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An Examination of Flood Damage Data Trends in the United States

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At this time an understanding of flood damages remains elusive from the perspective of a quantitative understanding of factors speculated to contribute to flood damages in the United States (Pielke 2000). As of September 2001, the Corps managed 383 lake and reservoirs (these serve multiple functions with flood control as a major function), and constructed or controlled 8,500 miles of levees. Total flood control expenditures from 1928 through 2000 amounted to $122 billion adjusted for inflation using 2001 dollars (Civil Works Information Paper 2002). Yet, despite all of these investments, flood damages in the U.S. have increased.[1] Suspected causes of increasing flood damages include: climate variability and climate change, population growth and development, increasing personal wealth, violations of flood management guidelines, and federal policies. However, none of these factors had been decisively proven or disproved as the reason behind increasing flood damages. Assessing empirically the reasons why flood damages are increasing is extremely difficult because of factors such as a lack of data on population and development within floodplains, and a poor understanding of the performance of flood control measures and implications of those and other floodplain management policies on land use decisions in floodplains. Given these uncertainties, the purpose of this paper is to examine how existing flood damage data can help us understand national flood damage trends. In order to fulfill this purpose, this paper evaluates the existing empirical analysis of flood damage trends, and considers the implications of data limitations for understanding flood damage trends and supporting floodplain management decision-making. This analysis is presented as three key questions:

- Where do the data come from?
- What can the data tell us?
- What can't the data tell us?

Were Do the Data Come From?

The National Weather Service (NWS) is the best source of information for conducting long run trend analysis since they are the only organization that has maintained historical records of annual flood damages. The NWS data do not include flooding from ocean floods caused by severe winds or tectonic activity resulting in tsunamis, nor damage from mudslides (Pielke, Downton and Miller 2002). The data are collected in NWS field offices, but these field offices do not act as a central clearinghouse for damage data. The field offices have to manually compile the data from various sources including local newspapers, local emergency managers, FEMA damage assessments in cases of Presidential disaster declarations, local insurance agents for insured property damages, USDA agents or monthly USDA reports for crop damages based on farmer self reporting.

Due to inconsistencies and inaccuracies in the NWS data, the data should be used in conjunction with a 2002 reanalysis of the NWS flood data entitled "Flood Damage in the United States, 1926-2000: A Reanalysis of National Weather Service Estimates" (Pielke, Downton, and Miller 2002). The reanalysis of the NWS data consist of augmenting the data with information from archived NWS files and publications, and reports of other federal and state agencies to evaluate the *consistency* of the NWS estimates. In addition, the authors use statistical comparison analysis to evaluate the variability of state NWS flood damage estimates with those of estimates from other state sources to evaluate the *accuracy* of the NWS estimates. The reanalysis of the NWS flood damage data provide the basis for answering: what can the data tell us and what can't the data tell us?

What Can the Data Tell Us?

The reanalysis of the NWS data found that the data are reasonably consistent and therefore, useful for analyzing trends in flood damages for aggregate geographical areas of aggregate time frames. However, the damages are not useful for interpreting individual flood events of flooding damages in smaller geographic areas (such as states) due to significant inaccuracies found by the authors. Therefore, the flood damage data provide information on flood damage trends at the national and regional level.

National Level Flood Damage Trends

At the national level, the flood damage data provide information on long run trends in national damages, and about the frequency of years experiencing severe flood damage levels. Figure 1 shows the national flood damage trend for the years 1934-2001.

The empirical trends from the national flood damages data set are presented as damages in 1995 dollars (adjusted for inflation). Data from 1980-1982 are missing because compilation of flood damages ceased during this time period. National flood damages are increasing as evident in Figure 1. The annual rate of change is estimated at 3.45 percent.

National flood damage data also tells us that relatively high damage years are becoming more common. By comparing three nineteen-year time periods, the number of years experiencing flood damages exceeding $5 billion has increased from one year in the 1942-1960 period, to four years in the 1961-1979 period, to seven years in the 1983-2001 period (Table 1). The $5 billion dollar threshold represents approximately the level of damages exceeding the 90th percentile of damages for the time series (only 10 percent of the damages estimates equal or exceed this level of damages). Therefore, $5 billion dollar years are considered severe flood damage years in this context.

