Booz Allen Hamilton

NOAA Reports on the Economic Impacts of Weather- and Climate-Related Disasters

Recommendations for Future Actions (Task 5)

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NOAA Coastal Services Center
LINKING PEOPLE, INFORMATION, AND TECHNOLOGY

Contents

Executive Summary

In support of its mission, the National Oceanic and Atmospheric Administration (NOAA) provides several economic impact estimates on losses suffered during weather- and climate-related disasters. . This report is part of a larger project, whose goal is to ensure that the estimates of economic loss produced by NOAA, and by the National Climatic Data Center (NCDC) in particular, employ the most up-to-date and valid approaches used in industry, academia, and government, as well as ensuring that all estimates are consistent throughout time and in different regions of the US. Improving estimates of the economic impacts of weather events are particularly important given that they are fundamental for effective policy decisions on mitigating future impacts of disasters, including decisions made during recovery from events and future infrastructure investments.

This report supports this goal by identifying alternative data sources and methods that will increase the consistency and accuracy of estimates developed by NOAA. The recommendations in this report are based on an in-depth analysis of the internal consistency of the NOAA estimates, gap analysis between NOAA estimates and other industry, and an extensive literature review on disaster loss estimation.

The recommendations also address potential new classes of economic impacts not currently considered by NOAA, such as those associated with the loss of ecological function and ecosystem services. This report describes the type and relative magnitude of benefits and costs associated with each recommendation, ranking them based on expected net benefits. Implementing these recommendations will improve the consistency of NOAA's estimates, while also aligning their methodology with those of peer-reviewed literature, other federal agencies, and leading experts and researchers.

1. Introduction

As part of its responsibility to “monitor and assess the climate,” NOAA’s National Climatic Data Center (NCDC) tracks and analyzes extreme weather and climate events in the U.S. and globally that have great economic and societal impacts. To ensure that it is fulfilling this mission, the NCDC sponsored a workshop to identify weaknesses and deficiencies in the methodologies used to calculate economic impacts of disasters. The workshop concluded that the NCDC methodologies required further examination and review to ensure that they dovetail with the most up-to-date and valid approaches used in industry, academia, and government, and are consistent over time, space, and event.

With the goal of addressing these issues, the NCDC and NOAA’s Coastal Services Center (CSC) commissioned a research group to vet the data and methodologies used in the various NOAA estimates of economic loss from weather- and climate-related disasters. This report addresses several specific ways to improve, update, and broaden these estimates. This report is the third and final report produced the current task order, and it draws on the two previous reports discussed below.

The first report provided a full analysis of NOAA’s loss calculations, including identifying areas of inconsistency and areas for improvement. It also included a review of the economics and disaster literature and the methodologies that are currently used in academia, business, and government. Further, in the report, NOAA estimates were reviewed for internal consistency both as stand-alone estimates as well as in the context of the work of other economic impact estimates. Additionally, as part of this analysis, the researchers identified many sources of data that could be useful in future estimation, as well as key studies of estimated multipliers and data estimates that might aide more robust estimation.

The second report focused on identifying issues and crafting recommendations for estimates of 2012 weather related disasters. These were geared specifically towards the NCDC’s efforts on the Billion Dollar Weather- and Climate-Related Disasters Database (BDWCD), and the recommendations focused primarily on the aftermath of Post-Tropical Storm Sandy and the extended severe drought that afflicted much of the country. The document was primarily a set of recommendations for how to improve or conduct the cost estimates for these types of events more accurate, consistent, and robust.

This report draws on the findings from these two previous reports in order to advise on process improvements and long-term goals that will strengthen NOAA’s estimation efforts. These recommendations identify alternative data sources and methods that will increase the consistency and accuracy of estimates developed by NOAA across time as well as with respect to the practices of other federal agencies, and leading experts and researchers. The recommendations also address potential new classes of economic impacts not currently considered by NOAA, such as those associated with the loss of ecological function and ecosystem services. This report categorizes the recommendations based on expected net benefits[1] to reaching NOAAs mission as well as feasibility of implementing each recommendation.

This report is divided into four main sections:

- Section 2: Overview of recommendations,
- Section 3: Detailed discussion of each recommendation ,
- Section 4: Prioritization of suggested actions
- Section 5: Conclusions

[1] The net benefits weigh the relative resources required to implement a change, the benefit in terms the accuracy and consistency of the economic loss estimates that the change will provide, and the relative importance of the change to comply with NOAA’s mission.

2. Overview of Recommendations

One of the primary focuses of the research team was examining the consistency of economic loss estimates from the different NOAA groups[2] producing estimates. This included both a rigorous analysis of the estimators' consistency across events, as well as benchmarking differences in methodologies between the different groups when focusing on the same event. Based on the research and analysis conducted in the production of the previous two reports, there are several areas which the research team identified as candidates for improvement, modernization, or increased organization. These recommendations generally fall into three categories: (1) improving coordination within and outside NOAA organizations; (2) improving estimates of direct costs; and (3) enhancing and expanding the output that NOAA currently produces. These recommendations should help improve the accuracy and consistency of NOAA economic loss estimates.

2.1 Improving Coordination within and outside NOAA Organizations

The research team concluded that increased coordination could improve NOAA economic impact estimates across agencies and eliminate discrepancies between the numbers reported by different divisions. This overlap is particularly true in the case of cyclones (where potentially four different NOAA groups could publish estimates of direct losses), though there is also scope for coordination in other event-types.

Taking these steps would help normalize some of the procedures in benchmarking and analyzing data across the groups, reduce redundancy in analysis, and harmonize numbers reported by the different efforts. For example, a centralized database could simplify analyzing the impact of using different inflation indices, as well as helping identify discrepancies between estimates. Additionally, some of the estimators arrive at different numbers using the same data (such as when the NHC and BDWCD both independently calculate uninsured flood loss based on National Flood Insurance Program data).

With greater coordination and collaboration, the different estimators also can pool resources or commission studies on the appropriateness or historical accuracy of certain assumptions associated with current methodologies. For example, both the NHC and BDWCD could benefit from a local analysis of private property insurance coverage, including insurance penetration rates, average deductible size, and the number of policies reaching their cap limits; these data could help verify the validity of the current Property Claims Service (PCS) uninsured-loss multiplier. Further, the WFOs (and NMFS in coastal communities) could be directly involved in the research effort of these insurance studies, as they regularly conduct local interviews and have working relationships with local responders and agencies that might facilitate such a pilot survey. Similar economies of scale may also exist with other governmental agencies, including USDA, USACE, and FEMA, who either are collecting some of the data used in NOAA's estimates or are making estimates of their own.

2.2 Improving Estimates of Direct Costs

The research team concluded that the NOAA sub-agencies could also improve their current estimates of direct losses by altering their methodology in a few ways. Some potential improvements are laid out below, as well as further discussed in Section 3.

First, **NOAA estimates may be improved by conducting deeper examination of how data are used.** This includes how some data are converted into loss estimates, the measurement of statistical uncertainty, and the potential inclusion of additional data sources. Also, inflation concerns can influence the consistency of how current values reported and which events are included in the various

[2] NWS's National Hurricane Center – NHC; NCDC's Billion Dollar Weather- and Climate-Related Disasters – BDWCD; NWS's Weather Forecasting Offices' entries into the Storm Events Database – WFO; National Marine Fisheries Service Regional Impact Evaluations – NMFS

databases. Additionally, there are significant consistency concerns with WFO estimates that need to be addressed.

Next, in some cases, **the current methodology or incorporation of direct costs of the disaster may need to be reevaluated.** For example, BDWCD multiplier on USDA losses may be changing due to the recent use of different programs by farmers; also, the NHC does not include these data in their estimates at all, and different WFOs may be using similar data sources in different manner.

Additionally, **the quantification of statistical uncertainty in the estimates should also be considered.** There are many sophisticated techniques that can help measure uncertainty in variables, surveys, cost estimates, and aggregation techniques. Adding procedures, such as developing graphical representations of uncertainty in the NOAA estimates could help create more effective communication to the public on what the estimates represent and thus better fulfill NOAA’s mission. A rudimentary procedure for doing so is outlined in Appendix C which might be used in the interim until a full study can be conducted.

Further, different inflation measures also can create divergences in the consistency of the different database. The groups rely on different inflation indices to adjustment historical events; as different inflation measure can vary over time, even harmonized estimates could then diverge as reported in a historical database. Further, since the BDWCD includes all disasters that caused $1B in inflation-adjusted damage, historical events need to be added to the database regularly as those that caused nearly $1B in nominal damage will pass the threshold as price levels rise; for example, the BDWCD has recently added 19 such events, a more formalized identification procedure may be necessary.

The WFOs can also have significant scope for improving consistency of estimates and procedures. There are potentially serious issues with the consistency of loss data produced by the WFOs, with different offices and staff members calculating losses (or even neglecting to calculate losses) in different manners. Creating an online tool or incorporating an automatic procedure into the Storm Event Database software or Performance Management site that helps staff generate costs estimates could further refine the direct loss estimates they produce.

NOAA also has several outreach opportunities that could directly improve access to data, data quality, and consistency of estimation. Outreach to private groups to obtain additional information could provide more refined estimates on loss; this could include insurers (such as Lloyd’s or Chubbs for excess flood insurance information) or state and local responders. Similarly, contact with local or state-level insurance regulators may help acquire better data on what is or is not included in some of the PCS loss information that is the backbone of these estimates. Further, as there is no consensus in the broader community on what to include or exclude in direct (or indirect) costs of a disaster, an external outreach by NOAA to other agencies, non-governmental organizations (NGOs), academic institutions, and foreign governments could help create such a standard. Additional refinement of these standards could help streamline and validate NOAA’s processes for estimating disaster costs. This could also be an opportunity to pair with other government organizations that are end-users of NOAA data.

2.3 Enhancing the Estimation of Indirect and Total Costs

The research team concluded that NOAA should expand its current cost estimates to include estimates of non-direct costs. Expanding the scope of cost estimates to include an analysis of indirect total costs and environmental damages could provide several benefits. Attempting to estimate all costs would provide additional nuance to defining the impacts of natural disasters. Additionally, having all three numbers (direct, indirect, total) could help explain divergences between NOAA estimates and those of private industry, as well as identifying where those estimates may be diverging from NOAA's current approaches.

This expansion into indirect cost account could be accomplished using resources that already publically exist. Further research into local multipliers and demand/supply elasticities could prove relevant for analysis of lost economic output; there are numerous articles in the economics literature that estimate or aggregate local demand- and supply-elasticities that could be used. Additionally, these estimates could be augmented by tapping into local, regional, and state data releases to further estimate loss impacts as statistics are produced (though most data are released with significant lags, so these would probably have to be used only in the revised impact numbers). Current data exist that allow for a more formalized examination of the multipliers used on uninsured losses, particularly as the coverage rates vary over time. Combining these data with increases in computing power and better real-time risk models of many insurance and reinsurance companies can likely provide better estimates of coverage in a timely way. Finally, formalized modeling of demand and employment responses to previous disasters (including those estimated in the literature) could prove valuable in creating an initial approximation of indirect disaster costs; this estimate could be calibrated as data are released.

Additionally, there is scope to analyze other types of losses beyond direct and indirect economic values. For example, the loss of ecological function and ecosystem services can be damaging beyond both the direct and indirect economic costs. Calculations of hedonic valuations and changes in hedonic prices of areas affected by disasters could provide an additional nuance to the direct and indirect losses. Cataloguing these other losses would provide a clearer picture of the true cost of a disaster, even if the results are not easily monetized.

3. Details of Each Recommendation

This section lists and reviews the 13 recommendation topics that the research team is advocating. As mentioned in the introduction, this list of recommendations was developed based on findings from previous research activities, including meetings with the project team, interviews with NOAA and other agency event damage estimators, private insurance agencies; additionally, several more interviews were conducted to determine the mechanics, feasibility, and costs associated with some of these proposals. The list of recommendations varies in the level of effort and resources needed and amount of immediate and future benefits they could provide to NCDC and NOAA event damage estimations. The team determined and assigned priority to best recommendations based on the greatest contribution to improving accuracy of estimates and feasibility of implementation. Each recommendation topic includes one or multiple suggested actions to implement solutions. The methodology to prioritize the recommendations' suggested actions followed the following structure:

1. For each recommendation topic, determine several suggested actions to solve a problem with or potential improvement to current methodologies and data sources
2. Consider costs and benefits associated with these potential solutions, including feasibility of implementation, resource level to implement, benefits of implementation, and immediate need for the suggested action.
3. Prioritize suggested actions accordingly based on the balance of these considerations.

The high-level recommendation topics are listed based on this ranking. Each recommendation includes a brief overview of the problem and its proposed solution(s)[3], a more in-depth discussion of the issue and the motivation behind the potential changes that are recommended, explicit discussion on the benefits and costs of the recommendations, and a summary of those fixes. The summary includes a rating of Importance, how critical the change is in terms of benefits to the process and NOAA's mission, and Resources, the expected effort and level of monetary resources required to implement the change. Note that some of the recommendations have multiple proposed solutions; in some cases, this is done to provide varying options with varying levels of resource requirements and in other cases to provide iterative steps. A brief reference table of the recommendations and their categories is provided on the next page, and a screenshot of the worksheet to prioritize the suggested actions is shown as well.

[3] The broad recommendation topics are based on the order that the research team believes should be addressed; note that a more granular ranking of the individual actions is provide in section 4, whereby individual action items are ranked in a similar manner to the discussion topics.

The following is the list of ranked topics to be addressed in this report, based on the prioritized suggested actions listed within each recommendation topic. Each specific recommendation includes one or more suggested actions for NOAA to consider adopting.

Rank	Specific Recommendation	Recommendation Category
1	Directional Bias and Uncertainty of NOAA estimates	Improving estimates of direct costs
2	Active impacts of NCDC data	Enhancing and expanding the output that NOAA currently produces
3	Coordination with external groups over definition of impacts	Improving coordination within and outside NOAA organizations
4	USDA multiplier drift	Improving estimates of direct costs
5	Additional Data Sources & Collaborations	Enhancing and expanding the output that NOAA currently produces
6	Cross-organizational Collaboration on Overlapping Estimates	Improving coordination within and outside NOAA organizations
7	Pilot Program: Sampling/Surveys of Insurance Statistics	Enhancing and expanding the output that NOAA currently produces
8	Indirect & Other Impact Numbers in Addition to Direct Loss Numbers	Enhancing and expanding the output that NOAA currently produces
9	Regional or Centralized WFO economic estimation	Improving estimates of direct costs
10	Uncertainty, Bias, & Efficiency of Private Sector Estimates	Improving estimates of direct costs
11	Long-Duration Disasters: Forecast-Residual Analysis, Substitution Analysis	Improving estimates of direct costs
12	Centralized Database of NOAA Organizations' Estimates	Improving coordination within and outside NOAA organizations
13	Additional historical billion-dollar weather- and climate-related disasters	Enhancing and expanding the output that NOAA currently produces

This screenshot shows the ranking of suggested actions based on the level of resources required to implement the action and the importance of the action to the NOAA team and its mission. A full list of prioritized actions is presented in Section 4.

Recommendation Ranking
NOAA Prioritization Worksheet

Category of Recommendation: All

Rank by: Importance and Resources

Ranking of Recommendations

Ranking	Category	Recommendation	Suggested Action	Resources Score	Importance Score	Total Score
1	(2) Improving estimates of direct costs	Directional Bias and Uncertainty of NOAA estimates	2. Based on the results of the study, consider including uncertainty bound surrounding in data releases. Options could include releasing 95% confidence bounds surrounding the mean estimate, graphics (such as fan charts or error bars) demonstrating the uncertainty of the estimates, etc. This includes error bars for a time-series graph of disasters dating back from 1980.	9	10	19
2	(3) Enhancing and expanding the output that NOAA currently produces	Active impacts of NCDC data	4. Write a paper and publish it on the NOAA NCDC BDWCD website informing users that a study has been commissioned to identify and suggest approaches to overcome time-dependent biases and uncertainties in the data and methods used by NOAA, recommending specific changes in methods and data sources that will improve estimates of the economic impacts of weather- and climate-related disasters. Include in the paper a summary of results and a timeline with next steps for improvement.	10	9	19
3	(1) Improving coordination within and outside NOAA organizations	Coordination with external groups over definition of impacts	1. Coordinate internal NOAA estimators (BDWCD, NHC, NWS, and NMFS) to agree on a standard across the organizations for defining direct losses. This would require a Working Group or equivalent team with members being estimators from each estimating organization as well as the NOAA HQ economists for oversight and approval.	9	9	18
4	(1) Improving coordination within and outside NOAA organizations	USDA multiplier drift	2. Capture the regional variability in crop patterns and insurance patterns across temporal space. "Place to place, over time, from crop to crop." Compile USDA data into one source to collect the temporal information. Reference crop insurance sources to further establish the analysis.	9	9	18
5	(3) Enhancing and expanding the output that NOAA currently produces	Additional Data Sources & Collaborations	5. Involvement with the Joint Field Office (JFO) could be mutually beneficial for NOAA estimators and for the JFO. A two-way street of information flow would inform each group on NOAA's data flow processes and the JFO protocols for government entities with data generation and integrated exercises into the JFO processes. NHC has 60-day estimate requirements, perhaps similar to the JFO 60-day Needs Assessment requirement. These 60-day operations windows could use teamwork between agencies for efficiencies.	9	9	18
6	(1) Improving coordination within and outside NOAA organizations	Cross-organizational Collaboration on Overlapping Estimates	3. Develop protocols to allow NCDC to build off the NHC 60-day disaster loss estimates.	8	9	17
7	(1) Improving coordination within and outside NOAA organizations	Coordination with external groups over definition of impacts	2. Produce a fully documented primer on the direct costs that NOAA currently estimates. The primer could be published in print or as a PDF online free to the public. It would be a valuable resource both internally and for the general public to reference. By defining assumptions in a clear and articulated manner, data users will have a better understanding of the information and be better suited to apply it to their interests.	8	9	17
8	(3) Enhancing and expanding the output that NOAA currently produces	Pilot Program: Sampling/Surveys of Insurance Statistics	1. Small/Pilot Program Verification- Commission a group to vet the uninsured-loss multiplier values of a few events by acquiring information on policy deductibles & caps, insurance penetration rates, and levels of underinsurance. This group would investigate the best/most feasible way to collect the data (residential/commercial surveys, local insurer surveys, partner with PCS survey or Insurance Information Institute, etc). A proper uninsured-loss multiplier could then be calculated. If the values is close to those currently used by NHC and BDWCD estimates, further investigation may not be necessary to justify current practices. While this approach would not confirm that the uninsured-loss multipliers are valid, results showing that they are "in the ballpark" could provide sufficient for verification purposes.	8	9	17

3.1 Directional Bias and Uncertainty of NOAA estimates

Overview

The research team recommends NOAA tasks a study to perform an in depth statistical review of specific directional bias and uncertainty quantifications associated with each element of disaster costs estimates. Specifically, analysis of the potential error and uncertainty associated with PCS and NFIP procedures, as well as further review of uninsured loss multipliers, can help refine the level of statistical uncertainty associated with these estimates, including directional bias (for both new and historical estimates). Quantification of these biases can help create more nuanced understanding of the estimates themselves (and likely is different based on disaster types), and can even be expressed graphically using fan charts or error bars; these graphics could be presented to the public to provide more robust information on the estimates than a single number indicates.

