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# Drought as a Component of Local Hazard Mitigation Plans: Are the 100 Fastest Growing Counties Ready?

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Drought as a Component of Local Hazard Mitigation Plans:  
Are the 100 Fastest Growing Counties Ready?

by  
Jeffrey Henson

A THESIS

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## Drought as a Component of Local Hazard Mitigation Plans:

### Are the 100 Fastest Growing Counties Ready?

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University of Nebraska, 2013

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Drought is one of the most destructive natural disasters that threatens nearly every environment on earth. Between 1980 and 2011 there were 16 drought events in the United States with impacts that exceeded \$1 billion with an average event cost of \$12.2 billion according to the National Climate Data Center. While many states have engaged in the creation of drought plans, little research has been done regarding drought planning at the local level. This research examines the local planning efforts in 62 of the 100 fastest growing counties in the United States from 2000 to 2009. It is expected that the rate of population growth and intensive land development in these counties will result in larger, more frequent demands for quality water resources while decreasing the resiliency of these counties following future drought events. In an effort to review the current preparedness level of these locations, Local Hazard Mitigation Plans were empirically evaluated using a matrix with measureable indicators. The matrix was developed to examine the integration of drought planning elements as a component of the Local Hazard Mitigation Plans. The findings of this research indicate that drought preparedness and planning, when done, is frequently fractured and lacking a comprehensiveness that is necessary for meaningful impact and effectiveness for their area. This may suggest that many municipalities remain unprepared to face drought when it strikes. Results of this

research should serve as a snapshot of what is currently being done in the field of drought planning in the realm of local planners and emergency managers, and is hoped to help increase awareness of changes that could be made to improve preparation, resiliency, and decrease the stress effects of future droughts.



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# Chapter 1: Introduction

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Drought is one of the most complex and challenging natural hazards that society faces.

The National Drought Mitigation Center defines drought as “...a deficiency of precipitation over an extended period of time--usually a season or more--resulting in a water shortage for some activity, group, or environmental sector...” (NDMC 2013).

Drought can affect a variety of different sectors within a community including agriculture, tourism, and food security. With the frequency and extended duration of drought in recent years, it is becoming increasingly important for local planners and emergency managers to recognize the danger and potential impact of drought that their specific areas face, and that they develop programmatic strategies to decrease that impact on their community.

In the summer of 2011, 81% of Texas was engulfed by drought (United States Drought Monitor 2011). It is estimated that agricultural impacts for Texas alone exceeded \$7.6 billion (Texas Water Resources Institute 2012) with additional indirect impacts adding another \$3.5 billion (Frederick et al.. 2011). ). In 2012, drought expanded to areas beyond the southern plains and resulted in impacts to more than 60% of the United States (NDMC 2012). While the final financial effects of the 2012 drought are not yet known, there is no doubt that they have been significant and devastating to many. Drought and its resulting effects impacted more than 1.5 billion people worldwide during the years of 1980-2008, more than any other natural disaster during that same time frame (Center for Research on the Epidemiology of Disaster [CRED] 2011). In 1995, a Federal Emergency Management Agency (FEMA) study estimated that drought costs exceed \$6-\$8 billion

annually (FEMA 1995). This number does not take into account the myriad of secondary or indirect drought impacts, and their resulting financial costs (NOAA 2008).

Drought is a creeping phenomenon whose impacts develop slowly over the course of a season or more (Tannehill 1947). Recent droughts, such as the 2011 and 2012 droughts in the United States, have developed through the spring and summer months while continuing through the winter and into the following spring season. There is a misconception that drought is confined to a spring and summer and relents as soon as fall or winter arrives. Unfortunately, this is not always the case.

A 1985 study determined that there are more than 150 definitions for drought, resulting from a wide spectrum of differences in regions, needs and research disciplines (Wilhite and Glantz 1985). As a result drought is now categorized in four different ways: meteorological, agricultural, hydrological, and socio-economical. Meteorological drought is typically defined based on the degree and duration of dryness relative to the regional norm. Definitions for meteorological drought should vary from region to region, as drought conditions for a rain forest differ from those in a desert. Agricultural drought definitions make the connection between meteorological characteristics and their impacts on agricultural systems, with results focusing on lack of precipitation, evapotranspiration, levels of soil moisture, and ground water and reservoir levels. Hydrological drought definitions focus on how hydrologic systems (stream flow, lake and reservoir levels, and snowpack) are impacted by precipitation deficiencies. As a result, hydrological drought often lags behind both meteorological and agricultural drought in identification. Finally, socio-economic drought focuses on impacts to the supply/demand cycle. Socio-

economic drought occurs when there is an inability to meet human and environmental needs as a result of deficient precipitation (NDMC 2013; Wilhite and Glantz 1985).

Though the occurrence rate of drought varies from year to year, it is indisputable that the U.S. will continue to confront this phenomenon and must develop methods of managing the risk that it represents. While the typical discussion related to drought impacts is geared toward the agricultural, there are many ways that drought manifests itself in urban areas. For example, we must account for food scarcity, insufficient water supplies, increased unemployment, loss of tourism, and decreased tax bases. These impacts, both direct and indirect, are exacerbated when areas are impacted by prolonged or repeated drought occurrences (Wilhite et al. 2007). It appears relevant to establish what is being done at the federal, state and local levels to develop resilience as we face a future that inevitably contains drought.

### *Drought Planning at the Federal, State, and Local Levels*

Currently there has been little planning activity at the federal level related to drought mitigation and preparedness. Despite repeated calls for a national drought policy, a report by the Congressional Research Service stated “...*There is no cohesive national drought policy at the federal level, nor is there a lead agency that coordinates federal programs*” (Fogler et al. 2012). Research conducted by the NDMC has found that state level drought planning has increased in recent years (NDMC 2010).

A 2012 study examined 19 states in the western United States, and found that there is a wide range in the level of resources and action planning related to drought at the state level (Fontaine et al. 2012). The states reviewed felt that their planning efforts were

appropriate for the level of threat posed by drought to their state. Some of the factors that were cited as assets by state drought planners included: engaged and active personnel, monitoring systems, strong leadership, and state level drought coordinators. State reported increased monitoring and access to drought indicators as an asset but also indicated that there were still needs in this area that went unmet. Coordination among officials was cited as a crucial component of drought preparedness as well as a key to an effective response and recovery. One specific deficit identified in the study was the failure for states to hold post-drought assessments of their planning efforts (Fontaine et al 2012).

While federal laws and state hazard mitigation plans provides much of the foundation for hazard mitigation planning, local plans are often most effective in addressing local threats (Newkirk 2002). This results from local planning bodies having a more complete understanding of the risk and vulnerabilities within their planning jurisdictions. The development of local hazard mitigation plans is required by the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) and the Disaster Mitigation Act of 2000 (DMA 2000) as part of receiving federal hazard grants.

The development of local hazard mitigation plans are critical in effectively mitigating and responding to the threats posed to a municipality (Newkirk 2002). Local planners are able to incorporate hazard mitigation strategies into other planning documents (i.e. comprehensive plans) making for a holistic approach to the planning process (Burby 2006, 2005; Nelson and French 2002; Burby et al. 1998).

At this time little is known about how prepared local governments are for drought, and even less is known about what strategies are actually being employed. There have been considerable efforts directed at state level drought preparedness, resulting in most states having some type of plan in place for preparation (or reaction to) drought (NDMC 2010). Whether these efforts at the state level have trickled down to regional or county level planning is not known in most cases. Drought is specifically identified in the Stafford Act as one of the natural disaster events that must be considered for inclusion in All-Hazard Plans, yet it remains a difficult area for hazard planners resulting from how drought differs from other natural hazards. As a result, this study was planned to provide a snapshot of the current level of preparedness at the local level while establishing a set of best practices that can be employed by a wide range of communities in their drought planning efforts. In addition, by establishing a matrix for evaluation based on current literature hazards planners now have a tool that can be used to evaluate the level to which they address drought in future hazard mitigation plans.

### *Project Overview:*

This study explores the extent of drought planning as a component in local hazard mitigation plans at the county level. It examined the salient literature related to the hazard mitigation planning process, specifically as it related to developing more resilient communities through the development of effective drought plans. The review of this body of literature assisted in the development of three primary research questions:

- 1) *To what extent do local hazard mitigation plans address drought risks?*
- 2) *What are the plan components and indicators that receive the most attention?*

3) *Do local drought planning efforts rely on traditional crisis management techniques or have adaptive risk management measures been incorporated into planning approaches?*

These questions were answered by reviewing local hazard mitigation plans from 62 of the 100 fastest growing counties in the United States from 2000-2009 as determined by the U.S. Census. This review focuses solely on hazard mitigation plans as required by the DMA 2000. Plans included in this study have been given a variety of names including: Multi-Jurisdictional Hazard Plans, Local Mitigation Strategy Plans, Comprehensive Hazard Plans, Multi-Hazard Mitigation Plans and All-Hazard-All-Discipline Plans. It should be noted that there are other planning documents that may also address the threats posed by drought. These plans may include but are not limited to: comprehensive plans, drought specific plans, water-district plans, and water conservation plans.

The research findings include the scoring of each plan as well as the identification of specific strategies currently being used to prepare for or respond to drought. The scoring of these plans results in a “Total Plan Quality” score, which references the extent to which drought is incorporated into the hazard mitigation plans reviewed. This score should not be confused as a score related to all of the natural hazards addressed in the plans. This study also helped to establish some recommendations that can be used by hazard mitigation planners to more effectively plan for drought as part of the hazard mitigation planning process.

## Chapter 2: Literature Review

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### *Hazard Mitigation Planning: History and Objectives*

Throughout history people and governments have been anticipating and adapting to natural disasters (Schwab and Topping 2010). However, the formal process of developing hazard mitigation plans has its basis firmly rooted in the 1988 Robert T. Stafford Disaster and Emergency Assistance Act (Stafford Act). The Stafford Act was the first legislation in the United States that discussed the need for formal hazard planning and established the four basic disaster management functions: mitigation, preparedness, response and recovery (Figure 2.1) (Schwab and Topping 2010). It is essential that the Stafford Act be discussed and understood as a guiding document in any research that hopes to better understand hazard plans.



**Figure 2.1 Disaster Management Functions as established in the Stafford Act**

The overall goal of the Stafford Act was to develop a systematic approach of administering federal disaster assistance. One of the mechanisms used to achieve this end was the use of local, state, and tribal hazard plans. The development of hazard mitigation plans at these various levels would result in better intergovernmental coordination before, during, and after natural and manmade disasters (FEMA 2008). The Stafford Act addresses the topics of Disaster Preparedness and Mitigation Assistance, Major Disaster and Emergency Assistance Administration, Major Disaster Assistance Programs, Emergency Assistance Programs, and Emergency Preparedness (Bea 2010).

The Stafford Act was instrumental in developing the foundation for the definitions of the planning process including terms such as “local” and “major disaster”. If plans were to be required at a “local” level, a clear definition was necessary to ensure that these requirements could be met without confusion. The Stafford Act defined local government as “...*a county, municipality, city, township, local public authority, school district, special district, intrastate district, or council of government...*” This definition of local level resulted in the adoption of hazard plans at the city, county, natural resource district, watershed, and other designated areas that fall under the formal definition. It is significant to note that while a plan may be developed at a county or regional level, it must have planning participation and adoption by all governmental bodies that are included in the plan development. For example, if a plan is developed at a county level, it must include specific information relating to the individual towns within the plan area, and the townships must participate in the planning process as well as then adopting that plan. (Stafford Act 2007)

When considering hazard mitigation research it is important to identify how the term “major disaster” is defined and what hazards are included in this definition. The Stafford Act defines a major disaster as “...*any natural catastrophe (including any hurricane, tornado, storm, high water, wind-driven water, tidal wave tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm, or drought)*...which in the determination of the president causes damage of sufficient severity and magnitude to warrant...assistance under this act...” (Stafford Act 2007)

The Stafford Act was not without its drawbacks or limitations. For example, the funding for mitigation was primarily available only following natural disasters, resulting in confusion between recovery-based efforts and mitigation. By establishing a funding structure based on major impacts following a natural disaster the effectiveness of many of the mitigation strategies was negated (Schwab and Topping 2010).

While the Disaster Mitigation Act of 2000 (DMA 2000) reinforced the principles of the Stafford Act, it corrected the problem of post-disaster mitigation funding by requiring the development and routine updating of hazard mitigation plans as a prerequisite for eligibility in pre- and post-disaster mitigation funding opportunities. The DMA 2000 went further than the Stafford Act in establishing the requirements for the hazard mitigation plans as a precondition for funding consideration. The DMA 2000 established the minimum content and process of approval used by the FEMA in the hazard planning process.

