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# **14 Wetland Assessment and Prioritization Tools**

## [Floodplain Prioritization Tool](https://freshwaternetwork.org/innovative-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](https://maps.freshwaternetwork.org/dev/missriverbasin-floodplain/) 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](https://tnc.app.box.com/s/yieaukg52h5k72vxq0q2z0h8mg9uhuz7). 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 population exposed to floods for the present day, and 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](http://adaptva.com/index.html) (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](https://cmap22.vims.edu/AdaptVA/AdaptVA_viewer.html) 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 be helpful in planning 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 is data layers specific to use for the Virginia Chesapeake Bay Preservation Act climate resilience assessment including 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)](http://adaptva.com/info/tools_fr.html) pulls data from ESRI GIS, FEMA, and the Fish and Wildlife Service to map special flood hazard areas (SFHA). [The Locality Road Flood Tool](http://adaptva.com/info/tools_rd.html) 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](https://experience.arcgis.com/experience/4c8fea3204fd47cc842df6b0de92ee3f/page/About-Project-/) 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](http://adaptva.com/info/tools_bmp.html) (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](https://www.deq.nc.gov/about/divisions/mitigation-services/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 phases](https://www.deq.nc.gov/about/divisions/mitigation-services/flood-resiliency-blueprint). 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](https://coastalreview.org/2022/02/state-to-begin-developing-blueprint-for-flood-resiliency/) 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](https://freshwaternetwork.org/projects/wetlands-by-design/) (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](https://www.michigan.gov/documents/deq/wrd-wetlands-strategy_555457_7.pdf) (Michigan)

*March 2015*

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

**Purpose**: [The LLWFA supports](https://www.epa.gov/wetlands/michigan-integrates-wetland-assessment-watershed-protection) 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](https://www.epa.gov/wetlands/michigan-integrates-wetland-assessment-watershed-protection) 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](https://www.michigan.gov/-/media/Project/Websites/egle/Documents/Programs/WRD/Wetlands/wetland-monitoring-assessment-strategy.pdf?rev=9d714a99e380443384d7021118a913f4) 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](https://www.michigan.gov/egle/about/organization/water-resources/wetlands/landscape-level-assessment) “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](https://www.michigan.gov/egle/about/organization/water-resources/wetlands/landscape-level-assessment) 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](https://www.epa.gov/wetlands/michigan-integrates-wetland-assessment-watershed-protection) which “aided hydrogeomorphic (HGM) descriptors to wetland polygons on National Wetlands Inventory (NWI) maps.”

[Lake County Wetland Restoration and Preservation Plan](https://www.lakecountyil.gov/2531/Wetland-Restoration-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](https://www.epa.gov/urbanwaterspartners/south-platte-natural-capital-project) (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](https://iwa.iowawis.org/about.php) (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:

 $ loss from potential flooding

POWAR F Ratio = 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](https://iwa.iowawis.org/about.php). Outside of Iowa, such flood losses can be estimated using [Hazus](https://www.fema.gov/flood-maps/products-tools/hazus), or by performing GIS analysis with flood depths and structure data (like that from the [National Structure Inventory](https://nsi.sec.usace.army.mil/downloads/)). The [Hazus Flood Assessment Structure Tool (FAST](https://github.com/nhrap-hazus/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](https://www.epa.gov/waterdata/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](https://iwa.iowawis.org/about.php). [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](https://iwa.iowawis.org/about.php). 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/.](https://homelandsecurity.iowa.gov/iowa-watershed-approach/.%20%20)

[Kentucky Silver Jackets Green Infrastructure Tool](https://www.kymitigation.org/wp-content/uploads/2021/09/Kentucky-Green-Infrastructure-Open-Space-Analysis-Laura-Mattingly-and-Rachel-Byrd.pdf) (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](https://ugspub.nr.utah.gov/publications/non_lib_pubs/contract_deliverables/WCD-11.pdf) (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](https://www.env.nm.gov/wp-content/uploads/sites/25/2019/10/Final-Report-Sacramento-Mountains-Map-Class-June-2019.pdf) (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]](#footnote-2)

**Types of Data**: GIS based labeling tool that provides a unique code for each wetland polygon and a draft interactive New Mexico wetlands [map](https://gis.web.env.nm.gov/oem/?map=wetlands)

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](https://www.frontiersin.org/articles/10.3389/fenvs.2019.00054/full%3B%20https%3A//www.epa.gov/water-research/rapid-benefit-indicators-rbi-approach)](https://www.frontiersin.org/articles/10.3389/fenvs.2019.00054/full) (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](https://geodata.md.gov/greenprint/) (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](https://geodata.md.gov/greenprint/).

This tool is intended to be accessible and readily used [by everyone from private citizens to conservation groups and land planners](https://mdplanningblog.com/2019/05/29/maryland-department-of-natural-resources-has-developed-a-tool-for-assessing-the-value-of-land-across-the-maryland/). 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).](https://mdplanningblog.com/2019/05/29/maryland-department-of-natural-resources-has-developed-a-tool-for-assessing-the-value-of-land-across-the-maryland/) 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](https://www.epa.gov/rps)

*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](https://www.epa.gov/rps/downloadable-rps-tools-comparing-watersheds) 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](https://www.epa.gov/wsio/download-and-use-wsio-tool).

The basis for RPS Tool comparative assessments is provided by [Recovery Potential Indicators.](https://www.epa.gov/rps/overview-selecting-and-using-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.

# **Relevant Literature (Annotated Bibliography)**

**Incorporating Nature-Based Solutions: Community Climate Adaptation Planning** *NOAA* [Incorporating Nature-Based Solutions: Community Climate Adaptation Planning (noaa.gov)](https://library.oarcloud.noaa.gov/noaa_documents.lib/OAR/CPO/Climate_Smart_Communities/Vol_05_CSC_Nature-basedSolutions.pdf)

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](https://link.springer.com/article/10.1023/a%3A1022917721797)

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.

1. The project also originally included a Wetland Change Analysis of the project area to analyze pre- and post-fire imagery (under gain, loss, and type conversion parameters). [↑](#footnote-ref-2)