

# **Improving the Accuracy, Consistency, and Usability of NOAA's Estimates of Economic Losses Associated with Extreme Weather and Climate Events**

## **Recommendations of Cross-NOAA Working Group for Consideration by NOAA's Social Science Committee**

**November 2, 2014**

**Executive Summary:** In 2012, NOAA commissioned an external review of four disaster loss estimates produced by NOAA resulting in 50 recommendations for improving the accuracy and consistency of these estimates. In 2013-2014, a cross-NOAA working group, including staff members from each office producing estimates under consideration, reviewed the 50 recommendations, identifying eight high-priority items for immediate implementation. The recommendations of the cross-NOAA working group were then reviewed by the NOAA Social Science Committee and revised to reflect their input, as reflected in the document below.

Next steps: establish a cross-NOAA implementation team to work with Social Science Committee to:

- determine which recommendations can be initiated with existing resources and which will require additional resources,
- develop an implementation plan, and
- begin implementation of the recommendations described below.

**1. Overview:** NOAA currently produces four separate estimates of the economic losses associated with extreme weather and climate events. Independent estimates are produced by NOAA Fisheries, the National Hurricane Center (NHC), the National Climatic Data Center (NCDC), and local Weather Forecast Offices (WFO). These data are important. Our nation's resilience to weather and climate events depends on an accurate understanding of their economic consequences. NOAA's loss estimates are frequently cited by policy-makers at all levels and by the news media.

These estimates vary in terms of scope and purpose, but there is also a significant overlap in the data sources, methods, and phenomena for which estimates are being developed. The declaration of a Commercial Fisheries Disaster in the wake of Superstorm Sandy, for example, precipitated an assessment by NOAA Fisheries of the economic impacts of this storm on the fisheries of New York and New Jersey. NHC and NCDC developed estimates of the direct economic losses associated with the storm, and a number of WFOs developed estimates of local damages associated with wind and riverine flooding.

Because the estimates are designed to address different questions, they reflect differences in economic measures (total impact vs. direct losses), geographic scale (local vs. area of impact), and even in the aspects of the phenomena that are considered (effects on fisheries vs.

wind/riverine flooding vs. all effects). With improved coordination, however, it would be possible to bring greater consistency to these estimates. Direct losses to fisheries (a component of the total impacts) are a component of total direct losses, as are direct losses associated with wind and riverine flooding. Eliminating arbitrary differences in NOAA's estimates of disaster losses and explaining necessary differences would greatly enhance the value of these estimates to users.

Furthermore, it is important to note the limitations inherent in each of these estimates. Three of the four must be reported within 60 to 90 days. Estimates prepared by NCDC are developed over a longer time horizon but still reflect very large data gaps. Data on uninsured losses, for example, are not available in any fashion but must be estimated based on insured losses and estimates of the proportion of persons or businesses with insurance and adjusted to reflect deductibles and the effects of insurance caps.

In an effort to improve the accuracy and consistency of these disaster loss estimates, NOAA commissioned Booz Allen Hamilton (BAH) to review the estimates produced by NOAA and to make recommendations for improving their accuracy and, where appropriate, their internal consistency. BAH made a total of 50 recommendations, focusing on:

- Improving the accuracy of the existing methods
- Expanding the scope of existing estimates to include non-market losses, human health, and other values
- Improving the consistency of the existing estimates by developing NOAA-wide standards, automating and integrating processes, and improving coordination among the NOAA offices generating loss estimates
- Improving the usability of our products by developing information resources that explain NOAA's loss estimates and describe how they relate to one and other

In September 2013, a cross-NOAA working group began reviewing the BAH recommendations to assess their validity, feasibility, desirability, and urgency. This working group included:

- Brent MacAloney, NWS
- Ron Morales, NWS WFO (Charleston)
- Adam Smith, NCDC
- Scott Steinback, NOAA Fisheries
- Eric Blake, NWS National Hurricane Center
- Jeffery Adkins, Coastal Services Center

Although not members of the working group, Tracy Rouleau (NOAA PPI) and Jen Sprague (NWS) also contributed to the review of the BAH report and recommendations.

The working group met in March 2014 to discuss their individual reviews and to identify actions that are desirable and feasible. Based on this assessment, this working group recommends a number of actions to improve the accuracy and consistency of NOAA's loss estimates, with the following having the highest priority:

### Actions with NOAA-Wide Relevance

1. Establish a standing working group to work with NOAA's Social Science Committee to increase the accuracy and consistency of NOAA's estimates of the economic losses associated with climate and weather events.
2. Produce a fully documented primer describing the economic loss estimates currently produced by NOAA
3. Assess and report the uncertainty associated with each NOAA estimate (this is currently being done for some but not all estimates)
4. Develop a standard definition of direct losses for use in all NOAA estimates.

