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Applying Wetlands Tools for Disaster Management

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WETLANDS AND HAZARD MITIGATION

OPPORTUNITIES FOR INTEGRATION

October 31 and November 1, 2023

Workshop Summary

This project is made possible through a Wetland Program Development Grant funded by the United States Environmental Protection Agency

Overview

Introduction & Workshop Objectives

Involving natural resource experts in the hazard mitigation planning and project implementation process can help fill information gaps and aid in the identification and prioritization of viable nature-based mitigation actions to address identified risks. State agencies and conservation organizations have invested significantly in developing wetland assessment and prioritization tools that could be leveraged to aid in hazard mitigation planning. These tools can help to determine the location and priority of governmental expenditures in the restoration and protection of aquatic resources and nonprofit conservation efforts. This project, made possible through a Wetland Program Development Grant funded by the U.S. Environmental Protection Agency (EPA), aimed to identify opportunities for integrating these tools into hazard mitigation planning to promote the adoption of nature-based strategies.

ELI hosted a workshop entitled "Wetlands and Hazard Mitigation: Opportunities for Integration" on Oct. 31 and Nov. 1, 2023. The goals of the workshop were to provide an opportunity for wetland agencies and hazard mitigation planners to discuss opportunities for using wetland and floodplain restoration and protection prioritization tools and methodologies in the hazard mitigation planning process, as well as to discuss partnership building among wetland and natural resource agencies and organizations and hazard mitigation planners and project developers.

Background

Science-based tools that prioritize wetlands and aquatic resources for conservation, restoration, and compensatory mitigation activities have been developed and integrated into decision-making systems in many states. ELI has identified and analyzed more than 30 wetland and stream conservation prioritization programs in use by states, including several in coastal watersheds (See for example, A Handbook for Prioritizing Wetland and Stream Restoration and Protection Using Landscape Analysis Tools, 2013). Overall, the tools used in these programs are highly influential in determining the location and priority of (1) governmental expenditures in the restoration and protection of aquatic resources, (2) nonprofit conservation efforts, and (3) the location and parameters for compensatory mitigation. These assessment tools identify high-priority areas for conservation and restoration by employing certain criteria, such as wildlife habitat, open space and recreation, water quality improvement, erosion control, and coastal conservation.[1] Although

[1] 173 JAMES MCELFISH ET AL., DEVELOPING WETLAND RESTORATION PRIORITIES FOR CLIMATE RISK REDUCTION AND RESILIENCE IN THE MARCO REGION (Env't L. Inst. 2016),

generally created to identify conservation opportunities in contexts other than hazard mitigation (e.g., water quality, compensatory mitigation, etc.), these tools can be used by practitioners and planners in a hazard mitigation context. (*see Appx. 1* for summarizations of the tools and their methodologies).

Several tools have been developed using GIS data to consider how various criteria overlap with wetlands and watersheds to allow planners to prioritize sites for restoration, conservation, and management on different scales. Each tool functions differently: some tools perform analysis to prioritize areas for conservation or restoration, while others provide outputs that serve as a basis for more analysis. Some tools have been developed for county-level use (e.g., the Lake County Wetland Restoration and Preservation Plan[2]) while other tools have been developed for nationwide use (e.g., EPA's Recovery Potential Screening Tool[3] and the Rapid Benefits Indicator[4]).

Summaries of the tools are listed below:

Tool	Developer	Purpose
Floodplain Prioritization Tool	The Nature Conservancy	To help federal, state, and local governments, county planners, land trusts, businesses, and citizens optimize their investments in floodplain restoration or conservation.
Adapt VA	Center for Coastal Resources Management, Virginia Institute of Marine Science	To act as an information gateway on climate change adaptation for individuals, local programs, and agencies.
North Carolina Flood Resiliency Blueprint	North Carolina Department of Environmental Quality Division of Mitigation Services	To allow users "to seamlessly visualize flood vulnerability for different flood risk conditions and choose from a suite of flood mitigations strategies" and output planning level cost estimates and potential funding sources, as well as help with tasks such as evaluating costs/benefits

https://www.eli.org/sites/default/files/filespdf/Targeting-Conservation-and-Restoration-in-the-MARCO-Region-Final-Report-December2016.Cover_.pdf; *see also* Appx. 1.

[2] Wetland Restoration & Preservation Plan (WRAPP) for Lake County, Illinois, STORMWATER MGMT. COMM., https://www.lakecountyil.gov/2531/Wetland-Restoration-Preservation-Plan (last visited Jan. 31, 2024).

[3] Recovery Potential Screening Indicators: Social Indicators, ENV'T PROT. AGENCY, https://www.epa.gov/rps/social-indicators#socio (last visited Jan. 19, 2024).

[4] Rapid Benefits Indicators (RBI) Approach, ENV'T PROT. AGENCY, https://www.epa.gov/waterresearch/rapid-benefit-indicators-rbi-approach (last visited Jan. 31, 2024).

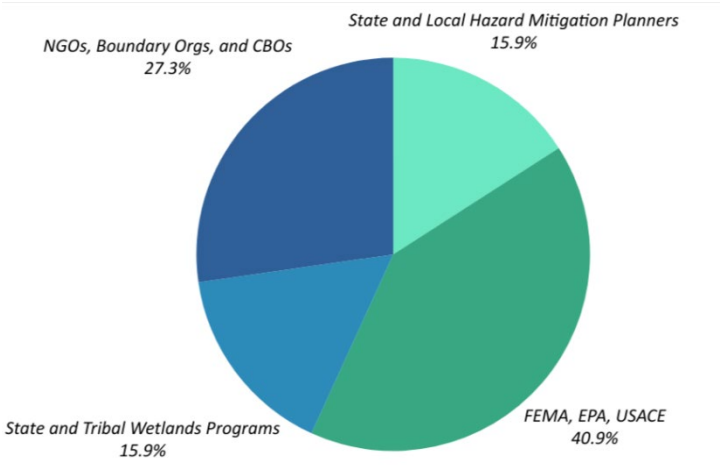
		across basin and sub-basin scales.
Wetlands by Design: A Watershed Approach	Wisconsin Department of Natural Resources, The Nature Conservancy in Wisconsin, and Conservation Strategies Group	To provide prioritized choices for where to invest in both voluntary and regulatory wetland and watershed conservation.
Michigan Landscape Level Functional Assessment Tool	Michigan Department of Environment, Great Lakes, and Energy (EGLE), Water Resources Division	To support watershed planning efforts, guide zoning decisions, help define wetland restoration priorities for resource managers, and assess wetland quantity and wetland functions to determine the impact of a given wetland on its broader watershed.
Lake County Wetland Restoration and Preservation Plan	Lake County Stormwater Management Commission (SMC), Lake County, Illinois	To identify and assess functional significance of existing and potentially restorable wetlands in Lake County, Illinois, to guide planning decisions and help with prioritization of wetland restoration and preservation efforts based on specific "wetland functions."
South Platte Natural Capital Resource Assessment and Ecosystem Valuation Tool	The Keystone Concept, CO State Forest Service, US Forest Service, US EPA	To prioritize and guide investment in preservation and restoration activities that will increase the quality and value of natural capital in the watershed.
Iowa Watershed Approach	Iowa Watershed Approach Homeland Security and Emergency Management (HSEMD), U.S. Army Corps of Engineers Rock Island District, and other Iowa Silver Jackets partners	To identify areas that have the greatest Potential Of using a Watershed Approach to Reduce Flooding (POWAR F).
Kentucky Silver Jacket Green Infrastructure Tool	U.S. Army Corps of Engineers, Interagency Group focused on flood risk management	To collect geospatial data and create a suitability model for future green infrastructure.
Upper Bear River Watershed Wetland Conservation and Prioritization	Ryhan Sempler and Diane Menuz, affiliated with the Utah Geological Survey, Utah	To explore the utility of ranking wetlands based on multiple benefits such as sensitive

	Department of Natural Resources	species habitat and water quality attenuation.
Fire and Water: The Interplay Between Wetlands and Fire Management Mapping	New Mexico Environment Department Surface Water Quality Bureau, Wetlands Program	To map and identify priority wetland resources for protection and restoration in the Sacramento Mountains and develop a landscape level functional assessment model.
Geospatial Assessment of Flood Vulnerability Reduction	Justin Bousquin (Gulf Ecology Division, National Health and Environmental Effects Laboratory, U.S. Environmental Protection Agency) and Kristen Hychka (University of Maryland Center for Environmental Science)	To develop a nationally consistent dataset and demonstrate how this dataset can be used at different scales (regional or local) to rapidly assess flood-reduction benefits.
Maryland Parcel Evaluation Tool[1]	Maryland Department of Natural Resources	To provide a Conservation Benefits and Ecosystem Service Assessment Report Card for every land parcel in Maryland by evaluating the conservation benefits and ecosystem "value" of every parcel of land across the state of Maryland.
EPA Recovery Potential Screening Methodology and Tool	EPA Office of Water	To identify differences among 12-digit Hydrologic Unit subwatersheds (HUC12s) that may influence their relative likelihood to be successfully restored, protected, or managed in other ways.

In advance of this workshop, we interviewed experts who have developed wetland assessment and prioritization tools and methodologies as well as state and local hazard mitigation planners and state and local wetland programs. Through these interviews, we examined the hazard mitigation planning process, learned about challenges faced when integrating wetland/floodplain conservation priorities in hazard mitigation plans, and gleaned recommendations for how to better integrate conservation and restoration assessment tools into the hazard mitigation planning process. We supplemented these interviews with an analysis of mitigation planning reports, academic literature, funding guidelines, and adaptation planning resources to compile an initial list of challenges and opportunities for incorporating these tools and methodologies into hazard planning. The following summary includes the challenges and opportunities identified in our research and by workshop attendees and panelists.

Attendance

The workshop convened experts and professionals from natural resource agencies, FEMA, state and local emergency management agencies, and NGOs to discuss how to integrate existing landscape prioritization tools and methodologies into the FEMA hazard mitigation planning process. Forty-four total participants attended the workshop over the two days, including 7 state and local hazard mitigation planners, 18 attendees from FEMA, EPA, and the U.S. Army Corps of Engineers, 7 attendees from State and Tribal wetlands programs, and 12 attendees from NGOs, boundary organizations, and CBOs. Expertise ranged from academic to technical. Participants were experts in mapping, GIS, resilience planning, local and state hazard mitigation planning, and watershed planning at various scales.



Format

The workshop presentations and discussions focused on the challenges and opportunities for using prioritization tools for hazard mitigation planning at the site-scale and the watershed-scale. The workshop also included discussions on building capacity at the local government level and how to scale up the formation of partnerships among wetland and hazard mitigation agencies and organizations.

Takeaways from the Workshop

The following describes some of the takeaways from the workshop. We detail the challenges and priority action items identified for using landscape prioritization tools in the hazard mitigation planning process at the site-specific and watershed scale.

Site-Scale

Site Scale Challenges

Participants discussed several site-scale challenges, ranging from funding and data limitations to language differences between hazard planners and natural resource experts.

