & science research	
cleaned drainage ditch to allow cleaner water to dugout for cattle		
Assist ranchers with grazing management	Restoration and creation of wetlands	Use of cover crops
Encouraged less removal of shelterbelts		
Firewise communities	decreased grazing on state owned lands	
plant more conservation reserve program grass	plant more trees	farm less
Pasture taps installed by rural water	Stock Dam repair and improvement	
na	na	na
Water quality projects	Increased funding for prescribed fire	Mountain Pine beetle projects with USFS
Collection of rain water when available		
Education	Irrigation	Wildfire prevention measures
Establishing crp to help with soil erosion	Leaving buffer strips to help hold snow for added moisture to trees	Only haying our alfalfa once to leave residual cover to hold snow
No-till farming practices	Requiring ranchers to properly implement cattle tank overflow systems to reduce wasting water	Planting drought tolerant crops

Question 7 (Continued): Please list up to three projects implemented by you, your organization, county, or other state or federal agency over the past five years that you consider the most worthwhile for reducing drought impacts.

Project 1	Project 2	Project 3
no till farming practices		
water restrictions	less bathing/quicker showers	preserving water that did fall
Soil Conservation	Proper Grazing Techniques	Controlled Burns
wetlands	crop irrigation	
Federal Duck Stamp Price Increase	Ducks Unlimited Revolving Habitat Program	
Additional water sources	Less water use	
planting of 30,000 trees	more CRP acres	
No yard watering		
Increase conservation measures (incentivize efficient appliances, etc)	Avoidance of over exploitation in "normal" years to help create reserves for years of shortage.	
No-till crop production		
NA	NA	NA
Crop Insurance	Reduced tillage	
None needed	None	None
Less municipal water usage.	Wetland protection and enhancement	Stop the usage of drain tiling in our State
Just be prepared a one year drought is not something new to the state.		
extension education		
irrigation		
Increase storage capacity	changed water supply route	
New roof on barn draining into cistern well		
Minimum ground tillage	Drought tolerant seed hybrids	
None		
Vote republican	Get the liberals out of government	Abolish the EPA
Put dams in the ranch		
Stationing fire fighting planes in Mobridge		
wildlife fixed remote waterers		
Opening CRP acres up for haying/grazing.		
crop insurance		
Zip	Nada	Nuttin
Rotational grazing	Stock piling hay	Elk Drought Contingency Tags
ADDING MID DAKOTA RURAL WATER FOR LIVESTOCK	NEW/BETTER TANKS WHERE WELL WATER IS AVAILABLA	

Question 7 (Continued): Please list up to three projects implemented by you, your organization, county, or other state or federal agency over the past five years that you consider the most worthwhile for reducing drought impacts.

Project 1	Project 2	Project 3
Water restrictions	Pheasant Habitat Conservation	Walleye netting and GFP gathering of eggs
we can implement water rashing	check the water usage and outflow to farmlands	also find out if we need new machinery that operates water flow
planting lower water needing plants	mow lawn 3"+ high so more draught tolerant	
reduced marketing	freeze hiring	reduce growth projects
None in Marshall County		
Less Drain Tile to protect lowland wetlands	Created new dugouts/resivoir to hold water	Planted more drought friendly crops for wildlife/food plots
Pipelines in pasture		
planting windbreaks	promote no till planting	
Drain tile	Better water conservation	Wetland protection
Interagency Cooperative Agreements		
Increased Severity Staffing	Increased Use of Fire Restrictions	Increased emphasis on Interagency Coordination
Drought Task Force interaction between agencies	News releases on effects of drought	Drought Mitigation Plan
Additional tender		
Water Conservation	Open Burning Restrictions	
Tribal Wildfire Mitigation Plans		
List of Farmers/ Ranchers who have water loaded on	List of farmers who have tractors and disks and are	
Water lines	Building dams	
Added a newer fire truck to the department.		
FSA coordination for water projects and pipeline burial	burn bans adaptability	
na	na	na
Rural Water	fire department better trained	fire department has better wildland fire apparatus
Fire Weather Knowledge and distribution	Added fire suppression equipment	Increased awareness
pumping river water into McCook lake		
Tripp County Water District upgrade water lines	set water restrictions	burn bans
Statewide drainge management plan by watersheds.	Slowdown countywide drainage tiling.	Have a landgrant univeristy study a drought's effect on our county.
personal pipeline for water in pastures	ample hay supply	herd reduction/more efficient
public/government communication	equipment updates/training	public education