Discussion & Motivation

All estimates and data sources come with a certain level of error and uncertainty associated with them. As the direct loss estimates produced by the various NOAA groups combine several different data sources, these level of uncertainty from each data source may compound and introduce bias or excessive uncertainty into the estimates. This excess bias may be particularly pronounced in initial estimates of both the NOAA data sources as well as the initial NOAA estimates themselves; this is because the majority of information comes either directly or indirectly from surveys (PCS initial estimates rely on aggregating insurer's surveys of their customers, WFO will do either direct surveying or confer with state and local responders who are doing surveys, NMFS does direct surveying). However, most established surveying techniques have a fairly robust understanding of the amount of uncertainty, bias, and margin of errors associated with their methodology.

A full analysis of the uncertainty and bias that each method introduces should be conducted. The statistical level of uncertainty associated with the surveys and data used in each of NOAA's estimates should be determined for each source, as well as further analysis of the extent to which the uncertainty from each data input interacts (e.g. initial PCS loss estimates may have a slight downward bias that is correlated with initial NFIP information). This analysis could influence the overall nature of the statistical uncertainty and potential bias of the results

Further, several of the other recommendations in this document are geared towards identifying or eliminating the amount of uncertainty associated with other uninsured loss multipliers. Understanding how much bias and uncertainty is associated with some inputs could be better understood based on the findings or the uninsured loss multipliers recommendation, the WFOs' collection improvement recommendation, forecast-residual estimation recommendation, and USDA insurance information recommendation.

Magnitude of Benefits and Costs

Understanding the directional bias and uncertainty of each data input, as well as how the uncertainty and potential bias of each source is correlated with other sources, is extremely important to verify the accuracy of these estimates. As the overall accuracy of the economic loss estimates is incorporated into disaster, relief, and infrastructure investment decisions, significant bias or uncertainty in the data and calculations could lead to suboptimal and costly mistakes in disaster planning and relief efforts. The benefit of identifying the amount of uncertainty in these estimates is potentially very large, informing multi-billion dollar public investment decisions and influencing millions of insurance premiums.

The costs of doing a comprehensive quantitative study of each data source and input varies with the level of detail desired in the project. A relatively simple study of the primary key data sources involved in calculating the costs of the largest disasters could be done by a small research team over a relatively short period of time. For example, commissioning a team to identify the directional bias and uncertainty of the three main data sources involved in hurricane and storm estimation (PCS, NFIP, & USDA) would capture more than 2/3rds of the loss data (when including the multiplied uninsured losses); the research team estimates that if this study were done under current contract vehicles using a team of 3 researchers over a 2-month period, the total expected cost could be in the $20,000-$35,000 range. A comprehensive analysis of all data inputs for all disaster types, including historical correlation and interaction quantifications, to be done over several months would require more resources (~$100,000, depending on how structured), but would also provide a significantly more complete picture of the uncertainty in the estimates.

Summary of Suggested Actions

1. Commission a study to investigate the bias and statistical uncertainty from each data source and multiplier used in estimation, as well as how those bias & uncertainty measures interact with each other. This study would pay special attention to both directional bias/uncertainty and correlation of the bias/uncertainty when combined into the NOAA estimates.
   Importance – High
   Resources – Low to Moderate

2. Based on the results of the study, consider including uncertainty bound surrounding in data releases. Options could include releasing 95% confidence bounds surrounding the mean estimate, graphics (such as fan charts or error bars) demonstrating the uncertainty of the estimates, etc. This includes error bars for a time-series graph of disasters dating back from 1980[4].
   Importance – Very High
   Resources – Low

[4] Appendix C provides a brief suggestion on how to provide such estimates for the current data available. These guidelines can be used on an interim basis until this study is completed.

3.2 Active impacts of NCDC data

Overview
To demonstrate the value of the NOAA estimates, **the research team suggests producing a series of reports outlining the positive impacts that past numbers had created.**

Discussion & Motivation
Currently, the NOAA estimates are used by several government agencies and organizations in their critical function. For example, the USACE uses several series of NOAA data (including some of the economic loss estimates) in their annual report to congress on the country's most pressing infrastructure needs. Several other state and local organizations based their investment planning on the impact analyses especially for economic and community resilience. Also, private-sector insurers and other risk-managers may use the data to set insurance premiums. NOAA could commission analysis of how integral their loss estimates are in the decision process of these and other groups, and attempt to quantify the positive impact that these estimates create.

While some users of NOAA economic estimates are well-known to the NCDC BDWCD community, others are using it as well and should be included in the "Active Impacts" report series. Tracking the NOAA data websites to better understand the demographic of users could be very beneficial for demonstrating the value of the estimates to the outside world. One way to continue learning about BDWCD users is by continuing "Dataset Discovery Day," the NCDC workshop series on climate data.

"Dataset Discovery Day" is a two-day workshop interaction focused on informing users of NCDC data and information of sector-specific needs in climate information. As part of the workshop, participants engage with specific sectors that use climate and environmental information and explore potential future research needs. The workshop brings together business leaders, decision-makers, entrepreneurs, innovators, and scientists to discuss NCDC's climate data, applications of the data, and future uses of climate information. Through this collaborative discussion, NOAA and NCDC we hope to uncover innovative opportunities for the market and research needs that can be provided to the scientific and academic community.

Magnitude of Benefits and Costs
The benefits of producing these reports would be the highlighting of the value these estimates produce, as well as increasing the visibility of NOAA's efforts in quantifying disaster costs. Increased awareness of the NOAA estimates could encourage further research from the private sector and academia, as well as provide ready-made documents showing the value that NOAA's efforts provide to society.

The costs of producing these reports would be determined by how many are commissioned and what the expectations are for them. A research team under current IDIQ contract structures could be commissioned to produce several of these reports at once, minimizing the administrative costs; estimates of how much time, effort, and money these would require would vary. The research team ran scenarios based on certain expectations and the number of reports produced, with the reasonable range per report being between $7,500-$35,000 based on the credentials of the researchers and the overall time commitment allowed for each project, including technical editing and peer review.

Summary of Suggested Action
1. Commission reports examining the end-use of NOAA estimates, specifically trying to quantify the value of the information that NOAA provides and the number of researchers who use it.
   Importance – Very Low
   Resources – Low

2. Continue Dataset Discovery Day and increase outreach to data users to better understand their perceived benefits of the BDWCD database. Encourage NOAA data users to participate in the meetings via links on the NCDC homepage or via other outreach opportunities.
   Importance – Low
   Resources – Moderate

3. Add pop-up surveys to the NCDC data websites to collect user information – data preferences, value of data, use of data, etc.
   Importance – Low
   Resources – Moderate

4. Write a paper and publish it on the NOAA NCDC BDWCD website informing users that a study has been commissioned to identify and suggest approaches to overcome time-dependent biases and uncertainties in the data and methods used by NOAA, recommending specific changes in methods and data sources that will improve estimates of the economic impacts of weather- and climate-related disasters. Include in the paper a summary of results and a timeline with next steps for improvement.
   Importance – High
   Resources – Very Low

5. Keep a NOAA estimators' technical assistance database to record the contact information of Q&A callers to allow follow-up to capture the value of the database information, how it is being used, etc. For an example, follow existing practices at the NOAA CSC.
   Importance - Low
   Resources - Low

3.3 Coordination with other groups over definition of impacts

Overview

Several academic and white papers note the lack of definition over what is a direct or indirect cost in calculations. Following the suggestions of Chagnon (2003), we suggest tasking an individual or group within NOAA to reach out to other organizations (BEA, USDA, USACE, Weather & Climate Extremes Working Group, AA Climate Board, LA Red, World Bank, IMF, and UN). Additionally, we advocated producing a fully documented primer on the direct costs that NOAA currently estimates, which would be a valuable resource both internally and for the general public.

Discussion & Motivation

While several loss estimators do not define direct losses in the same way, it is important to note that even organizations within NOAA do not have a standard definition of direct losses. The processes by which the WFO estimates are created vary greatly from office to office, storm to storm, and even across different office personnel and county-specific data sources within the same field office; as such, these cost estimates are likely inconsistent with the other NOAA estimates. Differing definitions of what is counted as a direct or indirect loss can contribute to significant divergences between the NOAA disaster loss estimates.

The BDWCD defines direct losses as actual losses sustained to physical property; indirect losses are based on the counter-factual analysis of non-property losses that would not have occurred had the weather or climate event not happened, but are not included in the BDWCD estimate. The NHC methodology has gone through several different iterations resulting from the combination of changes in data sources of cost estimates and definitions of key factors. Specifically, the NHC database is constructed using three different primary data sources (pre-1965, 1965-1994, and 1994-present), and these different sources have had three different definition of a direct hit (pre 1931, 1931-1989, and 1989-present), making it difficult have consistency across these time periods.

Outside of NOAA, other academics have noted inconsistencies in the definitions of direct loss. Examples of the project teams' previously summarized articles are listed below to illustrate the widespread difficulties in consistently defining a direct loss:

> *NCAR's own work and examination of the literature find that there are differences across hazard and disaster types in reporting and representation, changes in loss data methodology that make estimates from different years potentially incompatible for comparison, inconsistency in setting a minimum threshold for examination (i.e., there may be some storms that inflicted larger losses than the smallest storms in the database), **inconsistent definitions of what is or is not included as a loss**, and differences between the methodologies of the various loss databases. - Laidlaw, Lazo, & Bushek (2010)*

> *The timeframe and region size of the estimator's loss area, as well as **the definition of what is considered attributable to the disaster** (quantifying lost lives, economic knock-on effects, etc), unquantifiable effects, and proper identification of factors influencing the losses (did the affected area see increased population growth in recent years, has there been significant investment in disaster mitigation infrastructure, etc) are all important considerations that must be understood to properly analyze any loss estimates in context.- Kenneth E. Kunkel, Roger A. Pielke Jr., and Stanley A. Changnon (1998)*

> *Several key elements lead to* ***discrepancies between estimated costs*** *including scope, temporal period,* ***definitions****, and purpose of the estimate. The authors* ***propose a codified definition of what should be included in the calculations of cost****, as well as highlighting the important determinants of that cost… A universal definition of "cost" is nearly impossible to systematically define, and thus that any analysis of a disaster requires a significant amount of judgment that should be determined by the overall purpose of the estimate. - Stephane Hallegatte & Valentin Pryzluski (2010)*

A movement towards codifying what is or is not included in the disaster estimates could provide further consistency across countries and estimates from various groups. This applies both internally to the NOAA estimators and externally to the larger economic estimating community. Often, large deviations in two economic impact estimates of a disaster can be attributed as much or more to the definition of what is included rather than a methodological difference. Since many of the estimates of disaster costs use similar or identical data sources (particularly PCS in U.S. estimates), the role of differences in estimate definitions becomes particularly more obvious.

Magnitude of Benefits and Costs

The benefits of spearheading an effort to define direct losses (or and what should or should not be included in loss estimates overall) could provide a range of benefits. Internal consistency is especially valuable for the organizations within NOAA in solidifying the credibility of NOAA estimates, and should be a priority. Similarly, producing a document that is both an internal resources for NOAA estimators and publically available to those interested in NOAA methodologies could increase transparency and further NOAA's mission. Reaching out to other private and government agencies could further enhance NOAA's reputation.

The cost of standardizing the estimates would vary for the different recommendations. Creating an internal standard across the estimators would be relatively straightforward, requiring either a working group of the four agencies or simply a guidance document from HQ that outlines what is expected to be included in the estimates. A document outlining these policies that would be publically available would be a natural product of the working group or only require slight revisions from the centralized guidance document. However, a push for NOAA to reach out to other agencies to try and standardize the methodologies, definitions, and best practices of estimating disaster loss may require substantial time and effort from high-level staff.

Summary of Suggested Actions

1. Coordinate internal NOAA estimators (BDWCD, NHC, NWS, and NMFS) to agree on a standard across the organizations for defining direct losses. This would require a Working Group or equivalent team with members being estimators from each estimating organization as well as the NOAA HQ economists for oversight and approval.
   Importance – High
   Resources – Low

2. Produce a fully documented primer on the direct costs that NOAA currently estimates. The primer could be published in print or as a PDF online free to the public. It would be a valuable resource both internally and for the general public to reference. By defining assumptions in a clear and articulated manner, data users will have a better understanding of the information and be better suited to apply it to their interests.
   Importance – High
   Resources – Low to Moderate

3. Task tasking an individual or group within NOAA to reach out to other organizations (BEA, USDA, USACE, Weather & Climate Extremes Working Group, AA Climate Board, LA Red, World Bank, IMF, and UN) and spearhead the creation of a national (or international) standard for defining direct losses.

    Importance – Low

    Resources – High

3.4 USDA multiplier drift – in-depth analysis and possible liaison with USDA on coverage

Overview

The team suggests consulting with USDA economists to determine appropriate multiplier on crop losses on future estimates (or even retroactive ones). This could also help create a process for data-sharing or joint uninsured calculation across the agencies, as USDA may be interested in determining accurate values of uninsured losses, as well.

Discussion & Motivation

A major consideration for the estimation of uninsured crop losses is recent changes in the penetration rate of crop insurance. Currently, only the BDWCD uses the USDA crop insurance information to include both insured and uninsured losses from disaster, and the uninsured crop-loss multiplier is always the same in their calculations. However, as the penetration rate of crop insurance increases, the appropriate value of the uninsured crop-loss multiplier should decrease proportionally. Thus, since the acreage of uninsured crops has dropped significantly, a lowering of the uninsured-loss multiplier is likely required. The USDA RMA publishes state level Crop Insurance Profiles which the BDWCD could use in recalculating estimation; these profiles could require a rethinking of how RMA data enter the equations. The higher penetration rates may require lowering the current USDA multiplier of 2.00 down closer to 1.00.

The higher adoption of crop insurance also complicates the uninsured crop-loss estimation in other ways. Recently, Congressional decisions have continued to expand RMA-managed farmer insurance's role as the main safety net for many farmers (including losses from drought); as such, direct payouts from disaster relief organizations could decrease even more in the future. As the importance of RMA-managed insurance increases and the direct payouts from disaster relief decrease, the process to adequately capture the cost of a weather- or climate-related disaster should respond. A shift towards crop insurance and away from direct payments both leaves less acreage uncovered (making the appropriate value of the uninsured-loss multiplier lower) and shifts insured losses from one category with a low uninsured-loss multiplier (FEMA PDD) to another (USDA RMA). This latter effect takes some payments that are currently in the BDWCD estimate with a multiplier of 1.00 into a category that has a multiplier of 2.00; these changes bias the current BDWCD techniques into overestimating the amount of uninsured losses relative to historical estimates. Loss estimators could compensate for these changes by monitoring these USDA RMA quarterly reports for updates on definitions and deviations from traditional numbers, including the historical loss by crop, state, and county.

A further consideration is that overall loss associated with insured crop losses and payouts may not adequately reflect the actual direct losses inflicted on the economy. As the agricultural base in the US is enormous, losses in an area affected by a drought or other disaster may be offset by gains in other areas; sometimes these gains can involve drawing in less productive lands or less efficient techniques to boost overall production of a specific crop or crops in response to a disaster. As such, the uninsured loss multiplier should reflect that disasters have an impact on yields and price elsewhere in the US, in addition to the insured crop loss.

Magnitude of Benefits and Costs

The benefits of updating and revising the treatment of USDA data are extremely large, as increased accuracy of crop losses and other USDA information is a substantial portion of several disasters (especially drought). As discussed elsewhere in the document, the accuracy of the estimates is extremely important to public policy decisions; as crop insurance is run by a government agency, full and accurate information on all the costs (insured and uninsured) is important to setting appropriate premiums as well as making vital water and irrigation infrastructure decisions

The costs of creating a working group with USDA is relatively low, though the costs could vary substantially based on the level of engagement and staffing decisions for the group. Creating communication channels between the estimators, setting up a working group to combine efforts, and designing and implementing protocols for future analysis is relatively straightforward and would require few resources. A study to evaluate uninsured crop-loss multipliers and other issues associated with disaster estimates could be done internally, or it could also be conducted by outside contractors. A one-time study either by internal staff or outside contractors could be relatively low-resources, whereas designing an ongoing real-time system for data sharing and collaboration would require more resources in initial set-up (though it would also provide ongoing benefits). A small one-time working group could require as little as 100-200 man-hours between the two agencies; full integration or accessibility of cross-agency data could be significantly more costly but would provide ongoing benefits.