Funding limitations

- Benefit-Cost Analysis (BCA)/Benefit-Cost Ratio (BCR)

To apply for FEMA hazard mitigation grants, applicants must perform an analysis of cost-effectiveness by comparing the net present value of future risk reduction benefits to costs in a process called the Benefit-Cost Analysis (BCA). The BCA results in a Benefit-Cost Ratio (BCR), which should be 1.0 or greater for a project to be considered "cost-effective."

NBS have been difficult to quantify in the BCA, with applicants and observers citing the following reasons:

- Many local communities do not have the capacity to conduct the modeling and analysis necessary to conduct a BCA for NBS.[5]
- The BCA methodology does not account for all of the externalities avoided by choosing NBS over grey infrastructure. The framework is not inherently tailored for watershed decision-making and encourages projects with more narrowly defined goals.[6]
- Present hazard risk reduction is prioritized over future risk reduction in the BCA methodology.[7]
- There is a lack of data on $/acre/year values for hazard mitigation benefits for each existing land cover type.[8]

[5] Participant contribution to "Wetlands and Hazard Mitigation: Opportunities for Integration" workshop held by the Environmental Law Institute (Oct. 31 & Nov. 1, 2023).
[6] Participant contribution to "Wetlands and Hazard Mitigation: Opportunities for Integration" workshop held by the Environmental Law Institute (Oct. 31 & Nov. 1, 2023).
[7] THE NATURE CONSERVANCY & EARTH ECONOMICS, STRESS TESTING THE BCA TOOLKIT WITH NATURE-BASED SOLUTIONS: OBSERVATIONS AND RECOMMENDATIONS FOR THE FEDERAL EMERGENCY MANAGEMENT AGENCY (2021).
[8] Participant contribution to "Wetlands and Hazard Mitigation: Opportunities for Integration" workshop held by the Environmental Law Institute (Oct. 31 & Nov. 1, 2023).

- There are few pre-calculated benefits for NBS in the BCA toolkit and the BCA lacks flexibility to incorporate ecosystem service values.[9]
- There is a lack of technical guidance to help applicants complete the BCA.[10]

While major updates to the BCA Toolkit have been made to encourage greater uptake of NBS,[11] many applicants lack the capacity to undertake the extensive and expensive analysis and modeling necessary to conduct the BCA for many NBS projects. Stakeholders describe a lack of data[12] and a need for pre-calculated values for ecosystem services, like flood and fire mitigation, as challenges. For example, the Nature Conservancy has suggested that developing $/acre/year values for hazard mitigation benefits of existing land cover types, such as for the storm buffering value of wetlands, should be included in the FEMA BCA toolkit.[13] A 2021 GAO report also recommended the development of more pre-calculated benefits to simplify the mitigation grant application process for local communities while ensuring that investments are cost-effective.[14]

Language barriers

Natural resource experts, state and local hazard mitigation professionals, and other stakeholders often use different definitions for flooding and floodplains, as well as varying standards for defining flood risk. For instance, as Iowa Mitigation Planner, Jim Marwedel, highlighted, emergency management professionals might refer to "reducing flooding" in terms of the financial impact reduction, while natural resource experts might speak of "reducing peak flows," which is measured volumetrically. FEMA defines floodplain as “any land area susceptible to being inundated by floodwaters from any source”[15] and maps flood zones based on areas that have a 1% annual chance of flooding.[16] This is notably different than the EPA definition(s) of floodplain, which tied to

[9] THE NATURE CONSERVANCY & EARTH ECONOMICS, STRESS TESTING THE BCA TOOLKIT WITH NATURE-BASED SOLUTIONS: OBSERVATIONS AND RECOMMENDATIONS FOR THE FEDERAL EMERGENCY MANAGEMENT AGENCY (2021).
[10] *Id*.
[11] For a full review of these updates, see ELI ” Embedding Natural Resource Expertise in Hazard Mitigation Planning” (2024) pp. 15-16.
[12] Thomas H. Douthat et al., Stakeholder Perceptions About Incorporating Externalities and Vulnerability into Benefit-Cost Analysis Tools for Watershed Flood Risk Mitigation, SUSTAINABILITY, May 2023. 99 THE NATURE CONS
[13] THE NATURE CONSERVANCY & EARTH ECONOMICS, STRESS TESTING THE BCA TOOLKIT WITH NATURE-BASED SOLUTIONS: OBSERVATIONS AND RECOMMENDATIONS FOR THE FEDERAL EMERGENCY MANAGEMENT AGENCY 6 (2021).
[14] 021). 100 U.S. GOV’T ACCOUNTABILITY OFF., GAO-21-140, DISASTER RESILIENCE: FEMA SHOULD TAKE ADDITIONAL STEPS TO STREAMLINE HAZARD MITIGATION GRANTS AND ASSESS PROGRAM EFFECTS 37 (2021).
[15] *Glossary*, FED. EMERGENCY MGMT. AGENCY & NAT’L FLOOD INS. PROGRAM, https://www.floodsmart.gov/definitions#F (last visited Jan. 19, 2024).
[16] *Flood Maps*, FED. EMERGENCY MGMT. AGENCY, https://www.fema.gov/flood-maps (last visited Jan. 23, 2024).

hydrology: "the land adjacent to the baseflow channel residing below bankfull elevation"[17] and "the term 'floodplain' shall mean the lowland and relatively flat areas adjoining inland and coastal waters."[18]

Design goals may also differ among natural resource and emergency management agencies – with hazard mitigation agencies designing sites to move water quickly away while natural resource agencies may design sites to hold water.

Data limitations at the site level

Participants identified several data limitations at the site-specific level.

- Limited site-level modeling potential from watershed-level prioritization tools

Watershed-level prioritization tools can identify general areas for project siting but do not model more fine-grained and site-specific details. Large-scale prioritization tools often draw from national data sets like the National Wetlands Inventory (NWI) and are most commonly designed to function at a larger grain.[19] To be effective at the site scale, tools require data with high resolution and aggregated to a scale suitable for distinguishing variations within the designated management area.[20]

- Lack of data that shows areas of *past* wetlands, particularly in the Western U.S.

Multiple participants agreed that a significant data limitation is that many projects aimed at *restoration* are using tools that identify areas of existing wetlands or riparian areas. To identify opportunities for restoration, tools need to include areas that are not currently wetlands but *used* to be. As many datasets only show *current* wetlands, it is difficult to get the full picture of restoration potential without considering previous flow patterns and how riparian corridors have shifted. One notable exception to this is Wisconsin's Wetlands by Design: A Watershed Approach, which has a layer for potentially restorable wetlands.[21]

Limitations to the use of natural resource prioritization tools in the planning process

Natural resource experts can provide valuable capacity across the components of the planning processes, including assessing and summarizing vulnerability, identifying critical stakeholders, assessing community capabilities, developing mitigation goals, and evaluating potential mitigation

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[17] *Watershed Academy Web: Stream Corridor Structure*, ENV'T PROT. AGENCY, https://cfpub.epa.gov/watertrain/moduleFrame.cfm?parent_object_id=637 (last visited Jan. 19, 2024).

[18] Exec. Order No. 11,988, 42 Fed. Reg. 26951 (May 24, 1977) (Floodplain Management).

[19] Participant from a State Water Quality Division, contribution to "Wetlands and Hazard Mitigation: Opportunities for Integration" workshop held by the Environmental Law Institute (Oct. 31 & Nov. 1, 2023); *National Wetlands Inventory*, U.S. FISH & WILDLIFE SERV., https://www.fws.gov/program/national-wetlands-inventory (last visited Jan. 30, 2024).

[20] Justin Bousquin & Kristen Hychka, *A Geospatial Assessment of Flood Vulnerability Reduction by Freshwater Wetlands – A Benefit Indicators Approach*, FRONTIERS IN ENV'T SCI., May 2019.

[21] WIS. DEP'T OF NAT. RES. & THE NATURE CONSERVANCY, WETLANDS BY DESIGN: A WATERSHED APPROACH FOR WISCONSIN 8 (2017), https://freshwaternetwork.org/projects/wetlands-by-design/.

actions that align with community capabilities. While prioritization tools can provide a useful starting point for such an analysis, these planning components require additional capacity.

Most of the tools we evaluated primarily identify priority areas for the application of NBS, but do not identify site-specific projects. Once specific sites are identified, they still need development and engineering. Therefore, tools need to be used in combination with engineers and natural resource experts, reinforcing the need to include those experts early in the planning process.

Furthermore, FEMA grant staff need to know how to use landscape prioritization tools to 1) make sense of the data in applications *and trust it*, and 2) be able to recommend it as a resource for those using FEMA BRIC Direct Technical Assistance, FEMA BRIC project scoping, Hazard Mitigation Grant Program (HMGP) Project Assistance, etc. Building partnerships with natural resource experts and tool developers can aid in transferring this knowledge.

Embedding NBS before project designers and engineers are contracted

One potential challenge discussed in the workshop was that engineers are often brought in early in the development of a project and begin to work out a plan before NBS solutions are even contemplated. This can lead a community to default to brick-and-mortar strategies. From a municipal planning perspective, using a tool to identify the best place for an ecosystem service project to be located can help planners to visualize how projects that center restoration can aid in risk reduction. Once priority areas for NBS are identified (based on potential to provide ecosystem services or other criteria identified in prioritization tools) then engineers can be brought in to design the site.

FEMA funding favors grey infrastructure solutions

One FEMA participant noted that favoring NBS requires a very mindful and innovative planning process. However, planning grants are not generally large enough to hire a plan developer to lead a planning effort that meaningfully integrates natural infrastructure. Additionally, the FEMA funding structure was designed for the built environment and public safety—not explicitly wetlands restoration. Thus, ecosystem services, in this traditional structure, are seen as only ancillary benefits.

Site-Scale “Action Item” Priorities

Workshop participants identified action items that could be implemented and/or addressed to scale up site-scale nature-based projects.

Prioritizing siting and planning for nature-based projects based on impact and avoiding co-benefit “box-ticking”

There are multiple approaches to integrating nature-based projects into a mitigation strategy. On one end a community can add natural infrastructure elements into traditional grey infrastructure projects on an ad hoc basis on the other end a community could engage in a comprehensive process to identify and develop nature-based projects and prioritize these projects as part of the planning process. Although both methods are valid, the first may be the only feasible option in certain situations. However, it is crucial to emphasize that NBS should not be treated merely as a checkbox in funding applications. As one participant explained, creating small green spaces in a

project just to add a natural infrastructure component miss many of the large-scale watershed benefits that NBS can provide.

A State Hazard Mitigation Officer at the workshop proposed a policy to create a funding mechanism for Green Infrastructure projects. The policy would involve creating a restoration market, where impacts from planned grey infrastructure projects would be offset through the restoration of wetlands or floodplains on properties that have been previously acquired through buyouts by FEMA and the state. By siting compensation projects on properties where they could contribute most efficiently and functionally to the identified goals of a given jurisdiction, the NBS may be more effective and cost-effective for that community than co-locating nature-based benefits on the impact site. This policy envisions a cradle-to-grave approach for the land that has been acquired through a FEMA buyout: when an infrastructure project is planned, offset funding goes into the restoration of the buyout properties to create a cost-effective, impactful, and sustainable natural infrastructure strategy.