The NWS national flood damage dataset, reanalyzed by Pielke, Downton and Miller (2002) provides a nationwide long run assessment of flood damage trends in the U.S. This analysis serves as the basis for further analysis of national flood damage trends, specifically why flood damages are

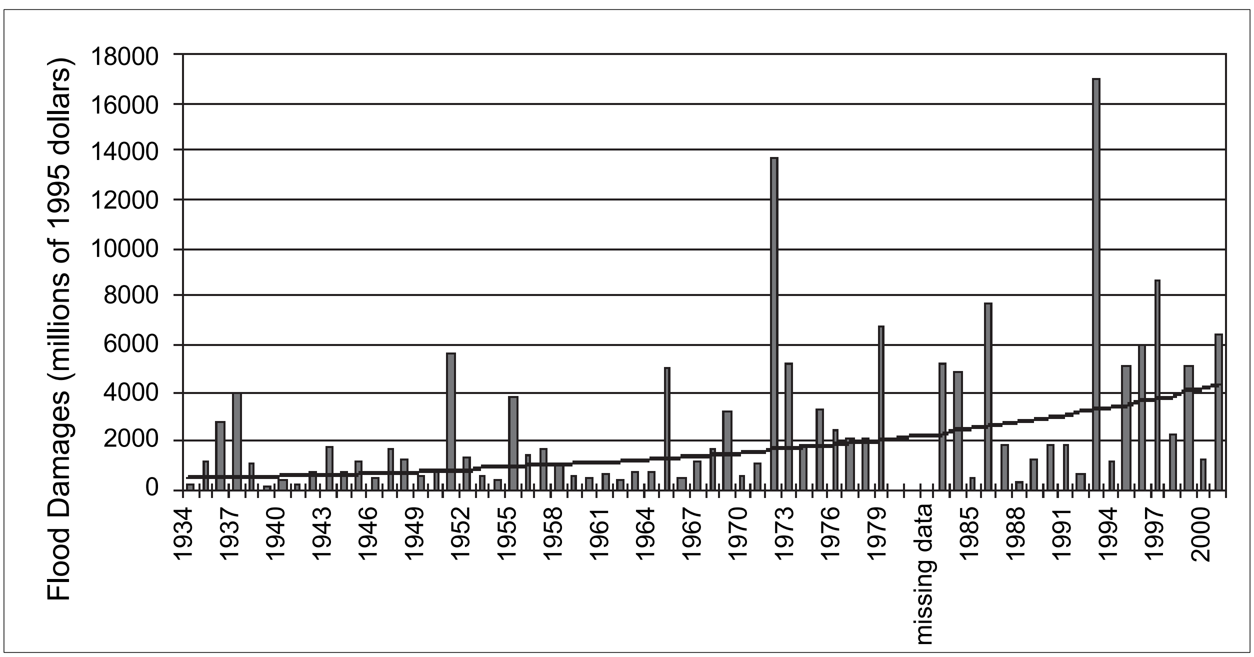


Figure 1. Real National Flood Damages 1934-2001 (NWS reanalyzed data)

Table 1. Years with more than $5 billion in Flood Damages

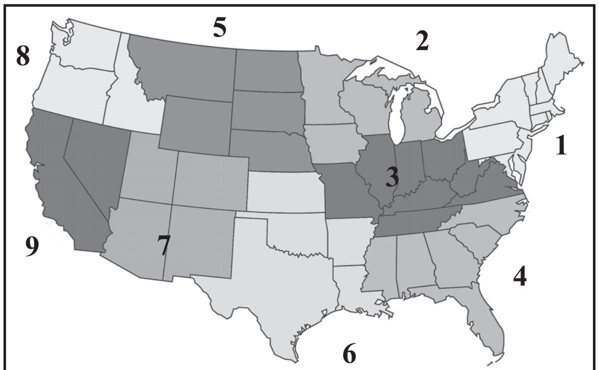
Time Peroid	Number (Percent) of Years with Damage Exceeding $5 Billion
1942-1960	1 (5%)
1961-1979	4 (21%)
1983-2001	7 (37%)

Source: Pielke, Downton and Miller 2002, NWS Reanalyzed National Flood Damage

increasing. Regional flood damage analysis provides the next step in understanding flood damage trends in the US.

Regional Level Flood Damage Trends

At the regional level, the flood damage data allow comparisons of damages between damages and across time. The National Climate Data Center's (NCDC) climate regions provide a convenient way to present regional flood damage trends (Figure 2).