Summary of Suggested Actions

1. Commission members of the BDWCD to liaison with USDA RMA economists to reevaluate uninsured crop-loss multipliers.
   Importance – High
   Resources – Low to Moderate

2. Capture the regional variability in crop patterns and insurance patterns across temporal space. “Place to place, over time, from crop to crop.” Compile USDA data into one source to collect the temporal information. Reference crop insurance sources[5] to further establish the analysis.
   Importance – High
   Resources – Low (interns)

[5] http://www.cropinsurers.com/images/pdf/focus-on-congress/Importance_of_Crop_Insurance_in_the_US.pdf

3.5 Additional Data Sources & Collaborations – USACE, EIA, CDC, Private Organizations

Overview

The team suggests consulting with USACE and other organizations to see about information sharing on their infrastructure estimates. For example, USACE flood cost estimates tend to be generated from pre-calculated estimates associated with each piece of infrastructure, including cost estimates based on various flood stages; access to this information, methodologies, or other calculations could harmonize flood estimates across the groups.

Discussion & Motivation

The U.S. Army Corp of Engineers (USACE) produces annual estimates of economic impacts avoided and lives saved from infrastructure that they have put in place. These estimates are derived from economic and cost benefit calculations that they performed as part of the infrastructure's cost-benefit analysis when determining where to allocate their capital budget. These estimated direct costs are derived using internal proprietary documents based on local costs of construction material and other inputs relevant to repairing flood damage, such as the cost of labor for construction. These recalculations are expected to occur at minimum every two years with index values standing in for any intermediate usage of the numbers. These inflation adjustments are based on local factors associated with each project, and they are re-tabulated with as much frequency as is reasonable and within the ability of the local district.

Currently, the USACE treats all of their cost-benefit information as proprietary and does not share it with the public. The research team suggests that collaboration between NOAA and the USACE may be possible; the two agencies could reach an information-sharing agreement to include some of their direct cost estimates into the NOAA estimates.

Additionally, the USACE also has an internal disaster response model that they use for estimating costs of their disaster response. This type of information could also be valuable for the estimation of direct impacts.

Other federal agencies could also provide valuable information and collaboration opportunities. During events with substantial disruption to energy-related systems, the U.S. Energy Information Administration (EIA) could provide significant information on the direct costs of the outages; these could include electricity power disruptions from wind and storms, "cap-in" losses on offshore oil rigs from hurricanes, hydroelectric power disruptions from drought, etc. The EIA collects, analyzes, and disseminates independent and impartial energy information to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment. Further, EIA has vast experience in quantifying the uncertainty associated with its estimates and might be a good example of publishing data error/uncertainties for the BDWCD to follow.

During weather- and climate-related disasters, there can also be significant impacts in terms of death and disease due to power outages, breathing conditions (extreme heat/cold), and other factors. The Department of Health and Human Services (HHS) and the Centers for Disease Control and Prevention (CDC) could also provide information on such occurrences. For example, the CDC's Wide-ranging Online Data for Epidemiologic Research (WONDER) online database utilizes a rich ad-hoc query system for the analysis of public health data. Reports and other query systems are also available. It is an easy-to-use, menu-driven system that makes the information resources of the Centers for Disease Control and Prevention (CDC) available to public health professionals and the public at large. NOAA may find some of this information valuable for estimation of indirect deaths/health impacts due to weather and climate disasters, the WONDER data is a useful source for future indirect studies.

Magnitude of Benefits and Costs

The benefits of including additional information from other government sources is extremely high, as more robust or complete data could improve accuracy, consistency, and transparency of the NOAA estimates. While the exact extent to which these other data sources could improve the NOAA estimates will be unknown until they are examined, any improvement in the input data would further NOAA's core mission in producing these estimates.

The costs of reaching out to these different organizations to discuss potential data-sharing or access is relatively low; the follow-on work that these initial discussions could produce might take a variety of levels. Simple discussions over partnership opportunities will likely be relatively modest in terms of staffing and personnel time. If potential sharing opportunities are identified, then the level of costs would go up, though the benefits would necessarily increase as well.

Summary of Suggested Actions

1. Contact and collaborate with USACE about potential data-sharing and cost estimation collaboration opportunities. These include both infrastructure estimates of costs from flooding as well as disaster response models.
   Importance – Moderate to High
   Resources – Low to Moderate

2. Contact and collaborate with EIA for similar collaboration opportunities with estimating energy-related losses. Further, look into uninsured loss with oil and gas infrastructure.
   Importance – Moderate to High
   Resources – Low to Moderate

3. Contact and collaborate with HHS/CDC for information on loss of life, disease, and other indirect costs associated with prolonged heat, cold, or electrical disruptions. Further, consider direct medical costs caused by extreme weather events.
   Importance – Low to Moderate
   Resources – Low to Moderate

4. Contact and collaborate with private insurers and reinsurers for additional partnership opportunities. Particular interest would be related to Excess Flood Insurance data from Lloyd's of London or Chubbs. Similarly, more interaction with insurance and reinsurance industry group could provide more or better access to date through Munich Re, Swiss Re, state insurance commissions, and trade groups (Insurance Information Institute, National Association of Mutual Insurance Companies, etc).
   Importance – Moderate to High
   Resources – Low to Moderate

5. Involvement with the Joint Field Office (JFO) could be mutually beneficial for NOAA estimators and for the JFO. A two-way street of information flow would inform each group on NOAA's data flow processes and the JFO protocols for government entities with data generation and integrated exercises into the JFO processes. NHC has 60-day estimate requirements, perhaps similar to the JFO 60-day Needs Assessment requirement. These 60-day operations windows could use teamwork between agencies for efficiencies.
   Importance - High
   Resources - Low

3.6 Cross-organizational Collaboration on Overlapping Estimates – NCDC & NHC

Overview

Due to duplication of effort and divergent interpretation of similar data, **the research team suggests greater collaboration, or even consolidation, between the BDWCD and NHC economic cost calculations of cyclones.**

Discussion & Motivation

Currently, there is significant duplication of effort on estimating the direct loss from cyclones, as well as several inconsistencies between the estimates produced by the BDWCD and the NHC. Both estimates primarily rely on Property Claims Service (PCS) insured-loss data and FEMA's NFIP insured-loss data; while both the NHC and BDWCD use the same uninsured-loss multiplier for the PCS data, each calculates their uninsured flood-loss multiplier independently which has historically led to different values. Further, the BDWCD uses additional data sources and types of loss, providing a broader estimate of direct losses. This has led to discrepancies between the two NOAA estimates, despite their intention to measure the same event. Despite both estimates using a "top down" approach to estimation and primary reliance on the same data sources, the two often arrive at different values for disaster loss. This is primarily due to a combination of different calculations of uninsured flood-loss multipliers and different definitions of what is included in direct loss definitions. Greater collaboration between the two organizations, or even a consolidation of the two efforts into a single joint estimate, could be addressed these issues NOAA-wide estimate.

NFIP Uninsured Flood-Loss Multiplier

At present, the biggest issue between the two estimates is the inconsistency of an uninsured flood-loss multiplier based on FEMA's NFIP. FEMA's NFIP handles flood related insurance claims. The NFIP is designed to mitigate future flood losses nationwide through sound, community-enforced building and zoning ordinances and to provide access to affordable, federally backed flood insurance protection for property owners. The NFIP provides an insurance alternative to disaster assistance to meet the escalating costs of repairing damage to buildings and their contents caused by floods. Participation in the NFIP is based on an agreement between local communities and the Federal Government whereby a community adopts and enforces a floodplain management ordinance to reduce future flood risks to new construction in Special Flood Hazard Areas (SFHAs); in exchange, the Federal Government makes flood insurance available within the community.

NOAA organizations uses NFIP insurance claims reported values to calculate flood losses from a storm. The economic costs of flooding are modeled based on the estimated insured losses of the NFIP, and then scaled based on the relative amount of flood coverage of the affected area. The uninsured flood-loss multiplier is an indicator based on the insurance penetration rate in the afflicted areas of the disaster, as well as the maximum coverage available to residents of the area.[6] This is done on a case-by-case basis, as there is extensive heterogeneity in the amount of flood insurance penetration in different areas. A NFIP multiplier is calculated to scale the overall flood impact to include all losses: insured, uninsured, and underinsured.

The independent calculation of multipliers by the NHC and BDWCD has meant that different storms will have significantly different uninsured flood-loss multipliers. In inland regions of the U.S. where flooding is infrequent and many structures do not have flood insurance coverage, the NFIP uninsured flood-loss

[6] Note that the maximum coverage is determined on a community compliance with NFIP requirements and other characteristics, though in practice the coverage limits are generally $250,000 for residential structures, $100,000 for residential contents, and $500,000 each for commercial structures & contents.

multiplier value is likely to be particularly high; with a low percent of NFIP penetration, most losses must be paid for out of pocket. For example, in the 1990's, there were two floods in North Dakota where very few communities in the area had flood insurance. In areas with such low flood risk, the NFIP multiplier may need to be 4.0 or higher to accurately capture total flood losses. Conversely, the NFIP uninsured-loss multiplier will be lower in high-risk hurricane regions; since the percentage of people with flood insurance is higher, the NFIP multiplier doesn't need to be as high (in some cases, this has been as low as 1.0).

There is not yet a standard NOAA-wide process to calculate the NFIP (National Flood Insurance Program) multiplier for flood loss estimates. The BDWCD and NHC do not work across organizations to identify a comparable multiplier for estimates of the same disaster losses, and their multipliers can be different even using the same insured-loss and insurance penetration data. This results in conflicting estimates. A simple way to resolve this issue is to establish a cross-organizational procedure for the calculation of the NFIP multiplier. Better coordination between NHC and BDWCD estimators could refine the calculation of uninsured-loss multipliers, especially in consideration of the NFIP multiplier. This would be particularly relevant in the determination of the NFIP Flood Loss multiplier in cases of hurricanes, where the NHC and BDWCD both independently calculate a unique multiplier.

Other Direct Loss Data

Presently, the NHC does not include USDA crop-loss data into their estimates of cyclone damage, while the BDWCD does. The BDWCD will occasionally include additional loss information from FEMA Presidential Disaster Declaration programs in lieu of PCS data (when the FEMA PDD values are large relative to the PCS estimates). Additionally, the BDWCD calculations will include information from state and local reports on the economic impacts[7]. As such, the BDWCD estimates encompass significantly more direct loss, and thus the numbers do not directly compare in the contents.

Magnitude of Benefits and Costs

The benefits of further collaboration between the different NOAA estimates derive from both the reduction in duplicated efforts and the harmonization of estimates. The scope for reducing duplicated effort depends on how much cooperation is expected between the groups. If the NHC and BDWCD are expected to merely consult each other on the NFIP multiplier before releasing their numbers, very little will be saved in the form of resources, though accuracy and credibility of a unified estimate would be gained; if the two groups consolidate estimation into a single number, the scope for staff reassignment and removal of duplicated effort is much higher. The benefit of harmonizing or even combining the direct loss estimates from the two agencies is harder to quantify, though eliminating the historical discrepancies between the two would increase the authority behind the estimate and improve the perception of the NOAA estimate(s) in terms of credibility.

The costs of collaboration or consolidation of effort also vary significantly depending on how much integration is envisioned. Creating communication channels between the estimators, setting up a working group to combine efforts, and designing and implementing protocols for future analysis is relatively straightforward and would require few resources. Officially instituting full integration of the analysis and production of a disaster cost estimate into a single organization could require significantly more time, effort, and attention as doing so would likely require structural changes to the organizations, staff realignment or reassignment, and potentially even executive or congressional approval to changes of NOAA mandates.

[7] It should be noted that these reports are often produced after a significant period of time has passed, and may be impractical to include in NHC estimates. The NHC is required to produce their disaster-cost estimates in a timely fashion after the event (usually within 60 days).

Summary of Suggested Actions

1. The NHC and BDWCD could immediately meet and harmonize methodologies for calculating uninsured flood-loss multipliers and inclusion of USDA crop-loss data/multipliers. Thus, future efforts to calculate the uninsured-loss multiplier would be aligned. This would require a one-time coordination between the two groups to set the methodology. To reduce duplication of effort, NHC and BDWCD could collaborate whenever a new cyclone hits. This could ensure that the uninsured flood-loss multipliers are identical for each new event. This would require setting up a protocol for initiating the collaboration (specifying contact persons and other protocols for the discussion).

   Importance – High
   Resources – Moderate

2. To eliminate duplication of effort, the NHC and BDWCD could jointly issue a single estimate. As the NHC is required to issue an estimate within 2 months of the disaster, and the BDWCD issues a preliminary estimate of the direct losses, collaborating would allow for a single release. The BDWCD could then finalize this jointly-released number later as they do with their preliminary estimates. This would likely require a mandate or guidance to be issued from NOAA HQ.

   Importance – High
   Resources – Moderate

3. Develop protocols to allow NCDC to build off the NHC 60-day disaster loss estimates.

   Importance – High
   Resources- Low

4. Coordinate with Fisheries and WFO to contextualize the efficiencies “connect the dot” between the estimates. Show how the numbers speak to one another.

   Importance - High
   Resources – Low

3.7 Pilot Program: Sampling/Surveys of Insurance Statistics

Overview

The research team suggests commissioning a survey or set of surveys to determine in-depth insurance information for those affected by a disaster. Focus of the survey would be to collect information on insurance deductibles, caps, & coverage rates, which could be used to validate or upgrade PCS uninsured-loss multipliers. Additionally, this effort could be coordinated with several possible organizations that already conduct partial analysis or have access to data (PCS insurance companies that report, FEMA aid groups, etc). This effort could also be partnered with academic or industry institutions.

Discussion & Motivation

The PCS database goes back to 1950 with estimates done at the state level, and uses losses reported by primary insurance companies which it then extrapolates to cover all insurance claims. PCS only reports covered losses. Thus, additional losses such as policy deductibles, losses in excess of policy caps, underinsured losses, and those without insurance policies are not included in PCS estimates. Effectively, each of these four types of uninsured loss is subsumed in the single uninsured-loss multiplier as currently used by NHC and BDWCD.

While PCS insured loss numbers are very accurate and widely used and accepted across the insurance market, the NOAA uninsured loss estimates do not have a clear gauge of the associated accuracy. The NOAA organizations use the same uninsured-loss multiplier for each storm or disaster type (for example, a cyclone has an uninsured-loss multiplier of 2.0, a large winter storm 1.42, etc). However, little research has been done to determine if (1) these types of losses are accurately reflected by the multiplier and (2) if the size of the four different types of uninsured losses relative to each other would distort the appropriate multiplier value. At present, there is not a large source of data that provides intelligence on the insurance penetration rates in specific areas affected by weather- and climate-related disasters. One way to resolve this area of uncertainty is to commission a survey or set of surveys to determine in-depth insurance information for those affected by a disaster.

The focus of the survey would be to collect information on insurance deductibles, caps, & coverage rates, which could be used to validate or upgrade PCS uninsured loss estimate information. There are several potential ways to collect this information, including direct interviews of consumers and residents, through direct insurers in afflicted areas, or as part of a larger effort to build a nation-wide database.

In a direct survey of residential and business, there are two timeframes in which the survey could be executed:

1. Post-Storm: The survey is taken after a disaster hits. People affected by the storm are surveyed and asked questions regarding their insurance coverage, insurance cap, deductible, and anticipated losses. This real-time information could be used to validate and improve PCS multipliers for the current disaster of interest. This information may be difficult to compile and acquire since people who dealt with the trauma and who incurred large property damages may be unavailable for input and biased based on the recent losses.

2. Pre-Storm: The survey is taken in high-risk areas prior to a disaster. This information can be extrapolated to similar areas or modified to apply to different regions, and can be used in future storms to validate PCS multipliers and better understand the impacts of the storm. This information may be easier to collect but homeowners may not know their insurance coverage.

A Booz Allen Hamilton survey-expert has estimated the cost of a generic survey of this sort. For statistically significant survey results, 600-800 respondents are required to provide information regarding their insurance coverage. In regards to logistics, the survey data can be collected via multiple methods: in person (most expensive), by phone, by mail or by web (least expensive). On average, the survey interview or phone surveys will cost between $80,000 and $100,000 to design, implement, and summarize; however, web-or mail-based surveys could cost significantly less ($35,000-$50,000), though this could also introduce more bias into the numbers.

In order to fund a survey (or multiple surveys) of this size, the different NOAA estimators could combine resources or commission studies to justify the cost and purpose. The different estimators can pool resources or commission studies on the appropriateness or historical accuracy of certain assumptions associated with current methodologies. For example, both the NHC and BDWCD could benefit from a local analysis of private property insurance coverage, including insurance penetration rates, average deductible size, and the number of policies reaching their cap limits; these data could help verify the validity of the current PCS multiplier. Further, the WFOs (and NMFS in coastal communities) could be directly involved in the research effort of these insurance studies, as they regularly conduct local interviews after such events (the NMFS already asks about insured and uninsured losses of those in the fishing industry) and have working relationships with local responders and agencies that might facilitate such a pilot survey.