### Actions with Relevance to NHC and NCDC

5. Integrate processes used by NHC and NCDC to estimate the losses associated with hurricanes.
6. Commission a study of the data used to assess insured losses and the multipliers used to capture uninsured losses; harmonize the application of these data and multipliers in estimates produced by NHC and NCDC.

### Actions with Relevance to NWS WFOs

7. Automate the processes used to estimate the losses associated with local storm events; use staff at regional NWS offices to collect, organize, and standardize these data
8. Provide training and procedural clarification for Weather Forecast Office staff members who estimate the losses associated with local storm events.

Another over-arching recommendation speaks to the need for general improvements in our estimates of direct costs of disasters. Although not explicitly discussed in the March 2014 meeting, there is general agreement within the group that NOAA should continuously seek to improve the quality of our disaster cost estimates.

After the completion of this review, a NOAA reviewer not previously engaged in the effort asked that we consider whether a recommendation calling for a study of directional bias in the estimates should be undertaken as a first step to the eight recommendations above; alternatively, the reviewer suggested that we note the need for such a study in the future to ensure that initial improvements of disaster loss estimates not be considered as final.

The eight recommendations are described in more detail below. A list of all the recommendations from the BAH report and the assessment of the working group regarding their desirability, urgency, and priority and NOAA's ability to address desirable recommendations with existing resources is included as Appendix A.

## **2. Next Steps**

- Social Science Committee reviews Working Group Letter Report (this document) by September 26, providing input to the Working Group for use in developing an implementation strategy, with special attention to:
  - Determining concurrence with the eight Working Group priorities
  - Recommending additional priorities from the list provided by BAH
  - Recommending additional priorities not included in the BAH report (e.g., potential changes to travel funding for assessments of disaster impacts)
- Working Group develops draft implementation strategy by November 28, 2014 that includes cost estimates, proposed time line, identification of actions that can be accomplished with current resources and those that will require further investments, and

description of anticipated benefits of proposed investments (this is the final action of the working group established to review the BAH reports)

- Submit revised letter report and implementation plan to NOAA's Senior Management requesting support for immediate implementation, beginning with the establishment of a standing working group representing each work unit that produces disaster loss estimates (this standing working group is likely to include members of the current working group but will be expanded to include others across NOAA who are engaged in related work)

**3. Description of High-Priority Recommendations:** The cross-NOAA working group recommends the immediate implementation of the following actions.

Recommended Action 1: Establish a Disaster Loss Working Group within NOAA. BAH Recommendation: Several BAH recommendations called for the establishment of working groups to develop consistent definitions of direct losses, automate and integrate existing NOAA estimation processes, and work with other agencies to ensure the appropriate use of data. A single working group, however, would better serve this purpose by promoting the development of institutional knowledge of the issues surrounding the estimation of disaster losses, allowing effective communication with NOAA's Social Science Committee, and promoting the effective implementation of change.

Risk Associated With No Action: This is the foundational recommendation; recommendations implemented without the guidance of a working group that includes representatives from all NOAA offices that produce disaster loss estimates will almost certainly miss the target, failing to improve the accuracy or consistency of the estimates.

Resource Requirements: This could be accomplished with existing resources.

Recommended Action 2: Develop Economic Loss Primer. BAH Recommendation: *"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."*

This document should describe the data sources, methods, purposes, similarities, and differences of all the estimates produced by NOAA. It should also include examples of instances where NOAA has prepared multiple estimates for a single weather event, explaining the similarities, differences, and complementary nature of the estimates.

Independent estimates of the economic losses associated with Superstorm Sandy, for example, were developed by NOAA Fisheries, NHC, NCDC, and local WFOs. Estimates developed by NOAA Fisheries focused on the direct, indirect, and induced impacts on the fisheries of the

region. The NHC estimates included a broader range of impacts, but focused only on direct losses. The estimates developed by NCEM are a refinement of the NHC estimates, with a more precise assessment of the value of uninsured losses. Local WFOs developed additional independent assessments, with a focus on the effects of riverine flooding and wind damage, with more extensive use of local data sources than the other estimates. An examination of the data sources, methods, scope, and complementary nature of these loss estimates could be used to explain the appropriate use and limitations of the various estimates produced by NOAA.