The DMA 2000 recognizes that expenditures for post-disaster assistance have significantly outpaced any real reduction in vulnerabilities and loss potential resulting

from exposure to natural hazards. These escalating recovery costs resulted in the need for greater emphasis being placed on the identification of potential hazards, the implementation of strategies that are sufficient to reduce losses from natural disasters, and the protection of the integrity and functions of critical infrastructure. The result of these goals is a greater emphasis being placed on mitigation and planning efforts at the local level. (DMA 2000)

One of goals of the DMA 2000 is to create a national disaster mitigation program that assists in creating resilient communities by reducing the loss of life, the destruction of property, and ensuring the continuity of public and private services. To achieve this goal, a source of pre-disaster funding was established that "...will assist...in implementing effective hazard mitigation measures that are designed to ensure the continued function of critical services and facilities after a natural disaster" (DMA 2000). To be eligible for the funds established, state, local, and tribal governments are required to develop and adopt hazard mitigation plans that meet the basic requirements and are approved by FEMA. The plan requirements outlined in the DMA 2000 consist of: 1) documentation that the plan has been adopted by the participating jurisdictions [DMA 2000 *Requirement 201.6(c)(5)*]; 2) as part of the planning process, the public is included and has the opportunity to participate in, and comment on, the planning during the drafting of the plan [DMA 2000 *Requirement 201.6(b)and 201.6(c)(1)*]; 3) the plan shall include a risk assessment that identifies all of the natural hazards that can affect the planning jurisdiction, historical occurrences for each identified hazard, and a description of the communities vulnerability [DMA *Requirement 201.6(c)(2)*]; 4) a description of the hazard mitigation strategies that will be employed in the reduction of vulnerability to the identified hazards with particular

emphasis being given to new and existing buildings and infrastructure [DMA 2000 *Requirement 201.6 (c)(3)(ii)/(iii)*]; 5) a discussion related to plan maintenance and future plan updates, including a description of the schedule and method of plan evaluation and the process of including the public in the planning process [DMA 2000 *Requirement 201.6 (c)(4)(i) and (ii)*].

To ensure that there is a clear understanding of the plan requirements and development process, FEMA has created planning guides that communities can use. These planning guides include the *State Multi-Hazard Mitigation Planning Guidance* (2004), *Tribal Multi-Hazard Mitigation Planning Guidance* (2010) and the *Local Multi-Hazard Mitigation Planning Guidance* (2008).

The *Local Multi-Hazard Mitigation Planning Guidance* (2008) document has the stated goals of guiding local planners through the process of developing local hazard mitigation plans that conform to the requirements of the DMA 2000. Additionally, the guide serves as an aid to viewers and evaluators of the plans so that there can be a fair and consistent evaluation of local hazard mitigation plans. The guide is divided into six sections that address the planning process from a holistic perspective (FEMA 2008). FEMA recognizes that while it is important to have a plan that is formally adopted by local jurisdiction, it is equally important that the plan be a living document that represents the need and concerns for the entire community. This is made evident in the approach taken in the planning guide. The six sections in this document include: 1) Prerequisites, 2) Planning Process, 3) Risk Assessment, 4) Mitigation Strategies, 5) Planning Maintenance, and 6) Local Mitigation Plan Crosswalk. The Local Mitigation Plan

Crosswalk is a planning review tool that helps ensure that planners have addressed each of the DMA 2000 requirements in the development of their plan (FEMA 2008).

Research regarding the importance of local mitigation planning as well as the effectiveness of these plans provides supporting evidence that incorporating natural hazards into comprehensive plans as well as land-use plans have resulted in more resilient communities, as proven by the lower cost of recovery following natural disaster events (Pearce 2003; Burby et al. 2000; Godschalk et al. 1998; Burby and Dalton 1994). The goal is to provide a clear path towards the mitigation of the hazards that a community faces and therein reduce the cost associated with the disaster impacts. This can be achieved by incorporating disaster planning into a community's planning process (Brody et al. 2003a; Godschalk 2003; Burby et al. 2000).

Currently there is considerable debate regarding the definition of resilience and how it can be applied to hazard mitigation planning, including the impact that this concept can have on the planning process (Paton 2005; Godschalk 2003; Tolbin 1999). While there are many different and competing definitions for resilience, there are three components of social-ecological resilience that can be clearly identified. These include the system's ability to undergo a change without losing the ability to retain control on existing structures and functions; the degree to which a system is able to adapt to or overcome external changes; and the ability to improve or increase the capacity to endure similar impacts in the future (Wardekker et al. 2010).

### *Drought Mitigation Planning History and Objectives*

While the DMA 2000 establishes planning requirements and specifically states that local plans must include an analysis of all hazards and specific actions to address them, the reality is that hazard mitigation planners do not have a clear understanding of the drought phenomenon and how it can be accounted for as a part of the mitigation process (Hayes et al. 2004). This typically is manifested in drought plans that rely on crisis response techniques rather than striking a balance between crisis response and risk management (Wilhite et al. 2000, Knutson et al. 1998). The National Drought Mitigation Center (NDMC) refers to this as the Hydro-Illogical Cycle (NDMC 2013).

Drought is a complex phenomenon that differs significantly from other natural disasters. The complexity of drought is evident through the sheer number of definitions that are used throughout drought literature to define it. According to Wilhite and Glantz (1985) there are more than 150 definitions for drought. This lack of consensus related how drought is defined may help one understand the difficulty of actually constructing a mitigation plan to address it.

Drought differs from other natural hazards in three main ways. First, drought is a “creeping phenomenon” with no clear onset or regression (Tannehill 1947). In many cases there is a failure to identify a developing drought until there are tangible impacts like dead or dying crops or an insufficient supply of water to meet the regular water demands. As a result there have been many calls for the development of a drought early warning system (Wilhite et al. 2005; Wilhite and Svoboda 2000; Lohani et al. 1997). By

identifying drought, or the likely occurrence of drought prior to tangible impacts a community can reduce its vulnerability and losses.

The slow onset nature of drought is compounded by a lack of understanding related to the seasonal impacts of drought. It is not difficult to understand the agricultural impacts that are likely to result from a drought occurring in the spring and summer months. There is, however, less understanding related to how drought impacts society during the fall and winter months. This lack of understanding can lead to more intense water shortages and a less prepared community when spring arrives.

The second way in which drought differs from many other natural hazards is related to the spatial characteristics of its impacts (Wilhite et al. 2007; Wilhite et al. 2005; Knutson et al. 1998). Drought is more often associated with regional or large area impacts rather than the more localized impacts of other natural hazards. By impacting a larger area drought can result in reduced food supplies, increased demand for energy, stressed ecosystems, and a reduction in available water resources (Wilhite et al. 2005). This reduction in water resources has resulted in “water wars” in different parts of the United States.

Drought differs from other natural hazards in one other significant way. It is much more difficult to accurately identify drought impacts beyond the visible agricultural losses. It is easy to see dead and dying plants in agricultural field; it is more challenging to identify the impact of drought in developed and urban areas. Often, in addition to the direct impacts of drought, there are also secondary hazards that result from the drought

conditions. An example of this would be wildland fires that are fed by vegetation that is dead and dried from the drought (Wilhite et al. 2007).

The 2011 drought in Texas and other southwestern states provides examples of each of these different complications that drought presents. There were a number of losses that cannot tangibly be prescribed a monetary value. In the city Houston, for example, there were 66 million trees lost or damaged in the urban canopy (Gerlich 2011). While the cost of removing and replacing a tree can be factored into a loss equation, it is not possible to place a value on the 100 year old oaks that have been a part of the Houston culture and appeal for generations. With the extreme drought of 2011 and 2012, there were also more direct impacts in urban areas than in many previous, less severe droughts. Again, in Texas there was a reported 41 miles of damaged and cracked interstate that would have to be replaced at a cost of \$30 million that resulted from the drying of the soil (Wear 2012). During the 2012 drought communities large and small reported increased numbers of water and gas line ruptures from the dried earth as well as a yet untold amount of damage to residential structures in the form of settling and cracking basements and foundations (Abraham 2012; Keen 2012; Salter 2012). These direct urban impacts are an alarming trend especially with drought likelihood for some areas extending into 2013.

To address these concerns, the Subcommittee on Disaster Reduction (SDR), a part of the National Science and Technology Council, completed a report in 2005 entitled *Grand Challenges for Disaster Reduction*. The report discussed a number of natural hazards including drought. The goal of this report was to identify the major hazards that face the United States and to outline a ten-year strategy to address each of the hazards. In the SDR's discussion of drought, they identify six "grand challenges" that must be addressed

in order to enhance resiliency. These challenges consist of providing information when and where it is needed, understanding the processes that produce natural hazards (drought), developing effective and appropriate mitigation strategies and technologies, reducing the vulnerability of infrastructure, assessing disaster resilience, and promoting risk-wise behavior. The specific short-term (1-2- years) goals for this report related to drought include increasing communication and tracking capabilities related to actual impacts and losses resulting from droughts; monitoring and analyzing key drought variables including land-use, climate data, stream flows, ground water levels, reservoir and lake levels, snow covered areas; satellite and meteorological modeling and monitoring of major climate processes related to drought; improved understanding of drought impacts and the monetary benefits of mitigation; improved coordination of Federal, state, and local drought planning efforts; and the development of local and state drought planning capabilities (SDR 2005).

While there has been some progress in these areas, there is still a considerable amount of work to be done in addressing drought in a comprehensive way. The lack of a national drought framework or even a lead federal agency related to drought is a reflection of the failure of the federal government to address the drought phenomenon in a meaningful way (Fogler et al. 2012; Jimenez 2011). There has been progress made at the state level to achieve some amount of drought awareness and preparedness (Fontaine et al. 2012). To aid in this process of drought planning process the NDMC has developed a drought planning guide.

This planning guide has been in the process of development and revision for two decade and has helped guide states and local communities in the development of drought plans.

*Drought Ready Communities: A Guide to Community Drought Preparedness* is a publicly accessible resource on the NDMC's website. The guide outlines a process that communities can use to develop drought mitigation plans and programs. The planning process outlined includes the development of a drought task force or planning team, outlining goals and objectives for the planning process, conducting a hazard assessment, identifying mitigation, preparedness, and response strategies, developing a drought early warning system, establishing a public education and involvement process, and ensuring an equitable distribution of resources for all members of the community. In addition to this guide, the NDMC is working with the National Integrated Drought Information Systems (NIDIS) and the American Planning Association (APA) in the development of a planning advisory report that will assist planners in the incorporation of drought into their existing planning process (NDMC 2013).

There have been some research studies examining drought preparedness at the local level. Examples of cities and counties developing drought resilience resulting from the 2011 drought are beginning to surface. An example of this is League City, Texas located in the Upper Texas Gulf Coast area. Schmidt and Garland (2012) explored the strategies employed by the city in response to the 2011 drought and considered how the principles of resilience had been incorporated into the community planning and response mechanisms. League City was able to use a number of strategies and mitigation techniques to lessen the impacts of the drought and develop a more comprehensive long-term plan to address the ongoing threat of drought. Some of the strategies employed include community education, water conservation and reuse, strengthening of infrastructure, enhanced building and landscape requirements, planning for increased

water availability through lift stations as well as purchasing water vouchers, and incorporating drought planning into the communities existing planning process (Schmidt and Garland 2012).

Studies specifically related to the inclusion of drought in the hazard mitigation planning process are less prevalent. In 1998, there was a study that examined drought mitigation plans for the Atlanta-Metro area. This study (Shepherd 1998) examined the ten counties that compose the metro area and their existing drought plans. The results showed that while the communities had indeed developed drought plans, the primary focus was on meeting the basic regulatory requirements rather than having developed a document that was a guide to communities in the process of mitigation, preparation, response, and recovery from drought (Shepherd 1998).