Additionally, NOAA may be able to coordinate with several possible external organizations that already conduct partial analysis or have access to more detailed and specific insurance coverage data. Such groups include primary insurance companies that report to PCS, FEMA aid groups, re-insurance companies, and others.

Further, another way to reduce costs is to partner the survey effort with academic or industry institutions interested in the information. NOAA and NCDC in specific have experience working with both academic and industry institutions for dual-coordinated efforts. This method could result in mutually beneficial survey results for both NOAA estimators and the partnering institutions.

Magnitude of Benefits and Costs

The benefits to assessing the appropriate value of the uninsured-loss multipliers would be large. Currently, the economic loss estimates rely heavily on assumptions of the ratio of uninsured losses to insured losses. As such, confirming this assumption would provide significant validation to current methodologies; alternatively, finding that the assumptions are flawed or invalid would require significant revisions to current approaches.

The cost of these surveys or sampling exercises varies based on the extent to which they are undertaken. Continuing studies would be much more costly than one-time or confirmation studies, and creating a nation-wide database of county-level insurance coverage using direct interviews would be much more costly than a partnership with PCS or an insurance institute to determine regional coverage rates and deductible levels.

Summary of Suggested Actions

We suggest three different ways to evaluate the uninsured loss multiplier. First, a study that could require relatively low levels of resources could be used to determine in a few instances if the uninsured-loss multiplier is roughly accurate in those few cases. A more resource-intensive approach would try to fully vet the multipliers. Finally, a large-scale effort could create an insurance information database that could be accessed after each event.

1. Small/Pilot Program Verification– Commission a group to vet the uninsured-loss multiplier values of a few events by acquiring information on policy deductibles & caps, insurance penetration rates, and levels of underinsurance. This group would investigate the best/most feasible way to collect the data (residential/commercial surveys, local insurer surveys, partner with PCS survey or Insurance Information Institute, etc). A proper uninsured-loss multiplier could then be calculated. If the values is close to those currently used by NHC and BDWCD estimates, further investigation may not be necessary to justify current practices. While this approach would not confirm that the uninsured-loss multipliers are valid, results showing that they are "in the ballpark" could provide sufficient for verification purposes.

   Importance – High
   Resources – Low to Moderate

2. Conduct a full study on the uninsured-loss multipliers. This would include a larger effort to collect data, including potentially employing multiple approaches (surveys of those directly affected, direct surveys of insurers, partnerships with other organizations). This approach would include calculating the level of uncertainty associated with each multiplier estimate, the consistency across regions, and whether each event would require a unique calculation (as is currently done with NFIP) or if the standard multiplier works. This would likely require sampling both affected regions and control regions.

   Importance – Low
   Resources – Moderate to High

3. Generation of a database with insurance information that could be accessed after each disaster. While much of the information on insurance policies is proprietary, there would likely be interest from potential industry partners or regulators to create state-specific or nation-wide databases with aggregated information on these characteristics. Partnership opportunities could include state insurance regulators, FEMA, industry groups (PCS, Insurance Information Institute, etc).

   Importance – Low
   Resources – High

3.8 Other Impact Numbers in Addition to Direct Loss Numbers

Overview

Currently, the NOAA estimates primarily focus on direct loss economic impacts associated with weather and climate disasters, as well as loss of life information. **The research team suggests expanding the scope of these estimates to also include measures of loss of ecological function and ecosystem services, public health impacts, and other disasters** that could benefit from a similar methodology could provide a more complete picture of the true damage inflicted by the disaster. This expansion could help NOAA further reach its goal to monitor and assess the climate.

Discussion & Motivation

In addition to the economic direct loss and loss of life, there are several other types of losses associated with any weather or climate-related disaster. The loss of ecological function and ecosystem services is another potential gap in analysis. While some of the NOAA estimates provide insight into these losses (particularly the NMFS estimate), the loss of an afflicted area's ability to provide vital services (such as clean drinking water, crop pollination, ecotourism, or hydroelectric power) are significant impacts that could be chronicled. While defining a dollar value for these services through hedonic pricing (or other methodologies) may be difficult, a chronicling of vital services that have been impaired could further inform the public on changes that occurred from the disaster. For example, producing an estimate of shore erosion (how widespread the erosion was and how severe an effect occurred in those areas) could provide a stronger picture of the effects that a hurricane had on a community. These reports could simply be a list of the vital functions that were disrupted (e.g. drinking water source impaired due to damage of sewage system upstream), a qualitative description of the damage (e.g. minor, significant, severe, total failure), and how long the function is expected to be compromised (short-term, moderate, extended disruption, complete loss).

Additionally, disruptions from disasters can provide conditions for epidemics or other health hazards to outbreak. NOAA could confer with public health officials to further understand and chronicle such impacts associated with the disaster. This could include estimates of loss of life due to electricity and emergency service disruptions, hospitalizations from asthma or other conditions associated with extreme heat/cold, costs of epidemics related to lack of sewage and trash services, poisonings, etc. These costs and estimates could be generated either by collaborating with public health organizations in each event or by developing a handbook or other guide on how to produce these cost estimates in the future.

Finally, the current BDWCD methodology may be suited to conduct similar estimates of disaster loss beyond those related specifically to weather- and climate-related disasters. Specifically, earthquakes and other geological events will see similar patterns of disruption to the weather and climate-related disasters, as could some man-made disasters. Producing estimates of these types of events could help contextualize the magnitude of weather- and climate-related disasters compared with other disaster events.

Magnitude of Benefits and Costs

The benefit to producing these additional measures of disaster cost would be to increase the informational content of NOAA estimates and provide nuance and context to the disasters. This information could enhance NOAA's output by giving a more robust description of how weather- and climate-related disasters influence communities beyond the direct impacts.

The costs to producing these estimates would be moderate. The estimates could be produced by bringing on additional staff, expanding or reassigning responsibilities of current staff to better facilitate these estimates, or licensing or developing tools and resources that could help produce these estimates.

Summary of Suggested Actions

1. Create a framework for listing damage to critical ecological functions and environmental services. This could take the form of a low-level list with qualitative descriptions, or may be expanded to include quantitative estimates based on hedonic pricing practices.
   Importance – Low
   Resources – Low to Moderate

2. Reach out to public health organizations to develop a methodology for reporting public health issues after crises.
   Importance – Very Low
   Resources – Low to Moderate

3. Determine if other non-climate or non-weather events could be candidates for determining direct economic losses using the current NOAA methodologies such as earthquakes or tsunamis. Potentially collaborate with USGS via an interagency agreement to facilitate such estimates. Look at the SHELDUS methodology for loss estimation sources.
   Importance – Very Low
   Resources – Low to Moderate

4. Look at direct losses directly attributed to nonmarket losses such as ecosystem losses, cultural losses, loss of human capital, etc. Work with existing NOAA groups to articulate these losses using a narrative as opposed to a publishing a quantified value. Stay involved and coordinate with internal NOAA and external academic entities analyzing these nonmarket losses.
   Importance - High
   Resources – Low to moderate

5. Deliver NOAA loss estimate data in a way that is useful for those who are doing indirect loss modeling (recognize limitations based on agreements with data providers). The data should be as granular as possible while recognizing proprietary limitations.
   Importance - High
   Resources – Moderate

6. Remove indirect losses from historical and future Drought estimates to ensure consistency across the methodologies for all weather and climate disaster estimates. In the BDWCD list, the primary number must the direct loss value to make it comparable to the other disaster loss values.
   Importance - High
   Resources – Low to Moderate

3.9 Regional or Centralized WFO economic estimation

Overview

The WFOs can also have significant scope for improving consistency of estimates and procedures. Creating an online tool or incorporating an automatic procedure into the Storm Data software or Performance Management site that helps staff generate costs estimates could further refine the direct loss estimates they produce. By implementing a series of process improvements for Storm Data estimates from WFOs, it would greatly increase the accuracy and consistency of estimates across the many offices. Potential improvements include: a web-based calculation tool for loss estimates or other data-entry software for cost estimators; staffing devoted to cost-estimation only at the local, regional, or national level; training or procedural clarification for WFOs' estimators; and standardization of how to split fresh-water flooding costs from storm-surge costs.

Discussion & Motivation

The 124 Weather Forecast Offices in the U.S. are responsible for producing local weather forecasts, as well as local weather-related watches and warnings. Each office is located within its coverage region, usually covering between 20 and 50 U.S. counties, depending on size, population, and geography. Each of these offices focuses on local weather events, including predictions of storm activity and in many cases the local costs of damage inflicted by severe storms. The processes by which these estimates are created vary greatly from office to office, storm to storm, and even across different office personnel and county-specific data sources within the same field office; as such, these cost estimates are more likely to be inconsistent than the other NOAA estimates.

While each WFO has slightly different resources available to them based on the size of the district and the state and local resources within, each primarily relies on data obtained from local emergency managers, the U.S. Geological Survey, the U.S. Army Corp of Engineers, power utility companies, and relevant media reports. When these sources are unable to provide an exact number, the WFOs generate estimates according to guidelines on storm damage as set out by the NWS. Generally, the smaller events (those relying on a single employee to assess, especially those without an on-site presence) are much more likely than larger events (with multiple staff making several on-site assessments) to be estimated based on a 2007 handbook that the NWS provided to each WFO as an appendix to the Storm Data Directive 10-1605 cost-estimating directive.

Since the WFOs are responsible for cataloguing all weather-related impacts of storms, large or small, the amount of resources devoted to each event is dependent on both the size of the impact and the number of events that are reported. For larger events, where multiple staff members (or even multiple WFOs) are making multiple on-site inspections, the primary method of data collection and cost estimation is based almost exclusively on the interviews conducted with officials at various levels of government and homeowner or business owners directly affected by the storm itself. With some smaller events, where a single staff member may be estimating costs based on a single phone interview or damage report, estimators do not contact the local authorities unless there is an injury or other issue requiring local aide; additionally, the afflicted site may not be visited by the researcher, relying more on written and oral reports from those affected, with cost estimates derived from the 2007 NWS guidance handbook for types of damage.

This inconsistency of the WFO estimates is of particular concern, especially when the damages inflicted are relatively small. The NWS has provided a manual with broad guidance on the value of property loss associated with different types of damage, though the manual is not updated annually nor is it calibrated to identify regional differences between costs and property values. Further, the application of these estimates may differ from office to office and even differ between individual estimators within the same office.

Magnitude of Benefits and Costs

The potential benefits of centralizing the economic costs estimation responsibilities of the WFOs could be enormous. Presently, the inconsistency, or even the absence, of the economic data for some storm events is quite large. Allowing staff to directly input data into an application-based program would reduce significant amounts of paperwork and administration, as well as facilitate higher-level aggregation and review procedures, as well as allowing updates to the NWS handbook (where dollar-costs of certain types of property are determined) to be programmed in automatically and managed in real-time. Further, centralizing or prioritizing the economic loss calculations to individual staff or departments may also improve the accuracy and consistency of the data.

The costs of implementing a centralized reporting system would require significant upfront cost. The development and proliferation of an application capable of handling the needs of the WFOs would be a substantial undertaking, though much of the distribution efforts would be obviated by making it a web-based application. However, the development of the interface, debugging, and maintenance of the application would probably require 1-3 full-time staff for several months (more if on-site training and rollout are required at the WFOs), and continuing maintenance may reasonably require 0.5-1.0 FTE permanently. Regionalizing or centralizing the economic cost estimation responsibilities would also require permanent staffing changes. Similarly, updating or increasing the amount of training that the WFOs' staff must undergo to increase cost-estimation skills would require fairly substantial outlays for travel, staffing, and time-management.

Summary of Suggested Actions

1. Create an online tool or incorporate an automatic procedure into the Storm Data software or Performance Management site that helps staff generate costs estimates to further refine the direct loss estimates they produce. This web-based tool would follow the existing NWS handbook and apply another layer of scrutiny to the data being collected and entered into the system. Implementing a series of process improvements with an on-line tool or data-entry software for Storm Data estimates from WFOs would greatly increase the accuracy and consistency of estimates across the many offices.
   Importance – High
   Resources – Moderate to High

2. Utilize staff at Regional NWS Offices to collect, organize, and standardize WFO-reported data to create direct loss estimates with the consistent methodologies. By analyzing and normalizing the data at a regional level, the irregularities between individual local WFO estimates are minimized.
   Importance – Moderate
   Resources – Moderate

3. Adjust staffing to include personnel whose job description is solely for disaster loss cost estimating. Whether at the local, regional, or national level, having a WFO position completely focused on cost estimating could result in grand improvements to the loss estimating system as a whole.
   Importance – Moderate
   Resources – High

4. Provide training or procedural clarification for WFOs' estimators. Ensure that NWS updates and expands the NWS Handbook, appendix to the cost-estimating Storm Data Directive 10-1605, to include additional estimating details and updated loss values. If there are not enough resources to modernize the WFO disaster loss estimation process with an online tool or automated procedure, the next best solution is to update the cost estimating handbook. This should also include language with standardization of how to split fresh-water flooding costs from storm-surge costs. By clarifying data collection procedures and loss estimation methodologies, WFO estimators may be able to calculate overall more accurate estimates.

    Importance – High
    Resources – Low

3.10 Uncertainty, Bias, & Efficiency of Private Sector Estimates

Overview

The team suggests conducting an in-depth analysis of directional uncertainty & statistical efficiency with respect to private estimates. The goal of this exercise is to construct a database of disaster cost estimates made by other government agencies and groups (banks, NGOs, etc.). This database could then inform research on patterns of historical differences between private estimates, as well as aide analysis of differences between NOAA estimates and those of other agencies.

Discussion & Motivation

There are often several different disaster impact costs released by other organizations, and these numbers may be compared to the NOAA estimates of disaster costs. Differences between NOAA estimates and those of private or other industry groups can come from a variety of sources (composition of direct/indirect loss, methodology, etc). A relatively straightforward study of how NOAA estimates compare to other organizations' values could provide better understanding of where these differences come from, as well as potentially identify significant differences in methodology or data sources. Identifying these differences could lead to further revisions in NOAA estimation strategies, as well as prepare NOAA for discussion of industry differences that may arise in future. The research team proposes that NOAA commission a quantitative study of the NOAA disaster loss estimates compared with non-NOAA estimates.

This quantitative study could be conducted in a variety of ways based on resource availability. However, the first step would be to create a database that included impact-cost estimates from as many sources as possible. The economic loss estimates would be collected from a variety of sources, including new reports, white papers, and academic publications. These should be indexed by the entity that produced the estimate, any relevant price index or adjustment made, disaster type, and a set of dummy variables that indicate what is included in the estimates (direct costs, indirect costs, etc.) if that information is available.

The analysis could then undergo a series of statistical tests to compare them to NOAA's estimates. To deal with the likely unbalanced nature of the panel (i.e., different sources may not cover all the same disasters as the BDWCD, NHC, or WFOs), pairwise comparisons of each source with the three primary NOAA estimates should be the first step. To understand the stability of the relationship between the NOAA estimates and those of the other estimates, we suggest following the Mincer & Zarnowitz (1969) framework, whereby a simple regression may take the following form:

$$NOAA_i = \alpha + \beta * Alt_i + \varepsilon$$

This equation implies that the NOAA estimate of disaster *i* is a function of the alternative estimate of economic impacts (Alt_i). Significance tests can then determine whether there is a consistent bias between the two estimates (present if $\alpha \neq 0$) or statistical inefficiency between the two ($\beta \neq 1$); note that these tests should be tested jointly. These tests should be run in both levels and logarithms; the latter will help determine if alternate forecasts tend to be off by roughly the same percentage of the NOAA each time, rather than the same dollar amount.

Further pair-wise comparisons could be done to test changes in the historical relationship between the alternative forecast and the NOAA forecast by using a modified parameter constancy test (see Ericsson 1992). This would test whether the mean squared differences between the NOAA and alternate estimates had a different variance over selected time periods (e.g., the researcher could test whether the common estimates prior to 2000 had the same variance as those after, using an F test).

Depending on the overall completeness of the panel, several other tests could be conducted. If the number of estimates from each source is fairly complete, several different entity-based techniques could be examined. If the panel of estimates is fairly incomplete, a set of three-way encompassment test could be run. Roughly, these tests would be run as follows:

$$NOAA_i - Alt_i^2 = \alpha + (\gamma_1 * Alt_i^1 - \gamma_2 * Alt_i^2) + \varepsilon_i$$

Three assumptions can then be used to test whether the alternative estimate 2 encompasses the alternative estimate 1. These are as follows:

Encompassment Tests			
Assumptions	**Null Hypothesis**	**Implications of Results**	
$\boldsymbol{\gamma_1 = \gamma_2 = \gamma}$	$\gamma = 0$	Reject the Null	- Alt_i^2 fails to encompass Alt_i^1
		Fail to Reject	- Alt_i^2 encompass Alt_i^1
$\boldsymbol{\gamma_1 = \gamma_2 = \gamma}$	$\gamma = 0$, $\alpha = 0$	Reject the Null	- Alt_i^2 fails to encompass Alt_i^1, and/or Alt_i^2 is biased
		Fail to Reject	- Alt_i^2 encompass Alt_i^1
$\boldsymbol{\gamma_1 = \gamma_2 = \gamma}$ $\boldsymbol{\alpha \equiv 0}$	$\gamma = 0$	Reject the Null	- Alt_i^2 fails to encompass Alt_i^1
		Fail to Reject	- Alt_i^2 encompass Alt_i^1

These tests can help identify which disaster costs estimates (if any) can consistently provide additional information to NOAA.

Magnitude of Benefits and Costs

The benefits from this analysis would provide further information about how the NOAA estimates relate to different private estimates. This knowledge would help contextualize NOAA estimates with regards to other proprietary loss estimates in a systematic and rigorous way.