Region	States
1	CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT
2	IA, MI, MN, WI
3	IL, IN, KY, MO, OH, TN, WV
4	AL, FL, GA, MS, NC, SC
5	MT, ND, NE, SD, WY
6	AR, KS, LA, OK, TX
7	AZ, CO, NM, UT
8	ID, OR, WA
9	CA, NV

Figure 1. National Climate Data Center (NCDC) Regions

Table 2 illustrates the regional analysis of flood damages between two equal time periods by region. As with the national damage analysis, severe flood damage years in the regional analysis are calculated using percentile analysis. Based on the regional data, damages exceeding $686 million (1995 dollars) fall into the range above the ninetieth percentile (only 10 percent of the historical record of annual damages equal or exceed $686 million).

The frequency of severe flood years is increasing in all regions except Region 1, 7 and 8. The most significant increase in the frequency of severe flood years is in Region 6 where the number of years experiencing severe floods increased from two to nine between the two time periods. Two years of severe damages in Regions 2 and 5 are the result of the flood events in 1993 (Upper Mississippi River) and 1997 (Red River), and one of the years of severe damages in Region 3 is the result of the 1993 flood event.

Table 2. Frequency of severe floods by region, 1961-1979 and 1983-2001

NCDC Region	Number of Severe Flood Years	
	1961-1979	1983-2001
1	**4**	**3**
2	0	4
3	1	3
4	2	4
5	0	2
6	2	9
7	**1**	**1**
8	**2**	**1**
9	2	3

Source: Pielke, Downton and Miller 2002, NWS Reanalyzed State Flood Damage Data

An example of three region's damage trends illustrates how damages vary substantially from region to region, and how regional trends are sometimes driven by outlier events (Figure 3a-c).

Region 1 (Figure 3a) is an example of a region where flood damages show a decreasing trend, and experienced one catastrophic event in 1972 as a result of Hurricane Agnes. Region 6 (Figure 3b) is a region of the country that experiences recurring high levels of flood damages, and is not characterized by one single catastrophic event. Some events of note occuring in Region 6 are 1979 from Tropical Storm Claudette, 1986 from Hurricane Bonnie and 2001 from Tropical Storm Allison. Thus, Region 6 seems to suffer recurring flood damages as a result of major hurricane and tropical storm events. Region 8 (Figure 3c) is a region that experiences relatively low flood damages, but has experienced a couple of catastrophic events; in 1976 from the Teton Dam breach, and in 1996 from persistent heavy rains and snowmelt.

