Watershed Approach Handbook

Improving Outcomes and Increasing Benefits Associated with Wetland and Stream Restoration and Protection Projects

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Contents

Executive Summary

This handbook is intended to advance the use of a “watershed approach” in the selection, design, and siting of wetland and stream restoration and protection projects. Using a watershed approach can help ensure that these projects also contribute to goals of improved water quality, increased flood mitigation, improved quality and quantity of habitat, and increases in other services and benefits that result from ecologically successful and sustainable restoration and protection projects.

Using a watershed approach allows decisions to be made in the context of a science-based analysis of watershed needs. Projects located using this approach are more likely to be achieved desired ecological outcomes and therefore help achieve broader conservation outcomes. Using a watershed approach requires some initial investment, but its use can improve state-federal coordination and may help improve efficiency by helping to prioritize actions and leverage efforts among and across a wide variety of regulatory and non-regulatory programs.

Watersheds are used as the planning unit for wetland and stream mitigation purposes because they are the context in which the major physical, chemical, and biological processes that determine functions and services of wetlands and streams occur.

Watersheds are used as the planning unit for wetland and stream mitigation purposes because they are the context in which the major physical, chemical, and biological processes that determine functions and services of wetlands and streams occur. Therefore, understanding and taking into account these watershed processes and conditions are critical to achieving the desired ecological outcomes of a restoration or protection project. Watersheds also provide the context within which restoration and protection projects can be evaluated and selected based on their ability to meet human needs, offset new or previous impacts, and help achieve desired future conditions. A watershed approach offers a concrete mechanism for considering various existing agency plans and goals and making them relevant to wetland and stream restoration projects. By explicitly considering these goals – such as water quality goals or habitat protection goals – the watershed approach provides the ability to have multiple programs work together to achieve multiple goals.

There are five elements that are generally included when taking a watershed approach to wetland and stream restoration and protection. These are:

1. *Identification of watershed needs*, including a determination of how watershed needs identified by various regulatory and non-regulatory programs can inform the watershed approach.
2. *Identification of desired outcomes,* or the specific and usually measurable results desired in the future. An outcome is a stated desired future condition that will result from undertaking a variety of projects within the watershed. Desired outcomes (e.g. meet water quality standards) help provide the goal by which to align and prioritize many types of projects and actions, including wetland and stream restoration projects.

3. *Identification of potential project sites,* generally based on the ability of wetlands and streams to develop and persist in a particular location. This focuses directly on identifying suitable sites that have a high likelihood of providing the desired ecological functions on a sustainable basis.
4. *Assessment of the potential of sites to meet watershed needs*, generally through analysis that ranks the relative ability of potential protection and restoration sites to support particular ecosystem functions and services that help address one or more established watershed needs.
5. *Prioritization of project sites,* based on their relative ability to sustain wetland characteristics and their ability to address watershed needs, and/or contribute to achieving desired watershed outcomes. Project sites that are likely to produce more functions and better able to address watershed needs should be prioritized over project sites that will provide smaller incremental results.

In general, greater clarity about watershed-scale needs and more specificity around desired outcomes – such as improvements in water quality, habitat, or flood attenuation – will lead to selection of sites that contribute most to meeting desired outcomes at the watershed scale. Individual projects selected using the watershed approach may not achieve watershed-scale desired outcomes. However, over time as a range of agencies and organizations undertake projects, the individual projects will add up to advancing outcomes on this scale. This is the power and potential of the watershed approach – the alignment of the work, energy, and skill that will add up to more than the sum of their parts.

Watershed approaches come in many forms. The range of approaches is best portrayed as spanning a spectrum, from simple and general logic frameworks to the more comprehensive and specific analyses and planning efforts. The three basic types of watershed approaches are:

- Watershed informed decision-making
- Watershed analyses with non-prescribed outcomes
- Watershed plans with prescribed outcomes

The approaches can involve different levels of efforts, from more comprehensive watershed planning efforts to using available watershed information to inform decision-making. Using information about the watershed to inform decision-making may help achieve better project outcomes and may be adequate to meet the requirements as described in the 2008 Compensatory Mitigation Rule. However, using either existing or new watershed analysis specific to wetland and stream protection and restoration, as outlined in Chapter 4, offers the best opportunity to achieve the desired ecological outcomes and produce projects with the highest return on investment.