The costs of developing a database of private estimate would be relatively low, potentially as small as 40-50 man-hours of a staff member (though likely more). Full analysis as described would be somewhat more substantial, requiring 1-2 months for a statistics-savvy researcher.

Summary of Suggested Actions

1. Build a database of disaster estimates from various industry and academic sources for comparison with NOAA estimates.
   Importance – Moderate
   Resources – Low to Moderate

2. Run a series of tests to determine NOAA forecasts' relationship to industry values, including bias, efficiency, and encompassment
   Importance – Moderate
   Resources – Low

3.11 Long-Duration Disasters: Forecast-Residual Analysis, Substitution Analysis

Overview

The research team suggests commissioning a study to incorporate expert forecasts and other improvements into drought and other long-duration event cost estimates. Recommendations of the study will include methodology for incorporation, as well as potentially developing web-based tools or scripts to pull WASDE or other information directly into a database to perform analysis.

Discussion & Motivation

For the BDWCD, the long-duration events such as drought create significant challenges for measurement and proper identification of direct losses. Currently, the BDWCD estimates rely on funds made available through the FEMA PDD programs and USDA data on crop losses. However, as the intensity or duration of a drought increases, the value of the uninsured loss multipliers associated with these effects may change, especially based on regional or idiosyncratic issues that might not be included under either program. While state reports and other material can help fill in some of these gaps, there is often a significant lag. As such, finding a way to quantify effects in real-time could potentially be of value to these estimates.

Several empirical studies of expert opinions have found that incorporating expert opinion into forecasts can improve their performance; this is particularly true with regards to agriculture economics literature. Additionally, there are several academic papers that use forecast error as a determinant of the impact of natural disasters. Tracking changes in expert opinions of crop or other forecasts as a drought develops could help derive an estimate of the drought's effects. Initial estimates of crop output activity could serve as a baseline for estimating the direct impacts of a drought on agricultural markets. The justification for including these changes is that, as the severity of the drought becomes more evident, the expert forecasts will incorporate this new information into their forecasts and adjust their forecasts accordingly[8]. While this will not perfectly isolate the true effect of the drought, the changes in the forecast can show how the experts view the likely impact in real time.

For further accuracy, the standard errors of the forecasts can be calculated by evaluating historical Root Mean Squared Forecasting Error (RMSFE); this would give a confidence bound to direct loss estimates, allowing for a greater quantification of uncertainty. Further, there are many resources of forecast evaluation that could improve the performance of such methods, bringing out a more accurate measure of the uncertainty associated with this approach.

In the example of crop estimates, the USDA produces a monthly report that could provide the real-time forecasts of crop outputs that could be used in this analysis. The World Agricultural Supply and Demand Estimates (WASDE) has a long track record, allowing for both a quantification of historical forecast accuracy and backward-looking evaluation of how the forecasters changed their forecasts in historical cases of drought. As this report is filed monthly in roughly the same format (excel), a web-script could be designed to pull the information each month, and the forecast changes and RMSFE calculation could be automated. An example of the procedure of can be found in the appendix.

A similar approach could be found for other forecasts that are produced at regular intervals; for example, hydroelectric power generation is another candidate for examination associated with drought events.

[8] Further discussion of this approach and a numerical example using the 2012 drought are available in Appendix D.

Another strategy to include in the examination of long-duration events includes the fact that those afflicted by drought can often change or modify behavior to minimize the droughts impact. This is presents a problem with proper identification of “compensated” direct losses, since the substitution away from the drought’s cost partially offsets some of the true direct costs of the drought. Since long-duration events can influence a wide variety of people in so many different ways, a full analysis of the way that a long-duration event influences behavior could provide significant illumination into the appropriate way that these costs are measured. This analysis could be done in conjunction with other agencies (e.g. USDA, U.S. Drought Mitigation Center) or academic researchers.

Magnitude of Benefits and Costs

The benefits from the forecast-residual analysis would center on the accuracy and consistency of the long-duration events, creating an improvement in accuracy and consistency of the process. The benefits from a substitution study could be very large in the context of the long-duration events; this is because the current methodology used in these events is similar to that used in other disaster-type, though it is unclear if it should be. A full analysis of historical long-duration events, as well as a potential revamping or reprogramming of how the losses are calculated, could provide a fairly substantial change in the accuracy of the estimates.

The costs associated with these vary based on which recommendations are incorporated. The incorporation of a simple forecast-residual from regular forecasts could be done with relatively few hours from the primary estimators and likely would not require any outside resources. Creating a script that would download the data every month would also require relatively few man-hours from a web technician or IT specialist, and the forecast-residuals could be calculated automatically for the cost estimator. A full study of the long-duration events would be more costly, though the costs would be dependent on the size of the research team, the level of detail that the team attempts to define, and whether the study is of a few historical cases or becomes an on-going group that collects real-time data during each disaster.

Summary of Suggested Actions

1. Assign a group to determine the feasibility and mechanics of including real-time forecasts of crop loss during droughts. This would include tracking historical estimates, as well as potentially automating data collection.
   Importance – Moderate
   Resources – Low

2. Have the same group identify and investigate other examples of long-term forecasts that could be used for forecast-residual analysis.
   Importance – Low
   Resources – Low

3. Have the same group identify other idiosyncrasies of long-duration events that could be added to direct costs, including substitutions that represent cost mitigation techniques
   Importance – Moderate to High
   Resources – Moderate

4. Look into national Agriculture projections to refine/adjust estimates to reflect crop production transfers nationally.
   Importance – High
   Resources - Moderate

3.12 Centralized database and inflation indices impacts on historical estimates

Overview

To facilitate public use of NOAA data, **the research team suggests creating an online database that houses all of the economic loss estimates produced by NOAA.** This could also provide a vehicle for smoothing some of the data differences between the estimates, as well as potentially improve the consistency of the Storm Events Database.

Discussion & Motivation

Currently, NOAA economic loss estimates are not contained in a centralized database. The BDWCD data is housed at the NCDC Billion Dollar Weather/Climate Disasters website[9]. The NHC data is available at the NHC Data Archive website[10]. The NWS data is published in the Storm Events Database website[11]. There is sufficient scope for improvement of all NOAA economic impact estimates by increasing coordination and cooperation between the estimators. One way to implement coordination among the major three estimators is via an online database that houses all of the NOAA disaster costs estimates in a single place. By combining all of these estimates in one location, NOAA and the NCDC could create a unified source of information for economists, press, students, and other interested users to obtain climate- and weather-related data.

This online database could serve as a vehicle for several other improvements or modifications to the current calculation and presentation of data. Some potential improvements are discussed below.

Streamlining the Storm Events Database & Improving Consistency of Economic Loss

Currently, the Storm Events Database is populated with information collection from the 124 different Weather Forecast Offices. This database could be the starting point for including the NHC and BDWCD estimates into the current structure. Additionally, the centralized database from the three groups could be further facilitated by creating a web-based application or other internal reporting system could help each WFO automatically upload different events into the database.

This centralized database would include both historical and new storm events. The web-accessible database could be easily downloaded in either PDF or Excel versions and would provide comprehensive data on NOAA disaster cost estimates.

Addressing Different Inflation Measures

Currently, while each of the disaster economic impact estimates are generated in nominal terms, each database has a different inflation index to adjustment historical estimates, and a different policy on how to treat historical numbers. This can be potential problematic for any systematic review or historical analysis using the NOAA databases. Each of the three comprehensive efforts is described below:

- BDWCD adjusts all historical estimates using the Consumer Price Index (CPI); further, this adjustment has led to the inclusion of more historical events as the present value of economic damage inflicted by historical storms to exceed $1B in real terms, even if the disaster was not close to cause $1B in nominal economic damage (this is particularly true earlier in the dataset, as inflation has been positive in every year since the database began).
- NHC adjusts its historical numbers using the McGraw-Hill Construction Cost Index for real cost estimates.

[9] http://www.ncdc.noaa.gov/billions/events
[10] http://www.nhc.noaa.gov/pastall.shtml
[11] http://www.ncdc.noaa.gov/stormevents/

- NWS numbers are from the WFO reports and are strictly in nominal terms, though the Hydrologic Information Center's Flood Loss Data does adjust the WFO information using the McGraw-Hill index.

There are many options for calculating inflation for the loss estimates depending on the purpose of the inflation index, the type of storm, and other factors. Many options are listed in the Table 1 following this section. Each inflation index has a specific purpose and focus which can be used pointedly for specific factors of disaster impact calculations. Some indices may be worth considering for specific disasters as a whole. For a more broad consideration of inflation for disaster impact estimates, another option is to consider using a more general inflation index across the different NOAA organizations which could improve consistency across estimates.

A centralized database could simplify analyzing the impact of using different inflation indices, and allow end-users of NOAA's data to adjust the nominal prices with the index of their choice. Different inflation indexes might be preferred depending on the focus and purpose of the user of NOAA's disaster cost estimate data. To create the most flexibility for data users, the estimates could initially be presented in nominal terms, the most simple and unaltered version. Then, users could select which specific inflation index they would like to apply to the data, across the board or just for specific data points, resulting in the preferred data set for the user's research and analysis needs. This option for different inflation indices allows users more standardization and flexibility. By enabling the data users to identify a preferred inflation index for the data, NCDC results in estimates that are more valuable and useful.

Magnitude of Benefits and Costs

The benefits from creating a common database are quite substantial. Creating a convenient public resource for the information could promote and facilitate significant research opportunities and knowledge creation. Further, direct uploading and applications-based entry of WFOs' data into a national system could improve the consistency and accuracy of future estimates, as well as allow cheaper redefinition and estimation of losses in the future (as changes to the NWS suggested costs handbook could be altered in the inputting system rather than have to be distributed to each office and ensure that staff are using the new numbers).

The costs of creating the centralized database are relatively moderate, though most of the costs would be an up-front and one-time expenditure. The process would include the creation of the database (including determining which agency would house and maintain the database); the system to upload or retrieve data from the different cost-estimating organizations; and design, creation, debugging, and publication of the web-based application for the public to access the database. Additionally, any features and functionalities (such as the inflation-index options) would need to be designed and incorporated into the framework that was designed.

Summary of Suggested Actions

1. Commission a team to create a database of all historical estimates from the four different NOAA estimates. Most likely, this would involve modifying the current Storm Event Database to incorporate the other estimates. The team should also create a query system that allows interested individuals to access and filter the data online and download information. Show the data as disaggregated as possible such as structural damages, business interruption, and other specifics that an I/O modeler would be interested in using. Strong examples of this database include the EIA query system and the St Louis FRED database.

   Importance – Moderate to High
   Resources – Moderate to High

2. Consider creation of automated reporting system, such that new events and information can be uploaded directly by the WFOs and other organizations on a web-based platform. Might consider crowd-sourcing and other methods for collecting local loss information.
   Importance – Moderate
   Resources – Moderate to High

3. Consider additional upgrades to the data for consistency purposes. For example, consider an inflation index option on the economic direct loss time series. Users could choose an inflation base-year and an inflation index resulting in more suitable data.
   Importance – Low
   Resources – Low if Recommendations 1 & 2 are implemented

Table 1 – Different Inflation Indices

Inflation Index Options		
Index	**Description**	**Considerations**
Consumer Price Index (CPI)	The CPI and its variants (Core, trimmed mean, etc.) track changes to goods consumed regularly by households, and weight those changes according based on historical expenditure. The basket of goods in the index tracks the impact of rising prices that could alter consumer behavior.	- Most widely known index - Adjusts costs to reflect consumer behavior, easily relatable - Isolates welfare effects by using fixed basket - Multiple variations and sub-indices for quick comparisons (including chain-type index)
Personal Consumption Expenditures Index (PCE)	The PCE Index is an alternative to CPI, measuring the prices influencing households and individuals, but allowing for more substitution in the face of inflation. This can more accurately track behavioral responses to inflation, but is less precise in measuring welfare loss from rising prices	- Adjusts costs to reflect consumer behavior, easily relatable - Compensates for actual substitution of goods by consumers
Producer Price Index (PPI)	The PPI measures the cost of primary inputs used in industry. Conceptually, this index is similar to a CPI for domestic industry, particularly those in manufacturing and construction.	Focuses on costs to industry and business, costs which are excluded by CPI and PCE measures
GDP Deflator	The GDP Deflator attempts to measure the inflation level across the entire economy, across all sectors and industries. The methodology is similar to the PCE deflator in that behavioral responses to rising prices are included in calculation.	- Broadest measure of inflation - Compensates for actual substitution of goods by economic agents
McGraw Hill Construction Index	This index is a measure of costs associated with local construction, including labor, materials, and other associated costs. The index is proprietary. The ENR (Engineer News Record) uses McGraw Hill data in its Construction Cost Index (CCI).	Most closely reflects replacement costs for local consumers and businesses
The Civil Works Construction Cost Index System	This index, produced by the U.S. Army Corp of Engineers, examines the local costs of construction including labor and materials, with a weighting towards large-scale infrastructure projects.	Most closely reflects replacement costs of infrastructure for governments

3.13 Additional billion-dollar historical weather- and climate-related disasters to the database based on FY13 inflation values

Overview

The BDWCD database is well known to only include weather- or climate-related disasters that caused $1B or greater worth of damage. However, **the research team has identified potential candidates for inclusion into the BDWCD database[12].**

The research and interviews conducted in this investigation found several potential events that imposed close to $1B in FY2013 dollars. The suggested disasters include the following:

Events Potentially at or Near $1B Threshold	
Grand Island Tornadoes 1980	Western Wisconsin Derecho 1980
California/Arizona Floods 1980	Midwest Drought of 1983
Midwest Drought of 1985	Hurricane Lili of Autumn 2002
Soybean Drought of 2003	

Discussion & Motivation

The BDWCD has recently added 19 weather- and climate-related disasters into the database; each of these events caused under $1B in direct losses at the time of the event, though inflation has since pushed the value of direct losses over the $1B threshold. Many additional events are likely to be close to or have already exceeded the billion dollar threshold.

Comparing high-value estimates among NOAA organizations' databases could reveal additional data points to add to the BDWCD database. The BDWCD estimators may be able to easily identify additional disasters to create a more comprehensive list. Further, they may be able to leverage specific data already collected and calculated to more easily determine a BDWCD disaster estimate.

These supplemental disaster events exemplify an additional issue with the BDWCD: as inflation continues to rise, more events will begin to qualify for inclusion into the database. This increase could potentially sap resources from the BDWCD estimators, requiring more historical analysis as part of the regular duties of the team. It is worth considering a restructuring of the methodology for inclusion of prior disasters, as historical loss values rise to the $1B threshold with inflation over time. Additionally, if a centralized database of events were to be created (see recommendation 3.6), this task could be significantly simplified.

Further, at the May 2012 Disaster Reanalysis Workshop, NOAA NCDC economist Adam Smith noted that "There would be huge value in pursuing a lower threshold than a Billion, and that would help put the Billion events into better perspective." A decision of this grandeur could require a large commitment from NCDC to agree to a scope increase in the BDWCD database threshold and to provide investment dollars to aggregate historical disasters to include.

Magnitude of Benefits and Costs

The benefits to investigating these historical incidences would be to ensure that the BDWCD database of events is as complete as possible, further fulfilling its mission. Additionally, even if these events are found to fall short of the billion dollar threshold, inflation would eventually push them above this level

[12] It should be noted that since the initial draft of this report, some of these events have been examined and incorporated, while others were determined to fall just short of the billion dollar threshold; however, these nominal values will be useful in a few years once inflation pushes their value above the billion dollar threshold.

and would need to be included in the database; thus, these investigations would not be wasted, but rather obviate the need for pricing the events at some future date.

The cost to investigating these historical episodes would be relatively minor. The costs would be limited to the man-hours of BDWCD staff. This is also not time-sensitive, so timing of the research could be strategically determined based on workload.

Summary of Suggested Actions

1. Investigate additional historical episodes to determine if their direct losses exceed the billion dollar threshold.
   Importance – Low
   Resources – Low

2. Have a high-level discussion amongst the leadership on how to (a) deal with the increasing number of historical events that exceed the billion dollar threshold, and (b) implement the decision. This could issue be handled in a number of ways: the threshold for historical events could be "locked", whereby events older than a certain number of years (e.g. 25 years) would not be eligible for inclusion; the threshold could be periodically raised from $1B and tracked to inflation; a permanent staff member could be hired with the primary function to examine historical values; or periodic audits of historical events could be schedule at regular intervals (e.g. to recur every 5 years).
   Importance – Low
   Resources – Low to Moderate

3. Identify and include additional threshold-level disasters which will soon reach $1 Billion impact with future inflation considered by conducting literature reviews of prior estimates to cull a preliminary list of disasters for analysis. While one review has already been conducted, another more thorough round of analysis might identify even more data points for the database.
   Importance – Moderate
   Resources – Low

4. Reduce the dollar value threshold to an amount lower than $1 Billion to put more disasters into perspective. More data-points and more comparisons would result in a more valuable NCDC Disaster database for all.
   Importance – Low
   Resources – High

5. Include major disasters in the BDWCD Database that occurred prior to 1980. This would increase the value of the database by adding disasters and providing more historical context to the information provided.
   Importance – Low
   Resources – High

6. Look at the collective impact of small storm events (e.g. WFO impact information, summed over time). Small droughts, small floods, etc. PCS records events as low as $25 million, which could often reference these smaller storms. To start, check what USACE reports for flooding as rolled-up WFO values.
   Importance - Low
   Resources – Moderate to High

4. Prioritized Ranking of Suggested Actions

The suggested actions have been ranked in a prioritized list based on the Importance and Resource valuations from the NOAA project team. The prioritization sums the Resource and Importance scores are result in the total score for each suggested action.

