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## 1. INTRODUCTION

Drought can strike just about anywhere around the world. In fact, droughts affect more people than any other natural hazard (Wilhite 2000). The recent upward trend in drought losses across the United States would also suggest that the nation's vulnerability to droughts is increasing.

Droughts differ from other natural hazards in a variety of ways. One of the major differences is that droughts normally lack the highly visible direct impacts associated with other hazards such as tornadoes, hurricanes, and earthquakes. The impacts from drought are generally nonstructural and spread out over large areas. Because of this difference, it is difficult to quantify the economic losses associated with droughts, making it difficult to appreciate how devastating droughts can be. To date, most estimations of the economic impacts of drought have been haphazard and incomplete.

Because drought impacts have not been well quantified economically, officials tend to underestimate the importance of drought and often fail to be proactive in preparing for droughts. In addition, because of the widespread geographic variability of drought, severe local impacts tend to be lost when compared in general to larger-scale averages, such as statewide losses.

This paper looks at the current status of economic drought impact evaluations in the United States and discusses the need to develop strategies and consistent methodologies to quantify drought impacts and the economic losses from drought. The better quantification of drought impacts will also improve understanding of the nation's vulnerability to drought.

## 2. RECENT ASSESSMENTS

The National Climatic Data Center in Asheville, NC, lists the 57 weather-related disasters that have caused more than \$1 billion in losses in the United States between 1980 and 2003 [<http://www.ncdc.noaa.gov/oa/reports/billionz.html>]. Of those 57 disasters, 10 are drought-related, ranging from \$61.6 billion in 1988 and \$48.4 billion in 1980 to \$1.1 billion during the East Coast drought during 1999 (normalized to 2002 dollars). The most important thing to remember about these 10 drought loss estimates is that they are very rough and not uniform in how they have been determined.

Of the ten drought-related loss estimates on the NCDC website, the estimate that was determined with the most detailed methodology was the estimate for the 1988 drought that struck a large part of the United States. The original economic loss estimate for this

drought was \$39.4 billion (Riebsame et al. 1991). In spite of the well-documented methodology, this estimate remains just an estimate, and has created some controversy because it may have "double counted" some of the agricultural-related impacts. It is true that this estimate mainly focuses on agriculture, so when the additional environmental and social impacts are considered, it is also likely that this estimate underestimates the total economic losses that occurred across the country in 1988. It clearly illustrates the problem with these types of estimates. The other nine drought event loss estimates are even more sketchy or rough than the 1988 estimate.

In 1995, the Federal Emergency Management Agency (FEMA), as part of a national mitigation strategy for all natural hazards, estimated that droughts in the United States cause an average annual economic loss of \$6-8 billion (FEMA 1995). This estimate was higher than the annual estimates for any other hazard. Although the placement of drought as the costliest hazard in the United States is probably correct, the estimate is likely to have been very rough and focused more heavily on the agricultural sector than other sectors.

Losses in the agricultural sector are somewhat easier to determine than losses in other sectors because the direct agricultural losses are more obvious and are part of some statistics already being gathered. For example, Table 1 shows the amount of indemnities paid for crop losses between 1995 and 2002 across Nebraska. Unfortunately, data like these collected by USDA's Risk Management Agency include all causes of loss, including excess moisture, excess heat, hail, frost, etc. Drought, however, is probably the major cause of loss, and the years with the highest indemnities paid out by RMA also happen to have been drought years in Nebraska: 1995, 2000, and 2002. These data also tell only part of the story, and do not reflect all crop losses or the rippling effect of agricultural drought impacts through the local and state economies.

## 3. 2002 DROUGHT

During the 2002 drought in the United States, the National Drought Mitigation Center began to collect economic loss information from a variety of sources. The NDMC also began to encourage various states to determine their losses in whatever sectors possible. Through this effort, the NDMC has been able to put together a table of some losses in a few sectors (mainly agriculture) at the state level (Table 2). The loss estimates in Table 2 for 2002 total approximately \$11 billion. Some additional losses were collected for regions and municipalities.

What becomes clear when examining Table 2 is the haphazard and incomplete nature of these estimates, which represent a variety of methodologies. For example, South Dakota's agricultural loss estimate

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for 2002 was fairly comprehensive and involved using an input-output model to determine the direct and indirect losses from the drought. Nebraska's estimate represented crop losses and included a factor to approximate indirect losses in the communities as well. The Nebraska estimate did not include livestock impacts, however. Ranching represents two-thirds of the agricultural economy of Nebraska. It is likely that ranchers were hit harder than crop producers by the drought in 2002, making a loss estimate for Nebraska of \$1.2 billion appear significantly underestimated. Kansas, however, included livestock impacts within the state's 2002 drought loss estimate, but did not include the factor to approximate the indirect losses to the agricultural communities, again making the \$1.4 billion estimate appear underestimated.