To make this idea work, there are several factors to consider (i.e., the necessity of contiguous property buy-outs; coordination required between FEMA, state governments, and local jurisdictions; and suitability of restoration sites), but large-scale NBS projects could effectively achieve restoration, hazard mitigation, and compensatory mitigation goals.

Facilitating "sister cities" initiatives with upstream and downstream cities

One participant recommended that more cities could develop partnerships along shared natural resources (e.g., rivers) to facilitate coordinated, effective adoption of natural infrastructure. For example, Montgomery County and Prince George's County in Maryland have collaborated to manage the Anacostia Watershed. Since 2006, the Anacostia Watershed Restoration Partnership has facilitated many nature-based projects along the Anacostia River focused on stream restoration, trash reduction, impervious surface treatment, wetland restoration, and reduction of suspended sediments under the leadership of a steering committee with representation from the U.S. Army Corps of Engineers and state and county environmental professionals from Montgomery County, Prince George's County, and the District of Columbia.[22] The steering committee and the U.S. Army Corps of Engineers partners help to coordinate and prioritize goals for this watershed-scale project that involves multiple cities.

Another large-scale example of river-based collaboration is the Mississippi River Cities and Towns Initiative's Disaster Resilience and Adaptation Program.[23] MRCTI is a mayor-led, mayor-comprised association of local governments formed to address priorities in clean water, sustainable economies, disaster resilience and adaptation, international food and water security, and river culture and heritage. The program engaged with FEMA to create a multi-state Pre-Disaster

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[22] *Anacostia Watershed Restoration*, U.S. ARMY CORPS OF ENG'RS, https://www.nab.usace.army.mil/Missions/Environmental/Anacostia-Watershed-Restoration/ (last visited Jan. 19, 2024); *Restoration Progress Dashboard*, ANACOSTIA PARTNERSHIP, https://www.anacostia.net/dashboard2020.html#goal5 (last visited Jan. 30, 2024).

[23] MISSISSIPPI RIVER CITIES & TOWNS INITIATIVE, DISASTER RESILIENCE AND ADAPTATION PROGRAM, https://static1.squarespace.com/static/5845a70859cc6819f2dfdb9e/t/5a1da14f085229dccc1f57c6/1511891306301/Disaster+Resilience+Prog+1-pager%5B2567%5D.pdf (last visited Jan. 19, 2024).

Mitigation Grant (PDM) option, which MCRTI funds at a rate of $100 million or greater annually. The program also worked with ten states in the Mississippi River corridor to complete a multi-state disaster vulnerability assessment that can be aggregated at the corridor level and builds the mitigation and response capabilities of the states in the Basin.

Creation of tool outputs that can meet Benefit-Cost Analysis (BCA) criteria

Several workshop participants suggested that modifying or creating natural resource prioritization tools that include criteria and outputs useful in calculating the BCA may be possible. Examples of criteria required by the current BCA include the initial project costs, number of maintenance years and annual maintenance costs, total mitigation project cost, damages ($) before mitigation, and expected damages ($) after mitigation.[24] Outputs from tools that produced these numbers could help planners complete the BCA more easily.

Addressing the information gap between people who create the tools and their intended users

Several participants emphasized the importance of developing prioritization and restoration tools with ongoing input from the intended end-users. When a tool is expected to have diverse end-users (i.e., conservation NGOs, community groups, hazard mitigation planners, county planners, natural resource experts, project consultants, scientists, etc.), participants stressed the need for tool creators to anticipate and identify specific phases in the planning process when each end-user could utilize the tool. For example, several of the landscape prioritization tool methodologies incorporate social indices that can be used to help target outreach to vulnerable groups and specific communities and could help planners meet the FEMA planning requirement to *ensure meaningful participation*. For example, the EPA Recovery Potential Screening Tool offers the option of comparing the restoration potential of watersheds by social indicator (examples of indicators include "watershed collaboration rating," "count of active watershed groups," "population," "average per capita income in watershed," and "aggregated socio-economic index in watershed").[25] The tool could also allow local watershed planners to quantify the local organizational engagement (that is, "the number of groups active in water quality restoration and protection in the watershed, or the magnitude of activity of such groups") based on metrics such as count of active watershed groups, the level of collaboration among stakeholder organizations in the watershed based on a watershed collaboration rating, government agency involvement in restoration and protection projects, participation in land conservation programs, large watershed management potential, university proximity, decision-maker support, percent of protected land, and applicable regulation, among others.[26]

According to a state emergency management officer at the workshop, while they are not opposed to using natural resource prioritization tools and see their potential benefits, integrating a new tool into their existing structured work streams would require additional effort. Therefore, tool creators

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[24] CDBG-MIT Webinar Series, HUD EXCHANGE, https://www.hudexchange.info/trainings/cdbgmit-webinars/ (last visited Jan. 22, 2024).
[25] 79 Overview: Selecting and Using Recovery Potential Indicators, ENV'T PROT. AGENCY, https://www.epa.gov/rps/overview-selecting-and-using-recovery-potential-indicators (last visited Jan. 19, 2024); Recovery Potential Screening Indicators: Social Indicators, ENV'T PROT. AGENCY, https://www.epa.gov/rps/social-indicators#socio (last visited Jan. 19, 2024).
[26] *Id*.

should design tools with a clear understanding of where and how they can seamlessly integrate into the planning process. The same officer also highlighted that a single training session might not be sufficient to persuade their office to adopt a new tool, emphasizing the importance of multiple exposures to encourage its use.

Watershed-Scale

Watershed-Scale Challenges

Participants discussed several watershed-scale challenges ranging from the mismatch of scale between jurisdictional/planning boundaries and ecological boundaries and interplay between local governments and regional planning structures.

The challenge of scale

Hazard mitigation planning is most often done by state and local officials at the jurisdictional scale rather than on the watershed (or ecological) scale. This "mismatch" of scales can present multiple challenges, including 1) the best mitigation strategies for the watershed may be sited upstream of the jurisdiction in question, 2) upstream conditions may limit the effectiveness of downstream NBS, and 3) planning by jurisdiction may overlook climate inequities and the historical marginalization of communities that extend beyond jurisdictional boundaries but align with a natural feature (one participant provided the example in Norfolk, Virginia, where two predominantly African American neighborhoods, in different jurisdictions, experience disproportionate and recurrent tidal and precipitation flooding).[27]

To create multi-jurisdictional, watershed scale plans, workshop participants suggested that the local planners could coordinate with a watershed agency or regional planning authority. One participant noted that local governments often avoid working with watershed NGOs because they are regarded as "focused on advocacy" and "unconcerned with the locals and their needs." While this shouldn't discourage the role of third parties, it is an important dynamic to understand.

Reluctance of towns/counties to give up authority

One participant noted that planning on the watershed scale is important, but that designating regional planning commissions or deferring to state watershed agencies to coordinate a plan could be unsuccessful due to the reluctance of individual counties and towns to give up authority over setting their own hazard planning priorities. Another participant agreed that planning on the watershed scale, if done without sufficient local input, can appear to supersede local authority and lead to resistance.

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[27] CITY OF NORFOLK, DEP'T OF PUB. WORKS, OHIO CREEK WATERSHED MASTER PLAN (2012), https://www.norfolk.gov/DocumentCenter/View/79660/2012-8-10_Ohio_Creek_Watershed_Master_Plan.

Watershed-Scale "Action Item" Priorities

Workshop participants identified several action items for implementing nature-based mitigation projects on a watershed scale.

Planning by watershed

Participants emphasized the significance of clearly defining the target watershed for planning NBS and incorporating community input into this delineation. One participant pointed out that, in the context of watershed-scale projects, there is a tendency to rely on jurisdictional boundaries, but an alternative ecosystem-based measure (i.e., a watershed approach), or a combination thereof, might prove to be more effective.

Opportunities for funding watershed scale planning

The watershed is the most appropriate scale for understanding the risk reduction benefits of NBS, and funding sources need to consider how to invest in planning and project development at that scale. Although public funding is often designated at the state or local level rather than by watershed, several basin-specific programs fund watershed scale planning (e.g., the Chesapeake Bay Program's Small Watershed Grants,[28] the National Fish and Wildlife Foundation's Five Star and Urban Waters Restoration Grant Program,[29] and the National Estuary Program's Watersheds Grant Program[30]). Participants agreed that applying more funding to watershed scale planning could be beneficial.

Participants also agreed that more funding is needed to build capacity for regional-scale authorities to engage in watershed-scale hazard mitigation planning. Several participants suggested that regional planning commissions may be able to help with crafting a plan, others noted it is difficult for them to apply for the planning grant. Therefore, state-level resource agencies may be a good place to coordinate. For example, Vermont helps apply for planning grants and then provides sub-awards to local jurisdictions for mitigation plans.

Another example was offered from Virginia, where the Department of Housing and Urban Development coordinated the Ohio Creek Watershed Project to increase floodplain resilience.[31] The Ohio Creek Watershed Project in Norfolk, Virginia involved planning a mix of green and grey infrastructure solutions to improve flooding and public access to waterways.[32] Actions completed under the project included retrofitting streets with green infrastructure, implementing rain gardens and retention ponds, and building a tide gate structure to restore the ecological function of the

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[28] *Small Watershed Grants Programming*, CHESAPEAKE BAY PROGRAM, https://www.chesapeakebay.net/what/grants/small-watershed-grants (last visited Jan. 30, 2024).
[29] *Five Star and Urban Waters Restoration Grant Program*, NFWF, https://www.nfwf.org/programs/five-star-and-urban-waters-restoration-grant-program (last visited Jan. 30, 2024).
[30] *National Estuary Program Watersheds Grant Program*, RESTORE AMERICA'S ESTUARIES, https://estuaries.org/nep-watersheds-grant (last visited Jan. 30, 2024).
[31] *Ohio Creek Watershed Project*, CITY OF NORFOLK, https://www.norfolk.gov/3867/Ohio-Creek-Watershed-Project (last visited Jan. 30, 2024).
[32] *Id.*

eroded wetlands.[33] While this example does not involve coordination on the scale of a watershed like the Mississippi River, it illustrates how planning based on watershed can entail *a mindset shift*: in this scenario, jurisdictional boundaries do roughly align with the watershed, however, the solutions implemented are focused on the watershed.

Building Community Capacity for Nature-Based Projects

Lack of capacity continues to be a major barrier to identifying and implementing nature-based hazard mitigation projects, particularly at the local scale. Local capacity is needed to help communities apply for funding, identify feasible nature-based projects, and to implement, administer, monitor, and assess projects. Hazard planners often do not have the analytical expertise and experience to site, determine, and monitor natural infrastructure projects. A recent GAO report cited lack of technical capacity and complexity of the grant application processes as significant challenges for hazard mitigation grant program applicants.[34] In fact, the challenges associated with the hazard mitigation grant application process were cited as among the reasons that states have not spent 35% of the funds FEMA has allocated under the Hazard Mitigation Assistance program from 1989 through early 2018.[35] Building partnerships with natural resource agencies into the hazard mitigation planning and project development process will help to scale up the use of NBS.[36] For capacity-strained local communities, these partnerships are crucial.