Further, the working group recommends expanding the scope of the BAH recommendation to include descriptions of the full range of losses considered in the various NOAA estimates (vice “direct costs”).

**Risk Associated With No Action:** Without a guidance document, it is likely that many users will fail to understand the meaning, limitations, and appropriate use of the disaster loss estimates.

**Resource Requirements:** This could be accomplished with existing resources, under the leadership of economists in NOAA PPI.

Recommended Action 3: Quantify Uncertainty. BAH Recommendation: “[Conduct] a study to perform an in depth statistical review of specific directional bias and uncertainty quantifications associated with each element of disaster costs estimates.”

The issue of directional biases is connected with the fact that data collection and analysis (both by NOAA and by the producers of data used by NOAA) focuses on extreme, low-probability events. This does not provide an adequate basis for assessing the expected value of disaster losses since a large number of medium to small-sized events might be even more costly than a relatively small number of much larger events. In addition, estimates of economic losses are most frequently reported as point estimates with little to no assessment and description of the associated uncertainty. A number of potential sources of bias, uncertainty, and error were cited by BAH, including, most importantly:

- data produced by the Property Claims Service
- data produced by the National Flood Insurance Program
- data produced by the U.S. Department of Agriculture’s crop insurance program
- multipliers used to estimate uninsured losses
- consistency of practices across local WFOs

It is also important to address means of communicating the uncertainty in NOAA estimates to users.

**Risk Associated With No Action:** Without quantifying the uncertainty associated with NOAA’s disaster loss estimates, non-scientific users are likely to assume that the numbers reflect no

bias or uncertainty. Among scientific users, the failure to quantify or even acknowledge the presence of bias and uncertainty will create doubt about the rigor of the underlying analyses.

Resource Requirements: Significant progress could be made in reducing and quantifying the uncertainty in estimates produced by NHC and NCDC with existing resources. Before significant progress could be made in quantifying uncertainty in estimates prepared by WFOs, it would be necessary to standardizing practices through automation as described in Recommended Action 7. Quantifying uncertainty in estimates produced by NOAA Fisheries would require additional labor to increase sample sizes and to formally assess remaining uncertainty (estimated at 2 FTEs for 90 days per event, or 0.5 FTEs per event).

Recommended Action 4: Develop a Standard Definition of Direct Losses. BAH

Recommendation: *“Coordinate internal NOAA estimators (BDWCD, NHC, NWS, and NMFS) to agree on a standard across the organizations for defining direct losses.”*

BAH continues, *“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). ... 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.”*

Estimates produced by NOAA Fisheries are reflected in broader loss estimates produced by NHC and NCDC; the primary value of this work to NOAA Fisheries is to ensure that their work is appropriately reflected in broader estimates.

Risk Associated With No Action: It is impossible to develop consistent estimates without working from a standard definition of what constitutes direct losses and indirect/induced losses.

Resource Requirements: Standardizing NOAA’s internal definitions of direct loss can be accomplished with existing resources. Expanding the scope to ensure consistency with definitions used by others will require resources for conducting a review of those definitions (estimated cost: \$75,000)

Recommended Action 5: Integrate Processes Used to Produce Comprehensive Hurricane Loss Estimates. BAH

Recommendations: *“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 would require setting up a protocol for initiating the collaboration (specifying contact persons and other protocols for the discussion). ... 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. ... Develop protocols to allow NCDC to build off the NHC 60-day disaster loss estimates. ... Coordinate with Fisheries and WFO to contextualize the efficiencies “connect the dots” between the estimates. Show how the numbers speak to one another.”*

The primary focus of this action is to integrate the processes used by NHC and NCDC to generate hurricane loss estimates. Since the NHC estimates are produced in a shorter time frame, an integrated process could allow these estimates to be treated as preliminary estimates and used as direct inputs to NCDC for refinement for publication in the BDWCD report. An important deficiency of the NHC estimates is related to the fact that there is not enough time to develop estimates of insurance penetration rates and associated multipliers for the area of impact and, thus, generalized multipliers must be used. Using the NHC estimates as a starting point, NCDC could focus on refining the multipliers to reflect local conditions and adding supplemental loss information. When a hurricane results in a declared fisheries disaster, NCDC would also coordinate with NOAA Fisheries to ensure the appropriate use of their estimates of fisheries-related losses in the estimate of total losses.

Risk Associated With No Action: Failing to integrate these processes increases the likelihood of accidental inconsistency between the estimates (vice refinements); it will also result in duplication of effort and, therefore, wasted resources.

Resources Required: This could be accomplished with existing resources.