Numerous planning tools and methods have been developed that are useful for informing a watershed approach to wetland and stream restoration and protection. These various efforts yield a rich diversity of experiences, methods, and models on which to base a watershed approach to stream and wetland restoration and protection projects. Over 65 examples are provided in this handbook to capture a variety of different tools and methods for carrying out a watershed approach. These techniques and approaches are organized by the five elements of the watershed approach.

Using a watershed approach to inform wetland and stream restoration and protection decisions offers the opportunity to achieve benefits beyond compensation for wetland loss and impacts to streams and beyond the benefits to a particular protection or restoration site. The approach allows decisions to be made in the context of a science-based analysis of watershed needs so that these projects can achieve broader conservation outcomes. Watershed health is more likely to improve with an increased understanding of watershed needs and an alignment of regulatory and non-regulatory wetland and stream restoration and protection efforts.
The audience for the handbook is broad and includes those individuals and organizations engaged in wetland and stream restoration and protection for regulatory and non-regulatory purposes and for those working in other aquatic resource programs. This includes, but is not limited to, federal, state, tribal, and local government program managers, non-governmental organizations, permit applicants, and mitigation providers.

...the use of a watershed approach can improve the return on investment for wetland and stream projects.

The handbook provides an overall framework for the spectrum of watershed approaches, examples of specific types of watershed approaches, examples of types of analysis that may be useful for using a watershed approach, and a list of national data sources that might inform all of the above. We outline the potential benefits of using a watershed approach and how the use of a watershed approach can improve the return on investment for wetland and stream projects. We also provide some guidance and lessons learned about considerations when developing wetland and stream protection and restoration projects.

The handbook was developed through a combination of research on existing efforts, discussion with many who had engaged in using watershed approaches, discussion with people with deep experience in wetland and stream protection and restoration projects, and direct experience in undertaking pilot watershed approach projects. Most importantly, we benefited from the deep and extensive engagement of the experts on our national advisory committee who helped us understand and frame the issues and information and therefore greatly inform the contents of this handbook. The document reflects the views of the authors, but we are deeply indebted to the members of the committee who helped shape and inform this handbook.

Part 1: The Watershed Approach

Introduction

This handbook is intended to advance the use of a “watershed approach” in the selection, design, and siting of wetland and stream restoration and protection projects. Using a structured, science-based analytical process to identify the types and locations of such projects can result in substantial environmental gains. Without such an approach, wetland and stream restoration and protection projects may improve site-specific conditions and sites may be sustained over time, but opportunities may be missed to advance watershed health and achieve broader environmental or social goals, such as improved water quality, increased flood mitigation, improved quality and quantity of habitat, and increases in other services and benefits. Thus, using a watershed approach to inform wetland and stream restoration and protection decisions offers the opportunity to achieve a broader range of benefits, and in the case of compensatory mitigation, to achieve results beyond the replacement of acres and functions lost at specific wetland and stream sites.

... using a watershed approach ... offers the opportunities to achieve a broader range of benefits.

Although employing a watershed approach may require some initial investment, its application could reduce costs of failed mitigations associated with improper siting, improve state-federal coordination, and may help improve efficiency by helping to prioritize actions and leverage efforts among and across a wide variety of regulatory and non-regulatory programs.

This handbook describes a range of approaches, tools, and techniques for applying a watershed approach. The approaches and techniques discussed are intended to support both regulatory decisions made under federal and state wetland and stream programs and to support voluntary restoration and protection projects carried out by a wide variety of agencies and organizations. However, as an important driver for wetland and stream restoration and protection projects are those associated with compensatory mitigation programs under the federal Clean Water Act, we briefly review the history and context of wetland and stream compensatory mitigation.