Table 2 becomes more amazing when it is realized that this table is the best and only estimate for the comprehensive drought loss for the United States in 2002. In fact, the NCDRC estimate for the loss was derived from this NDMC table. However, very few sectors are represented from only a handful of states. There are certainly other states that were significantly affected by drought in 2002 that do not appear in the table. Agriculture is the main sector included, although the 2002 drought had a major impact on other sectors as well. For example, energy production in the southeastern United States had a huge economic impact that nobody has estimated. And, using Colorado as an example, an argument could be made that the losses to the tourism and recreation sector were similar to, if not greater than, losses in the agricultural sector. Other states, not just in the West, rely heavily on tourism- and recreation-based companies that were badly affected by drought. South Carolina saw major tourism- and recreation-related losses that devastated local communities during their 5-year drought ending in 2002 (Knutson and Hayes, 2001).

Table 2 illustrates a few of the issues in estimating economic losses of drought on a larger, statewide scale. There are a few cases where economic losses at the local or regional scales have been well-documented, but generally across the entire country, there is very little knowledge about the economic losses at these scales. Denver Water estimated the impact of lost revenue due to water restrictions in early 2002 at approximately \$14 million (Smith 2002). Recreation facilities around Lake Mead spent nearly \$1 million making adjustments because of the low water levels during 2002 (Ken Dewey, personal communication, October 2002). Toole County, Montana, has estimated livestock losses at \$8 million during the recent drought years. (Tom Gordon, County Commissioner, personal communication, October 2003). Unfortunately, we do not know the total sum of lost water revenues to municipalities across Colorado or the country, nor the livestock losses for other counties in Montana or across the West, nor all the other impacts that have occurred in a variety of ways in a variety of communities across the country.

#### 4. Recommendations

The 2002 experience illustrates that the United States needs to develop a comprehensive and consistent methodology for determining economic drought losses across all necessary sectors and scales. This methodology needs to be able to capture the complex nature of drought impacts, including the direct and indirect drought losses. In a soon-to-be-released report, Canada has made a major step in making standardized national and provincial drought loss estimates caused by the 2001 and 2002 droughts across the country. The United States could capitalize on this example when the Canadian report is released.

The major advantage to understanding the economic impacts of drought would be to highlight the full magnitude of drought losses, and encourage more local, state, and federal officials to increase the efforts in drought planning and mitigation. Many mitigation actions require initial costs to implement these actions. Accurate drought loss estimates and mitigation projections would provide cost/benefit ratios that many officials rely on in order to make their decisions.

As drought has continued during 2003, there appear to be fewer estimates of the drought losses than there were in 2002, even though the impacts have been just as severe in some locations. Current national policy initiatives, such as the National Drought Preparedness Act introduced in Congress in 2003, need to provide the incentives and resources for developing and promoting these consistent and comprehensive drought economic impact estimations.

#### 5. REFERENCES

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Table 1. Indemnities Paid for Crop Losses in Nebraska (USDA/RMA Policy Database).

| Year | Indemnities Paid (\$) |
|------|-----------------------|
| 2002 | >372,000,000          |
| 2001 | 75,135,250            |
| 2000 | 190,954,577           |
| 1999 | 50,960,674            |
| 1998 | 37,545,806            |
| 1997 | 41,606,984            |
| 1996 | 53,356,825            |
| 1995 | 76,529,965            |

Table 2. Economic Loss Estimates Caused by Drought During 2002.

| State          | Estimate  | Sector  |
|----------------|---|---|
| Colorado       | \$1.1 billion<br>\$640 million<br>\$460 million | Agriculture<br>Crop losses<br>Livestock                   |
|                | \$1.7 billion<br>\$200 million<br>\$800,000     | Tourism<br>Outfitters<br>Fishing licenses                 |
| Kansas         | \$1.4 billion<br>\$1.1 billion<br>\$300 million | Agriculture<br>Crop losses<br>Livestock                   |
| Missouri       | \$460 million                                   | Agriculture   |
| Montana        | \$2.0 billion<br>\$150 million                  | Agriculture<br>Crop losses                                |
| Nebraska       | \$1.2 billion                                   | Agriculture   |
| North Carolina | \$398 million                                   | Agriculture   |
|                | \$15-20 million                                 | Municipalities  |
| South Carolina | \$84 million                                    | Agriculture   |
|                | \$526 million<br>\$276 million<br>\$250 million | Timber<br>Growth loss<br>Beetle mortality                 |
|                |   |   |
| South Dakota   | \$1.8 billion<br>\$311 million                  | Agriculture<br>Crop losses                                |
|                | \$23 million                                    | Environmental   |
| Utah           | \$250 million                                   | Agriculture   |
| Wyoming        | \$14 million                                    | Crop losses   |
|                | \$1.8 million<br>\$161,538                      | Wildfire suppression<br>Timber value<br>loss due to fires |