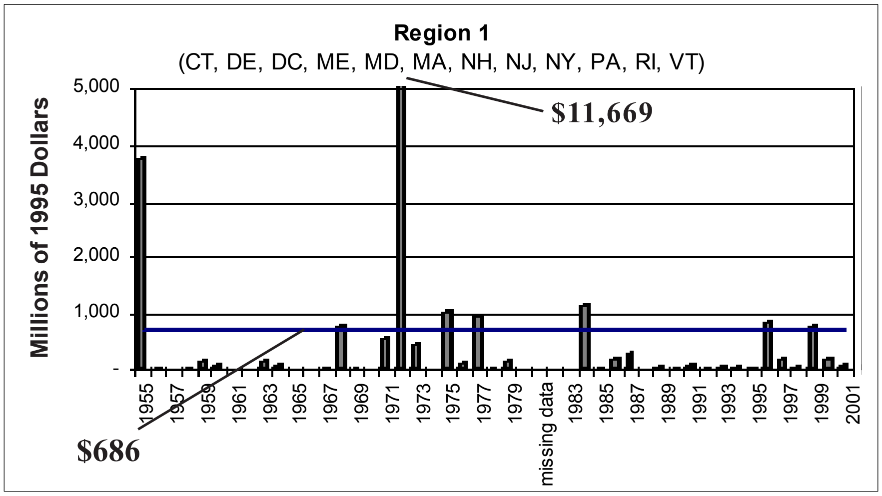


Figure 3a. NCDC Region 1 Flood Damage Trend

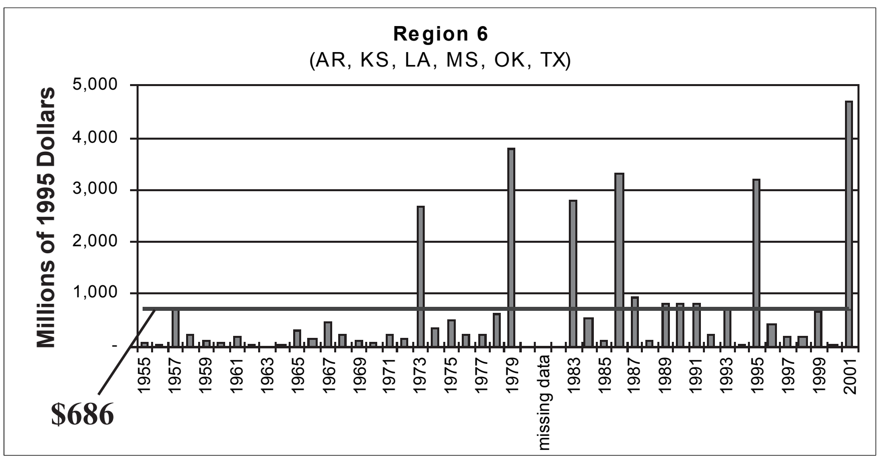


Figure 3b. NCDC Region 6 Flood Damage Trend

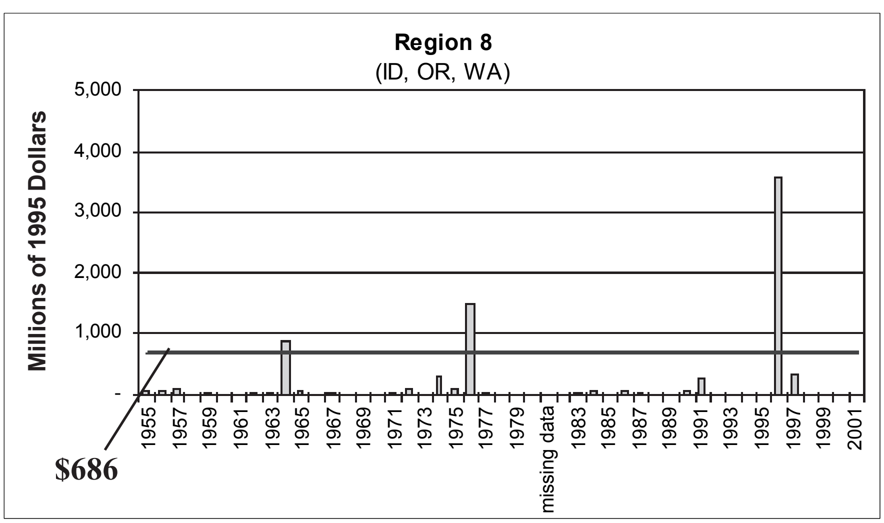


Figure 3c. NCDC Region 8 Flood Damage Trend

This type of regional analysis allows researchers to isolate regions characterized by 1 or 2 severe events and those that experience severe flooding more regularly. Analyzing national flood damage trends by region allows researchers to develop a clearer picture of how flood damages are distrubuted among regions of the United States.

What Can't the Data Tell Us?

Understanding limitations of the data is equally as important as understanding what information the data can provide. Acknowledging limitations in the data prevents misinterpretation of the data and provides a clear picture of where investments in data gathering should be focused if such an effort is deemed important to the national interest. There are two main limitations of the NWS flood damage data. First, the data cannot inform how flood damages are distributed across different economic sectors. Second, the NWS data cannot explain how demographic, economic and land use trends within floodplains influence flood damages.

The first major limitation of the NWS data is that they cannot tell how flood damages are distributed across different economic sectors. Understanding how damages are distributed across economic sector prevents misinterpretation of the flood damage data, and pinpoints which economic sectors are experiencing the most damages. Pielke, Downton and Miller (2002) provide an example of how the NWS flood data could cause misinterpretation of flood damages in this manner. The state of Minnesota was hit particularly hard by the 1993 Mississippi River flood and 1997 Red River flood events. Comparison of the NWS damage estimates shows the 1993 flooding was worse than 1997, $1 billion in 1993, compared to $715 million in 1997 (Figure 4).