Question 8: What projects would help you, your organization, or your county reduce impacts from future droughts? Place a check next to the types of mitigation action(s) that would be most desired.

Answer Options2	Response Percent	Response Count
Public education and outreach	42.5%	374
Improved drought monitoring/early warning	34.7%	306
Diversification of water supplies	34.4%	303
Workshops/information on water efficiency/conservation practices	30.6%	270
Wildfire mitigation	27.0%	238
Workshops/information on agricultural best practices	26.3%	232
Improving awareness of/participation in federal aid programs	25.2%	222
Developing local or organizational -level drought mitigation plans	25.1%	221
Economic diversification	16.7%	147
Increased crop insurance	11.9%	105
Other (please specify)	10.6%	93
Increased behavioral/mental health resources	2.6%	23
<i>answered question</i>	881	
<i>skipped question</i>	564	

Response Date	Other (please specify)
Aug 31, 2015 11:08 AM	Juniper removal
Aug 30, 2015 7:25 PM	reduce drainage and runoff (no drainage of marsh land)
Aug 29, 2015 1:35 AM	Release informational findings of this survey for an exchange of innovative ideas
Aug 27, 2015 10:38 PM	Training on low water lawns and plants
Aug 27, 2015 10:30 PM	Stop plowing up every inch of ground requiring exponential water to grow corn!
Aug 26, 2015 2:25 AM	restore wetlands, remove all tile installed in last 5 years
Aug 26, 2015 12:13 AM	have USFS do better on more water when doing road maintenace!
Aug 25, 2015 4:33 PM	Clear dead trees
Aug 24, 2015 1:54 PM	creat a network of pipe lines,underground stoage and resivores transferring water from Eastern US to western US with series of hydro plants on down hill section to energize and pay for project puting 1000s of people to work.
Aug 24, 2015 12:46 PM	More CRP for wildlife
Aug 24, 2015 12:22 AM	being proactive! !
Aug 23, 2015 10:14 PM	Just leave it alone. It is a natural cycle
Aug 23, 2015 2:06 PM	I don't believe in climate change.

Question 8 (Continued): What projects would help you, your organization, or your county reduce impacts from future droughts? Place a check next to the types of mitigation action(s) that would be most desired.