The actions with the highest importance to the NOAA team are ranked "10." This is a logical scoring system. The actions with lowest necessary resources, by FTE or by funding, are ranked "10." This is contrary to the idea that higher resources would get a higher score. The rank instead gives the "better" or "cheaper" actions a "better" or "higher" score. With the two scores combined, the actions with low-resources and high-importance prioritize to a high rank while the actions with high-resources and low-importance rank at the bottom of the list.

Rank	Recommen-dation Category	Specific Recommen-dation	Suggested Action	Resources Score	Importance Score	Total Score
1	Improving estimates of direct costs	Directional Bias and Uncertainty of NOAA estimates	Based on the results of the study, consider including uncertainty bound surrounding in data releases. Options could include releasing 95% confidence bounds surrounding the mean estimate, graphics (such as fan charts or error bars) demonstrating the uncertainty of the estimates, etc. This includes error bars for a time-series graph of disasters dating back from 1980.	9	10	19
2	Enhancing and expanding the output that NOAA currently produces	Active impacts of NCDC data	Write a paper and publish it on the NOAA NCDC BDWCD website informing users that a study has been commissioned to identify and suggest approaches to overcome time-dependent biases and uncertainties in the data and methods used by NOAA, recommending specific changes in methods and data sources that will improve estimates of the economic impacts of weather- and climate-related disasters. Include in the paper a summary of results and a timeline with next steps for improvement.	10	9	19
3	Improving coordination within and outside NOAA organizations	Coordination with external groups over definition of impacts	Coordinate internal NOAA estimators (BDWCD, NHC, NWS, and NMFS) to agree on a standard across the organizations for defining direct losses. This would require a Working Group or equivalent team with members being estimators from each estimating organization as well as the NOAA HQ economists for oversight and approval.	9	9	18
4	Improving coordination within and outside NOAA organizations	USDA multiplier drift	Capture the regional variability in crop patterns and insurance patterns across temporal space. "Place to place, over time, from crop to crop." Compile USDA data into one source to collect the temporal information. Reference crop insurance sources to further establish the analysis.	9	9	18

Rank	Recommen-dation Category	Specific Recommen-dation	Suggested Action	Resources Score	Importance Score	Total Score
5	Enhancing and expanding the output that NOAA currently produces	Additional Data Sources & Collaborations	Involvement with the Joint Field Office (JFO) could be mutually beneficial for NOAA estimators and for the JFO. A two-way street of information flow would inform each group on NOAA's data flow processes and the JFO protocols for government entities with data generation and integrated exercises into the JFO processes. NHC has 60-day estimate requirements, perhaps similar to the JFO 60-day Needs Assessment requirement. These 60-day operations windows could use teamwork between agencies for efficiencies.	9	9	18
6	Improving coordination within and outside NOAA organizations	Cross-organizational Collaboration on Overlapping Estimates	Develop protocols to allow NCDC to build off the NHC 60-day disaster loss estimates.	8	9	17
7	Improving coordination within and outside NOAA organizations	Coordination with external groups over definition of impacts	Produce a fully documented primer on the direct costs that NOAA currently estimates. The primer could be published in print or as a PDF online free to the public. It would be a valuable resource both internally and for the general public to reference. By defining assumptions in a clear and articulated manner, data users will have a better understanding of the information and be better suited to apply it to their interests.	8	9	17
8	Enhancing and expanding the output that NOAA currently produces	Pilot Program: Sampling/Surveys of Insurance Statistics	Small/Pilot Program Verification– Commission a group to vet the uninsured-loss multiplier values of a few events by acquiring information on policy deductibles & caps, insurance penetration rates, and levels of underinsurance. This group would investigate the best/most feasible way to collect the data (residential/commercial surveys, local insurer surveys, partner with PCS survey or Insurance Information Institute, etc.). A proper uninsured-loss multiplier could then be calculated. If the values is close to those currently used by NHC and BDWCD estimates, further investigation may not be necessary to justify current practices. While this approach would not confirm that the uninsured-loss multipliers are valid, results showing that they are "in the ballpark" could provide sufficient for verification purposes.	8	9	17

Rank	Recommendation Category	Specific Recommendation	Suggested Action	Resources Score	Importance Score	Total Score
9	Improving coordination within and outside NOAA organizations	Cross-organizational Collaboration on Overlapping Estimates	Coordinate with Fisheries and WFO to contextualize the efficiencies "connect the dot" between the estimates. Show how the numbers speak to one another.	8	9	17
10	Enhancing and expanding the output that NOAA currently produces	Indirect & Other Impact Numbers in Addition to Direct Loss Numbers	Look at direct losses directly attributed to nonmarket losses such as ecosystem losses, cultural losses, loss of human capital, etc. Work with existing NOAA groups to articulate these losses using a narrative as opposed to a publishing a quantified value. Stay involved and coordinate with internal NOAA and external academic entities analyzing these nonmarket losses.	8	9	17
11	Enhancing and expanding the output that NOAA currently produces	Indirect & Other Impact Numbers in Addition to Direct Loss Numbers	Remove indirect losses from historical and future Drought estimates to ensure consistency across the methodologies for all weather and climate disaster estimates. In the BDWCD list, the primary number must the direct loss value to make it comparable to the other disaster loss values.	8	9	17
12	Improving estimates of direct costs	Directional Bias and Uncertainty of NOAA estimates	Commission a study to investigate the bias and statistical uncertainty from each data source and multiplier used in estimation, as well as how those bias & uncertainty measures interact with each other. This study would pay special attention to both directional bias/uncertainty and correlation of the bias/uncertainty when combined into the NOAA estimates.	7	9	16
13	Improving coordination within and outside NOAA organizations	Cross-organizational Collaboration on Overlapping Estimates	The NHC and BDWCD could immediately meet and harmonize methodologies for calculating uninsured flood-loss multipliers and inclusion of USDA crop-loss data/multipliers. Thus, future efforts to calculate the uninsured-loss multiplier would be aligned. This would require a one-time coordination between the two groups to set the methodology. To reduce duplication of effort, NHC and BDWCD could collaborate whenever a new cyclone hits. This could ensure that the uninsured flood-loss multipliers are identical for each new event. This would require setting up a protocol for initiating the collaboration (specifying contact persons and other protocols for the discussion).	7	9	16

Rank	Recommendation Category	Specific Recommendation	Suggested Action	Resources Score	Importance Score	Total Score
14	Enhancing and expanding the output that NOAA currently produces	Additional Data Sources & Collaborations	Contact and collaborate with USACE about potential data-sharing and cost estimation collaboration opportunities. These include both infrastructure estimates of costs from flooding as well as disaster response models.	8	8	16
15	Enhancing and expanding the output that NOAA currently produces	Additional Data Sources & Collaborations	Contact and collaborate with EIA for similar collaboration opportunities with estimating energy-related losses. Further, look into uninsured loss with oil and gas infrastructure.	8	8	16
16	Enhancing and expanding the output that NOAA currently produces	Additional Data Sources & Collaborations	Contact and collaborate with private insurers and reinsurers for additional partnership opportunities. Particular interest would be related to Excess Flood Insurance data from Lloyd's of London or Chubbs. Similarly, more interaction with insurance and reinsurance industry group could provide more or better access to date through Munich Re, Swiss Re, state insurance commissions, and trade groups (Insurance Information Institute, National Association of Mutual Insurance Companies, etc).	8	8	16
17	Improving estimates of direct costs	Regional or Centralized WFO economic estimation	Provide training or procedural clarification for WFOs' estimators. Ensure that NWS updates and expands the NWS Handbook, appendix to the cost-estimating Storm Data Directive 10-1605, to include additional estimating details and updated loss values. If there are not enough resources to modernize the WFO disaster loss estimation process with an online tool or automated procedure, the next best solution is to update the cost estimating handbook. This should also include language with standardization of how to split fresh-water flooding costs from storm-surge costs. By clarifying data collection procedures and loss estimation methodologies, WFO estimators may be able to calculate overall more accurate estimates.	7	9	16
18	Improving estimates of direct costs	USDA multiplier drift	Commission members of the BDWCD to liaison with USDA RMA economists to reevaluate uninsured crop-loss multipliers, including the consideration of deductibles.	7	9	16

Rank	Recommendation Category	Specific Recommendation	Suggested Action	Resources Score	Importance Score	Total Score
19	Improving estimates of direct costs	Uncertainty, Bias, & Efficiency of Private Sector Estimates	Run a series of tests to determine NOAA forecasts' relationship to industry values, including bias, efficiency, and encompassment	9	6	15
20	Improving estimates of direct costs	Long-Duration Disasters: Forecast-Residual Analysis, Substitution Analysis	Look into national Agriculture projections to refine/adjust estimates to reflect crop production transfers nationally.	6	9	15
21	Enhancing and expanding the output that NOAA currently produces	Indirect & Other Impact Numbers in Addition to Direct Loss Numbers	Deliver NOAA loss estimate data in a way that is useful for those who are doing indirect loss modeling (recognize limitations based on agreements with data providers). The data should be as granular as possible while recognizing proprietary limitations.	6	9	15
22	Improving coordination within and outside NOAA organizations	Cross-organizational Collaboration on Overlapping Estimates	To eliminate duplication of effort, the NHC and BDWCD could jointly issue a single estimate. As the NHC is required to issue an estimate within 2 months of the disaster, and the BDWCD issues a preliminary estimate of the direct losses, collaborating would allow for a single release. The BDWCD could then finalize this jointly-released number later as they do with their preliminary estimates. This would likely require a mandate or guidance to be issued from NOAA HQ.	5	9	14
23	Improving coordination within and outside NOAA organizations	Centralized Database of NOAA Organizations' Estimates	Consider additional upgrades to the data for consistency purposes. For example, consider an inflation index option on the economic direct loss time series. Users could choose an inflation base-year and an inflation index resulting in more suitable data.	9	4	13
24	Enhancing and expanding the output that NOAA currently produces	Additional Data Sources & Collaborations	Contact and collaborate with HHS/CDC for information on loss of life, disease, and other indirect costs associated with prolonged heat, cold, or electrical disruptions. Further, consider direct medical costs caused by extreme weather events.	8	5	13

Rank	Recommendation Category	Specific Recommendation	Suggested Action	Resources Score	Importance Score	Total Score
25	Improving estimates of direct costs	Long-Duration Disasters: Forecast-Residual Analysis, Substitution Analysis	Assign a group to determine the feasibility and mechanics of including real-time forecasts of crop loss during droughts. This would include tracking historical estimates, as well as potentially automating data collection.	9	4	13
26	Improving estimates of direct costs	Long-Duration Disasters: Forecast-Residual Analysis, Substitution Analysis	Have the same group identify other idiosyncrasies of long-duration events that could be added to direct costs, including substitutions that represent cost mitigation techniques	5	8	13
27	Enhancing and expanding the output that NOAA currently produces	Additional historical billion-dollar weather- and climate-related disasters	Have a high-level discussion amongst the leadership on how to (a) deal with the increasing number of historical events that exceed the billion dollar threshold, and (b) implement the decision. This could issue be handled in a number of ways: the threshold for historical events could be "locked", whereby events older than a certain number of years (e.g. 25 years) would not be eligible for inclusion; the threshold could be periodically raised from $1B and tracked to inflation; a permanent staff member could be hired with the primary function to examine historical values; or periodic audits of historical events could be schedule at regular intervals (e.g. to recur every 5 years).	9	4	13
28	Improving coordination within and outside NOAA organizations	Centralized Database of NOAA Organizations' Estimates	Commission a team to create a database of all historical estimates from the four different NOAA estimates. Most likely, this would involve modifying the current Storm Event Database to incorporate the other estimates. The team should also create a query system that allows interested individuals to access and filter the data online and download information. Show the data as disaggregated as possible such as structural damages, business interruption, and other specifics that an I/O modeler would be interested in using. Strong examples of this database include the EIA query system and the St Louis FRED database.	4	8	12

Rank	Recommendation Category	Specific Recommendation	Suggested Action	Resources Score	Importance Score	Total Score
29	Improving estimates of direct costs	Regional or Centralized WFO economic estimation	Create an online tool or incorporate an automatic procedure into the Storm Data software or Performance Management site that helps staff generate costs estimates to further refine the direct loss estimates they produce. This web-based tool would follow the existing NWS handbook and apply another layer of scrutiny to the data being collected and entered into the system. Implementing a series of process improvements with an on-line tool or data-entry software for Storm Data estimates from WFOs would greatly increase the accuracy and consistency of estimates across the many offices.	3	9	12
30	Improving estimates of direct costs	Uncertainty, Bias, & Efficiency of Private Sector Estimates	Build a database of disaster estimates from various industry and academic sources for comparison with NOAA estimates.	7	5	12
31	Improving estimates of direct costs	Regional or Centralized WFO economic estimation	Utilize staff at Regional NWS Offices to collect, organize, and standardize WFO-reported data to create direct loss estimates with the consistent methodologies. By analyzing and normalizing the data at a regional level, the irregularities between individual local WFO estimates are minimized.	5	6	11
32	Improving estimates of direct costs	Long-Duration Disasters: Forecast-Residual Analysis, Substitution Analysis	Have the same group identify and investigate other examples of long-term forecasts that could be used for forecast-residual analysis.	9	2	11
33	Enhancing and expanding the output that NOAA currently produces	Additional historical billion-dollar weather- and climate-related disasters	Investigate additional historical episodes to determine if their direct losses exceed the billion dollar threshold.	9	2	11

Rank	Recommendation Category	Specific Recommendation	Suggested Action	Resources Score	Importance Score	Total Score
34	Enhancing and expanding the output that NOAA currently produces	Additional historical billion-dollar weather- and climate-related disasters	Identify and include additional threshold-level disasters which will soon reach $1 Billion impact with future inflation considered by conducting literature reviews of prior estimates to cull a preliminary list of disasters for analysis. While one review has already been conducted, another more thorough round of analysis might identify even more data points for the database.	9	2	11
35	Enhancing and expanding the output that NOAA currently produces	Active impacts of NCDC data	Keep a NOAA estimators' technical assistance database to record the contact information of Q&A callers to allow follow-up to capture the value of the database information, how it is being used, etc. For an example, follow existing practices at the NOAA CSC.	9	2	11
36	Enhancing and expanding the output that NOAA currently produces	Active impacts of NCDC data	Commission reports examining the end-use of NOAA estimates, specifically trying to quantify the value of the information that NOAA provides and the number of researchers who use it.	9	1	10
37	Improving coordination within and outside NOAA organizations	Centralized Database of NOAA Organizations' Estimates	Consider creation of automated reporting system, such that new events and information can be uploaded directly by the WFOs and other organizations on a web-based platform. Might consider crowd-sourcing and other methods for collecting local loss information.	4	5	9
38	Enhancing and expanding the output that NOAA currently produces	Indirect & Other Impact Numbers in Addition to Direct Loss Numbers	Create a framework for listing damage to critical ecological functions and environmental services. This could take the form of a low-level list with qualitative descriptions, or may be expanded to include quantitative estimates based on hedonic pricing practices.	7	2	9

Rank	Recommendation Category	Specific Recommendation	Suggested Action	Resources Score	Importance Score	Total Score
39	Enhancing and expanding the output that NOAA currently produces	Active impacts of NCDC data	Continue Dataset Discovery Day and increase outreach to data users to better understand their perceived benefits of the BDWCD database. Encourage NOAA data users to participate in the meetings via links on the NCDC homepage or via other outreach opportunities.	7	1	8
40	Enhancing and expanding the output that NOAA currently produces	Indirect & Other Impact Numbers in Addition to Direct Loss Numbers	Create a framework for estimating indirect losses associated with disasters. This could be done by current/future staff, or in partnership with other agencies, trade groups, or institutions.	7	1	8
41	Enhancing and expanding the output that NOAA currently produces	Indirect & Other Impact Numbers in Addition to Direct Loss Numbers	Reach out to public health organizations to develop a methodology for reporting public health issues after crises	7	1	8
42	Enhancing and expanding the output that NOAA currently produces	Indirect & Other Impact Numbers in Addition to Direct Loss Numbers	Determine if other non-climate or non-weather events could be candidates for determining direct economic losses using the current NOAA methodologies such as earthquakes or tsunamis. Potentially collaborate with USGS via an interagency agreement to facilitate such estimates. Look at the SHELDUS methodology for loss estimation sources.	7	1	8
43	Improving estimates of direct costs	Regional or Centralized WFO economic estimation	Adjust staffing to include personnel whose job description is solely for disaster loss cost estimating. Whether at the local, regional, or national level, having a WFO position completely focused on cost estimating could result in grand improvements to the loss estimating system as a whole.	2	5	7
44	Enhancing and expanding the output that NOAA currently produces	Active impacts of NCDC data	Add pop-up surveys to the NCDC data websites to collect user information – data preferences, value of data, use of data, etc.	6	1	7

Rank	Recommendation Category	Specific Recommendation	Suggested Action	Resources Score	Importance Score	Total Score
45	Enhancing and expanding the output that NOAA currently produces	Additional historical billion-dollar weather- and climate-related disasters	Look at the collective impact of small storm events (e.g. WFO impact information, summed over time). Small droughts, small floods, etc. PCS records events as low as $25 million, which could often reference these smaller storms. To start, check what USACE reports for flooding as rolled-up WFO values.	5	1	6
46	Enhancing and expanding the output that NOAA currently produces	Pilot Program: Sampling/Surveys of Insurance Statistics	Conduct a full study on the uninsured-loss multipliers. This would include a larger effort to collect data, including potentially employing multiple approaches (surveys of those directly affected, direct surveys of insurers, partnerships with other organizations). This approach would include calculating the level of uncertainty associated with each multiplier estimate, the consistency across regions, and whether each event would require a unique calculation (as is currently done with NFIP) or if the standard multiplier works. This would likely require sampling both affected regions and control regions.	3	2	5
47	Improving coordination within and outside NOAA organizations	Coordination with external groups over definition of impacts	Task tasking an individual or group within NOAA to reach out to other organizations (BEA, USDA, USACE, Weather & Climate Extremes Working Group, AA Climate Board, LA Red, World Bank, IMF, and UN) and spearhead the creation of a national (or international) standard for defining direct losses.	2	1	3
48	Enhancing and expanding the output that NOAA currently produces	Pilot Program: Sampling/Surveys of Insurance Statistics	Generation of a database with insurance information that could be accessed after each disaster. While much of the information on insurance policies is proprietary, there would likely be interest from potential industry partners or regulators to create state-specific or nation-wide databases with aggregated information on these characteristics. Partnership opportunities could include state insurance regulators, FEMA, industry groups (PCS, Insurance Information Institute, etc).	2	1	3
49	Enhancing and expanding the output that NOAA currently produces	Additional historical billion-dollar weather- and climate-related disasters	Reduce the dollar value threshold to an amount lower than $1 Billion to put more disasters into perspective. More data-points and more comparisons would result in a more valuable NCDC Disaster database for all.	2	1	3

Rank	Recommen-dation Category	Specific Recommen-dation	Suggested Action	Resources Score	Importance Score	Total Score
50	Enhancing and expanding the output that NOAA currently produces	Additional historical billion-dollar weather- and climate-related disasters	Include major disasters in the BDWCD Database that occurred prior to 1980. This would increase the value of the database by adding disasters and providing more historical context to the information provided.	2	1	3

5. Conclusions

As part of its responsibility to "monitor and assess the climate," NOAA's National Climatic Data Center (NCDC) tracks and analyzes extreme weather and climate events in the U.S. and globally that have great economic and societal impacts. This report has provided several different areas for improving or augmenting NOAA's estimates of economic loss from weather- and climate events. These recommendations broadly fell into three categories: (1) improving coordination within and outside NOAA organizations; (2) improving estimates of direct costs; and (3) enhancing and expanding the output that NOAA currently produces. Taken together, these recommendations will improve the overall accuracy and consistency of the estimates of direct costs, harmonize the estimates across the different NOAA organizations, increase the information content provided in the estimates, and incorporate the most modern disaster-loss techniques used in academia and industry.