Using Regional Capacity to Bolster Local Capacity for FEMA Mitigation Planning

This section discusses ways that existing regional-scale organizations that are already performing wetlands assessments and setting priorities for the watershed could provide capacity for state and local hazard mitigation planning. By determining where wetlands restoration goals overlap with hazard mitigation planning opportunities, these organizations could inform the implementation of local hazard mitigation planning and bolster local capacity.

Regional prioritization for local implementation

The most efficient flood risk mitigation projects should be coordinated through a basin-wide planning effort. Watershed scale coordination is important for large basins—but it is also important

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[33] CITY OF NORFOLK, DEP'T OF PUB. WORKS, OHIO CREEK WATERSHED MASTER PLAN (2012), https://www.norfolk.gov/DocumentCenter/View/79660/2012-8-10_Ohio_Creek_Watershed_Master_Plan.

[34] U.S. GOV'T ACCOUNTABILITY OFF., GAO-21-140, DISASTER RESILIENCE: FEMA SHOULD TAKE ADDITIONAL STEPS TO STREAMLINE HAZARD MITIGATION GRANTS AND ASSESS PROGRAM EFFECTS 37 (2021).

[35] Thomas Frank, *States Shun Billion in Federal Aid as Climate Costs Soar*, CLIMATEWIRE (Feb. 26, 2021), https://www.eenews.net/climatewire/stories/1063726077/search?keyword=hazard+mitigation.

[36] Laurie Pearce, *Disaster Management and Community Planning, and Public Participation: How to Achieve Sustainable Hazard Mitigation*, 28 NAT. HAZARDS 211 (2003).

for smaller watersheds. Local community involvement in the planning, design, and maintenance of nature-based projects is critical to ensure that NBS equitably addresses the needs of local communities while addressing watershed-scale mitigation priorities.

Pinpointing hubs of potential capacity for regional hazard mitigation prioritization and planning

There are regional entities (such as watershed organizations, regional planning commissions, state agencies, and statewide conservation organizations) that focus on creating region-wide priorities for conservation. EPA, for example, supports several regional monitoring and assessment efforts, including working groups in the Mid-Atlantic and Pacific Southwest region. These working groups focus on the ecological health and function of the wetlands in these regions and build the capacity of states to assess the integrity of wetlands and develop long-term implementation plans to achieve restoration priorities determined by the assessments.[37] One example is the Lower Mississippi River Batture Reforestation project that is reforesting cleared land from Cairo, Illinois to the Port of Baton Rouge to expand habitats, reduce flooding, and lessen the amount of nutrients entering the river.[38]

There are opportunities for regional working groups or conservation organizations to formally integrate a hazard planning component into the development of long-term implementation plans by considering how nature-based mitigation strategies could improve the functioning of wetlands while also reducing hazard risk. These regional working groups may be able to help ensure planned NBS are effective by coordinating with upstream and downstream users across jurisdictional and state boundaries.

For example, the Upper Mississippi River Conservation Committee (UMRCC) and the Lower Mississippi River Conservation Committee (LMRCC) may provide regional frameworks for building capacity at the local level for scaling up NBS. Both committees have undertaken assessment efforts, including studies on habitat connectivity and water quality, and share a focus on long-term conservation planning and habitat restoration.[39] The board memberships of these committees are composed of representatives from each state's natural resource agencies and involve the EPA, United States Geological Survey, and Department of Agriculture as federal partners (with the addition of USFWS and USACE as federal partners for the LMRCC). This kind of regional expertise could help local planners determine where conservation and hazard mitigation goals overlap in each basin and communicate the benefits of the ecosystem services of the resources. However, these committees do not list any emergency management agency representatives or reference FEMA among the other federal partnerships. Engaging hazard mitigation planners and emergency

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[37] *Mid-Atlantic Wetland Monitoring and Assessment*, *supra* note 143; For an example, *see Monitoring & Assessment Strategy*, VIRGINIA DEP'T OF ENV'T QUALITY, https://www.deq.virginia.gov/our-programs/water/wetlands-streams/monitoring-assessment-strategy (last visited Jan. 19, 2024).

[38] Lower Mississippi River Batture Reforestation, LOWER MISSISSIPPI RIVER CONSERVATION COMMITTEE, https://www.lmrcc.org/our-work/projects/lower-mississippi-river-batture-reforestation/ (last visited Jan. 30, 2024).

[39] *See* LOWER MISSISSIPPI RIVER CONSERVATION COMMITTEE, https://www.lmrcc.org/about-us/what-we-do/ (last visited Jan. 19, 2024) *and* UPPER MISSISSIPPI RIVER CONSERVATION COMMITTEE, https://umrcc.org/ (last visited Jan. 19, 2024).

management professionals in the UMRCC may help bridge the gap between natural resource experts and hazard mitigation professionals.

Another regional group that provides capacity is the Mississippi River Cities and Towns Initiative (MRCTI).researching the effectiveness of nature-based solutions in addressing flooding in the region and could inform local mitigation plans with a suite of preferred nature-based projects based on various criteria. The association has an "Infrastructure Facility" group which provides capacity in the form of expertise and financial resources to members applying for Jobs Act funding. Assistance with resilience, FEMA, and mitigation strategy are listed as competencies currently available through the Facility.[40]

Leveraging regional capacity building at the local scale

By embedding a focus on hazard mitigation in group priorities and projects and helping to determine where conservation and mitigation goals overlap, regional entities might feasibly create regional planning priorities that could inform state and local hazard mitigation planning. The plans developed by regional entities could be listed in the capabilities assessment section of the hazard mitigation plan.[41] For example, in California, the Western Governors Association—a regional entity composed of Western state agencies—created a 10-year strategic plan to reduce wildfire hazard through restoring fire-adapted ecosystems.[42] This strategic plan is listed as a capability to mitigate risk in the state hazard mitigation plan. The outputs from this type of regional planning commission could conceivably bolster local capacity in the same way.

Other Recommendations for Building Capacity at the Local Scale

In addition to the support and assistance that regional entities may be able to provide local governments, there are other opportunities to build capacity at the local level to help local planners scale up the use of NBS.

Educating local governments to encourage buy-in for NBS

To scale up the use of NBS, it is necessary to have buy-in from local governments. Many local officials are more inclined to pursue traditional grey infrastructure risk reduction methods that are already familiar to them and may have already been employed in the community. Local officials may need more information on the benefits of NBS, including examples from other communities of similar size. This entails 1) educating local officials on *why* nature-based mitigation projects are effective risk reduction measures, and 2) describing how existing (or potentially restorable) natural assets can provide risk reduction for a community.

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[40] MISSISSIPPI RIVER CITIES & TOWNS INITIATIVE, INFRASTRUCTURE FACILITY, https://static1.squarespace.com/static/5845a70859cc6819f2dfdb9e/t/637e90b7098cb316c0dccb12/1669238970610/Capitol+Mtg+2022+Infra+Facility.pdf (last visited Jan. 19, 2024).

[41] FED. EMERGENCY MGMT. AGENCY, LOCAL MITIGATION PLANNING HANDBOOK 205 (2023), https://www.fema.gov/sites/default/files/documents/fema_local-mitigation-planning-handbook_052023.pdf.

[42] CAL. GOVERNOR'S OFFICE OF EMERGENCY SERVICES, CALIFORNIA STATE HAZARD MITIGATION PLAN 46-47 (2023), https://www.caloes.ca.gov/wp-content/uploads/Hazard-Mitigation/Documents/2023-California-SHMP_Volume-1_11.10.2023.pdf.

Education on why and how NBS should be implemented is needed in all decision-making spaces, from elected officials to the emergency management office to the planning division. One possible opportunity is for natural resource experts to partner with emergency managers on presentations at large gatherings of local governments, where local officials and/or the public will be present. At the national level, this could be National League of Cities conferences and the U.S. Conference of Mayors, or other similar events. At the state level, this could be Leagues of Cities and Towns State conferences, among others.[43]

There is also a continuing need to develop a more solid evidence base on the multiple benefits and cost-effectiveness of NBS.[44] However, multiple participants in the workshop noted that local decision-makers often do not have time to read and digest lengthy reports. Participants also indicated that local government employees do not have the time or resources to proactively pursue NBS unless they are brought something of value that would allow for easier implementation. Therefore, one idea is to develop concise, one-page case studies that exemplify potential NBS tailored based on a community's size, capacity, and natural assets. These one-page studies could be coupled with a brief analysis quantifying a county's natural infrastructure to make the case that such infrastructure is *critical infrastructure*.

Workshop participants stressed that continued engagement among natural resources experts, community planners, and decision-makers is necessary to ensure continuity in the understanding of the value of NBS and the willingness of local governments to adopt nature-based projects. For example, mayoral or leadership turnover can make it difficult to establish consistent interest in maintaining partnerships among natural resource agencies and emergency managers and pursuing NBS in the community. A coordinated effort from a regional or local natural resource group could help ensure that momentum is not lost.

Identifying a community's natural assets

Identifying the adaptation and resilience benefits that a community's natural assets already (or could potentially) provide can encourage greater local interest in pursuing NBS and may identify opportunities for funding the protection and restoration of such resources.

More funding for NBS can also expand local capacity to plan and implement nature-based mitigation projects. In the City of Snoqualmie, Washington, for example, funding greatly increased once the value of the natural capital was communicated to the city by an external consulting group. With more funding, the Forestry Department hired more people; expanding the city's local capacity

[43] Examples include the Montana League of Cities and Towns (https://mtleague.org/conference/), Florida League of Cities (https://www.flcities.com/), and New Jersey State League of Municipalities (https://www.njlm.org/).

[44] NATURE-BASED SOLUTIONS TO CLIMATE CHANGE ADAPTATION IN URBAN AREAS: LINKAGES BETWEEN SCIENCE, POLICY AND PRACTICE 275-289 (Nadja Kabisch et al. eds. 2017) (Ch. 16: Partnerships for Nature-Based Solutions in Urban Areas – Showcasing Successful Examples).

to implement and maintain natural infrastructure projects.[45] Furthermore, a community may be a more willing participant in a regional plan if the value of their natural assets is communicated.[46]

Capitalizing on bridging organizations

Nonprofits, academic institutions, community-based organizations, and so-called boundary organizations can identify opportunities for nature-based hazard mitigation projects in local jurisdictions that reduce flood risk, encourage local buy-in, and ensure meaningful stakeholder participation. Boundary organizations are institutions, organizations, or partnerships, that bridge scientific and political groups in coordinating efforts on and managing environmental issues.[47] An example of a boundary organization is Wetlands Watch in Norfolk, Virginia, which collaborates with local governments and academic institutions to identify needs related to floodplain management and sea-level rise adaptation.[48] The organization creates adaptation guides and provides essential training to help local governments address community needs, enable the design of projects, and secure necessary funding. Such boundary organizations can play a pivotal role in connecting various stakeholders and facilitating the exchange of knowledge and resources.