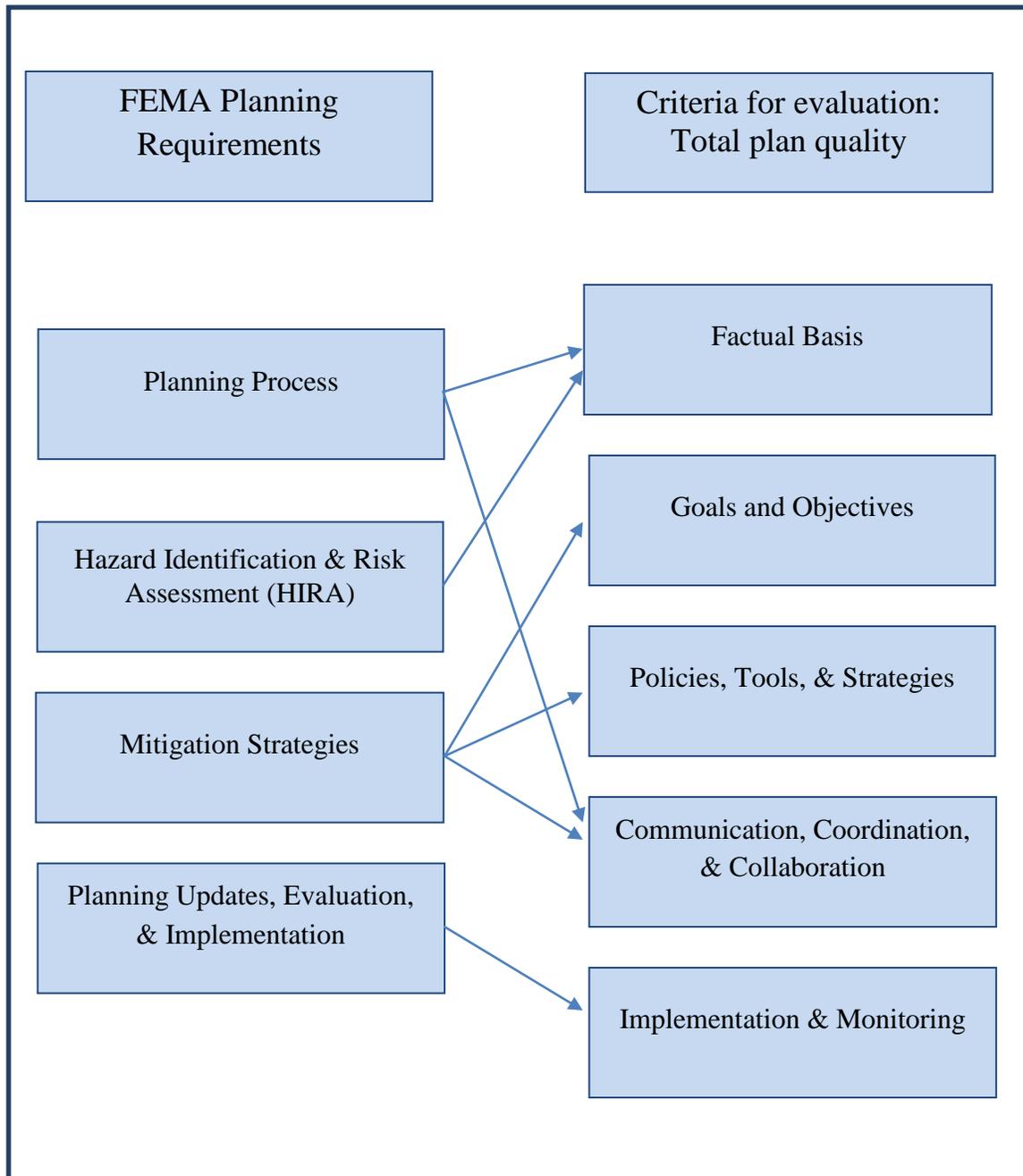
# Chapter 3: Conceptual Framework

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## *Connecting Hazard Mitigation Plan Components with Plan Evaluation and Criteria*

The purpose of developing local hazard mitigation plans is to “...provide a methodical way to encourage the whole community in thinking through the life cycle of potential crisis, determining required capabilities, and establishing a framework for role and responsibilities.” (FEMA 2008). FEMA’s *Local Multi-Mitigation Planning Guidance* discusses the necessary elements for local hazard mitigation plans to meet the standards established in the Stafford Act and the DMA 2000. There are four basic elements that should be considered: the Planning Process, Hazard Identification and Risk Assessment, Mitigation Strategies, and Plan Updates, Evaluations, and Implementation. These elements are directly related to the criteria established for evaluating the total plan quality indicated in Figure 3.1. The planning process and hazard identification and risk assessment is achieved by establishing a strong factual basis for the planning area. These elements identify specific details in the planning area including demographic trends, current and future land uses, water supply and concerns, threats and hazards for the planning area, and potential impacts. The third element of the plan, Mitigation Strategies, directly relates to the goals and objectives for the planning area as well as specific strategies, tools, and policies that will be used to achieve the stated goals and objectives. These strategies may include specific mitigation actions, such as incentives for reduced water consumption, or funding opportunities, such as grants through the USDA for farmers. The criteria of communication, coordination, and collaboration are

found within each of the four planning components. Community planning partners may be identified through discussion related to the planning process or even covered as an available resource in the Mitigation Strategies. Finally, the element of updates, evaluation, and implementation directly addresses the evaluation criteria of the same label.



**Figure 3.1 Relationship between FEMA plan requirements and criteria for evaluation**

### *Evaluation Criteria*

For this study a matrix was developed for evaluating the hazard mitigation plans that were collected and reviewed. The evaluation criteria were established through FEMA guidelines for local plan development, checklist (provided by FEMA) for mandatory multi-hazard mitigation plan criteria, recommendations regarding effective drought planning as published in the National Drought Mitigation Center's *Drought Ready Communities: A Guide to Community Drought Preparedness*, and Best Practices as identified throughout the body of research related to hazard (specifically drought) mitigation. The criteria for evaluation are divided into five components: Factual Basis; Goals and Objectives; Policies, Tools, and Strategies; Communication, Coordination, and Collaboration; and Implementation and Monitoring.

### *Factual Basis*

Communities must develop a firm factual basis for the planning process; this is especially true for events such as drought that can have devastating impacts (Tang et al. 2008). A factual basis can be established by conducting an analysis of the population in the planning area. This analysis must include an inventory of vulnerable populations so that mitigation actions can be developed (CDC 2010). As related to drought, vulnerable populations include the agriculture sector, tourism, animal owners, and communities with insufficient water supplies (Schmidt and Garland 2012; Gupta et al. 2011; CDC 2010).

Establishing a clear definition for the threat is a critical element in establishing a factual basis. Drought definitions are generally divided into four basic types: meteorological, agricultural, hydrological, and socioeconomic (Steinemann et al. 2005; Wilhite and Glantz 1985). It can be helpful for a community to adopt a standard drought definition

developed by leading research, but it is most important that communities define drought based on local manifestations and impacts (CDC 2010; FEMA 2008; Newkirk 2002; Wilhite 2000; Wilhite and Glantz 1985).

The identification of past events is essential in the process of identifying the threats that the community currently faces, as doing so aides in the development of possible mitigation strategies (FEMA 2013; Fontaine et al. 2012; Gupta et al. 2011; FEMA 2008). Establishing a factual basis for a plan by analyzing past events as well as identifying and mapping potential hazards provides parameters that can guide decisions regarding future events (Deyle et al. 1998).

The process of Hazard Identification and Risk Analysis (HIRA) related to drought is a complex issue. Due to the spatial and temporal components of drought, effects can be spread over a wide area and timeframe. An accurate and comprehensive HIRA makes for the foundation of the plan (Burby et al. 2000). When conducting the HIRA communities should consider the frequency of drought, potential impacts and specific vulnerabilities they face (FEMA 2008; Wilhite et al. 2006; Geringer 2003). A review of the vulnerabilities related to drought should include not only direct impact concerns, but social and economic impacts as well (CDC 2010; FEMA 2008; Wilhite et al. 2000). In some cases planners fail to objectively assess the drought hazards a community faces, typically underestimating the potential threat (Newkirk 2002).

Another key component of drought preparedness is the establishment of the community view of the progression of drought manifestation. This is accomplished by defining drought levels or classifications and the triggers that will be used in identifying drought

progression (FEMA 2013; Fontaine et al. 2012; Knutson 2008; Steinemann and Cavalecanti 2006; Steinemann et al. 2005; Wilhite et al. 2000). Drought indicators should be clearly defined while including in the definition both spatial and temporal scales (Steinemann et al. 2005). Communities should plan not only for drought progression levels but also drought regression levels/criteria (Stienemann et al. 2005).

The identification of the community's water sources is essential in understanding the potential threat that the community faces (FEMA 2013; Fontaine et al. 2012).

Monitoring the community's water supply leading up to drought helps in mounting a timely and effective response (CDC 2010; Wilhite and Svoboda 2000). In doing so, attention should be given to both water supply as well as concerns with water quality or water system capacity (Gupta et al. 2011; Wilhite 2000).

The composition of local land-use is another of the factors that should be analyzed and understood when planning for any type of natural hazard (Burby et al. 2006; Burby 2005; Burby et al. 1998; Nelson and French 2002). Land-use concerns specially related to drought include the vulnerability of agricultural lands, tourism dependent areas, recreational areas, and other urban features such as parks and tree canopies.

### *Goals and Objectives*

The development of goals and objectives help the community envision how this planning process will result in a more resilient community (Tang et al. 2008, Burby 2005). The goals and objectives identified in the hazard plan should serve as long term, consistent guidelines for the adoption and implementation of effective policies and strategies in developing a resilient community (Tang et al. 2008; Burby 2005; Nelson and French

2002). These goals and objectives should also be considered in the development of other community based plans such as comprehensive plans, sustainability plans, flood mitigation plans, and drought mitigation plans (FEMA 2008, 2013).

For the purpose of multi-hazard mitigation plans, goals should be broad policy statements that identify what the community hopes to achieve through the planning process (FEMA 2008). These goals help to identify the desired outcomes related to the community's ability to mitigate, prepare for, respond to, and recover from a given threat or disaster.

Objectives should be more concrete than goals in that they are specific, measurable, and achievable statements (FEMA 2008, Tang et al. 2008). They should be directly related to specific activities, implementation procedures, operating procedures, preparedness measures, and required resources. The use of goals and objectives helps to establish what strategies and tools will be employed throughout the planning process as well as how well a community will be prepared for response and recovery (FEMA 2008).

Goals directly related to drought mitigation and preparedness include: reduced water consumption (Vicker 2005; Wade 2000), public education related to the vulnerability (Wilhite 2000; Burby et al. 2000; Wade 2000) and property protection (FEMA 2008; Godschalk 2003).

Water conservation is a frontline defense related to drought (Wade 2000). By establishing water conservation programs, communities can reduce water consumption significantly (Vickers 2005).

Public education is a key component of hazard mitigation (Burby et al. 2000). A goal related to educating the public about drought can have the result of creating a level of

empowering for residents to enact personal conservation efforts (Wardekker et al. 2010). Property protection is at the heart of mitigation planning (FEMA 2008; Godschalk 2003). Property protection means a reduction in hazard impacts and as a result lower disaster related costs.

#### *Policies, Strategies, and Tools*

Establishing specific policies, tools and strategies for realizing the stated goals and objectives constitutes the bulk of a plan (Tang et al. 2008; Brody 2003; Berke and French 1994). Policies and strategies are aimed at what will be necessary to help the core capabilities remain intact during a disaster situation. Specific strategies and policies may include regulations, protective policies, land-use restrictions, and incentives (Tang et al. 2008).

Among the most significant tools related to drought is the development of an early warning system related to local drought impacts (Fontaine et al. 2012; Gupta et al. 2011; Knutson 2008; Wilhite et al. 2000). Early warning systems may include monitoring soil moisture, stream flow, snow pack, reservoir levels, and groundwater (Steinemann et al. 2005). Having an early warning system in place enables communities to take early action, which has proven to be more effective in offsetting drought impacts (Vickers 2005).

Specific to drought, policies and tools directed at the agricultural sectors are particularly important (Rockstrom 2003). Potential mitigation and preparedness measures related to the agricultural sector include improved soil and water management practices, including

adaptive tilling practices, intercropping, crop insurance, and agricultural irrigation standards (FEMA 2013; Rockstrom 2003; Wilhelmi and Wilhite 2002; FEMA 2002).

If communities have a goal to reduce water consumption, they must first identify specific actions to be taken to address water conservation (FEMA 2013). There are two types of water conservation: behavioral and technological (Knutson 2008). Behavioral measures include examples such as taking shorter showers, reducing lawn watering or car washing, or turning off local water fountains or splash parks; technological measures include low-flow fixtures, water system audits, and improved irrigation standards (Knutson 2008; Vickers 2005). A 2005 study of water conservation as drought management tool showed that implementing water harvesting systems, incentives for voluntary water restrictions, water conservation pricing, and low-flow fixtures are effective strategies in reducing water consumption (Vickers 2005). Incentive programs for retrofitting structures can be helpful in water conservation by transferring the cost of upgrades from individual property owners to governmental bodies (FEMA 2013).

Other studies have reinforced the findings related to water conservation; in India the use of water harvesting systems reduce the strain on treated, potable water (Gupta et al. 2011). Schmidt and Garland (2012) discuss water reuse as a form of redundancy in hazard planning; this redundancy is achieved by introducing a water source that was not previously available.

The use of water restrictions is a common tool used by municipalities to address short-term water shortages (FEMA 2013; Knutson 2008; Kenney 2004). Water restrictions have proven to reduce water consumption. A study of the 2002 drought that impacted the

Denver metro area examined water restrictions in several communities as the drought progressed. The findings showed that voluntary water restrictions had negligible impacts (1% reduction in water consumption) and in some cases led to increased water demand. Mandatory water restrictions were more effective in reducing water consumption. The most effective restrictions were those that were introduced earlier and were more restrictive (restrictions allowing lawn watering only one time weekly resulted in a 55% reduction in water consumption, restrictions allowing lawn watering two times per week resulted in a 33% reduction and restrictions allowing lawn watering 2.33 times per week resulted in a 22% reduction) (Kenney et al. 2004).

Building codes are another tool or strategy that can be employed in mitigating and preparing for drought. The use of low-flow fixtures has been identified as a technological adaptation that will result in a long-term reduction in water demand (Knutson 2008; Perry and Lindell 2006; Vickers 2005; Godschalk 2003). Incentives, such as rebates for low flow fixtures, can be developed to encourage the retrofitting of structures to include improved fixtures (FEMA 2013; FEMA 2002). In addition to codes addressing interior improvements, landscape standards can be enacted that are helpful in reducing water consumption (FEMA 2013; Schmidt and Garland 2012; Vickers 2005; FEMA 2002). Landscape standards can be used to require high-efficiency irrigation heads (Schmidt and Garland 2012; Knutson 2008), xeriscaping (FEMA 2013; Vickers 2005) and rainwater harvesting (Gupta et al. 2011; CDC 2010). Enhanced building and landscape standards represent impacts that can be made by all residents in the community, which is essential in developing a resilient community (Wardekker et al. 2010).