Response date:	Other (please specify)
Aug 23, 2015 2:01 PM	nothing much helps we just stockpile feed when we can and try to cut debt down as much as possible
Aug 23, 2015 1:31 PM	Reduce corn/soybean/wheat mono-systems
Aug 23, 2015 12:38 PM	Crop Tile study and limitations
Aug 23, 2015 2:44 AM	Assistance to secure hay/feed supplies from surplus areas
Aug 23, 2015 2:17 AM	you can't make it rain
Aug 22, 2015 9:20 PM	Watering grass should be very limited or even stopped.
Aug 22, 2015 8:30 PM	Irrigation and stock dam investment
Aug 22, 2015 8:26 PM	greater radio/tv coverage and discussion on how to prepare for drought and regular updates on severity
Aug 22, 2015 6:09 PM	educate the public to cut back on being "lawn loonies" that insist on watering during drought. I met people that brag about running their wells "dry" by watering!
Aug 22, 2015 3:55 PM	dam to retain water runoff
Aug 22, 2015 11:54 AM	fine businesses for watering the greener the grass the more water they are wasting
Aug 22, 2015 3:47 AM	the project that would help me most is educating people on how mother nature works. nobody really no's. that's what the dinasours told us any way..
Aug 22, 2015 2:49 AM	Limit how much drain tile is put in the fields!
Aug 21, 2015 9:39 PM	Education: effects of drought on natural resources, including wildlife
Aug 21, 2015 7:50 PM	Dust mitigation funding
Aug 21, 2015 4:55 PM	My problem is flooding since the mid 1980s. Lake Sinai has/and does need a flood mitigation plan, not a drought mitigation plan.
Aug 21, 2015 2:38 PM	Establish a statewide procedure for prescribed burns and burn bans. Prescribed fire is a tool that could effectivly improve grassland productivity and reduce the fire hazards of the fast-developing cedar encroachment problem.
Aug 21, 2015 1:17 PM	lawn watering education/restrictions
Aug 21, 2015 1:08 PM	Limit tile draining
Aug 21, 2015 12:57 PM	Stop using recreational water supplies for ag purpose. That's what crop insurance is for. They shouldn't get both.
Aug 21, 2015 11:38 AM	GFP needs to do more trapping/ predator control programs to allow pheasant population growth. Drought years should have had an increase in # in eastern counties. No one traps predators anymore.
Aug 21, 2015 5:23 AM	n/a
Aug 21, 2015 4:49 AM	Animal management= no outside state hunters for a year
Aug 21, 2015 4:33 AM	Less wetland drainage, more wildlife/habitat emphasis
Aug 21, 2015 3:44 AM	None
Aug 21, 2015 3:13 AM	Retention of water, i.e. not letting it flow downstream.
Aug 21, 2015 3:05 AM	do not let US fish @wildlife burn pasiure ,graze them

Question 8 (Continued): What projects would help you, your organization, or your county reduce impacts from future droughts? Place a check next to the types of mitigation action(s) that would be most desired.