However, upon further analysis Pielke, Downton and Miller (2002) obtained a report, *A Decade of Minnesota Disasters*, that provides actual disaggregated damage costs from both floods. They isolated the non-agricultural related direct damage costs. By analyzing the damages in a disaggregated context, the damages in Minnesota appear much higher in 1997 than 1993, explained by the fact that the 1997 flood inundated entire towns, while the1993 floods covered mainly rural areas further south in Minnesota (Figure 4).

Analyzing flood damages in a disaggregated manner portrays a more detailed picture of flooding damages not possible with the historical flood damage data set. Unfortunately, except where local disaggregated damages are available (as in Minnesota) separation of agricultural and urban damages is not possible.

Existing NWS flood damage data also do not allow comparison of demographic, economic and land use trends inside of floodplains with those elsewhere because there is no single standard for delineating flood plains. However, assuming that population and wealth trends withing floodplains are similar to national population and wealth trends, trend analysis of the national population and wealth data indicate some combination of wealth and population growth can explain some of the increase in flood damages, but the relative contribution of each is not possible to deduce.

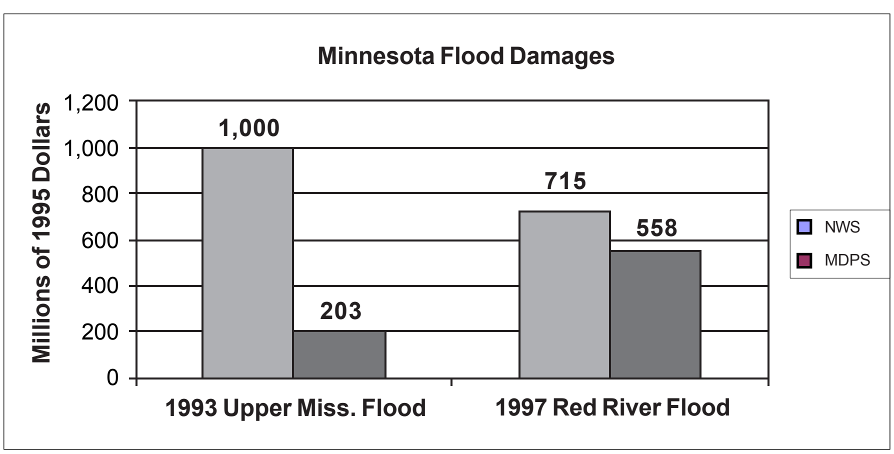


Figure 4. Comparison of Damages from Major Flooding Events in Minnesota

Conclusion

The NWS flood damage data are the best data available for analyzing trends in flood damages over a long period of time and comparing regional damages. Improvements in flood damage data collection would greatly enhance our understanding of national and regional flood damage trends. One factor in improved data collection is a standardized process and categories for data collection. Flood damage data categories could include: economic sector data (agricultural, residential, structural), coastal versus inland flooding, and underlying causes of flooding (soil inundation, backwater flooding, etc.). Another approach to improved data collection is standards for establishing the areal extent of floodplains, which is currently underway through FEMA's map modernization program. Finally, utilizing GIS technologies to present spatially referenced data tracking demographic, economic and land use trends within floodplains would also greatly enhance our understanding of flood damage trends in the U.S.. A more complete understanding of flood damages in the U.S. will educate and improve the nation's ability to address flood problems.

Author Bio and Contact Information

Lauren Cartwright received her M.S. in Agricultural and Applied Economics from Virginia Tech in Blacksburg, Virginia in 2002. At this time her research and work focused on collaborative simulation modeling for water demand forcasting on a river basin level. Since then she has worked with the US Army Corps of Engineers Institute for Water Resources where she became interested in the nation's flooding problems and related policies. Currently she works with the Natural Resources Conservation Service in Missouri as part of an interdisciplinary team developing and evaluating flood damage reduction projects for watersheds in Missouri. Contact author at: lauren.cartwright@mo.usda.gov.

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Notes

1. This increasing trend is despite the investments in flood control by the Army Corps of Engineers (Corps), Tennessee Valley Authority (TVA), Soil Conservation Service (SCS) and Bureau of Reclamation. Although all of these agencies are tasked with building flood control projects, the Corps has the major responsibilities for "mainstem and downstream projects" and thus makes the major investments in flood control projects (Federal Interagency Floodplain Management Task Force 1992, p.35).
2. The report and data are available at www.flooddamagedata.org.
3. Nineteen year time periods are utilized because there are nineteen years of data available since the missing data period.