Individually, each of these recommendations is designed to provide incremental improvements to the NOAA disaster estimates. In some cases, such as recalculation of NFIP and USDA multipliers, this involves process improvements to the estimates themselves. Other recommendations focus on enhancing current organization structures to make the process more consistent and efficient; for example, NHC and BDWCD could reduce duplicated efforts by deeper collaboration, or the WFO could improve consistency by restructuring their cost-estimation staffing structure and data-reporting mechanisms. Additionally, there are several recommendations that focus on quantitative studies of current techniques, including confirmation of multiplier values through surveys and sampling techniques, systematic comparisons with other estimates, analysis of direction bias and uncertainty of data inputs. Finally, there are several recommendations on how NOAA can increase the accessibility of their numbers, from simple website changes by creating an online database joining their estimates to more ambitious goals of reaching out to other organizations to formalize definitions and methodologies for assessing impacts of natural disasters.

These recommendations, and the successful implementation of some or all of them, will help promote the NOAA estimates as useful resources to inform strategic planners, infrastructure investment decisions, insurance underwriters and premium decisions, and the public policy debate on environmental and climatic issues.

Appendix A: Acronyms and Abbreviations

Acronyms and Abbreviations

ADRC	Asian Disaster Reduction Center
ASEAN	Association of Southeast Asian Nations
BDWCD	Billion Dollar Weather and Climate Disasters
BEA	Bureau of Economic Analysis
BI	Business Interruption
BLM	Bureau of Land Management
BLS	Bureau of Labor Statistics
CBA	Cost-Benefit Analysis
CBI	Contingent Business Interruption
CDBG	Community Development Block Grant Program
CDC	Center for Disease Control and Prevention
CPHC	Central Pacific Hurricane Center
CPI	Consumer Price Index
CRED	Centre for Research on the Epidemiology of Disasters
CSC	Coastal Services Center
DIR	Drought Impact Reporter
DLDS	Disaster Loss Data Standards
DSR	Damage Survey Report
EIA	Energy Information Administration
EM-DAT	International Disaster Database
EPA	Environmental Protection Agency
EWP	Emergency Watershed Protection
FAO	Food and Agriculture Organization of the United Nations
FCIC	Federal Crop Insurance Corporation
FEMA	Federal Emergency Management Agency
GAO	U.S. Government Accountability Office
GIS	Geographic information system
GLIDE	Global Identifier number
HUD	U.S. Department of Housing and Urban Development
HURDAT	Hurricane Database
IDB	Inter-American Development Bank
IFPRI	International Food Policy Research Institute
ISO/PCS	Insurance Services Office/ Property Claims Services
JFO	Joint Field Office
LA RED	Network of Social Studies and Prevention of Disasters in Latin America
MRIP	Marine Recreational Information Program
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NASS	National Agricultural Statistics Service
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center

NDMC	National Drought Mitigation Center
NEMS	National Energy Modeling System
NFIP	National Flood Insurance Program
NHC	National Hurricane Center
NIFC	National Interagency Fire Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resource Conservation Service
NWCC	National Water and Climate Center
NWS	National Weather Service
OCE	Office of the Chief Economist
PCS	Property Claims Services
PDD	Presidential Disaster Declaration
PERILS	Pan-European Risk Insurance Linked Services
RMA	Risk Management Agency
RUC	Rapid Update Cycle
SBA	Small Business Administration
SCAN	Soil Climate Analysis Network
SDR	Subcommittee on Disaster Reduction
STEO	Short Term Energy Outlook
UN	United Nations
USACE	U.S. Army Corp of Engineers
USAID	U.S. Agency for International Development
USDA	United States Department of Agriculture
USFA	U.S. Fire Administration
USGCRP	US Global Change Resource Program
USGS	US Geological Survey
WFO	Weather Forecast Office
WWCB	Weekly Weather and Crop Bulletin

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Appendix C: Guidelines for calculating uncertainty surrounding data inputs and multipliers

In section 3.1, Directional Bias and Uncertainty of NOAA estimates, the guidelines are discussed at a high-level for calculating uncertainty surrounding data inputs and multipliers. This Appendix C provides greater detail on determining uncertainty of disaster loss estimates using the current information and techniques available.

One way to improve the information content of the various NOAA estimates is to include rough calculations of the amount of uncertainty in each estimate; this could also help provide additional nuance to the numbers as well as help show the precision of the estimates on graphs and charts. Currently, there is a level of uncertainty associated with each data input, as well as with the multipliers used to account for uninsured losses based on the level of insured loss. While this report advocates commissioning a study to explicitly quantify the uncertainty surrounding the data inputs, a preliminary estimate of uncertainty can be calculated using some (relatively) straightforward assumptions. Specifically, the uncertainty associated with **each data source** should be considered:

1. **The input data are unbiased, or not systematically above or below the true direct loss.** This is a necessary part of the overall quantification of direct loss. This assumption is not particularly restrictive since a large portion of the true population is included in many of the data sources (crop and flood insurance measure the entire population of insured payouts, PCS surveys 70%+ of the actual payouts, etc).
2. **Uncertainty around the input value is normally distributed**. That is, the shape of the uncertainty space around the input value is symmetric and not skewed or kurtotic. This is also a relatively common assumption, though one that should be tested in future analysis of uncertainty.
3. **Uncertainty associated with different inputs is uncorrelated with those errors from other sources**. This is a slightly more bold assumption and should be a main focal point of future research into quantify uncertainty; however, the uncorrelated assumption allows for the calculated uncertainty of each source to be additive, as a multiplier or data sources uncertainty should not be influenced by the amount of uncertainty in other sources under this assumption.

The most straightforward data source in terms of finding an uncertainty bound is those of **insured losses**. Generally, the information on insured losses can be considered relatively robust and with small uncertainty bounds. For calculation purposes, using the final insured loss information with low or non-existent levels of uncertainty is proper, though preliminary or intermediate releases will have some uncertainty due to incompleteness of the data. This is because the USDA and NFIP data on crop and flood loss, respectively, encompass *all* payments made under the program, and so there is no uncertainty surrounding the actual insured payouts from these programs. While there may still be idiosyncratic insured losses not paid, or excess payments made in cases of fraud or abuse, these can generally be considered negligible and not consistent from event to event; therefore, **these insured loss numbers do not have any uncertainty associated with them**.

Similarly, the PCS numbers cover significant portions of the overall insured loss in the three categories covered (residential, automotive, and commercial), and the PCS numbers thus have relatively small level of uncertainty is associated with these estimates. Based on PCS' own analysis, it appears that their estimates of insured loss are routinely within 3% of the values reported by states and other organizations making similar calculations. For PCS final results, a 3% bound of uncertainty should be adequate. However, in cases where the PCS number is not finalized, their estimates generally have a strong upward bias in revisions; when intermediate PCS numbers are used, the uncertainty bound should be larger than 3% and have an upward skew. The size of the bound should be based on the percentage of respondents to the survey, while the upward skew should be based on which iteration the resurvey analysis is currently using, the projected number of resampling surveys to be conducted by PCS, and the average cumulative historical revisions to those iterations of PCS surveys (these data are available from PCS).

For **uninsured losses**, the uncertainty surrounding the estimates will depend on the availability of what other estimates are available. Due to the unique characteristics of the different disasters (type, intensity, region), the data set is too small to calculate a traditional standard error of uninsured-loss multipliers for events of a certain characteristics. Thus, the research team recommends parameterizing the uncertainty surrounding a particular event based on what other estimates are available to give a spread of uninsured estimates *in the context of the single event;* the average deviations from the BDWCD multiplier and the other sources can give a rough idea of the variance of the estimates, and **multiplying the average deviations between the numbers and the BDWCD's value by 1.96 can provide a very rough guide to the 95% confidence interval**[13]. For example, once state reports on the disaster is produce, the reported difference between the NCDC and the state estimate of uninsured loss can be used to determine the uncertainty of that particular event by treating that differential as the standard error[14]. This can help parameterize the uncertainty surrounding the uninsured loss multiplier for that event, as well. However, in estimates made prior to a state report or other ground-up analysis being present, the historical uncertainty estimates between similar event types & sizes should serve as the sample for quantification of uncertainty until a state report is published.

The level of uncertainty should also scale up with the size of the event. **Most of the uncertainty quantifications are expressed as a percentage of the total estimates, which allows for this scaling up of the estimate as the dollar cost rise**; thus, the uncertainty associated with larger disasters is proportional to the size when percentages are used. However, for long duration events such as drought, a further uncertainty adjustment should be created that increases over time. Unlike discrete events, such as hurricanes and storms where most damage is done in a few days, the amount of damage that a drought inflicts increases as the drought becomes more severe and persistent, with some costs accumulating rapidly after certain thresholds are crossed[15]. Thus, **the uncertainty of drought disruptions will increase at a faster rate than the straight-line dollar value increase in direct losses**. As such, a duration scale should be added such that total uncertainty increases with the duration of the event in addition to a base level of uncertainty for each drought loss measure. For droughts lasting under two years, an equation of the following form (in either weeks or months) could suffice until further analysis is done:

$$Total\ Uncertainty = Base\ uncertainty +\ Duration\ Parameter * \left[\left(\frac{weeks}{52}+1\right)^{\frac{weeks}{52}} - 1\right]$$

$$Total\ Uncertainty = Base\ uncertainty +\ Duration\ Parameter * \left[\left(\frac{Months}{12}+1\right)^{\frac{Months}{12}} - 1\right]$$

[13] When the true standard error is known, the 95% confidence bound is 1.96*S.E.

[14] Note again that this is assuming the BDWCD and state report data are unbiased, and thus the state reports' values of uninsured direct losses are just as likely to be above the BDWCD number as they are to be below. If the state reports systematically report values above (below) the BDWCD uninsured-loss value, then the multiplier may need to be increased (decreased).

[15] For example, a severe drought may lower river-levels and disrupt shipping channels, whereas a slightly more moderate drought may not impact inland waterway shipping at all.

For example, a drought whose base inputs have a 2.5% level of uncertainty associated with their calculation and using a duration parameter of 1.5% would have different uncertainty levels based on the length of the event. If the drought lasted 6 months, the uncertainty level would be 2.83%. If the drought lasted a year, that would increase to 4%. If the drought persisted, uncertainty would rise to 6.9% after 18 months and 14.5% after 2-years. This rapidly-expanding level of uncertainty would accommodate the various additional ways that a long-duration event evolves over time, with some impacts rapidly increasing in costs while others involve people adapting, mitigating, or substituting behavior in a way that is difficult to capture in the estimate. However, for periods beyond two years, this formula should be bounded by some overall maximum level of uncertainty; in cases of a long & severe event, a full investigation into the event should be done to identify additional direct losses that are not being included in the base BDWCD estimates.

While some of these assumptions and shortcuts will inevitably be overly-simplistic, and thus, potentially skew the true amount of statistical uncertainty associated with these events, the guidelines listed above should serve as a fair first-order approximation of such uncertainty until further research can be completed. These suggestions can help make the best estimate of statistical uncertainty based on the information currently available and until a full study can be conducted.

Appendix D: Long-Duration Disasters: Forecast-Residual Analysis, Substitution Analysis

There is a high-level summary of forecast-residual analysis and substitution analysis in Section 3.11, Long-Duration Disasters. Appendix D provides a detailed explanation of long-duration disaster analysis using expert forecasts with the examples of corn and wheat output during the 2012 drought.

In order to approximate the overall impact of a long-duration event, the researcher must identify the baseline value. In the case of a drought's impact on agriculture, for example, identifying the baseline output of a crop or set of crops can be difficult, as there is no way to know how large a harvest would have been in the absence of a drought; this process is further complicated by attempting to identify the drought's effect over time while disentangling that effect from other events. One potential method to identify the baseline is to conduct post-event surveys or interviews of experts[16] in the industry, though the selection of these experts can be subjective such that the overall estimates can change based on which expert or experts are consulted; further, it is nearly impossible to determine the amount of uncertainty associated with the experts' forecast ability. As such, consistency of these estimates may be suboptimal, though this approach is preferable if no other alternatives are available for a specific loss type.

A more robust approach in using expert opinion to quantifying long-duration disaster costs is to use a consensus forecast (i.e. a panel of estimators) with a proven track record (with a known margin of error) when they are available. Using the panel of regular forecasts can demonstrate the effects of a long-duration disaster on the forecasts in real time, which can be used as an additional tool to estimate the overall loss. This is done by quantifying large changes or revisions to a series of forecasts for the same period (e.g. annual production of corn), particularly revisions that fall outside the traditional accuracy range of the panel, as the potential "expert opinion" on the size of the event. For example, if a the forecasters' estimate for annual production of corn drop by 30% from May to June, this substantial drop likely represents the forecaster panel incorporating additional (negative) information into their forecasts based on developments in the month of May. Additionally, the timing of the large forecast revisions can also help identify the likely impacts of multiple non-coincident events that occurred during the season[17], if necessary. What follows is an example of how to conduct this type of analysis, as well as a brief discussion of how the lost crop production can be monetized.

Numerical Example: Calculating 2012 drought's impact on overall production of corn

This section will provide numerical examples on how to use the forecast-residual approach to quantify expert opinion. The example uses a panel of forecasters as described below, and demonstrates the approach with a crop that was greatly affected by the drought during the forecast sample (corn) and contrasts this with a crop that generally was unaffected by the drought during the forecast sample due to an early harvest (wheat).

The World Agricultural Supply and Demand Estimates (WASDE) provides monthly forecasts of expert output for several large crop and livestock industries for the U.S. (and the world, as well). Forecasts are made for a particular year's output starting in May of that year, and the forecasts run through April of the following year (at which point, enough data have come in that the actual output is known with

[16] There is a long history of evaluating the information content of expert forecasters in agricultural economics, starting with Dorfman (1998) incorporating expert opinions into forecasts.

[17] For example, if a May cold snap and an August flood both hit a particular region, we would expect to see forecasts drop from May to June then subsequently drop again in September; both shifts in forecast could be considered as unique forecast events.

some precision[18]). WASDE also publishes the historical forecast accuracy (including 90% error bounds) of the forecasters for that specific month. Note that initial estimates (those made in May and June) tend to have much wider confidence bounds than those made later in the year (with those made in the following February, March, and April have very tight confidence intervals and very little historical error). Since these estimates occur every month, and the forecasters are working with as much information that is available at the time, the forecasters will change their estimates as the presence, size, and severity of a drought becomes known. That is, as data on the drought come in, the forecasters will incorporate the new drought information into their crop output estimates and change their forecasts accordingly. This reaction is essentially the expert's real-time quantification of the drought, and thus changes in the forecast can be viewed as identifying this change (ceteris paribus). Note that coincident events can also alter the forecasts, so researchers should be careful to note that the change in forecasts is not necessarily a true reflection of the drought's overall impact, we can say that the overall impact of the drought is subsumed in the estimates and that the timing of data releases (and the timing of the change in forecasts) could further help disentangle coincident events.