One idea generated at the workshop is the creation of a loose partnership of experts with the following expertise: 1) capacity to identify potential communities, provide education on NBS, quantify natural assets to encourage buy-in, and provide suitable options for NBS, 2) knowledge of the funding opportunities available to local communities, 3) knowledge of potential tools that can be helpful with siting a project and quantifying NBS, and 4) capacity to aid in developing funding applications and helping with capacity-building on the local level to ensure a project's success. This "roving band of experts" would function similarly to a boundary organization.

Community-based organizations and academics can also ensure stakeholder consultation goes beyond "box-checking." In hazard mitigation and adaptation planning, there has to be a shift from planning *for* to planning *with* communities.[49]

Advisory Committees

A final recommendation for building local capacity is to form advisory committees structured around specific hazards (i.e., flooding, fires, etc.) or environmental justice to allow for data sharing, stakeholder input, and ideation that can be integrated into hazard mitigation plan updates. Forming regional advisory committees based on the goal of reducing a specific hazard can allow for synergizing various local plans to address the hazard and more effectively reduce the risk. For example, the Portola Valley, California conservation committee integrates landowners' feedback when determining strategies to cope with persistent landslide hazards. Forming advisory committees to center the needs of marginalized communities in planning can also ensure that

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[45] Thank you to Lance Davisson and Zac Christin for this information.

[46] This was a sentiment echoed by a local emergency management department in a recent hazard mitigation workshop.

[47] DENIS BOISSIN, BOUNDARY ORGANIZATIONS: AN EFFICIENT STRUCTURE FOR MANAGING KNOWLEDGE IN DECISION-MAKING UNDER UNCERTAINTY (2009).

[48] WETLANDS WATCH, https://wetlandswatch.org (last visited Jan. 8, 2024).

[49] Laurie Pearce, *Disaster Management and Community Planning, and Public Participation: How to Achieve Sustainable Hazard Mitigation*, 28 NAT. HAZARDS 211 (2003).

these priorities are met when mitigation plans come up for review. In King County, Washington, the Hazard Mitigation Steering Committee dedicated two meetings to facilitating environmental justice structured discussions around environmental inequities and how hazard mitigation strategies may address these inequities in the development of the King County Regional Hazard Mitigation Plan.[50]

Short-term committees established during mitigation plan updates can also be effective in reaching vulnerable communities. In Harris County, Texas, the Houston NAACP was involved in the planning process, and in Orleans Parish, Louisiana community-based organizations such as Housing NOLA and Greenlight played active roles in the updating of local mitigation plans.[51]

[50] KING COUNTY EMERGENCY MGMT., KING COUNTY REGIONAL HAZARD MITIGATION PLAN: 2020-2025 (2020), https://kingcounty.gov/en/legacy/depts/emergency-management/emergency-management-professionals/-/media/depts/emergency-management/documents/plans/hazard-mitigation/KCRHMP_Final; Fiona Osborn & Rebecca L. Kihslinger, *Incorporating Environmental Justice into Hazard Mitigation Plans* (Oct. 4, 2021), https://www.eli.org/vibrant-environment-blog/incorporating-environmental-justice-hazard-mitigation-plans.

[51] Fiona Osborn & Rebecca L. Kihslinger, *Incorporating Environmental Justice Into Hazard Mitigation Plans* (Oct. 4, 2021), https://www.eli.org/vibrant-environment-blog/incorporating-environmental-justice-hazard-mitigation-plans.

Post-Workshop Engagements

Follow-up Report

The insights, examples, and context provided during informational interviews, the workshop itself, and follow-up emails informed the development of a report, Embedding Natural Resource Expertise in Hazard Mitigation Planning: Opportunities for Integration in the Mississippi River Basin.

Group Engagement

While the workshop aimed to identify opportunities for integrating natural-resource assessment and prioritization tools into hazard mitigation planning to promote the adoption of nature-based strategies, we learned that many communities are still unaware of *why* they should be using natural infrastructure as hazard mitigation strategies and that there are systemic barriers in funding structures to planning for NBS.

In a follow-up survey, 8 participants indicated they would be interested in continuing to engage with this group on the following topics:

- Improving benefit-cost analysis (focusing on how to incorporate/quantify NBS and tailor tools to meet BCA criteria)
- Developing a roving band of experts to determine where conservation and mitigation goals overlap with risk reduction goals and to aid communities in planning NBS projects and facilitating hazard mitigation plan updates that will address these overlapping priorities
- Determining pathways for better siting and implementation of NBS projects in the hazard mitigation planning process

Appendix 1: Prioritization Tools and Relevant Literature

14 Wetland Assessment and Prioritization Tools

Floodplain Prioritization Tool (Mississippi River Basin)

2019

Who: The Nature Conservancy

Purpose: To help federal, state, and local governments, county planners, land trusts, businesses, and citizens optimize their investments in floodplain restoration or conservation.

Types of Data: The Floodplain Prioritization Tool uses data from the University of Bristol, Fathom, University of Iowa, US Geological Survey, US Army Corps of Engineers, US Environmental Protection Agency, National Fish Habitat Partnership, US Fish and Wildlife Service, American Bird Conservancy, Natural Resources Conservation Service, and USA National Phenology Network to provide 15 data layers and 3 parameters. The parameters include flood frequency (1-in-5-year, 1-in-100-year, and 1-in-500-year), watershed (HUC-8, HUC-12, and catchment), and management action (protection and restoration). The data layers can be divided into 7 categories: area, nutrients, habitat, land conversion, population exposure, flood damages, and social vulnerability.

For area, the data includes the area of the floodplain that is: not currently in protected status, of the specified flood frequency, and in land covers pertaining to the specified management action. For nutrients, the data layers include local nutrient loading (the kg/yr of nitrogen and phosphorus exported at the mouth of the watershed, accounting for all loading from upstream), nutrient loading to the Gulf of Mexico (the kg/yr of nitrogen and phosphorus from within a given watershed that reaches the Gulf), and growing degree days (for accumulated growing degree days for 2016-2017).

For habitat, the data layers include important bird areas (sites identified by the National Audubon Society as having significance for the conservation of birds), Nature Conservancy Ecoregional Assessment Units (all features identified in ecoregional assessment by TNC as places of biodiversity significance and priority areas for conservation action), at-risk wetland species (total number of wetland species in the watershed considered Imperiled by NatureServe or threatened/endangered under the Endangered Species Act), U.S. Fish and Wildlife Service threatened and endangered species active critical habitat, American bird conservancy corridors and key habitat areas, and the National Fish Habitat Partnership cumulative habitat condition index.

For land conversion, the data layers include the agricultural productivity potential of soils (only available when “management action” is restoration). For population exposure, the data layers include the population exposed to floods in the present day and the population exposed to floods

in 2050. For flood damage, the data layers include potential future flood damage to structures in 2050. The final data layer is an index of social vulnerability to environmental hazards (which draws on 22 demographic variables to characterize social vulnerability).

Adapt VA (Virginia)

Who: Center for Coastal Resources Management, Virginia Institute of Marine Science, William & Mary in collaboration with state, academic, and non-profit partners.

Purpose: To act as an information gateway on climate change adaptation for individuals, local programs, and agencies.

Types of Data: The AdaptVA Interactive Map combines protection/restoration, flood risk, shoreline management, infrastructure, natural resources, sea level rise, and vulnerability/risk layers. The protection/restoration layer shows restoration opportunities (target areas for restoring or creating shoreline habitat) and lands for protection that may offer benefits to conservation lands and easements. The infrastructure layer shows general infrastructure, all buildings at an elevation of 10 feet or less, and critical infrastructure that could help plan an emergency response. The Shoreline Management layer shows the recommended approaches for shoreline erosion control (see Shoreline Management below) and existing shoreline structures. Under the Shoreline Management heading are data layers specific for use for the Virginia Chesapeake Bay Preservation Act climate resilience assessment, including the 5-year interval sea level projects and a 2050 landward shoreline. The Natural Resources Layer shows Natural and Nature-Based Features (NNBFS) located on lands generally less than 10 feet in elevation, shoreline conditions from the Virginia Shoreline Inventory, Virginia-wide Non-tidal wetlands (NWI), Submerged Aquatic Vegetation (SAV), Hydrology (from the National Hydrography Dataset), and Contours (from the USGS National Map). The Sea Level Rise/Flooding layer shows flooding layers and sea level rise (see Flood Risk below). The Vulnerability/Risk layer shows social vulnerability and physical risk layers for Virginia's Tidewater area and for the state, as well as the Tidal Marsh Vulnerability Assessment.

Flood Risk: The Virginia Flood Risk Information System (VFRIS) pulls data from ESRI GIS, FEMA, and the Fish and Wildlife Service to map special flood hazard areas (SFHA). The Locality Road Flood Tool is an interactive map for incorporating current and future road flooding into locality planning efforts. This tool has developed layers like inaccessible roads and flooding duration maps, while also providing additional information layers (I.e. Infrastructure, Accessible roads, Social Vulnerability, and 2020 FEMA flood hazard zones), a dashboard of road impacts, and downloadable Detailed Road Flooding Summaries. The Wastewater Data Viewer was created to understand patterns of septic system failure and to forecast the effects of SLR on septic systems in Virginia. The Emerging Hot Spot Analysis tool in ArcGIS was used to identify continuous hot spots, which have constant and high numbers of septic system repair permits; and rising hot spots, which represent new, intensifying, or diminishing clusters of repair permits. Like the Locality Road Flood Tool, this viewer has additional layers that show the

projected increase in groundwater tables with sea level rise and the social context of census tracts.

Shoreline Management: The Shoreline Management Model (SMM) is a GIS model that uses geospatial data and integrated shoreline management approaches to help a user decide the best management strategy for their shoreline.

North Carolina Flood Resiliency Blueprint (North Carolina)

Who: North Carolina Department of Environmental Quality Division of Mitigation Services

Purpose: Provide an online decision support tool, a blueprint process document, and basin-specific action strategies. The decision support tool will allow users "to seamlessly visualize flood vulnerability for different flood risk conditions and choose from a suite of flood mitigations strategies" and output planning level cost estimates and potential funding sources, as well as help with tasks such as evaluating costs/benefits across basin and sub-basin scales. The blueprint process document will solidify a process for flood resiliency planning at multiple scales. The basin-specific action strategies will validate the decision support tool and provide additional modeling for priority geographic areas.

Types of Data: The online decision support tool will integrate standardized H&H models (hydraulic and hydrologic), landuse layers, community level data, and climate projections to produce watershed scale risk assessments, evaluation of potential solutions, and approximate cost estimates to support planning and prioritization within communities and across state programs.

This tool will be rolled out in a couple of phases. Phase One, which will be completed by the end of 2023, involves developing a mockup of the online decision support tool, ultimately producing a Neuse River Action Strategy. Phase Two will produce new H&H models and a functioning decision support tool. Phase Three will entail the application of the support tool in river basins throughout North Carolina to develop basin level action strategies. The tool is expected to meet its goals by identifying sources and types of flooding, causes, frequencies, scale of damage, and statewide distribution of risk. It will also inventory existing data and data gaps.