Reinforcing and improving infrastructure represents another area that can be addressed with specific strategies and tools. In 2000, it was estimated that water supply systems experienced 10%-20% of water loss that was unaccounted for (Lahlou 2001). This water loss was a result of water theft, unapproved users, unmetered uses (e.g., firefighting), but the most significant source of water loss was leakage (Lahou 2001). Water leakage can be addressed through the auditing of water delivery systems (Knutson 2008; Vickers 2005). There are many benefits to auditing water systems that include reduced property damages, more responsible consumption of resources, and improved public relations between public water utilities and water customers (Lahlou 2001). Water audits can be offered to homeowners as well as farms.

Public education programs are useful in addressing drought awareness and informing the public in how they can have an impact on the situation. Communities may consider developing a website that can be used to keep community members informed as the drought condition progresses or regresses (Wade 2000; Wilhite et al. 2000).

#### *Communication, Collaboration, and Coordination*

Inter-organizational coordination is a key component in defining local plan quality in the management of trans-boundary environmental hazards and disasters (Tang et al. 2008, Brody 2003b). Local hazard mitigation plans must identify who is involved in all phases of the disaster cycle (preparation, mitigation, response, and recovery). This coordination includes providing information related to vertical communication within the planning area. FEMA defines vertical integrations as "...the meshing of planning both up and down the various levels of government...the foundation for operations is at the local level and that support from Federal, state, territorial, tribal, regional, and private sector entities

is layered onto the local activities. (FEMA 2010). Additionally, we should define horizontal coordination as the integration of operations across a jurisdiction (FEMA 2010).

This horizontal and vertical integration establishes a relationship between FEMA regions as well as federal, state, and local partners that “...ensure[s] effective collaboration before, during, and after emergency operations” (FEMA 2010). This integration of plans defines roles, establishes lead agencies, assigns responsibilities, and outlines how all of the moving parts will interact and function throughout the disaster cycle.

Drought is different than other hazards and as a result should include a different group of planning experts. Research suggests that establishing a drought committee is a good idea and can be beneficial in helping communities prepare (FEMA 2013; Gupta et al. 2011; Wilhite et al. 2000). In developing drought committees it is crucial to identify important stakeholders and experts in the community that can help anticipate impacts and develop effective mitigation and response options (Fontaine et al. 2012; CDC 2010; Wilhite et al. 2000). The drought committee can be helpful in developing a list of information that is important for decision making when considering options available to communities (CDC 2010; Wilhite 2000).

Another key to collaboration is participating in drought impact reporting (Fontaine et al. 2012). The NDMC has developed the Drought Impact Reporter to help collect data related to how drought impacts both urban and rural communities (NDMC 2013). The Drought Impact Reporter acts as a database and mapping system that will increase the understanding of how drought affects communities. The Drought Impact Reporter is a

free resource to communities and serves as an aid to drought researchers and local planners.

Plan consistency is an important component of coordination, collaboration, and communication. FEMA has clearly stated that the goal is to incorporate hazard plans with other existing plans (FEMA 2013). This includes incorporating hazards plans into comprehensive plans, but also incorporating other independent plans (e.g., watershed plans, drought plans, etc.) into hazard mitigation plans. Plan integration is the building of institutional capacity and resilience (Wilhite 2000).

#### *Implementation and Monitoring*

In preparing for the threats and hazards that a community faces it is essential that planning be seen as a dynamic ongoing process rather than an exercise in writing and updating a plan every five years as required (FEMA 2008). This dynamic approach to planning should result in the ongoing monitoring of the plan as well as any changes to the planning area. As a result, plans should be adapted to meet these changing needs.

Plan reviews are mandated for FEMA approval as part of the DMA 2000; however this is not the only guide that is offered for a timeline when plans should be reviewed. FEMA recommends reviewing and updating plans after the following events: a major incident, a change in operational resources, a change in elected officials, major exercise for response plans, a change in demographics or the threat profile, a change in the acceptability of various risks and the enactment of new or amended laws and ordinances (FEMA 2010).

The assignment of responsibility and defining a timeframe for mitigation projects is important in the process of getting things accomplished (Burby et al. 1998; Nelson and

French 2002). When monitoring and addressing the ongoing effectiveness of plan components, a responsible group for implementing the outlined actions should be identified.

Drought as a component of the local hazard mitigation plan can effectively be measured using the indicators previously outlined. While FEMA does not outline specifically what hazards must be included in the planning process, each of these components identify how drought can be included in a method that meets the requirements outlined in the DMA 2000. The DMA 2000 requires an examination of the planning area, discussion related to historical events, establishing demographic and land-use trends and concerns, conducting a HIRA (hazard identification and risk assessment), and encourages the evaluation of local water sources; these components make up the factual basis component of the evaluation matrix. The DMA requires goal setting and objectives as a component of local hazard mitigation. Strategies, tools, and policies outline how a community will go about achieving the goals and objectives identified earlier in the plan; these strategies, tools, and policies provide the action items that a community will engage in to achieve resilience. Establishing and outlining stakeholders and methods of communication is essential as it outlines how the local plan is aligned with other local planning documents as well as planning at the state and federal level. The communication, coordination, and collaboration component also defines what data are needed by policy makers to ensure sound decisions are made before, during, and after drought related emergencies/disasters. Finally, the DMA requires responsible agencies and a timeframe for completion be established for the specific strategies and policies identified in the plan as well as establishing the procedure for plan updates. The five components developed for this

study are based on a review of research from recent years. As each of the five components (Table 3.1) is required through the DMA 2000, they will receive equal weight and consideration as a part of this research.

**Table 3.1 Plan Evaluation Matrix**

<b>Factual Basis</b>	<b>Goals and Objectives</b>	<b>Policies, Strategies, and Tools</b>	<b>Communication, Coordination, and Collaboration</b>	<b>Implementation and Monitoring</b>
Current trends for planning area (population, development, climate)	Reduce water consumption	Drought indicator(s) used (PDSI, Drought Monitor, Keetch-Byrum)	Participate in databases to share drought insights and experiences (Drought Impact Reporter)	Assign lead agency in drought related activities
Drought defined (meteorological, hydrological, agricultural, socioeconomic)	Increase public awareness related to drought	Agricultural adaptations	Establish drought communication plan	Timetable for implementing drought related measures
Drought History	Reduce property damage/ losses resulting from drought	Water conservation measures	Define data needs of decision makers	Identify update schedule for plan
Drought criteria defined (onset, regression)		Water reuse	Establish drought monitoring/planning board	
Drought included in Hazard Identification		Water Restrictions	Inventory of programs to assist with/ respond to drought related emergencies	
Risk/Impact assessment		Building codes	Identify consistency with regional and state level drought plans	
Establish/Define descriptive words for drought progression		Landscape standards		
Water supply identified		Infrastructure hardening		
Inventory of land use		Public education program		
		Establish early warning system for drought		

## Chapter 4: Methodology

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### *Study Sample*

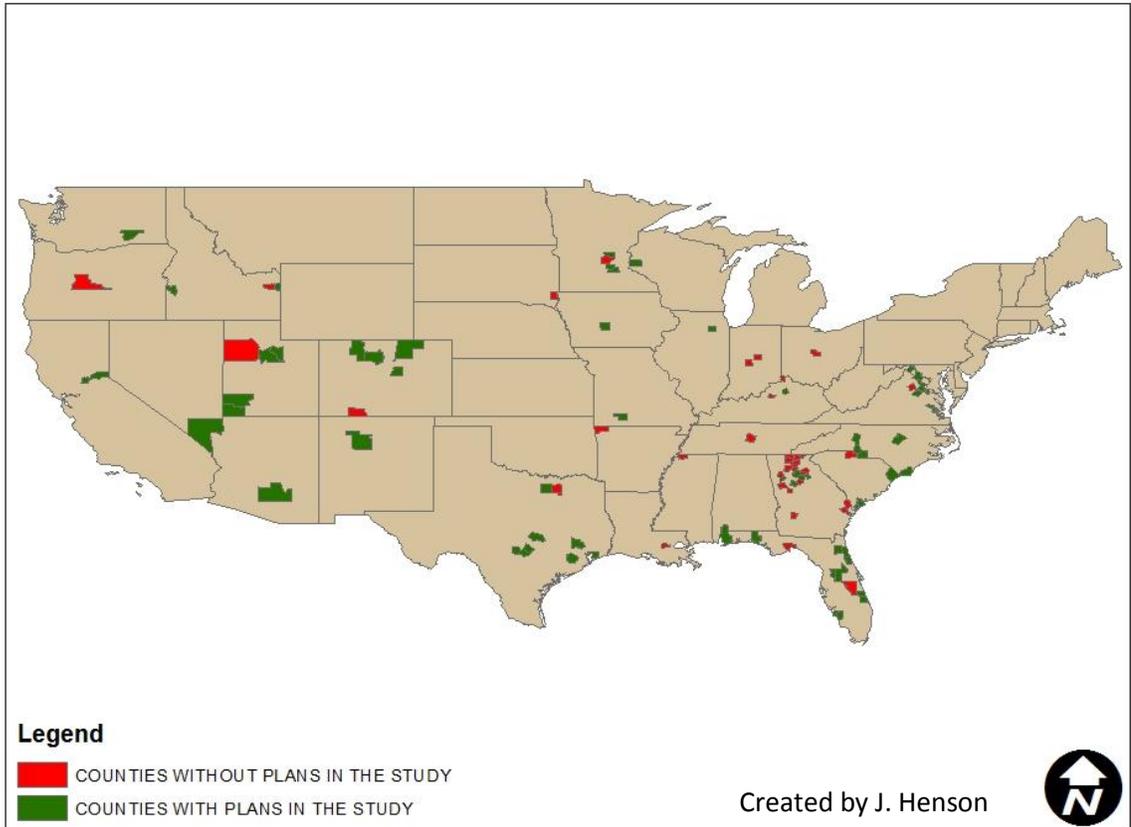
To answer the questions posed in this study, a sample was developed from the 100 fastest growing counties in the United States from 2000-2009 taken from the U.S. Census (Map #4.1). The sampling strategy is subject to plan availability. The sample consists of 62 of the 100 counties as measured by housing units in each county with a minimum of 5000 units. The counties included in the study represent 22 different states including: Alabama, Arizona, California, Colorado, Florida, Georgia, Idaho, Illinois, Iowa, Kentucky, Minnesota, Missouri, North Carolina, New Mexico, Nevada, South Carolina, Texas, Utah, Virginia, Washington, Wisconsin, and West Virginia.

Plans were collected in two stages. First, local FEMA approved Multi-Hazard Mitigation Plans were located via websites from county emergency management websites. At this stage, plans were collected in downloadable, searchable PDF format. Each county was then contacted; if no plan was available via the county website, a request was made for that county to provide their local hazard mitigation plan that was most appropriate for this study. If a plan was available for a county via their website, the local emergency management department was contacted to verify that the available plan was the most recent and accurate plan for this study. Plan collection was completed in January 2013. Every attempt was made to develop the largest possible sample with the most current and accurate information to ensure the findings are as meaningful as possible. In this process some counties stated that they chose not to share their local plans due to sensitive information contained therein. Two counties reported that their plan was currently under

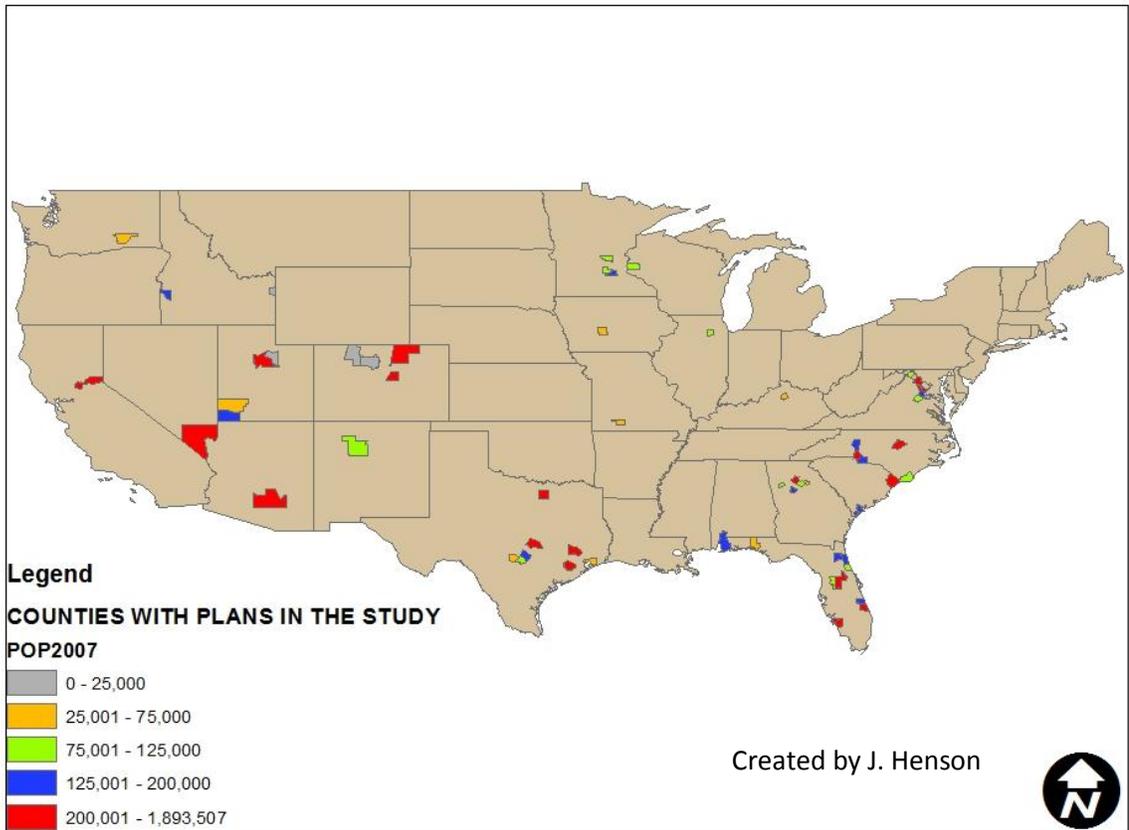
review by FEMA and was not available to the public. The remaining counties did not to respond to emails and phone calls requesting information. Some of the counties provided an Emergency Operation Plan or a portion of a plan. These plans have been removed from the study sample due to a different focus than that of a hazard mitigation plan. Emergency Operation Plans focus on response related matters rather than mitigation based efforts. As a result of these factors the final study sample total was 62 plans.