In order to quantify the impact of the drought on a crop's production, we suggest the following procedure:

1- Create a time-series of the forecasts for a given year, starting with May of that year and running through the end of the year's forecasts (up to April)
2- Create the 90% confidence bounds surrounding the forecasts based on the historical performance of the panel (these are provided in WASDE tabs 35-37)
3- If large movements in the forecast (or the actual production) shift the new estimates below the May or June's lower of the 90% confidence interval, and the shift occurs at roughly the same time as the scope of the drought is becoming evident[19], we suggest that the event will classify for this type of quantification. In cases where the estimates stay within the 90% threshold, we suggest that caution applying this approach if there is not strong corroborating evidence with regards to the timing of the forecast shifts.
4- Calculate the residual between the initial forecasts of the panel (May or June) and the final estimates (or the final output numbers released the following year). Also, calculate the residual between the May (or June) lower 90% confidence bound and the final.

These two residuals can provide an estimate of the size of the drought's impact on the crop. The residual from the original forecast and the final forecast represents the best guess as to how large the results were, while the residual between the 90% bound and the actual provides a lower-bound estimate on the drought size with 95% certainty[20].

There are two examples that illustrate the potential different impact of this approach: long-duration forecasts of corn output and wheat output.

The severe drought of 2012 had pronounced impacts on the production of corn, and offers an excellent example of how to provide this type of analysis. This methodology is contrasted by repeating the technique with the forecasts on the wheat crop, which proved to be significantly less affected by the drought during the forecast window. The table below contains the corn forecasts from each month, as well as the historical forecast accuracy for that month.

[18] Note that the final numbers of actual output are not finalized for several more months; however, the estimates made at this point in the process are generally within 0.05% of the final tally.
[19] Or some of these experts or other sources report to the media that the drought is severely impacting a crop's production
[20] Note that the 95% certainty is due to the test being one-sided.

Table A.1 – Annual Corn Output for 2012, Monthly Forecasts

	Forecast Corn Output	90% C.I. Upper Bound	90% C.I. Lower Bound	Root mean square error
May-12	14,790	17,023	12,557	15.1
Jun-12	14,790	17,260	12,320	16.7
Jul-12	12,970	14,487	11,453	11.7
Aug-12	10,779	11,566	9,992	7.3
Sep-12	10,727	11,242	10,212	4.8
Oct-12	10,706	11,027	10,385	3.0
Nov-12	10,725	10,875	10,575	1.4
Dec-12	10,725	10,875	10,575	1.4
Jan-13	10,780	10,834	10,726	0.5
Feb-13	10,780	10,802	10,758	0.2
Mar-13	10,780	10,802	10,758	0.2
Apr-13	10,780	10,802	10,758	0.2

As can be seen, there is a pronounced downward shift in the panel's forecast after the May forecast; this drop reflects the ongoing drought being incorporated into the panel's forecast. As can be seen in graph A.1, the forecasts quickly exit the May-June 90% confidence intervals and stabilize at a much lower level starting in August (this graph is shown at the end of this appendix). Based on the historical accuracy of these forecasts, there is a 95% certainty that a drop of this magnitude is not attributable to normal factors, but rather represents a rethinking of the initial forecasts due to the incorporation of new information (specifically, the severe drought). From this set of forecasts, two relevant pieces of information can be ascertained: the best estimate of the drop in corn production is 4.01 billion bushels, and the lower bound of the drought's impact on corn production is 1.78 billion bushels (based on 95% significance level).

In contrast to the corn case, wheat production provides an example of where little or no adjustment is required. Wheat production saw relatively little disruption from the drought relative to that of corn[21]. Producing the same table and graph for wheat shows a very different pattern in the forecasts than that experienced by corn; in fact, there is a slight upward revision in the forecasts during the drought period as it became clear that the drought would not have large impacts on the crop. As can be seen in Table A.2, both the original wheat forecast (May, 2012) and the minimum wheat forecast (June, 2012) are below the estimated final production numbers, which is well within the 90% confidence bounds of the May & June values. As such, the impacts of the drought on wheat can be considered negligible[22] under this approach. Graph A.2 demonstrates visually the relative stability of the forecasts over the year (this graph is shown at the end of the appendix section).

[21] This is due to the timing of the harvest of wheat. The hit the Midwest hard, but did so after the spring and early summer wheat harvests in the area. Fall harvested wheat in the upper Midwest and northern plains saw much milder drought conditions, and so the wheat harvests were still relatively robust.

[22] Note that this does not necessarily mean that the drought had no impact on wheat, but rather that the forecasters did not find that any of the new information on the drought provided after May 2012 significantly altered the production of wheat; it is possible that some information on the drought that was available prior to May was influencing the initial forecasts. It is worth reiterating that this approach to estimating overall production loss is robust only with regards to information (or disasters introduced during the forecast period. As some elements of the drought were already evident in May, the changes in the forecasts thus quantify the surprising increase in the severity and duration of the drought.

Table A.2 – Annual Wheat Output for 2012, Monthly Forecasts

	Forecast Wheat Output	Upper Bound	Lower Bound	Root mean square error
May-12	61.1	68.3	54.0	15.1
Jun-12	60.8	67.1	54.5	16.7
Jul-12	60.5	64.3	56.7	11.7
Aug-12	61.7	64.3	59.1	7.3
Sep-12	61.7	63.7	59.8	4.8
Oct-12	61.8	62.3	61.3	3
Nov-12	61.8	62.2	61.3	1.4
Dec-12	61.8	62.2	61.3	1.4
Jan-13	61.8	61.9	61.6	0.5
Feb-13	61.8	61.9	61.6	0.2
Mar-13	61.8	61.9	61.6	0.2
Apr-13	61.8	61.9	61.6	0.2

Calculating the Economic costs of the loss using the estimated production loss

Having calculated the overall expected loss of crop output, the value of that lost output needs to be assessed. This involves taking the lost output calculated in the previous exercise and multiplying that by a price. When calculating economic crop losses, the World Bank simply uses the market price for the commodity to value the lost production. This is the simplest and most straightforward approach to value the "replacement cost" of the foregone crops, and has the appeal of not making additional assumptions or calculations that introduce more uncertainty into the overall exercise. Thus, particularly in cases where there is relatively low production loss, any price-differential approach may be unnecessary. This will be particularly true when the commodity is widely traded between the U.S. and the rest of the world and the U.S. represents relatively small amounts of production, as the market price will generally be sufficient to measure the overall loss; this is because the production loss is less likely to shift the market prices much, as small changes in U.S. supply represent a small (but non-trivial) part of the market. Thus, the divergence between the market price and the baseline market price (in absence of the production loss due to drought) multiplied by the lost production is likely to be relatively unimportant. The estimate of economic loss from the reduced crop production can then be calculated as:

$$Economic\ Loss = Production\ Loss \times Median\ Market\ Price$$

As such, the market price should be used if the three following criteria are true: (1) the higher of exports or imports of the commodity represent more than 30% of overall U.S. production in the previous three years; (2) the U.S. production represents less than 10% of world output in past three years; and (3) the U.S. production loss is under 10% of the initial forecast. Additionally, the market price should be used in cases where a U.S. price forecast is not produced in WASDE.

However, as the NCDC calculations are focused on the direct costs associated with the crop loss rather than the replacement costs, a supply-demand adjustment may be desirable in some cases. This can be done by multiplying the production loss by a baseline price, where the baseline price is derived from the WASDE forecasts in a manner similar to that of the production loss. For most commodities, WASDE provides price estimates (usually ranges); these WASDE price estimates from the original May or June forecasts can be used as the baseline market price (or the mid-price in the range) produced by the forecasters, with the subsequent April estimates used as the “actuals”. This should be done only if the market price exceeds the initial forecast price range.

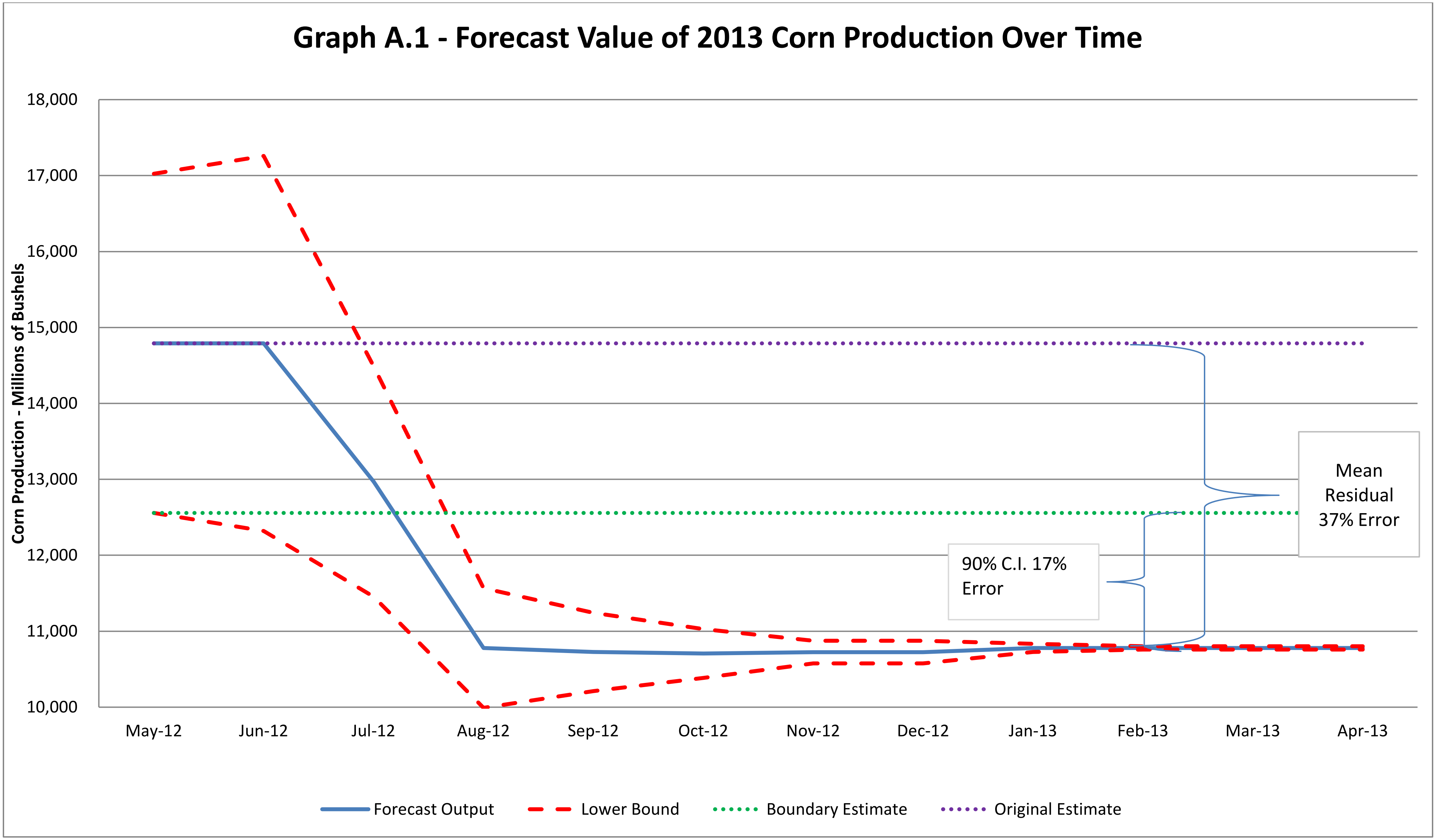
In the case of a WASDE price, both the “best” estimates from production loss and the “lower bound” estimates (where the value is 95% certain) can be calculated. For the “best” estimate, the median value of each price range should be used; that is, the median May or June forecast price can be used as the baseline estimate, with the median value from the latest or last estimates (March or April of the following year) is the “actual” price. For the “lower bound” estimate, the high value from the May or June forecast will serve as the baseline, and the low value from the March or April forecasts will be the actual. These price differentials are then multiplied by the lost production value[23]. Thus, the median forecast of the loss and the lower bound estimates can be calculated as follows:

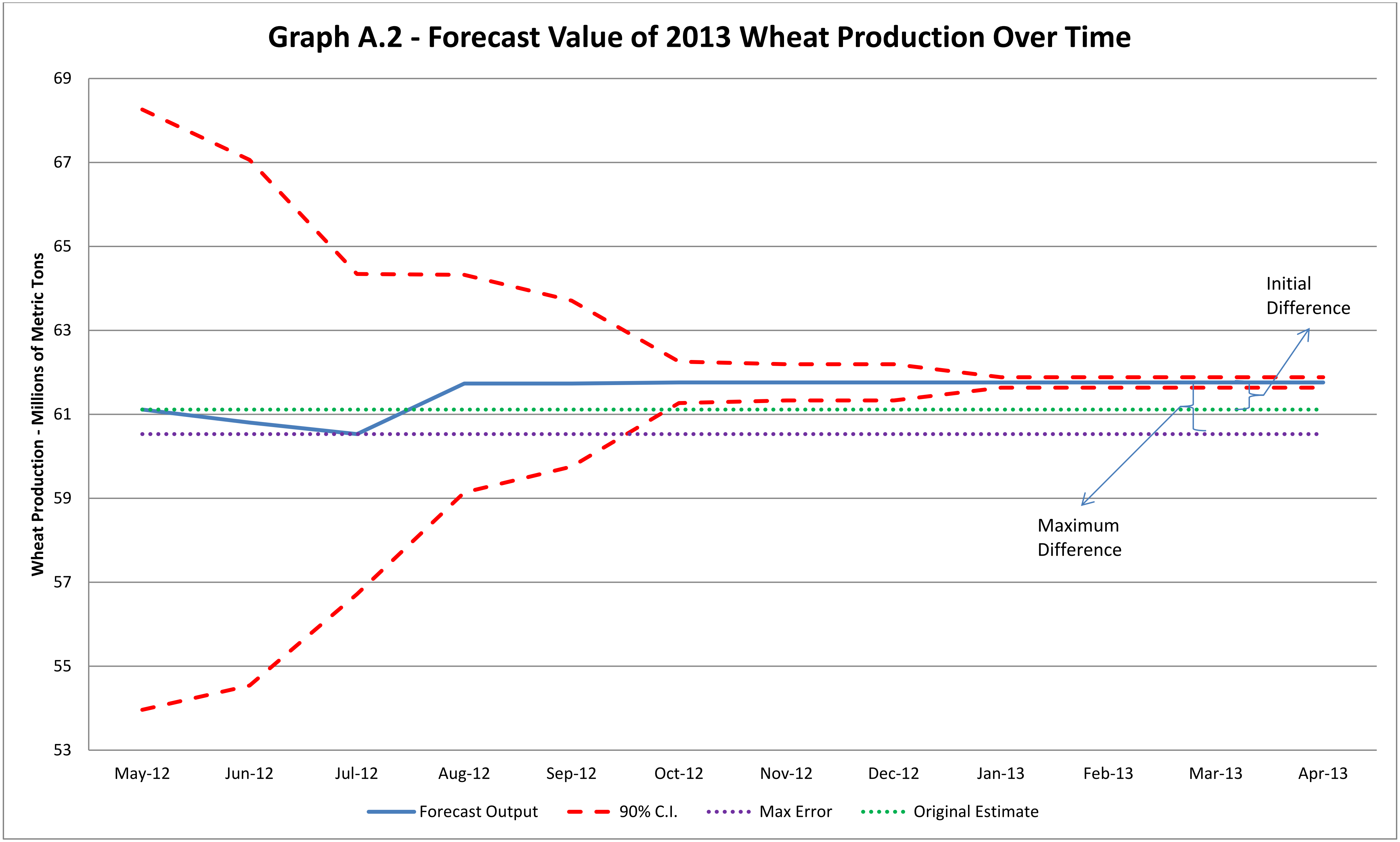
$$Best\ Economic\ Loss\ = Best\ Production\ loss \text{ x } ([median\ April\ Price] - [median\ May\ price])$$

$$LB\ Economic\ Loss\ = LB\ Production\ loss \text{ x } ([low\ April\ Price] - [high\ May\ price])$$

Using the earlier example, the projected price for corn in the initial forecast release (May 2012), the price was projected to be between $4.20 and $5.00 per bushel. By April 2013, the range had shifted to between $6.65 and $7.15 per barrel. As such, the estimated production loss of 4.01 billion bushels, at a price differential of $2.55 per bushel ($7.15-$4.60 = $2.55) suggests a mean estimate of $10.2B in corn loss from the drought. The conservative lower bound estimate of drought loss, using the estimated lower bound of 1.777 billion bushels and the lowest price differential of $1.65 (current lower bound of $6.65 less the original upper bound of $5.00 = $1.65) suggest that the drought cost at least $2.9B (with 95% certainty). As such, the “true” loss should fall within the two estimated ranges ($10.2B and the $2.9B), and can be calibrated.

[23] Note that this approach excludes the redistribution effects caused by higher prices, whereby the producers of the remaining crops receive higher payments at the expense of the consumers, as the net effect to society sums to zero (at least at a first order of approximation).


Graph A.1 - Forecast Value of 2013 Corn Production Over Time
Corn Production - Millions of Bushels
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
May-12
Jun-12
Jul-12
Aug-12
Sep-12
Oct-12
Nov-12
Dec-12
Jan-13
Feb-13
Mar-13
Apr-13
Mean Residual 37% Error
90% C.I. 17% Error
Forecast Output
Lower Bound
Boundary Estimate
Original Estimate


Graph A.2 - Forecast Value of 2013 Wheat Production Over Time
Wheat Production - Millions of Metric Tons
69
67
65
63
61
59
57
55
53
May-12
Jun-12
Jul-12
Aug-12
Sep-12
Oct-12
Nov-12
Dec-12
Jan-13
Feb-13
Mar-13
Apr-13
Initial Difference
Maximum Difference
Forecast Output
90% C.I.
Max Error
Original Estimate