Wetlands by Design: A Watershed Approach for Wisconsin (Wisconsin)

December 2017

Who: Wisconsin Department of Natural Resources, The Nature Conservancy in Wisconsin, and Conservation Strategies Group

Purpose: Provide prioritized choices for where to invest in both voluntary and regulatory wetland and watershed conservation.

Types of data: Various datasets centering around watershed identification, geographic mapping, and land surveying (including Watershed Boundary Dataset (WBD), Wisconsin Wetland Inventory (WWI), SSURGO Soil Surveys, and 303d Impaired Waters List)

The Wetlands by Design tool aims to use "extensive Geographic Information System (GIS) analysis of land and water features to identify both wetlands, and potentially restorable wetlands, that are most likely to provide substantial ecosystem services" (p. ii). Throughout their analysis, there is an emphasis on the potential of wetlands for flood abatement purposes. By centering on wetlands currently providing services, this tool can identify former wetlands that have the potential ability to provide these services again. For example, they identified wetlands located upstream from city centers as crucial in flood reduction and public safety.

When considering those wetlands that have been lost, this approach does not only consider the areal extent of lost wetland, but also the associated lost ecosystem services like flood abatement and water quality protection. At each watershed level, wetlands were assessed based on flood abatement, fish and aquatic habitat, sediment reduction, nutrient transformation, and surface water supply. These categories were assessed based on the *opportunity* for the service to be performed, the *effectiveness* of its provision, and the *significance* to neighboring communities. For example, "a site surrounded by steep slopes or impervious surfaces has the *opportunity* to perform the flood abatement service. If that same site is situated in a geographic depression and has dense vegetation, it is likely *effective* at slowing and temporarily storing floodwaters. And, if it is situated above developed flood- prone areas, it *significantly* benefits people" (pg. 8).

Using WWAL, this study developed correlations between WWAL attributes and several wetland functions or services and gave them designations based on their applicability in providing a specific service. Wetlands that are Vegetated lentic and lotic wetlands, Island wetlands, Ponds, terrene basin and terrene flat wetlands, or that have inflow, throughflow, or intermittent throughflow are given a high designation in the flood abatement category. However, that same wetland could still receive a moderate designation in other categories. The level of services wetlands could provide were assessed by Modeled GISRAM Ecosystem Service Ranks *and* On-site Assessments. They were then cross-checked.

The ultimate goal for this tool is for community partners (like hazard planners) to be able to use it when setting wetland restoration goals. For example, "where communities experience damaging floods, county planners can use the *Explorer* to look upstream for the best places to protect and restore wetlands that will store water and help with flood control" (p. 27).

Michigan Landscape Level Wetland Functional Assessment Tool (Michigan)

March 2015

Who: Michigan Department of Environment, Great Lakes, and Energy (EGLE), Water Resources Division

Purpose: The LLWFA supports watershed planning efforts, guides zoning decisions, helps define wetland restoration priorities for resource managers, and assesses wetland quantity and

wetland functions to determine the impact of a given wetland on its broader watershed. The tool also allows users to compare current wetland quantity and function with pre-settlement data to assess the change in both wetland extent and condition. The ultimate goal of the tool is to provide potential sites for wetland restoration or enhancement to achieve the goals of Michigan's Monitoring and Assessment Strategy.

Types of Data: The current approach "uses a computer model to integrate wetland maps, updated with current aerial photography, with hydrologic data, site topography, and other ecological information to evaluate the wetland functions provided by each mapped wetland area." The analysis then provides a generalized map of wetland functions within a given watershed, the loss of these functions previously, and what potential exists for restoring these areas. It builds on work done on by the U.S. Fish and Wildlife Service which "aided hydrogeomorphic (HGM) descriptors to wetland polygons on National Wetlands Inventory (NWI) maps."

Lake County Wetland Restoration and Preservation Plan (Illinois)

Who: Lake County Stormwater Management Commission (SMC), Lake County, Illinois

Purpose: The Wetland Restoration and Preservation Plan (WRAPP) identifies and assesses functional significance of existing and potentially restorable wetlands in Lake County, Illinois, to guide planning decisions and help with prioritization of wetland restoration and preservation efforts based on specific "wetland functions."

Types of Data: technical report and interactive online planning tool

The basis for the assessment of wetland function is a Landscape, Landform, Waterbody, and Water Flow Path (LLWW) hydrogeomorphic wetland classification scheme developed by the U.S. Fish and Wildlife Service. The WRAPP assesses 13 wetlands functions. These functions are each classified as contributing to hydrologic, biodiversity, or water quality characteristics of the wetland. Hydrologic functions include flood water storage and stream baseflow maintenance. Biodiversity functions include native fish habitat, unique wetland resources, stream shading, waterfowl habitat, wetland-dependent bird habitat, wildlife movement corridors, and woodland amphibian habitat. Water quality functions include carbon sequestration, nutrient transformation (with a focus on Phosphorus), sediment and other particulate retention, and shoreline/stream bank stabilization. For each function, the WRAPP qualitatively estimates both the degree to which each function is performed by existing wetlands, as well as the degree to which functions *may be restored.*

South Platte Natural Capital Resource Assessment and Ecosystems Valuation Tool (Colorado)

December 4th, 2017

Who: CO State Forest Service, US Forest Service, US EPA

Purpose: Stakeholders can use the data and tools from this assessment to prioritize and invest in preservation and restoration activities that will increase the quality and value of natural capital in the watershed.

Types of data: over 40 key data sources (CUSP Priority HUSC, Metro Vision 2035, National Land Cover Dataset, Transportation DRCOG, Urban Tree Canopy Denver Parks & Rec, Watershed Wildfire Protection Group, etc.)

The South Platte Watershed exists between the Denver metro area and the nearby Rocky Mountains. This project brings together stakeholders to perform a collaborative natural capital assessment on the area, integrating various datasets, including those that spoke directly to hazard analysis. These stakeholders were involved in a variety of management roles including "urban infrastructure, outreach and education, water quality, wildland fire, water resources and more" (pg. 5). In doing so, they created a Meta-analysis, Natural Capital Map atlas and layers (natural capital layer and ESV layer), and a Natural Capital Decision Support Tool.

Datasets were primarily used to create a Natural Capital Asset Map, inform the Ecosystem Services Valuation, and define the prioritization and case studies for this resource assessment. In creating the Natural Capital Asset Map, natural assets of importance were first identified. These included native forest resources, productive agricultural resources, wildlife habitat, clean drinking water, healthy waterways, access to nature, and urban ecosystem resources and parks. There is also a mention of wildfire as contributing to this aspect of the assessment.

The Ecosystem service valuation has a much clearer focus on hazards. The authors acknowledge that, "ecosystems perform natural functions (such as intercepting rainfall and preventing soil erosion) and provide goods and services that humans need to survive (e.g., a clean water supply and reduction of downstream flooding)" (pg. 10). They go on to define hazard mitigation as part of an overarching regulation services branch and identify "disaster risk reduction" as actively playing a role in the South Platte Natural Capital Assessment. When the top ten prioritization categories are established for South Platte, wildland fire and flooding are two among them. These prioritization categories are then used to "develop and map priority areas for resource investment" (pg. 28). In the map, there is a layer that pertains to wildfire risk, aggregated from data from the 2012 Colorado Wildfire Risk Assessment Project. It demonstrates the possibility of loss or harm from a wildfire created by combining the probability of a wildfire occurring with the potential impacts, if a wildfire did occur. There is also a flood layer, based on FEMA's flood hazard layer, which impacts portions across the watershed. Finally, these various databases are brought together to "create a more refined prioritization that meets multiple adjectives" (pg. 41). For example, the water quality/quantity project looks at how improving the overall watershed condition can also protect residents downstream of the Chatfield Reservoir from flooding.

Potential Of Using a Watershed Approach to Reduce Flooding (Iowa)

2023

Who: Iowa Watershed Approach Homeland Security and Emergency Management (HSEMD), U.S. Army Corps of Engineers Rock Island District, and other Iowa Silver Jackets partners

Purpose: To identify areas that have the greatest Potential Of using a Watershed Approach to Reduce Flooding (POWAR F). The methodology to identify such areas seeks to use annualized expected flood loss estimates for cities and quickly illustrate how much or how likely watershed approach practices upstream could reduce future flood losses in those cities. The methodology was developed consequent to the Iowa Watershed Approach (IWA) initiative, whose purpose was to reduce flood risk, improve water quality, increase resilience, and engage stakeholders.

Types of Data: Two factors are especially important in locating where watershed approach practices are most likely to result in flood reduction. They are:

1. The smaller the watershed above a flood impact area, the fewer watershed approach practices are needed to realize a reduction in flood levels.
2. The greater the dollar damage at the flood impact area, the more opportunity there is for reducing potential dollar losses.

These factors can be expressed in a single relationship, or ratio, that illustrates the **P**otential **O**f using a **W**atershed **A**pproach to **R**educe **Floods**, or **POWAR Floods** Ratio. That ratio is:

$$\text{POWAR F Ratio} = \frac{\text{\$ loss from potential flooding}}{\text{Watershed Area}}$$

The loss from potential/expected future flooding can include loss from flood impacts to buildings, crops, or roads (which would include costs associated with consequent detours). HSEMD has developed flood loss estimates for buildings in Iowa. The IWA Information System (IWAIS), an interactive tool that displays information on 9 watersheds in Iowa, contains such building flood loss estimates for several watersheds in Iowa. Outside of Iowa, such flood losses can be estimated using Hazus, or by performing GIS analysis with flood depths and structure data (like that from the National Structure Inventory). The Hazus Flood Assessment Structure Tool (FAST) can be used for such analysis.

The watershed area needed for calculating the POWAR F ratio can be calculated using EPA's WATERS GeoViewer (a user can click on a certain point and find the area upstream). EPA also has watershed area data in spreadsheets for each state on its Recovery Potential Screening tools website. These Excel files are available for each state and include the area of each HUC 12 watershed, and which HUC12 watersheds are upstream of a particular watershed.

Besides the POWAR F ratio, the potential of using a watershed approach to reduce flooding is also influenced by slope, soil characteristics, impervious surface, and how many suitable locations there are for the various types of watershed approach best management practices. Many of these factors may be visualized in maps in the IWAIS, including best management practice (BMP) mapping. BMP Mapping gathers baseline information on existing BMPs in IWA

watersheds and across the state to establish baseline conditions and assist with planning and implementation efforts. The Agricultural Conservation Planning Framework (ACPF) tool can also be used to identify hypothetical BMPs.

More about the suitability of different types of BMPs and how to use the POWAR F methodology can be found in the report *Strategies for Flood Resilience: A Four Point Guide to Helping Locals with Watershed Approach Flood Reduction,* available at https://homelandsecurity.iowa.gov/iowa-watershed-approach/.

Kentucky Silver Jackets Green Infrastructure Tool (Kentucky)

September 23, 2021

Who: U.S. Army Corps of Engineers, Interagency Group focused on flood risk management

Purpose: To collect geospatial data and create a suitability model for future green infrastructure

Types of Data: GIS suitability model (using thematic datasets like land use, depth to water table, FEMA 100-year flood plain, public/private, hydrologic soil groups, canopy cover, impervious surfaces, and proximity to structures (slide 8)) for future green infrastructure.