The plans for these counties are all mandated and are either approved or pending approval by FEMA as appropriate hazard mitigation plans as defined in the Disaster Mitigation Act of 2000. See Appendix A for a list of plans reviewed.

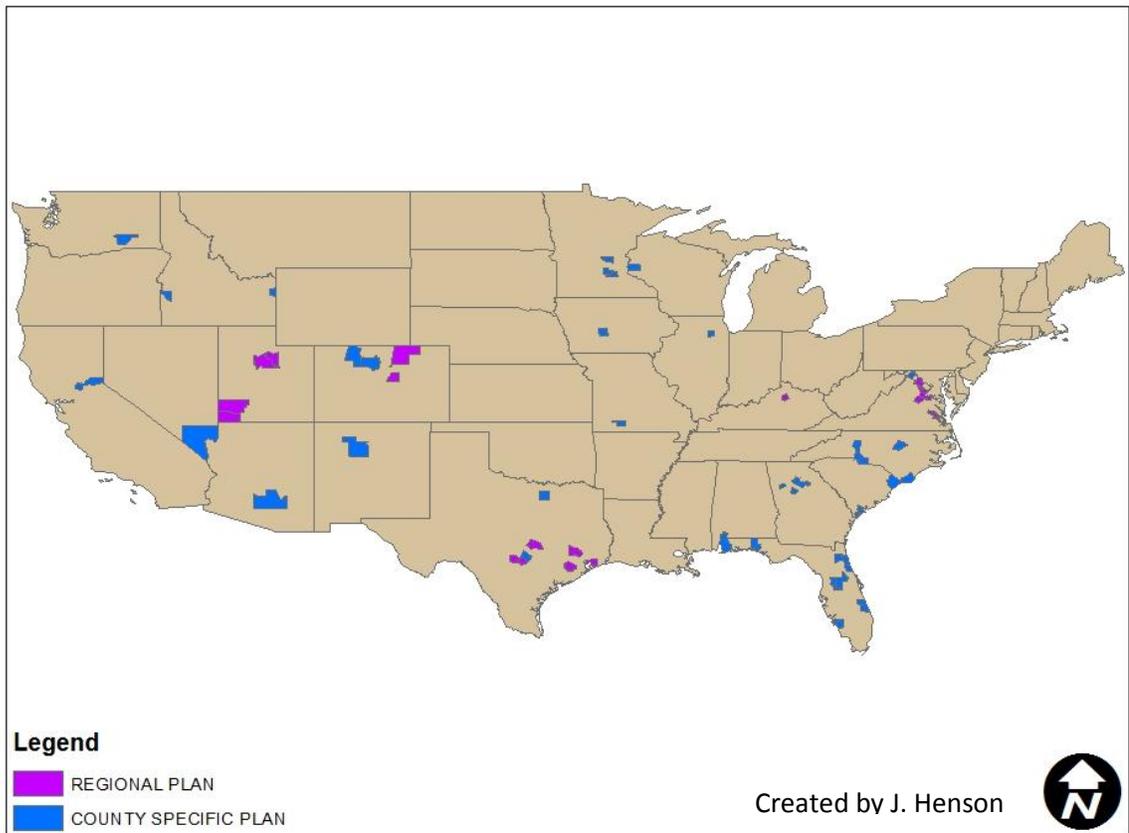
Map 4.1 Fastest Growing Counties in the U.S. 2000-2009 by Housing Units



Map 4.2 Study Sample, Counties by Population



Map 4.3 Study Sample, Counties by Plan Area



### *Coding Protocol*

The hazard mitigation plans were evaluated by reviewing the document for each of the elements outlined in Table 3.1. The indicators used are divided into five basic areas: (1) factual basis, (2) goals and objectives, (3) policies, strategies, and tools, (4) communication, coordination, and collaboration, and (5) implementation and monitoring. Within each of the areas, an indicator is scored on a scale of 0-2. A score of “0” indicates that that indicator is not included in the plan, a score of “1” means that an indicator is considered but not thoroughly, while a score of “2” means that the indicator included in the plan and is fully considered. As this is a review of drought preparedness, plans that failed to include the word “drought” a score of “0” will be given even if some non-drought specific indicators (i.e. current planning trends) are included in the document. Each of the evaluation components will receive the same weight in the scoring protocol. This is a result of each of these components being required by the criteria established in the DMA 2000.

### *Total and Component Scores*

Based on previous research (Tang et al. 2008, Brody 2003 a, b), total plan quality and plan components quality can be calculated by the following equations:

$$PC_j = \frac{10}{2m_j} \sum_{i=1}^{m_j} I_i$$

and

$$TPQ = \sum_{j=1}^5 PC_j$$

Where  $PC_j$ = quality of the  $j^{\text{th}}$  plan component (ranging 0-10);  $m_j$ = number of indicators within the  $j^{\text{th}}$  plan component;  $I_i$  represents the  $i$ th indicators score (ranging from 0-2); and TPQ= total scores of the whole plan (range 0-62).

# Chapter 5: Results

## Introduction

This section identifies the findings of the plan reviews. Each of the evaluation criteria is outlined and quantified, as well as the overall plan, providing a comprehensive and quantitative basis for the recommendation that follow.

## Total Quality and Component Quality of Local Plan

**Table 5.1 Descriptive Statistics for Plan Quality**

Plan Components <sup>a</sup>	Mean	Standard Deviation	Minimum	Maximum
Factual Basis	5.67	1.69	0	8.89
Goals and Objectives	2.98	2.84	0	10
Policies, strategies and tools	2.9	2.17	0	8
Communication, coordination, collaboration	1.35	1.4	0	6.67
Implementation and monitoring	5.77	3.18	0	10
Total <sup>b</sup>	18.57	8.96	0	34.95
<sup>a</sup> Maximum score for each component is 10				
<sup>b</sup> Max score for each plan is 50				

As Table 5.1 indicates, the mean total score for the 62 hazard management plans is 18.57 out of a total possible score of 50. Forty-two of the plans received less than half of the total points, indicating that these municipalities have not established a well-organized and thorough approach to reducing their vulnerability to future droughts. Only seven of the

plans total scores exceeded 30 of the possible 50 points. The highest overall score was 35.

Of the five plan components, implementation and monitoring received the highest score (M=5.77), meaning there are mechanisms in place to assign responsibilities for implementing the prescribed actions related to drought mitigation and preparedness as well as ongoing plan updates. Factual basis scored slightly lower (M=5.67) demonstrating a lack of understanding directly related to the drought phenomenon and its impacts. Goals and objectives scored even lower yet (M=2.98) indicating these plans have limited mechanism in place to reducing drought vulnerability. Policies, strategies, and tools received the second lowest score of all five components (M=2.90) meaning municipalities have not developed specific outcomes that will help in the reduction of drought vulnerability. Finally, communication, coordination, and collaboration received the lowest score of all (M=1.35) indicating that these plans have little or no mechanism in place to coordinate drought hazard management with other agencies.

To assess the effect of contextual factors on plan quality the component scores were compared with population size. This comparison revealed that county population appears to have little influence on plan quality. Counties with a population greater than 500,001 (eight counties) scored highest in over-all plan quality (M=20.54). Municipalities with populations between 50,001 and 100,000 (twelve counties) next highest in over-all plan quality (M=20.48) followed closely by municipalities with a population between 300,001 and 500,000 (six counties) (M=20.28). Municipalities with population between 200,001 and 300,000 (seven counties) were next highest (M=18.52) followed by communities with a population between 100,001 and 150,000 (eleven counties) (M=18.23). Finally

communities with populations between 10,000 and 50,000 (eleven counties) was second lowest (M=16.32) and communities between 150,001 and 200,000 (seven counties) scored lowest for over-all plan quality (M=15.73).

### Indicator Quality

The mean scores for the individual indicators were calculated by first evaluating the individual plans and then calculating the mean for each component. For example the mean score for Factual Basis 1.1 was first determined by calculating the component for each individual plan, while the overall mean for the indicator was then calculated for the entire study sample. The mean displayed for the individual components for each indicator in the following tables were each first calculated for every plan with a total quality mean then derived from those scores.