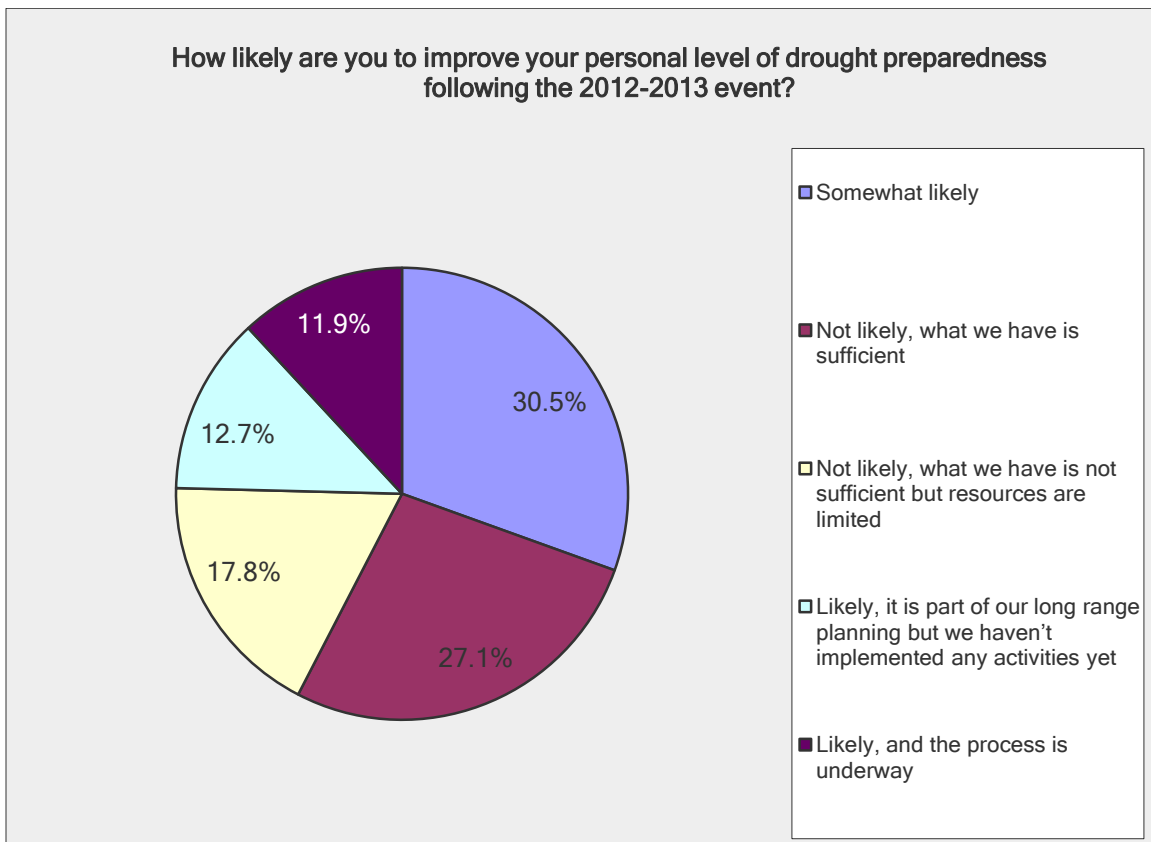
Response date:	Other (please specify)
Aug 21, 2015 2:55 AM	Control tilling of fields and drainage of wetlands. Also keep fence rows and wind breaks in tact.
Aug 21, 2015 2:07 AM	Decrease pasture and shelter belt removal.
Aug 21, 2015 12:52 AM	eliminate government and this foolish waste of taxpayer resources
Aug 21, 2015 12:10 AM	Improved farm methods. Common sense ...
Aug 21, 2015 12:07 AM	Education to the public and government that fire is a needed part of our ecosystem. Crop insurance in a dry part of the country like this, just promotes risky behavior within agrbiz
Aug 20, 2015 9:56 PM	really don't know what a person could do when in the pheasant hunting/guiding business maybe state helping with cost of placing released birds on properties who use bird hunting to generate business
Aug 20, 2015 9:17 PM	having the coe pull their heads out of their ass
Aug 20, 2015 8:42 PM	usage of state and federal water basins
Aug 20, 2015 8:37 PM	none
Aug 20, 2015 8:06 PM	Helping the public understand how easy wildfire can start in dry conditions
Aug 20, 2015 7:57 PM	crp haying
Aug 20, 2015 7:47 PM	Irrigation
Aug 20, 2015 7:36 PM	Issues with Indian land water use/practices affecting deeded land water availability
Aug 20, 2015 7:23 PM	reduce irrigation output /force people to Stop watering their lawns!!/state assistance to burn slash piles to reduce potential extreme fire behavior
Aug 20, 2015 7:06 PM	urban water restrictions
Aug 20, 2015 7:02 PM	increase dams, dredge spots in creeks to allow water storage when the creeks are full and still have water in time of drought.
Aug 20, 2015 6:01 PM	get the cattle off of public lands during droughts so the wildlife have ample water supplies
Aug 20, 2015 5:53 PM	Stop drain tiling and tearing out trees
Aug 20, 2015 5:49 PM	Less drain tile and wetland draining
Aug 20, 2015 5:27 PM	Plant some trees instead of tearing them out!
Aug 20, 2015 5:20 PM	Pray more
Aug 20, 2015 5:10 PM	Ban tiling
Aug 20, 2015 5:01 PM	Reduce the amount of tiling activity. This practice has a large impact on replenishment of groundwater and aquifers.
Aug 20, 2015 4:55 PM	slow the runoff into our lakes, especially from agg. ground
Aug 20, 2015 4:33 PM	spend NO tax dollars on this!!!!
Aug 20, 2015 4:15 PM	I don't think increased crop insurance is going to help the drought situation. More regulation on Drain tile going in to drain fields
Aug 20, 2015 4:11 PM	Regulations on tiling of fields and the affects this is having on water ways, wet lands, and water quality.

Question 8 (Continued): What projects would help you, your organization, or your county reduce impacts from future droughts? Place a check next to the types of mitigation action(s) that would be most desired.