The Nature Conservancy's Cranesville Swamp Preserve in West Virginia. Credit © Kent Mason

Background

Each year over $3 billion is spent on wetland and stream protection and restoration projects.[1] The primary drivers behind these widespread investments in wetland and stream restoration and protection is the regulatory program under Section 404 of the Clean Water Act, which is designed to protect wetlands and streams from the discharge of dredged or fill material. Under the program, the U.S. Army Corps of Engineers (Corps) or a state with an approved §404 program can issue permits for discharges of dredged or fill material into jurisdictional wetlands and streams. Under implementing regulations for §404 (i.e., the §404(b)(1) Guidelines), the permitting agency must first seek to avoid and minimize impacts as much as possible and then compensatory mitigation is generally required to offset losses to jurisdictional wetlands and streams. Nationally, the regulatory agencies have adopted a no net loss policy that is intended to ensure that through avoidance, minimization, and compensation, lost wetland and stream acreage and functions are offset with restored, created, or enhanced resources.[2]

In 2008 the Corps and the U.S. Environmental Protection Agency (EPA) adopted a rule guiding compensatory mitigation for losses of aquatic resources, and this rule requires the permitting

1 Austin, J., L. Breggin, V. Buckingham, S. Kakade, J. McElfish, K. Mengerink, R. Thomas, J. Thompson & J. Wilkinson. (October 2007). *Mitigation of Impacts to Fish and Wildlife Habitat: Estimating Costs and Identifying Opportunities.* Washington, DC: Environmental Law Institute.
2 33 U.S.C. 2317(a)(1).

1.1: Background

agency to "use a watershed approach to establish compensatory mitigation requirements to the extent appropriate and practicable."[3]

The history of using a watershed approach to compensatory mitigation

Since the Clean Water Act was passed in 1972 and federal agencies began requiring compensatory mitigation to offset permitted impacts, much has been learned about the elements that lead to successful wetland and stream restoration and protection projects. In the 1980s and 1990s, studies began to emerge that called into question the ecological effectiveness of many wetland restoration or establishment projects and in the following decades similar concerns were raised about stream restoration practices.[4] Guidance issued by the Corps and EPA on mitigation banks, in 1995, and in-lieu fee mitigation, in 2000, began to acknowledge that a watershed approach to site selection could best meet the specific needs of the watershed under consideration and improve ecological outcomes.[5]

To further address concerns about the effectiveness of these projects, EPA and the Corps, in 1999, requested that the National Research Council (NRC, part of the National Academies) form a committee to evaluate the practice of wetland compensatory mitigation under the Clean Water Act §404 permit program. In 2001, the National Research Council released its report, *Compensating for Wetland Losses Under the Clean Water Act*.[6] The Committee found that many of the concerns were justified and that compensatory mitigation projects "often are not undertaken or fail to meet permit conditions."[7]

The Committee attributed much of this failure to poor siting of compensatory mitigation projects. It noted "[p]roper placement within the landscape of compensatory wetlands to establish hydrological equivalence is necessary for wetland sustainability."[8] Rather than continue with the long-standing preference for compensation to be carried out on-site and in-kind, the Committee concluded that compensatory mitigation decisions should "follow from an analytically based assessment of the wetland needs in the watershed and the potential for the compensatory wetland to persist over time."[9]

Following the release of the 2001 NRC report, EPA and the Corps began developing policies to implement the recommendations in the study. The Corps issued a Regulatory Guidance Letter on December 24, 2002, (RGL 02-02) which discussed using a watershed approach for compensatory mitigation for Department of the Army permits. And then in 2003, Congress directed the Corps to develop new regulations establishing equivalent standards and criteria for all forms of compensatory