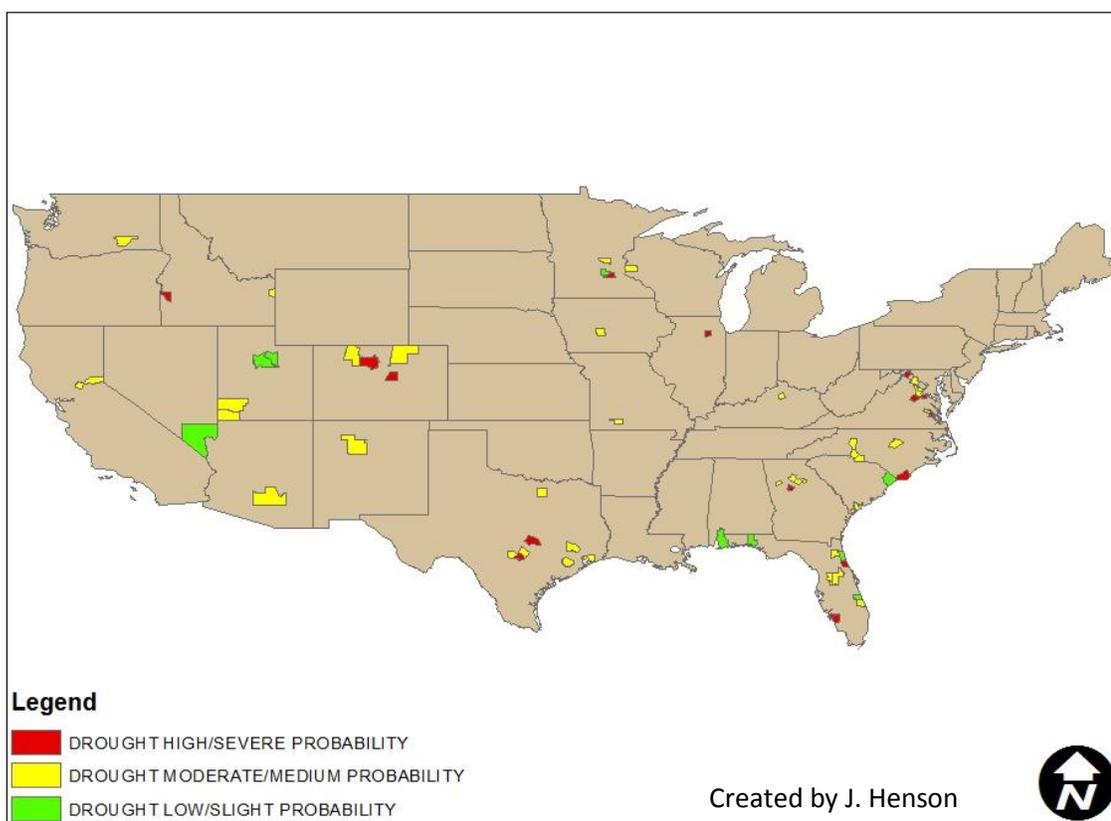
### *Factual Basis*

**Table 5.2 Descriptive Statistics for Factual Basis Component**

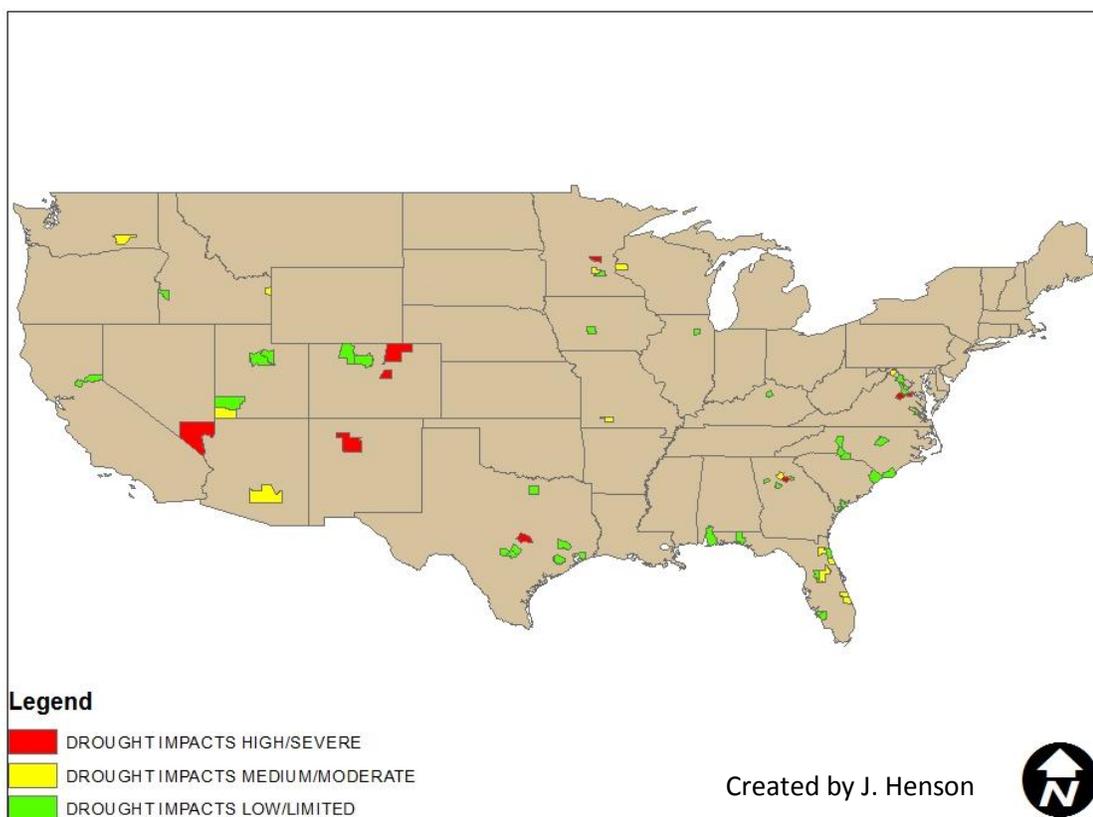
Factual Basis:	Mean	Standard Deviation	Percent of plans scoring 1 or 2
1.1 Identify trends for planning area	1.45	0.55	93%
1.2 Drought defined	1.40	0.66	85%
1.3 Historical Drought events	1.55	0.68	89%
1.4 Drought included in HIRA	1.67	0.55	95%
1.5 Risk/Impact Assessment	1.42	0.67	95%
1.6 Drought criteria established	0.37	0.48	40%
1.6a On-set criteria	0.67	0.87	40%
1.6b Regression criteria	0.04	0.19	<1%
1.7 Establish/Define descriptive words for drought progression	0.27	0.44	34%
1.8 Identify water supply	0.61	0.72	50%
1.9 Inventory of land-use	1.51	0.74	81%
Component Total Statistics (max score 10)	5.67	1.70	

The results of the indicator evaluation show that many of the plans established a solid factual basis regarding the demographic trends for the planning area. More than 93% of the plans considered the current population as well as the growth trends that are present in the study sample. 81% of the plans examined current land-uses within the planning area. When considering the historic occurrence of drought, 53% of the plans identified drought as having occurred within the past ten years, 29% identified drought as having occurred between 10 and 20 years, and 7% stated that it had been more than 20 since the last drought (11% did not report their most recent drought). 95% of plans also include drought as a part of the Hazard Identification section. Of those plans 19% consider drought to be highly or moderately highly likely to occur in the planning area in the future, 61% of those plans consider future droughts to be likely or somewhat likely, and 15% consider drought occurrence to be unlikely (Map 5.1). 95% of the plans also consider the risks and potential impacts that future droughts could have on the planning area. Of the plans that analyzed drought vulnerability 16% of the plans considered the threat of drought impacts to be high or moderately high for the planning area, 24% of the plans identified moderate impacts likely during/after drought, and 55% of the plans defined the likely level of drought impacts as low to moderately low for their planning area (Map 5.2). 40% of plans identified criteria for determining the on-set of drought while less than one percent of the plans identified any criteria for the regression of a drought. 34% of the plans provided terminology for classifying drought progression (i.e. drought advisory, alert, emergency, etc).

Map 5.1 Drought Probability Reported in Plans



**Map 5.2 Likely Levels of Drought Impacts Reported in Plans**



## Goals and Objectives

**Table 5.3 Descriptive Statistics for Goals and Objectives Component**

Goals and Objectives	Mean	Standard Deviation	Percent of plans scoring 1 or 2
2.1 Reduce water consumption	0.47	0.74	32%
2.2 Increase public awareness about drought and water supply	0.77	0.84	53%
2.3 Reduce property damage/losses resulting from drought	0.54	0.79	50%
Component Total Statistic (Max score 10)	2.98	0.28	

In the goal and objectives component 50% of the plans set or mentioned a goal related to reducing property damages that result from drought. 53% of the plans mentioned goals related to educating the public about the threat of drought or other water supply related issues. Only 32% of the plans identified reduced water consumption or water conservation as a goal or objective.

## Policies, Strategies, and Tools

**Table 5.4 Descriptive Statistics for Strategies, Tools, and Policy Component**

Strategies, Tools and Policies	Mean	Standard Deviation	Percent of plans scoring 1 or 2
3.1 Drought indicator used	1.27	0.80	81%
3.2 Establish early warning system	0.33	0.62	24%
3.3 Agricultural Adaptations	0.31	0.66	21%
3.4 Water Conservation	0.71	0.83	44%
3.5 Water Reuse	0.35	0.73	21%
3.6 Water Restrictions	0.33	0.61	29%
3.7 Building Codes	0.42	0.71	27%
3.7 Landscape Standards	0.49	0.81	29%
3.8 Infrastructure Hardening	0.71	0.94	40%
3.9 Establish an Education Program	0.93	0.89	60%
Component Total Statistics (Max score 10)	2.90	0.22	

The policy, strategies, and tools section covers a wide range of options and represent the component with the most indicators. Due to the slow onset nature of drought it is important to have an early monitoring process to help protect a community from drought impacts. Early warning systems consist of monitoring rainfall, snowpack, stream flow, soil moisture, and reservoir levels. Of the 62 plans reviewed, 24% contained early warning components. It is also beneficial for communities and planners to use one of the indices available for drought monitoring, including the Palmer Drought Severity Index (PDSI), the National Drought Monitor, the Keetch-Byram Drought Index, and National Drought Outlook. 81% of the plans identified one of these tools as a resource.

This component also examined the specific tools and strategies that counties use to mitigate and prepare for drought. The most common approach for counties to prepare for drought was establishing some sort of public education program directed at increasing awareness of the drought threat. 60% of plans mentioned drought education as a strategy for decreasing drought vulnerability. 29% of plans identified providing written information about the threat of drought and potential impacts in for the planning area. Additionally 21% of plans identified conducting public education workshops to educate residents. 10% of plans identified the use or development of a website for disseminating drought related information.

To achieve the goal of water conservation, 23% of the plans identified incentives for voluntary water conservation measures while 13% of the plans cited the use of a water conservation pricing structure. 52% of the plans mentioned infrastructure hardening to

develop a drought resilient community. Specific strategies that were identified include: 11% of the plans wished to identify an additional water source such as creating a reservoir or purchasing additional water credits, 16% of the counties planned to audit the existing water system to identify leaks or other needed repairs, 6% of counties planned to offer water system audits to private residents and business, while 5% of the plans identified the need to dig deeper wells to ensure sufficient water supply.

The use of building codes represents another group of strategies that were often cited in the plans. 27% of the plans at least mentioned the use of building codes as a mechanism to reduce the demand on the water supply. 8% of the plans specified the use of low-flow fixtures in newly built structures as a method of increasing water conservation.

Landscape standards were also identified by 29% of the plans as a method of demand reduction. The use of xeriscaping was the strategy most commonly identified, represented in 18% of plans. Landscape irrigation standards were also identified by 13% of the plans. Agricultural adaptations were at least mentioned in 24% of plans. The most common recommendation for the agricultural sector was purchasing crop insurance, indicated in 9% of plans, while agricultural irrigation standards were also identified by 15% of the plans. Adaptive cultivation practices (3%), water pumps to increase rural water supply (3%), and water hauling programs for livestock (1%) were also included as strategies.

29% of the plans identified water restrictions as a policy for use during a drought though specific details were not included. Finally, 21% of plans identified water reuse or recycling as a strategy to be employed. Specifically, 13% of plans recommended the use of water harvesting systems (i.e. rain barrels, stormwater absorption, etc.) and 5% of

plans required water intensive business (i.e. carwashes, golf courses) to implement water recycling programs.

### *Communication, Coordination, and Collaboration*

**Table 5.5 Descriptive Statistics for Communication, Coordination, and Collaboration Component**

Communication, Coordination, and Collaboration	Mean	Standard Deviation	Percent of plans scoring 1 or 2
4.1 Participate in database to share drought insight and experiences	0.00	0.00	0%
4.2 Establish drought communication plan	0.37	0.55	32%
4.3 Define data needs for decision makers	0.04	0.19	3%
4.4 Establish drought monitoring/planning board	0.25	0.62	18%
4.5 Provide inventory of programs to assist with/respond to drought	0.11	0.33	13%
4.6 Identify consistency with regional or state level drought plans	0.86	0.88	47%
Component Total Statistic (Max score 10)	1.35	0.14	

The communication, coordination, and collaboration component was the lowest scoring component of the five. 47% of the 62 plans identified other drought planning documents (i.e. state drought plans) and 18% of the plans identified a drought related planning body. In addition 32% of the plans identified other agencies, vertical or horizontal, that would be consulted or included in drought related communication before, during, or after the occurrence of a drought. 13% of plans identified programs aimed at assisting community members with drought related issues; of these the most common resource identified was that of the USDA for agricultural needs. Most surprising was the fact the zero plans indicated the use of or intent to contribute to databases aimed at tracking drought impacts, such as the Drought Impact Reporter at the NDMC.

### *Implementation and Monitoring*

**Table 5.6 Descriptive Statistics for Implementation and Monitoring Component**

Implementation and Monitoring	Mean	Standard Deviation	Percent of plans scoring 1 or 2
5.1 Assign lead agency for drought related activities	0.99	0.92	63%
5.2 Establish timetable for implementing drought related measures	0.67	0.86	53%
5.3 Identify schedule for plan updates	1.80	0.52	97%
Component Total Statistic (Max score 10)	5.77	0.32	

Finally the implementation and monitoring component, which received the highest overall scores of any of the components measured. This component consisted of three indicators, 97% of the plans discussed the need and schedule for future updates. 63% of plans identified a lead agency for the implementation of drought related issues, and 53% of the plans identified a timeframe for implementing the prescribed actions.

## Chapter 6: Conclusions

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Regarding the first question (“To what extent do local hazard management plans effectively address drought risk?”), the results indicate an overall low quality for the drought component of the local hazard mitigation plans examined. The low scores for each of the five components used reinforce this finding. For the second question (“What are the plan components and indicators that receive the most attention?”), the results indicate that these counties plans were strongest in establishing mechanisms to implement and monitor progress of established goals (M=5.77); these counties were somewhat weaker in developing a factual basis (M=5.67); weaker still in establishing goals and objectives (M=2.98) as well as identifying policies, strategies, and tools (M=2.9); and weakest in the area of developing communication, coordination, and collaborative mechanism (M=1.35). Regarding the third question (“Do local drought planning efforts rely on traditional crisis management techniques or have more adaptive risk management measures been incorporated into the planning approaches?”), the results show that the use of water conservation, building codes, infrastructure hardening, landscape standards, and public education have surpassed the reliance on water restrictions and crop insurance as preferred approaches.

The findings in this study suggest that hazard mitigation plans employ both risk management tools as well as using the crisis management tools, which is in contrast to previous study results examining local drought plans (Shepherd 1998). This deviation is tempered, however, due to the overall low scores related to goals and objectives as well as specific policies, strategies, and tools. Shepherd’s 1998 study examined local plans

specifically developed for drought rather than hazard mitigation plans. It is hoped that the trend identified in this study of increased use of risk management will continue to be better incorporated into future plans, rather than reverting to reliance on traditional approach of crisis management, which leaves communities less prepared and more vulnerable to drought impacts.

This study makes a small but significant contribution to the theories of hazard planning by developing a model of how to incorporate drought into local hazard plans. First, this study adds to the theory of rational planning by incorporating drought preparedness and management into local hazard plans, to date this topic has received little attention. This study also provides a model to assist local hazard planners in the development of drought specific components for already existing hazard plans. By gaining an understanding of planning deficits, policy makers and planners can increase effectiveness in developing more resilient communities. The research conducted for this study provides insight to local hazard mitigation plans and the tools currently being employed by hazard planners. Specifically drought components of local hazard mitigation plans should address the five components identified in this study - factual basis; goals and objectives; policies, strategies, and tools; communication, coordination, and collaboration; and implementation and monitoring.