Response date:	Other (please specify)
Aug 20, 2015 3:36 PM	Reduce the amount of Drain tiling
Aug 20, 2015 3:34 PM	na
Aug 20, 2015 3:18 PM	Develop Missouri River water. Arizona built hundres of miles of canals to send water from the Colorado River to Phoenix and crop lands. South Dakota could build canals to Western South Dakota to do the same. Irrigation and drinking water could be plentiful. A few years ago the Missouri flooded it would not have been so bad if water was being sent to western areas.
Aug 20, 2015 3:14 PM	Stop tiling farm fields that don't contain water. Stop burning off cat tails and tilling under grass land.
Aug 20, 2015 3:07 PM	nothing you can do. Lack of rain is just that. Please do not increase any govt spending of our funds
Aug 20, 2015 3:00 PM	Funding/organization for projects listed #7
Aug 20, 2015 2:54 PM	Reduce amount of tiling by landowners.
Aug 20, 2015 2:46 PM	keep all personnel trained in drought working conditions
Aug 20, 2015 2:45 PM	Planned wildfire management
Aug 20, 2015 2:37 PM	Livestock insurance parady with crop insurance
Aug 20, 2015 2:36 PM	plant crp and trees.
Aug 20, 2015 2:34 PM	na
Aug 20, 2015 2:34 PM	Increased funding for prescribed fire
Aug 20, 2015 2:34 PM	Private dam/storage management
Aug 20, 2015 2:32 PM	Less government.....take a look at California...
Aug 20, 2015 2:22 PM	Increased incentives for conservation
Aug 20, 2015 2:21 PM	Last thing we need is another government program, just do what people have have always done, wait for rain! Being diverse in an operation always helps though
Aug 20, 2015 2:20 PM	Less draining of sloughs
Aug 20, 2015 2:19 PM	No program is needed
Aug 20, 2015 2:18 PM	Protection of wetlands and stop use of drain tile
Aug 20, 2015 2:14 PM	Stop the installation of drain tile. This is devastating the ground water supply and is polluting the surface waters by increasing the nitrate levels. Plus it is increasing the water elevations on the rivers and streams causing more frequent flooding with higher water levels during the flood events.
Aug 20, 2015 2:08 PM	City water reaching out to more rural areas east of Rapid City
Aug 20, 2015 2:05 PM	None
Aug 20, 2015 2:04 PM	Dredge shallow lakes periodically to prevent low water conditions and danger to fish
Aug 20, 2015 2:03 PM	Drain Tile education for farmers to understand what negative effect it has on ground water/wild life
Jul 8, 2015 7:05 PM	Don't know, won't use govt programs ever!

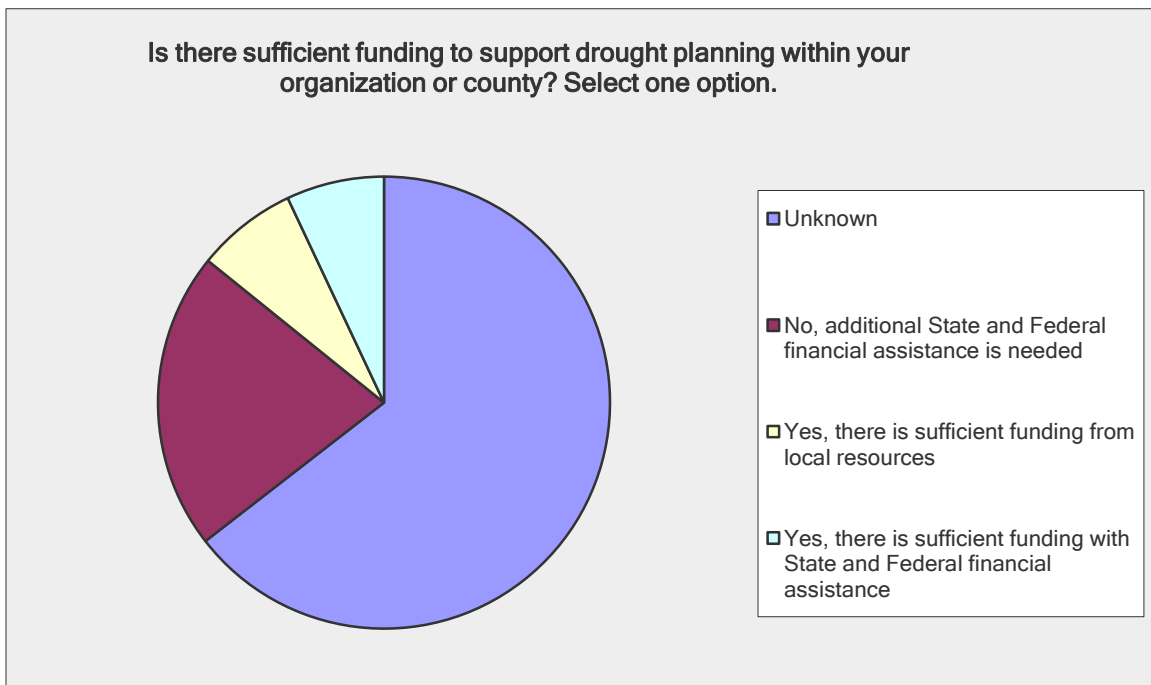
Question 9: How likely are you to improve your personal level of drought preparedness following the 2012-2013 event?