Recommended Action 6: Study of Uninsured Losses. BAH Recommendation: *“...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.”*

The study should generate two products: (1) a refined generalized estimate of multipliers at a scale that captures a significant portion of the variability from place to place (e.g., regional or state-level multipliers) for use in preliminary estimates prepared by NHC and (2) recommended

methods and data sources for efficiently producing event-specific estimates for use in refined estimates produced by NCDC.

**Risk Associated With No Action:** Without such a study, it will be impossible to assess the validity of “rules of thumb” used in rapid assessments or the methodologies used to estimate event-specific multipliers.

**Resources Required:** The study would cost an estimated \$125,000. Coordinating the application of these multipliers by NHC and NCDC could be accomplished with existing resources.

Recommended Action 7. Automate WFO Processes. BAH Recommendation: *“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.”*

**Risk Associated With No Action:** Failure to automate the WFO estimation processes will make it unlikely that significant improvements in the accuracy and consistency of these estimates can be achieved. It is also likely that the manual computation of local storm damage estimates will require more labor in the long run.

**Resources Required:** Significant internal resources for outreach among WFOs and financial resources for technical support (estimated cost: \$150,000).

Recommended Action 8: Train Estimators at Local WFOs. BAH Recommendation: See Recommended Action 7 above.

Provide training and procedural clarification for Weather Forecast Office staff members who estimate the losses associated with local storm events.

**Risk Associated With No Action:** Failure to provide improved training to WFO estimators will make it unlikely that significant improvements in the accuracy and consistency of these estimates can be achieved, even with an automated process.



Resources Required: This could be accomplished with existing resources.

General Recommendation: Improving Estimates of Direct Costs. The contractor offered concrete suggestions for approaching this. First, conduct an examination of how the data are used to determine the users' needs for actual vs. inflation-adjusted values, uncertainty measures, and information that reflect inputs from other sources of data. Second, a general reevaluation of methods and multipliers could help NOAA identify further refinements that promote the accuracy and consistency of the data they are producing. Third, statistical uncertainty should be assessed and quantified to the extent possible. Fourth, NOAA should be consistent in the selection of indexes used to adjust disaster cost estimates to reflect the effects of inflation. Many of the other recommendations also address the need for refining estimates of the direct costs of disasters.

## **Appendix A**

### **Complete Listing of Recommendations for Improving the Accuracy and Consistency of NOAA's Estimates of Disaster Losses**

# 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.” 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 | Recommendation Category   | Specific Recommendation                            | 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          |

| Rank | Recommendation Category   | Specific Recommendation                                      | Suggested Action   | Resources Score | Importance Score | Total Score |
|------|---|--|--|-----------------|------------------|-------------|
| 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          |
| 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          |

| Rank | Recommendation Category   | Specific Recommendation                                      | Suggested Action  | Resources Score | Importance Score | Total Score |
|------|---|--|---|-----------------|------------------|-------------|
| 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          |
| 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          |

| Rank | Recommendation Category   | Specific Recommendation  | Suggested Action   | Resources Score | Importance Score | Total Score |
|------|---|--|--|-----------------|------------------|-------------|
| 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 be 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 data through Munich Re, Swiss Re, state insurance commissions, and trade groups (Insurance Information Institute, National Association of Mutual Insurance Companies, etc). | 8               | 8                | 16          |

| Rank | Recommendation Category   | Specific Recommendation  | Suggested Action  | Resources Score | Importance Score | Total Score |
|------|---|--|---|-----------------|------------------|-------------|
| 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          |
| 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          |



| Rank | Recommendation Category   | Specific Recommendation  | Suggested Action   | Resources Score | Importance Score | Total Score |
|------|---|--|--|-----------------|------------------|-------------|
| 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          |
| 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          |

| Rank | Recommendation Category   | Specific Recommendation   | Suggested Action   | Resources Score | Importance Score | Total Score |
|------|---|---|--|-----------------|------------------|-------------|
| 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 |   | Keep a NOAA estimators' technical assistance database to 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.  |                 |                  | 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    |   | 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.  |                 |                  | 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           |

| Rank | Recommendation Category   | Specific Recommendation   | Suggested Action  | Resources Score | Importance Score | Total Score |
|------|---|---|---|-----------------|------------------|-------------|
| 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           |
| 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           |

| Rank | Recommendation Category   | Specific Recommendation   | Suggested Action   | Resources Score | Importance Score | Total Score |
|------|---|---|--|-----------------|------------------|-------------|
| 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           |
| 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           |