This project used a form of suitability modeling called a "weighted overlay" (categorizing and ranking values from a variety of thematic datasets) to receive continuous output from "suitable" to "not suitable" (i.e. high index to low index) (slides 5, 6). 5 counties were evaluated using the GIS map with an overlay of index values ranging from 0 to 1, where the higher the index, the darker the region (slide 12-23). Those regions closest to 1 indicated the strongest fit in terms of suitability (with consideration of the weighted model variables) for future green infrastructure (slide 12).

Upper Bear River Watershed Wetland Conservation and Prioritization (Utah)

September 2016

Who: Rhyan Sempler and Diane Menuz, affiliated with the Utah Geological Survey, Utah Department of Natural Resources

Purpose: To explore the utility of ranking wetlands based on multiple benefits such as sensitive species habitat and water quality attenuation. The tool is intended to be used to evaluate conservation opportunities (such as for those interested in looking at the sage-grouse habitat to determine whether priority wetlands should be considered targets for conservation easements), or to act as a first pass in determining restoration opportunities (pg. 6).

Types of Data: water quality and sensitive species habitat used to create an interactive prioritization model

The authors considered 3 wetland functions for this model of Rich County, Utah: sensitive species habitat, water quality attenuation, and flood control (although they ultimately did not include flood control in the final model due to data limitations) (pg. 1). For sensitive species

habitat, the authors compiled a list of all federally threatened, endangered, and Utah-sensitive species found in the watershed (ibid). For water quality attenuation, the authors categorized wetlands in order of importance (the most important being "riparian wetlands adjacent to perennial streams in impaired catchments" and the least important being "non-riparian wetlands outside of impaired watersheds") (pg. 2). For the selected species (i.e. the boreal toad, beaver, sage-grouse lek, and Bonneville cutthroat trout), the authors also considered various factors related to the importance of the wetlands for that species (pg. 3). The authors also acquired land ownership data to better understand current protection status (pg. 1).

From these wetland function inputs, wetlands were given a prioritization score, and those scoring in the 99th percentile were deemed "top priority" wetlands (pg. 5). All top priority wetlands were at least marginally important for the Bonneville cutthroat trout and water quality, though only four top priority clusters were high priority for the sage-grouse (ibid).

Fire and Water: The Interplay Between Wetlands and Fire Management Mapping (New Mexico)

June 2019

Who: New Mexico Environment Department Surface Water Quality Bureau, Wetlands Program

Purpose: "To map and identify priority wetland resources for protection and restoration in the Sacramento Mountains and develop a landscape level functional assessment model" as well as identify some wetlands that have had segments classified by water quality for future wetlands standards development (pg. 2).[1]

Types of Data: GIS based labeling tool that provides a unique code for each wetland polygon and a draft interactive New Mexico wetlands map

This project filled a critical data gap for wetlands protections efforts undertaken by the Department of Surface Water Quality Bureau (SWQB) and its partners (pg. 4). It is the goal of this project that these mapping products will help local government protect, restore, and sustain wetland habitats, allow for the development of classified segments of water quality standards for wetlands, and assist the U.S. Army Corps of Engineers in determining CWA Section 404 for protected waters (pg. 5). To create the mapping products, habitat, hydrogeomorphic, and Western Riparian classifications were applied to the wetlands and mapped in the project area to allow for the assessment of up to 12 different wetlands functions (pg. 20-21). This project highlights just one area that has been mapped, and the project intends to update and improve mapping for all lands in New Mexico under state jurisdiction (pg. 23) to encourage a statewide emphasis on wetlands restoration in fire management plans

Geospatial Assessment of Flood Vulnerability Reduction (Texas)

May 3, 2019

Who: Justin Bousquin (Gulf Ecology Division, National Health and Environmental Effects Laboratory, U.S. Environmental Protection Agency) and Kristen Hychka (University of Maryland Center for Environmental Science)

Purpose: To develop a nationally consistent dataset and demonstrate how this dataset can be used at different scales (regional or local) to rapidly assess flood-reduction benefits.

Types of Data: a nationally consistent GIS dataset with a set of high-resolution indicators of highly flood prone populations (taken from USEPA flood model results) and areas of wetland restoration to characterize where people benefit from reduced flood risk through existing wetlands.

Analysis of Harris County, Texas identifies communities that have both a highly flood-prone population *and* wetland restoration potential to show how areas where there is an overlap could greatly benefit from restoration. Thus, mapping these two indicators can be used to set wetland protection and restoration priorities.

Authors characterized a series of sub-region catchments as either A, B, or C, where Priority A catchments had both high demand and a strong restoration candidate or strong protection candidate (pg. 10). Priority B catchments had medium demand and were medium restoration or protection candidates (ibid). Priority C catchments had low demand and few restoration or protection candidates (ibid). This facilitated the identification of priority areas for wetlands restoration or protection (ibid).

The authors note that actual restoration decisions should consider priority catchments identified here alongside additional characterizations "of project feasibility and restorable wetland function" (pg. 12). The hope is that the metrics used for the catchments and aggregation method will make it easier to integrate results with other datasets or indicator frameworks for larger watershed scales (ibid).

Maryland Parcel Evaluation Tool (Maryland)

2018

Who: Maryland Department of Natural Resources

Purpose: Provide a Conservation Benefits and Ecosystem Service Assessment Report Card for every land parcel in Maryland by evaluating the conservation benefits and ecosystem "value" of every parcel of land across the state of Maryland.

Types of Data: GIS data on road, stream, wetland and other resource features, and biological databases. The Parcel Evaluation Tool also displays information about state operated land conservation programs like Program Open Space, Maryland Agricultural Land Preservation Foundation, the Maryland Environmental Trust, and the Rural Legacy Program.

This tool is intended to be accessible and readily used by everyone from private citizens to conservation groups and land planners. To assign a monetary value to each parcel of land, the tool derives the value of the land from the environmental functions a parcel performs (such as air pollution removal for ozone and various particulate matters, carbon sequestration, groundwater recharge, stormwater mitigation, among numerous others). While this does not amount to a fair market appraisal, it can help inform interested parties in their decision-making process by adding both qualitative *and* quantitative data.

Recovery Potential Screening methodology and tool

Updated August 2022

Who: EPA Office of Water

Purpose: RPS is a systematic, comparative method for identifying differences among 12-digit Hydrologic Unit subwatersheds (HUC12s) that may influence their relative likelihood to be successfully restored, protected, or managed in other ways.

Types of Data: RPS Tool files are available for all US states and territories. Each file is a custom-coded Excel spreadsheet that is configured for a state or territory which stores pre-calculated watershed indicators for that area. Indicators measure distinct watershed characteristics and serve as the basis for comparison in the RPS Tool. The RPS Tool uses three categories of indicators to compare subwatersheds: Ecological, Stressor, and Social. The RPS Tool performs all RPS index calculations and generates RPS outputs as rank-ordered tables, maps, and bubble plots. Users can also download their own custom tool using an adapted online tool called the Watershed Index Online Tool.

The basis for RPS Tool comparative assessments is provided by Recovery Potential Indicators. The screening approach has four parts: 1) identifying a group of watersheds to be compared and a purpose for comparison, 2) selecting appropriate ecological, stressor, or social indicators, 3) calculating index values for the watersheds, and 4) varying the analysis iteratively and applying the results as part of strategic planning and prioritization.

Appendix 2: Relevant Literature (Annotated Bibliography)

Incorporating Nature-Based Solutions: Community Climate Adaptation Planning *NOAA*
Incorporating Nature-Based Solutions: Community Climate Adaptation Planning (noaa.gov)

This document is provided by the Climate Resilience Fund to supplement the "Steps to Resilience" Practitioners Guide, which is a generalized climate adaptation planning framework, with a step-by-step process to incorporate Nature-Based Solutions (NbS) into adaptation planning. The intended audience for this guide is climate service practitioners who are working with communities to steer resilience efforts.

This guide recognizes that the first step in the adaptation planning process must be the opportunity to connect communities with their natural assets and set the overall scope of adaptation planning with a nature-based framing (p. 20). In this step of exploring hazards, practitioners should help communities identify the full range of natural assets, explore interactions between natural processes and hazards and pinpoint the local and climate drivers that which may exacerbate the risk of such hazards, and determine geographic and temporal scale for NbS.

The next step involves assessing vulnerability and risk, followed by investigating options for identifying NbS. Some of the vulnerability and risk assessment models discussed include the three-part framework based on exposure, sensitivity, and adaptive capacity (p. 31-34), the Habitat Climate Change Vulnerability Index (p. 35), and the Sea Level Affecting Marshes Model (p. 35) among others. The discussion of options for NbS include conventional approaches to hazards and potential NbS alternatives, as well as NbS specifically for ecosystems and biodiversity (p. 67), water quality (p. 68), and carbon sequestration/storage (p. 69).

Following this, the rest of the guide discusses how to prioritize and plan for implementing NbS. The authors provide a four-part evaluation framework summarizing guiding questions for prioritizing NbS based on value, trade-offs, planning, decision points, and key NbS considerations (p. 72). Some important elements the guide highlights include how to embed NbS within existing planning process (p. 85) and the federal disaster programs that can support NbS (p. 107).

The guide concludes with case studies on NbS. One example includes the Rattlesnake Creek Dam in Montana, which was removed to reestablish stream connections between the Rattlesnake Wilderness and the Clark Fork River. In this project, attention was paid to sediment BMPs, fish salvage, and restoring as well as protecting natural streambank vegetation (p. 112-114). The outcomes include both reduced flood hazard as well as increased water filtration and

groundwater recharge, storage capture, habitat restoration, and enhanced recreational opportunities (ibid).

Promoting Nature-Based Hazard Mitigation Through FEMA Mitigation Grants *The Nature Conservancy* https://www.nature.org/content/dam/tnc/nature/en/documents/Promoting-Nature-Based-Hazard-Mitigation-Through-FEMA-Mitigation-Grants-05-10-2021-LR.pdf

With the explicit purpose of guiding "stakeholders pursuing FEMA [Hazard Mitigation Assistance (HMA)] grants for nature-based solutions to mitigate risks associated with flooding (riverine and coastal) and wildfire," this guide is primarily aimed at assisting stakeholders in securing funding for nature-based hazard mitigation solutions. In doing so, it walks readers through applicable funding programs, mitigation techniques, benefit quantification (including benefit-cost analyses (BCA)), consensus building, and impact maximization.

The FEMA grants outlined in the guide are all under the umbrella of the HMA program but differ in the way they are designed and awarded. The guide explores these differences for the Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance (FMA), and Building Resilient Infrastructure and Communities (BRIC) through the types of projects to which they can apply, minimum requirements, and the role of the state in securing funding. The guide also walks users through the process of selecting the appropriate nature-based solution for these grants, including steps like "determine the hazard to be mitigated" and "prioritize applicable nature-based solutions that offer the greatest ancillary benefits."