Answer Options	Response Percent	Response Count
Somewhat likely	30.5%	289
Not likely, what we have is sufficient	27.1%	256
Not likely, what we have is not sufficient but resources are limited	17.8%	168
Likely, it is part of our long range planning but we haven't implemented any activities yet	12.7%	120
Likely, and the process is underway	11.9%	113
<i>answered question</i>	946	
<i>skipped question</i>	499	



Question 10: Is there sufficient funding to support drought planning within your organization or county? Select one option.

Answer Options2	Response Percent	Response Count
Unknown	64.5%	604
No, additional State and Federal financial assistance is needed	21.3%	200
Yes, there is sufficient funding from local resources	7.2%	67
Yes, there is sufficient funding with State and Federal financial assistance	7.0%	66
<i>answered question</i>	937	
<i>skipped question</i>	508	



Question 11: If you are interested in receiving future correspondence from SDOEM reading the 2015 South Dakota Drought Mitigation Plan, please provide an email address:

<i>answered question</i>	165
<i>skipped question</i>	1280

Question 12: Please provide any remaining comments here:

<i>answered question</i>	111
<i>skipped question</i>	1334

Day county has too much water. The game fish and parks says it is public. I would like the public to get their water off of my land. Can I charge the public for trespassing for them having their water on my land?
Have to quite draining wetlands and stop drain tile
Cities need to teach their resident to use drought resistant grasses and plants in their yards. My yard is a mix of fescue and buffalo grass
This problem is being looked at from a "band-aid" approach which will fail. Tackling the problem at the lowest common denominator is necessary but that involves giant philosophical and managerial paradigm changes .
I was unsure how to answer some of the questions. I live in Minnehaha county, I cash rent my land in Sanborn county, and I do most of my hunting in Gregory county.
If the Lord made it a wetland, don't farm it!
I
Water control device at outlet of Anderson slough would help maintain water levels instead of relying on beaver dams.
The southern part of Perkins County is totally different than the northern part of the county. Each part of the county should be looked at seperately when declaring a drought/disaster.
thanks for your efforts
You can try and implement any plan you like, but you can't change the federal govt. or Mother Nature, it is what it is
I believe that the tiling of our farm lands was a very bad move. I believe our lakes and streams will and are being devistated by farm runoff.
drought happens and we try to handle it the best we can
while in a drought...or not...people water their lawns for 45 mins during the hottest part of the day...the Govs manion is one of them. This is not a smart use of water resources. putting a pamphlet into the water bill isnt enough.who reads that stuff...besides me?
western states should not allow drain tiling,
Quit wasting money
See last Pheasants Forever article on problems in Iowa. Mn
would like to see the results through SD GFP webmail and other public forums/not in our personal email
less waste in departments
tax \$\$ should not be spent in any large amt. to put out a message to use common scense!
Thank you
In my region, coming off a very wet period into a drought caused many ag producers to be complacent about water management, I support the dough plan concept!
this is a huge problem in our country. groups like you lying and stealing. global warming does not exist...