Specifically, jurisdictions must first improve the factual basis for their local hazard management plans. Most plans reviewed provided definitions for drought; these definitions were primarily standard definitions rather than being established specifically or the plan area. Local hazard mitigation plans should define drought based on local characteristics rather than simply employing a generic definition. Likewise, most plans

currently identify drought in the Hazard Identification and Risk Assessment (HIRA) section of the plan, it is important to go beyond a basic identification and examine local manifestations and impacts beyond those in the agricultural sector. Establishing needed terminology and criteria specific to their local setting creates a level of preparedness that was lacking in all plans. Multiple indices are available to assist in drought monitoring (PDSI, United States Drought Monitor, and National Drought Outlook). At this time the USDA employs the United States Drought Monitor in determining eligibility for drought assistance. Communities should evaluate the drought monitoring tools that are available and select the most appropriate mechanism for their community. The selected drought monitoring tool can then be combined with the locally defined triggers to establish a more comprehensive and better defined drought response mechanism.

Second, it is important that local hazard management plans identify drought specific goals. The nature of drought, slow onset and potentially widespread impacts, are different than nearly all other hazards. Many of the plans stated that drought poses little threat to life and structures with most potential harm residing in agricultural impacts. This view of drought may result in identifying communities without agricultural sectors, as having a low vulnerability to drought impacts. The reality is while drought does have significant direct impacts on the agricultural sector there are a number of direct impacts that can affect urban areas as well. These direct urban impacts include reduced water supply, stressing of infrastructure, increased litigation related to disputed water supplies, and loss of local businesses (lawn and landscape, nurseries, carwashes, golf course, etc.). Drought can result in many secondary or indirect losses in addition to the direct drought losses. These secondary or indirect impacts may include: loss of tourism, loss of tax

revenues, loss of recreational activities, increased demand and cost for legal services, decreased food supply and elevated food cost, and the list goes on. With the severity of the drought of 2012, this study suggests there will be a window of opportunity for municipalities to develop and implement goals and objectives specific to reducing drought vulnerability and developing more drought resilient communities.

Third, municipalities should continue to use a risk management approach to planning for drought. It is important to take a holistic approach to drought planning rather than relying on reactive policies, strategies, and tools to ease the pain resulting from drought. Municipalities should use all tools available to manage their drought vulnerability. This includes risk management strategies such as: incentives for water conservation, auditing water systems to reduce waste and leaks, adaptive agricultural practices, and broad based public education programs to inform citizens about what they can do related to drought. Municipalities should also have policies and procedures in place for responding to drought when it occurs. Establishing terminology for communicating with the public helps to reduce confusion related to drought measures. Communities should also have formal procedures and plans in place outlining when, where and how water restrictions will be employed as well as potential repercussions for failure to comply with said restrictions.

Fourth, local hazard planners should seek to develop a more comprehensive approach to communication and collaboration with other drought planning entities. At this time many communities already have a Local Emergency Board established by the USDA's Farm Service Agencies (FSA). These Local Emergency Boards are responsible for monitoring weather related phenomenon that impact agriculture at the local level including drought.

Water planning districts are also active in developing water conservation plans. In addition to these groups local planners help guide the growth of the community through the development of local comprehensive and land-use plans. Each of these groups possesses skills that can be used to develop a comprehensive drought preparedness plan. It is essential that hazard planners work with a broad base of planning professionals. It is possible that much of the work that needs to be done for drought preparedness can be found in existing plans; it is just fragmented at this time. One of the greatest skills of emergency managers is the ability to coordinate large and diverse groups of people; this skill should be applied to drought planning as it has previously been done in other areas. In addition to collaborating with other planning bodies, local hazard mitigation plans should consult regional and state level planning documents related to drought preparedness. Many local comprehensive plans contain specific strategies that that can be used to address drought, as can water conservation plans for regional water supply districts. FEMA has recently reiterated the importance of incorporating a holistic planning approach; this consists of incorporating the various plans developed for a community. Local hazard mitigation plans should be incorporated into local comprehensive plans and vice versa.

In addition to modifying how drought is planned for changes need to be made in how drought response is conducted. Communities should also plan to participate in drought impact reporting via services/programs like NDMC's Drought Impact Reporter. As more communities participate in reporting drought impacts, we will develop a better understanding of drought manifestations as well as establishing more accurate data related to drought losses.

Since drought is identified in and is a part of the Stafford Act, it is important that the principles of the National Incident Management System (NIMS) be applied to it. Included in this is the use of the Incident Command System (ICS) as dictated by Homeland Security Presidential Directive 5 (HSPD 5). The policies of HSPD 5 were established to provide the foundation for prevention, preparation, response and recover from major disasters. ICS should be used when a disaster necessitates the involvement of multiple jurisdictions, multiple agencies, and/or multiple layers of government. ICS proved a systematic approach to how and who manages an event. ICS is designed so it can be employed at the local, state, or federal level.

### *Limitations*

As is the case with all research, there are some limitations in this study. The primary limitation is the availability of hazard mitigation plans. 38 of the 100 fastest growing counties did not make their hazard management plans available. The use of the scoring protocol also introduces a potential personal bias by allowing for interpretation using the 0, 1, 2 score mechanism. While consistency was a goal in plan evaluation, it is possible that personal bias could have influenced the scoring of individual plans. The use of multiple plan evaluators could have reduced this potential personal bias but that was not possible for this project.

There is certainly a need to continue the analysis of local drought preparedness. Studies should be conducted to examine what contributions are being made related to local comprehensive plans as well as regional water districts. By examining all local planning bodies' contribution, a comprehensive picture will begin to develop. In addition, this

study provides a snapshot of current planning. Local hazard plans are mandated to be updated every five years by the DMA of 2000. It will be interesting to see how the drought events of 2011 and 2012 will impact drought planning.

## Bibliography:

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- Abraham, Justin. "Water Main Breaks Increasing." Accessed March 02, 2013.  
<http://www.abc17news.com/news.php?id=7247>.
- Bea, Keith. "Federal Stafford Act Disaster Assistance: Presidential Declarations, Eligible Activities, and Funding." Library of Congress Washington DC Congressional Research Services, 2010.
- Berke, Philip R., and Steven P. French. "The influence of state planning mandates on local plan quality." *Journal of Planning Education and Research* 13, no. 4 (1994): 237-250.
- Berke, Philip R., and Thomas J. Campanella. "Planning for postdisaster resiliency." *The Annals of the American Academy of Political and Social Science* 604, no. 1 (2006): 192-207.
- Brody, Samuel D. "Are We Learning to Make Better Plans?: A Longitudinal Analysis of Plan Quality Associated with Natural Hazards." *Journal of Planning Education and Research* 23, no. 2 (2003a): 191-201.
- Brody, Samuel D. "Implementing the Principles of Ecosystem Management through Local Land Use Planning." *Popular Environment* 24, no. 6 (2003b): 511-40.
- Burby, Raymond J. "Have State Comprehensive Planning Mandates Reduced Insured Losses from Natural Disasters?" *Natural Hazard Reviews* 6, no. 2 (2005): 67-81.
- Burby, Raymond J., and Linda C. Dalton. "Plans can matter! The role of land use plans and state planning mandates in limiting the development of hazardous areas." *Public Administration Review* (1994): 229-238
- Burby, Raymond J., Robert E. Deyle, David R. Godschalk, and Robert B. Olshansky. "Creating Hazard Resilient Communities through Land-Use Planning." *Natural Hazards Review* 1, no. 2 (May/June 2000): 99.
- Burby, Raymond J., Timothy Beatley, Philip R. Berke, Robert E. Deyle, Steven P. French, David R. Godschalk, Edward J. Kaiser. "Unleashing the power of planning to create disaster-resilient communities." *Journal of the American Planning Association* 65, no. 3 (1999): 247-258
- Cohrssen, John J., and Vincent T. Covello. *Risk analysis: a guide to principles and methods for analyzing health and environmental risks*. DIANE Publishing, 1999.
- Center for Disease Control (CDC). *When Every Drop Counts Protecting Public Health during Drought Conditions : A Guide for Public Health Professionals*. [Atlanta,

GA]: National Center for Environmental Health, Division of Emergency and Environmental Health Services, Centers for Disease Control and Prevention, 2010.

Centre for Research on the Epidemiology of Disasters (CRED). "International Disaster Database." Accessed February 24, 2013. <http://www.cred.be/projects>.

Deyle, Robert E., Steven P. French, Robert B. Olshansky, and Robert G. Paterson. "Hazard assessment: The factual basis for planning and mitigation." *Cooperating with nature: confronting natural hazards and land use planning for sustainable communities* (1998): 119-166.

*Disaster Mitigation Act of 2000, Public Law 106-390*. Washington, D.C.: 2000.

Federal Emergency Management Agency (FEMA). *Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards*. [Washington, D.C.]: Dept. of Homeland Security (2013).

Federal Emergency Management Agency (FEMA) . *Local Multi-Hazard Mitigation Planning Guidance*. [Washington, D.C.]: Dept. of Homeland Security (2008).

Federal Emergency Management Agency (FEMA). *Mitigation Ideas: Possible Mitigation Measures by Hazard Type*. [Washington, D.C.]: Dept. of Homeland Security (2002).

Federal Emergency Management Agency (FEMA). *Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards*. [Washington, D.C.]: Dept. of Homeland Security (2013).

Federal Emergency Management Agency (FEMA). *National Mitigation Strategy: Partnerships for Building Safer Communities* . [Washington, D.C.]: Dept. of Homeland Security (1995).

Fontaine, Matthew M., Anne C. Steinemann, and Michael J. Hayes. "State Drought Programs and Plans: Survey of the Western US." *Natural Hazards Review* (2012).

Frederick, J. and B. Stacey. *Economic Watch US: Texas Drought Impacts*. *BBVA Research*, Houston TX (2011).

Fogler, P., B. Cody, and N. Carter. "Drought in the United States: Cause and Issues for Congress." [Washington, D.C]: Congressional Research Service, 2012.

Geringer, Jim. "The Future of Drought Management in the States." *Spectrum: The Journal of State Government*, Summer 2003, 23-28.

Girlich, William J. "66 Million Trees Expected to Die in the Houston Area: City's

Canopy Will Never Look the Same." CultureMap Houston. September 1, 2011. Accessed March 02, 2013. <http://houston.culturemap.com/newsdetail/09-01-11-more-than-66-million-trees-expected-to-die-in-the-houston-area-city-canopy-will-never-look-the-same/>.

Godschalk, David R. "Urban hazard mitigation: Creating resilient cities." *Natural Hazards Review* 4, no. 3 (2003): 136-143.

Godschalk, David R., Edward J. Kaiser, and Philip R. Berke. "Integrating hazard mitigation and local land use planning." *Cooperating with nature: Confronting natural hazards with land-use planning for sustainable communities* (1998): 85-118.

Gupta, Anil K., Pallavee Tyagi, and Vinay K. Sehgal. "Drought disaster challenges and mitigation in India: strategic appraisal." *Curr Sci* 100 (2011): 1795-1806.

Hayes, Michael J., Olga V. Wilhelmi, and Cody L. Knutson. "Reducing drought risk: bridging theory and practice." *Natural Hazards Review* 5, no. 2 (2004): 106-113.

Jimenez, Stephen and Amanda Jimenez. "Catastrophic Drought Highlights Inherent Weakness within the U.S. System of Emergency Management: A Need for Presidential Action." (2011)

Keen, Judy. "Drought of 2012: Misery in the Midwest." *USA Today*. September 20, 2012. Accessed March 02, 2013. <http://usatoday30.usatoday.com/news/nation/story/2012-09-20/midwest-drought-homes/57813692/1>.

Kenney, Douglas S., Roberta A. Klein, and Martyn P. Clark. "Use and Effectiveness of Municipal Water Restrictions during Drought in Colorado." *Journal of the American Water Resources Association* 40, no. 1 (2004): 77-87.

Knutson, C. L. "The Role of Water Conservation in Drought Planning." *Journal of Soil and Water Conservation* 63, no. 5 (September/October, 2008): 154A-60A.

Knutson, C., M. Hayes, and T. Phillips. "How to reduce drought risk. A guide prepared by the preparedness and mitigation working group of the Western Drought Coordination Council. National Drought Mitigation Center, Lincoln, Nebraska." *drought.unl.edu/plan/handbook/risk.pdf* (1998).

Lahlou, Zacharia M. "Leak detection and water loss control." *Water Encyclopedia* (2001).

Lohani, V. K., and G. V. Loganathan. "An Early Warning System for Drought Management Using The Palmer Drought Index." *Journal of the American Water Resources Association* 33, no. 6 (1997): 1375-386.