Later, the guide dives into BCA, schooling readers on economic, community, and environmental benefits of nature-based solutions as well as their quantification as it relates to providing ecosystem services. There is discussion of ancillary benefits and qualitative benefits, while costs are considered on a budgetary basis.

Finally, the guide considers the logistical details of designing these projects – should it be small or large-scale? How should stakeholders be engaged? Are there any residual benefits? In addition to answering these questions specifically, the guide concludes with case studies that speak to past successes and demonstrate the ways those projects tackled comparable questions.

Building Community Resilience With Nature-Based Solutions: A Guide For Local Communities *FEMA* https://www.fema.gov/sites/default/files/documents/fema_riskmap-nature-based-solutions-guide_2021.pdf

This FEMA published document aims to help "communities identify and engage the staff and resources that can be used to implement nature-based solutions to build resilience to natural hazards, which may be exacerbated by climate change." The guide emphasizes the partners that can be involved in nature-based hazard mitigation and the importance of building those partnerships. Taking a four-step approach, it first walks through types of nature-based solutions and identifying the proper one for a given case, then offers economic incentives for the private sector to engage with nature-based solutions, and then gets into inter-departmental policy building for these solutions, before ending with a zoomed out look at implementation integrating the public and private sector. Finally, the guide offers some information on federal funding and key takeaways.

The key takeaways offer insight into the heart of the document. There are four: 1) Speaking about nature-based solutions myriad functions and goals (improving community life, reducing loss of property, etc.) can help build interest from the private sector, thereby generating widespread interest and buy-in; 2) Successfully integrated nature-based solutions rely on a diverse set of partners working together to overcome barriers to making nature-based solutions standard practice; 3) Scaling up nature-based solutions will require public and private collaboration; 4) Since nature-based solutions have co-benefits, they are also eligible for many different types of grants.

It is these key takeaways that the document explains and further elucidates by explaining more in depth how readers can build the kind of partnerships and secure the kind of funding they enumerate.

Incorporating Green Infrastructure/Low Impact Development, Open Space, and Nature Based Systems into the Denton County Hazard Mitigation Plan *Texas AM AgriLife Extension*
https://agrilife.org/lid/projects/incorporating-gi-lid-nature-based-systems-hazard-mitigation-plan/

This report was prepared by Texas A&M AgriLife Extension in collaboration with EPA, the city of Denton, Texas, and the Upper Trinity Regional Water District. It reflects efforts to institute "Green Infrastructure and Low Impact Development" in Denton County, Texas with particular emphasis on flood mitigation, stakeholder involvement, GIS modeling for prioritization, creating training materials, and providing a framework for this type of work in other localities. The authors take an area-wide approach, considering the various watersheds in the county and their interaction with one another.

In discussing stakeholders, this report acknowledges that the traditional hazard planning process was a largely insulated one, with stakeholders divorced from the natural resource divisions of government. In this case, environmental professionals from several Texas departments were invited to the table through structured meetings. Public engagement and approval were already implicit in the hazard planning process.

Another element of the project was the creation of a GIS map of Denton County to help identify where these green solutions would be best placed. The GIS system built included layers for elevation, slope, flow accumulation, land use/land cover, soil flooding frequency, and normalized difference vegetative index. The GIS analysis is used to help determine the cost and benefit of implementing nature-based hazard mitigation solutions.

Disaster Management and Community Planning, and Public Participation: How to Achieve Sustainable Hazard Mitigation *Pearce*
https://link.springer.com/article/10.1023/a:1022917721797

This academic paper appeared in the Journal of Natural Hazards and was written by an author associated with the University of British Columbia. Although not chiefly concerned with nature-based strategies, it offers important commentary on coalition building and community participation in sustainable hazard mitigation planning, primarily in Australian and American contexts.

A big element of this report is a shift in strategies from being reactive (action after an emergency occurs) to proactive (preventative hazard mitigation efforts). The author also emphasizes shifting the process from being driven by a single agency to being based in partnerships, from planning *for* communities to planning *with* communities, and from response management to risk management. These shifts evince a changing focus from one that centers on specific hazards to one that takes a systematic approach to hazard risk, a more natural system for the introduction of nature-based solutions as well.

The second section of the paper explains how to better integrate disaster management planning and community planning, tools that can also be used in forming nature-based hazard mitigation partnerships. Most important to an effective partnership is to launch it before the disaster occurs using stakeholder participation, planning components, plan types, and mitigation strategies. There is also the issue of ensuring public participation. The paper suggests that emergency planners provide more information to the public and share power with community members once they are involved. The author also suggests the creation of an advisory committee.

The paper ends with a case study in Portola Valley, California where an incorporated town established a conservation committee that incorporated feedback from landowners when determining strategies to cope with landslides common in the area.

Building Resilience through Natural Infrastructure: Barriers and Opportunities within FEMA Hazard Mitigation and HUD Community Development Block Grant Programs *Theodore Roosevelt Conservation Partnership and The Water Foundation by the National Wildlife Federation* https://www.nwf.org/-/media/Documents/PDFs/Press-Releases/2021/07-29-21_Building-Resilience-through-Natural-Infrastructure

Prepared by the National Wildlife Federation for the Theodore Roosevelt Conservation Partnership and The Water Foundation, this white paper focuses specifically on barriers and opportunities within FEMA grant programs for nature-based hazard mitigation.

Starting with a presentation of case studies, the report demonstrates the efficacy of these nature-based strategies and then transitions to the history of FEMA's investment in said programs. The report highlights various programs – Public Assistance Mitigation, Hazard Mitigation Grant Program, Building Resilient Infrastructure and Communities, and Flood Mitigation Assistance – and goes on to zero in on BRIC specifically. The paper guides readers through the project tracks available under BRIC, the amount of funding available for each, and requirements for securing funding. Later, there is a transition to HUD funding and the Community Development Block Grant-Disaster Recovery (CDBG-DR) Program. Similarly, there is a discussion of processes for achieving CDBG-DR funding.

Finally, the authors explore broader barriers and opportunities for federally funded nature-based solutions. One primary point is increasing local involvement with nature-based projects. They recognize a barrier that localities must work through their state to apply for this funding but also emphasize the opportunity to advance the knowledge of these solutions within the hazard planning community. There is also a discussion of including nature-based solutions in hazard mitigation plans, property buyouts and floodplain restoration, benefit-cost analysis, increasing access to non-federal match assistance, enhancing community engagement, and HUD CDBG-DR. Each discussion includes barriers, opportunities, and any congressional or agency actions that have been taken. There is also mention of planning, education, and outreach under each of these umbrellas, when relevant.

Nature-Based Flood Solutions and the National Flood Insurance Program *Resources for the Future* https://media.rff.org/documents/IB_22-06.pdf

Unlike the other resources featured in this list, this paper focuses exclusively on the National Flood Insurance Program (NFIP) and nature-based solutions that can be derived to help prevent flooding. The authors highlight three key findings: 1) flood reduction by specific nature-based solutions can be predicted using analytical tools; 2) premium setting practices in the NFIP do not properly recognize nature-based solutions; and 3) community specific flood and storm hazard reduction predictions could offer NFIP premium savings for nature-based solutions and encourage more communities to adopt such measures.

Because this document focuses specifically on floods, there is more depth about types of flooding and nature-based solutions suited for each type. For example, they distinguish between coastal and inland floods and speak about green infrastructure as a viable solution for both.

The primary focus of the paper is setting insurance premiums and proposing a new way "the NFIP can recognize [nature-based solutions] hazard reduction when setting NFIP premiums for a group of insured properties." Risk Rating 2.0 was a program designed by FEMA to better estimate the flood risk of a particular property, but it does not consider the benefits to a particular property if nature-based solutions are implemented. This paper concludes and argues that those should be considered, and they should lower premiums for properties that would benefit from nature-based solutions. In this way, it could help further incentivize the important development of nature-based solutions for hazard mitigation.

Nature-Based Solutions for Disaster Risk Management *Global Facility for Disaster Reduction and Recovery, World Bank Group, Profor, World Resources Institute*
https://naturebasedsolutions.org/sites/default/files/2021-02/NBS%20for%20DRM%20booklet.pdf

Based on research performed by the World Resources Institute and the World Bank, this booklet intends to guide "staff at governments, development finance institutions (DFIs), and other development institutions" in their understanding and use of nature-based solutions. The booklet is divided into three sections: 1) an overview of the World Bank's nature-based solutions program, 2) examples of nature-based solutions for coastal flooding and erosion, urban stormwater flooding, and river flooding, and 3) guidance to support the implementation of nature-based solutions, including a discussion of policies and financing options.

Taking a more international lens than the other resources on this list, the World Bank Nature-based Solutions Program, in particular, aims to identify nature-based solutions around the world.

Additionally, when discussing examples of effective nature-based solutions for disaster mitigation, the examples are worldwide. A section on coastal flooding and erosion highlights the United States, the Netherlands, and Vietnam, for example. The example from the United States centers on oyster reef restoration in the Gulf of Mexico. Further on, there is an example of urban wetlands for flood reduction in Sri Lanka.

The discussion of implementing and funding these projects revolves around working in harmony with traditional disaster mitigation processes, including regional planning and infrastructure master planning. The booklet encourages those proposing these types of projects to consider the technical, social, and economic dimensions alongside the environmental ones. It also offers a framework for considerations in considering the policy dimensions of this issue.

Nature-Based Mitigation Goals and Actions in State and Tribal Hazard Mitigation Plans
Environmental Law Institute, https://www.eli.org/research-report/nature-based-mitigation-goals-and-actions-state-and-tribal-hazard-mitigation-plans

This overview of state and tribal hazard mitigation plan considers whether nature-based thinking is incorporated into said plans and finds that 38 out of 50 state plans had goals and objectives relevant to natural systems protection. The authors then subsect these 38 relevant plans into three categories: "1) broad goals that mention protecting the environment in addition to protecting other state aspects (24 plans), 2) goals that specifically focus on the environment (7 plans), and 3) goals that specifically focus on nature infrastructure/nature-based solutions (14 plans)." In total, across these state plans, 177 nature-based actions were identified, and these 177 actions were sorted into categories as well: conservation/preservation/management, restoration, green infrastructure, land use, funding and programmatic, policy and law, technical and information, education and awareness, agency coordination, and partnerships.

This paper also considers Tribal plans and found that the types of actions present in Tribal plans were of the same kind as those found in state plans. Still, there is a recognition of the unique cultural and political positioning of tribes in this paper and a recommendation that more work be done in this space, considering tribes specifically.

After reviewing both state and tribal plans, the authors identified several characteristics that may influence the integration of nature-based solutions in the hazard planning process. First, they found that hazard planners that better understand the concept and role of nature-based solutions in risk and vulnerability are more likely to incorporate them into plans and more likely to make them effective once implemented. Second, it is important for states and tribes to identify possible sources of funding for these types of projects. Third, the guide recommends leveraging existing

natural resource plans and facilitating key partnerships with natural resource experts. When necessary, involving technical experts can also be helpful.

This paper also includes key takeaways, a step-by-step guide for states and tribes to better integrate nature-based solutions into their hazard plans, and recommendations for FEMA to improve the process by which nature-based solutions are incorporated into hazard plans.