Question 12 (Continued): Please provide any remaining comments here:

Landowners who install drain tile should have to run the supposed excess water in their fields to a pond set up by the state, instead of into the creeks. It could then be monitored for quality and then it could be used in numerous different ways (wildlife, irrigation, etc.)
None
long range weather predictions
they need to get assistance for clean out and digging new stock dams like they had years ago
fairness to all who have drought losses
Promote projects to keep surface water rather than tiling/draining water to rivers!
During drought, wildlife and native habitats take a back seat to public land management: domestic grazing, motorized recreation, surface water diversions, etc. And, there is not conservation practices in place immediately following drought on public lands to allow for recovery. Even this survey ignored native habitats and wildlife in selection of questionnaire choices.
See comment on Question # 5.
ounty has had problems with since the mid 1980s. We need a flood mitigation plan, not a drought mitigation plan.
Mostly doesn't apply to my lifestyle.
Mitigation? How do you mitigate drought? Looks like a waste of taxpayers dollars to me!!!
As agriculture drives our economy this is where the emphases needs to be. Farmers are to concerned about every bit of land needs to be in production. Conservation is the name of the future for our children. We need to control the use of our land and the resources that used for that control
At least in the Black Hills - I'd like to see a much improved timber management plan which reduces the basal density of the forest. This would allow more rain water into the ground systems rather than being pulled out by the trees. It would also reduce the bug issue.
Better understanding of the long term impact of tiling fields is needed
Your survey showed very low concern for wildlife impact. Seemed more like created by department of agriculture
none
can not get insurance on cattle or pasture land
People should care enough to be good stewards of land without having to be paid for everything. The exception is continue with CRP and have payments increase to meet the demands on current rent. Save all remaining wetland, don't let anymore be drained.

Question 12 (Continued): Please provide any remaining comments here:

Educartion in water supply and conservation would be helpful to general public.
I would like to see a plan in effect for restocking of fish in dams prior to a drought instead of lets just wait and then decide.
It is hard finacially since it seems to happen every 5 years since we were married in 1976
tile drainage of ag land will have negative long-term impacts on water quality and quantity
Survey Monkey is a lousy survey process that can and often is written to generate the preferred outcome for the sponsor's.
I think there should be a restriction on water lawn grass in the city of aberdeen during such droughts.
Thanks for involving public sector
When we are in a dry spell people realize the importance of water. Please do not allow uranium mining or anyone else to possibly pollute or use to much precious groundwater. As our population grows in the state and nation...water becomes more and more important, I realize we need to continue to feed our growing population, but as we see agbiz draining wetlands/potholes that support our wildlife and specifically waterfowl we must realize that this decreases our hunting tourism and I see no reason to reward this type of behavior with crop insurance for crops planted in areas where it is know to be risky to plant them due to potential drought.
Look ahead. Don't wait for a disaster to come and then feel sorry for yourself. Plan a little ahead . Save up a little for tough times.
projections are for a 20-30 year exceptional drought in this century, worse than ever seen before. I would get all resources in order to deal with the aforementioned.
Big wealthy operators receive all, or most federal cost share dollars
agricultural tiling is decreasing the available groundwater
The extended drought resulted in an attitude of ignoring predicted storms that would result in large amounts of precipitation falling in a short time, i.e. Winter Storm Atlas. This may have been a contributing factor resulting in large livestock losses as ranchers did not think the drought would end with a blizzard and were ill prepared.
Cycles are a way of life in farming get use to it
be always aware that droughts do happen
federal water is not being utilized and is setting vacant, but not usable by commercial farmers
Use the Missouri River water to irrigate