- National Drought Mitigation Center (NDMC). "Current U.S. Drought Monitor." US Drought Monitor. Accessed March 02, 2013. <http://droughtmonitor.unl.edu/>.
- National Drought Mitigation Center (NDMC). "Drought Planning Resources, by State." Drought Planning Resources, by State 2010. Accessed March 02, 2013. <http://www.drought.unl.edu/Planning/PlanningInfobyState.aspx>.
- Newkirk, Ross T. "The increasing cost of disasters in developed countries: A challenge to local planning and government." *Journal of Contingencies and Crisis Management* 9, no. 3 (2001): 159-170.
- Nelson, Arthur C., and Steven P. French. "Plan Quality and Mitigating Damage from Natural Disasters: A Case Study of the Northridge Earthquake with Planning Policy Considerations." *Journal of the American Planning Association* 68, no. 2 (2002): 194-207.
- NOAA. "Drought: Public Fact Sheet." May 2008. Accessed March 2, 2013. <http://www.nws.noaa.gov/om/brochures/climate/DroughtPublic2.pdf>.
- Paton, Douglas F. *Community resilience: integrating hazard management and community engagement*. School of Psychology, Launceston, 2005.
- Pearce, Laurie. "Disaster Management and Community Planning and Public Participation: How to Achieve Sustainable Hazard Mitigation." *Natural Hazard* 28, no. 2 (2003): 211-228
- Perry, Ronald W., and Michael K. Lindell. "Preparedness for Emergency Response: Guidelines for the Emergency Planning Process." *Disasters* 27, no. 4 (2003): 336-350.
- Robert T. Stafford Relief and Emergency Assistance Act, Public Law 93-288, as amended, 52 U.S.C. 5121-5207, and Related Authorities*. Washington, D.C.: 2007.
- Rockstrom, J. "Resilience Building and Water Demand Management for Drought Mitigation." *Physics and Chemistry of the Earth, Parts A/B/C* 28, no. 20-27 (2003): 869-877.
- Salter, Jim. "U.S. Homes Cracking Due to Drought-parched Soil | Timesfreepress.com." U.S. Homes Cracking Due to Drought-parched Soil | Timesfreepress.com. August 31, 2012. Accessed March 02, 2013. <http://www.timesfreepress.com/news/2012/sep/01/us-homes-cracking-due-drought-parched-soil/?print>.
- Schmidt, Deanna H., and Kathleen A. Garland. "Bone Dry in Texas: Resilience to

Drought on the Upper Texas Gulf Coast." *Journal of Planning Literature*, January 2012, 1-12.

Schwab, James and Kenneth Topping. "Hazard Mitigation: An Essential Role for Planners." In *Hazard Mitigation: Integrating Best Practices into Planning*, edited by James Schwab, 1-14. Chicago: American Planning Association, 2010.

Shepherd, Anne. "Drought Contingency Planning: Evaluating the Effectiveness of Plans." *Journal of Water Resources Planning and Management* 124, no. 5 (1998): 246-251.

Steinemann, Anne C., and Luiz F. N. Cavalcanti. "Developing Multiple Indicators and Triggers for Drought Plans." *Journal of Water Resources Planning and Management* 132, no. 3 (May/June 2006): 164-174.

Steinemann, Anne C., Michael J. Hayes, and L.F.N. Cavalcanti. "Drought Indicators and Triggers." *Drought and Water Crises: Science, Technology, And Management Issues* 86 (2005): 71.

Subcommittee on Disaster Reduction (SDR). "Grand Challenges for Disaster Reduction." [Washington D.C.]: National Science and Technology Council. Committee on Environmental and Natural Resources, 2005.

Tang, Zhenghong, Michael K. Lindell, Carla S. Prater, and Samuel D. Brody. "Measuring Tsunami Planning Capacity on U.S. Pacific Coast." *Natural Hazards Review* 9, no. 2 (2008): 91-100.

Tannehill, Ivan Ray. "Drought, its causes and effects." *Soil Science* 64, no. 1 (1947): 83.

"Texas Water Resources Institute." 2011 Ag Losses. Accessed February 25, 2013. <http://twri.tamu.edu/publications/drought/2012/march/2011-ag-losses/>.

Tobin, Graham A. "Sustainability and Community Resilience: The Holy Grail of Hazard Planning?" *Global Environmental Change Part B: Environmental Hazards* 1, no. 1 (1999): 13-25.

Vickers, Amy. "Managing Demand: Water Conservation as a Drought Mitigation Tool." In *Drought and Water Crisis: Science, Technology, and Management Issues*, edited by Donald A. Wilhite. New York: Dekker/CRC Press, 2005.

Wade, Beth. *Tapping into Water Shortage Solutions*. American City & County, 2000.

Wardekker, J. Arjan, Arie de Jong, Joost M. Knoop, and Jeroen P. van der Sluijs. "Operationalising a Resilience Approach to Adapting an Urban Delta to Untertain Climate Changes." *Technological Forecasting and Social Change* 77, np. 6 (2010): 987-998.

- Wear, Ben. "Drought Causes \$30 Million in Damage to Texas 130 Toll-way under Construction." 2012. Accessed March 02, 2013.  
<http://www.statesman.com/news/news/local/drought-causes-30-million-in-damage-to-texas-130-1/nRp94/>.
- Wilhelmi, Olga V., and Donald A. Wilhite. "Assessing vulnerability to agricultural drought: a Nebraska case study." *Natural Hazards* 25, no. 1 (2002): 37-58.
- Wilhite, D. A., and C. L. Knutson. "Drought management planning: conditions for success." *Options Mediterraneennes Series A* 80 (2008): 141-148.
- Wilhite, Donald A., Mark D. Svoboda, and Michael J. Hayes. "Understanding the Complex Impacts of Drought: A Key to Enhancing Drought Mitigation and Preparedness." *Water Resources Management* 21, no. 5 (2007): 763-774.
- Wilhite, Donald A. and Margie Buchanan-Smith. "Drought as Hazard: Understanding the Natural and Social Context." *Drought and Water Crisis* (2005): 1.
- Wilhite, Donald A. "Drought Preparedness and Response in the Context of Sub-Saharan Africa." *Journal of Contingencies and Crisis Management* 8, no. 2 (June 2000): 81-92.
- Wilhite, Donald A. and Mark D. Svoboda. "Drought Early Warning Systems in the Context of Drought Preparedness and Mitigation." *Early Warning Systems for Drought Preparedness and Drought Management* (2000): 1-21.
- Wilhite, Donald A., Michael J. Hayes, Cody Knutson, and Kelly Helm Smith. "Planning For Drought: Moving From Crisis To Risk Management." *Journal of the American Water Resources Association* 36, no. 4 (2000): 697-710.
- Wilhite, Donald A. "Drought Planning: A Process For State Government." *Journal of the American Water Resources Association* 27, no. 1 (1991): 29-38.
- Wilhite, Donald A., and Michael H. Glantz. "Understanding: The Drought Phenomenon: The Role of Definitions." *Water International* 10, no. 3 (1985): 111-120.

## Appendix A: Plans by County and Name

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<b>County Name</b>	<b>2010 Pop</b>	<b>Plan Name</b>	<b>Plan Date</b>
Flagler County, FL	95,696	Flagler County Local Mitigation Strategies	2011
Sumter County, FL	93,420	Sumter County Local Mitigation Strategies	2010
Teton County, ID	10,170	Teton County Multi-Jurisdictional All Hazard Mitigation Plan	2008
Pinal County, AZ	375,770	Pinal County Multi-Jurisdictional Hazard Mitigation Plan	2010
Kendall County, IL	114,736	Kendall County Multi-Hazard Mitigation Plan	2011
Henry County, GA	203,922	Henry County Hazard Mitigation Plan	2008
Loudoun County, VA	312,311	Northern Virginia Hazard Mitigation Plan	2010
Douglas County, CO	285,465	Denver Regional Natural Hazard Mitigation Plan	2010
Williamson County, TX	422,679	Texas Colorado River Floodplain Coalition Multi-Jurisdictional Hazard Mitigation Plan Update	2011
Washington County, UT	138,115	Five County Association of Government Natural Hazard Mitigation Plan	2010
Union County, NC	208,292	Union County Multi-Jurisdictional Hazard Mitigation Plan	2013
Brunswick County, NC	107,431	Brunswick County Multi-Jurisdictional Hazard Mitigation Plan	2011
Wasatch County, UT	23,705	Mountain Association of Governments Pre-Disaster Hazard Mitigation Plan	2010
Broomfield County, CO	55,889	Denver Regional Natural Hazard Mitigation Plan	2010
Hays County, TX	157,107	Hays County Hazard Mitigation Plan Update	2011
St. John's County, FL	190,039	St. John's County Local Mitigation Strategies	
Lee County, FL	618,754	Lee County Master Mitigation Plan	2007

Montgomery County, TX	455,746	Houston-Galveston Area Council Regional Hazard Mitigation Plan	2011
Scott County, MN	47,173	Scott County Hazard Mitigation Plan	2009
Dallas County, IA	66,135	Dallas County Multi-Jurisdictional Hazard Mitigation Plan <b>FINAL DRAFT</b>	2012
Clark County, NV	1,951,269	Clark County Multi-Jurisdictional Hazard Mitigation Plan	2005
St. Lucie County, FL	277,789	St. Lucie County Local Mitigation Strategies	2010
Walton County, FL	55,043	Walton County (Florida) Hazard Mitigation Plan	2010
Comal County, TX	108,472	Alamo Area Council of Governments Regional Mitigation Action Plan Update <b>FINAL DRAFT</b>	2012
Franklin County, WA	78,163	Franklin County Hazard Mitigation Plan	2011
Sandoval County, NM	131,561	Sandoval County Hazard mitigation Plan	2004
Walton County, GA	83,768	Walton County Multi-Jurisdictional Hazard Mitigation Plan	2009
Horry County, SC	270,430	Horry County All-Hazard Mitigation Plan	2006
Canyon County, ID	188,923	Canyon County All Hazard Mitigation Plan	2006
Kendall County, TX	33,410	Guadalupe Basin Hazard Mitigation Action Plan	2011
Douglas County, GA	132,403	Douglas County Multi-Jurisdictional Hazard Mitigation Plan <b>FINAL DRAFT</b>	2013
Weld County, CO	252,825	Northeastern Colorado Regional Hazard Mitigation Plan	2009
Baldwin County, AL	182,265	Baldwin County Multi-Hazard Mitigation Plan	2010
Grand County, CO	14,843	Grand County Multi-Jurisdictional All-Hazard Pre-Disaster Mitigation Plan	2008
Lake County, FL	297,052	Lake County Local Mitigation Strategies Multi-Jurisdictional Plan	2010
Mecklenburg County, NC	923,427	Mecklenburg County Hazard Mitigation Plan Update	2010
Christian County, MO	77,422	Christian County Multi-Jurisdictional Natural Hazard Mitigation Plan	2011
New Kent County, VA	18,429	Richmond Regional Hazard Mitigation Plan	2011

Prince William County, VA	406,110	Northern Virginia Hazard Mitigation Plan	2010
Fort Bend County, TX	590,350	Houston-Galveston Area Council Regional Hazard Mitigation Plan	2011
Sherburne County, MN	88,499	Shelburne County Hazard Mitigation Plan <b>PENDING APPROVAL</b>	2012
Beaufort County, SC	162,989	Beaufort County Hazard Mitigation Plan	2011
Wake County, NC	906,969	Wake County Hazard Mitigation Plan	2009
James City County, VA	67,237	Peninsula Multi-Jurisdictional Natural Hazard Mitigation Plan	2006
St. Croix County, WI	84,442	St. Croix All-Hazard Mitigation Plan	2007
Iron County, UT	46,310	Five County Association of Government Natural Hazard Mitigation Plan	2010
Stafford County, VA	129,745	Rappahannock Area Development Commission All Hazard Mitigation Plan	2006
Placer County, CA	348,432	Placer County Multi-Hazard Mitigation Plan	2005
Utah County, UT	516,564	Mountain Association of Governments Pre-Disaster Hazard Mitigation Plan	2010
King George County, VA	23,675	Rappahannock Area Development Commission All Hazard Mitigation Plan	2006
Gwinnett County, GA	805,321	Gwinnett County Hazard Mitigation Plan	2010
Carver County, MN	91,042	Carver County Multi-Hazard Mitigation Plan	2012
Denton County, TX	667,053	Denton Count Local Mitigation Strategies	2010
Chambers County, TX	35,096	Houston-Galveston Area Council Regional Hazard Mitigation Plan	2011
Iredell County, NC	159,437	Iredell County Multi-Jurisdictional Hazard Mitigation Plan <b>FINAL DRAFT</b>	2010
Routt County, CO	23,509	Routt County Multi-Hazard Mitigation Plan <b>PENDING APPROVAL</b>	2010
Clay County, FL	190,895	Clay County Local Mitigation Strategies	2010
Berkeley County, WV	104,169	Berkeley County Multi-Jurisdictional Hazard Mitigation Plan <b>FINAL DRAFT</b>	2009
Oconee County, GA	32,808	Oconee County Pre-Disaster Hazard Mitigation Plan	2008
Spotsylvania County, VA	122,397	Rappahannock Area Development Commission All Hazard Mitigation Plan	2006

Indian River County, FL	138,028	Unified Local Mitigation Strategies	2010
Scott County, KY	129,928	Bluegrass Area Development District Regional Hazard Mitigation Plan	2011