3 Compensatory Mitigation Rule, 33 C.F.R. § 332(c).
4 For example: Brown, P & C. Lant. (1999). The effects of wetland mitigation banking on the achievement of no-net-loss. *Environmental Management*, 23(3), 33-345; Galatowitsch, S.M. & A.G.van der Valk. (1996). Characteristics of recently restored wetlands in the prairie pothole region. *Wetlands,* 16(1),75–83; Kusler, J.A. & M.E. Kentula. (1990). *Wetland Creation and Restoration.* Washington, DC: Island Press; Pfeifer, C.E. & E.J. Kaiser. (1995). An Evaluation of Wetlands Permitting and Mitigation Practices in North Carolina. Raleigh, NC: Water Resources Research Institute of the University of North Carolina.
5 Note: Both guidance documents have been superseded by the 2008 Compensatory Mitigation Rule.
6 National Research Council. (2001). Compensating for Wetland Losses Under the Clean Water Act. Washington, DC: The National Academies Press. Online at: http://www.nap.edu/books/0309074320/html.
7 National Research Council. (2001). Compensating for Wetland Losses Under the Clean Water Act. Washington, DC: The National Academies Press, p. 3.
8 National Research Council. (2001). Compensating for Wetland Losses Under the Clean Water Act. Washington, DC: The National Academies Press, p. 4.
9 National Research Council. (2001). Compensating for Wetland Losses Under the Clean Water Act. Washington, DC: The National Academies Press, p. 4.

mitigation.[10] In 2008, the Corps and EPA released the final rule – Compensatory Mitigation for Losses of Aquatic Resources; Final Rule (*April 10, 2008*),[11] which established the requirement that, to the extent appropriate and practicable, a watershed approach should be used to guide compensatory mitigation decision-making.[12]

This regulation created an opportunity to align regulatory and non-regulatory tools to help advance large-scale conservation outcomes, including those identified or described in other state, federal, or local plans or assessments. A watershed approach can be applied in a variety of contexts, such as stormwater management, water quality, including helping achieve goals set in Total Maximum Daily Load (TMDLs), or state wildlife action plans. However, to be used in the context of §404 permitting and mitigation decisions, the permitting authority must determine that a watershed plan is appropriate for supporting compensatory mitigation decisions. It should be noted, as described later in this document, a watershed approach is not limited to full watershed plans, but includes a range of types of watershed approaches, from watershed plans, to watershed analysis and watershed-informed decisions.

Overview of the 2008 Compensatory Mitigation Rule

As discussed above, the watershed approach was adopted by EPA and the Corps in 2008 as part of their effort to improve the ecological outcomes and sustainability of wetland and stream restoration and protection projects associated with compensatory mitigation decisions. As the rule notes, the objective of a watershed approach "is to maintain and improve the quantity and quality of wetlands and other aquatic resources in watersheds through strategic selection of compensatory mitigation project sites."[13] The rule provides additional flexibility in siting compensatory mitigation projects and strengthens the focus on finding sites that have a higher likelihood of achieving the desired ecological results.

The watershed approach – defined under the rule as an analytical process for making decisions about the location and type of compensatory mitigation projects that should be carried out – can be implemented in one of two ways. First, where there is an existing watershed plan available, the permitting agency must determine if the watershed plan, or parts of the watershed plan, is appropriate for use. The rule provides a definition of acceptable watershed plans (see Appendix A). The key is that the plan should include goals and assessments helpful in informing decisions about aquatic resource restoration, establishment, enhancement, and/or preservation and should include consideration of watershed conditions. The rule provides significant flexibility about what can be considered a watershed plan and significant discretion to permitting agencies about which plans to use or not use. Such flexibility was designed to ensure that the agencies can take into account regional and resource differences.

In the second situation, when an appropriate watershed plan is not available, the agency will have to rely on available information and exercise its judgment about how (or if) to implement a watershed approach for wetland or stream compensatory mitigation. The rule lists the "information needs" that are to be taken into account when using a watershed approach for compensatory mitigation site selection. This includes information related to "watershed conditions and needs, including potential sites for aquatic resource

10 PL 108-136. See: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=108_cong_public_laws&docid=f:publ136.108.pdf.
11 Compensatory Mitigation Rule, 33 C.F.R. pt. 332 (2008).
12 33 CFR 332.3(c)(1).
13 Compensatory Mitigation Rule, 73 Fed. Reg. 19598 (Apr. 10, 2008) (Preamble to the Final Rule).

restoration activities and priorities for aquatic resource restoration and preservation."[14] Information could be available from a variety of sources or could be specifically developed for determining the compensatory mitigation requirements for a specific §404 permit of set of anticipated impacts. The rule states that compensatory mitigation decisions will be based on that which is environmentally preferable and therefore affords the permitting agencies significant flexibility in seeking to achieve this outcome.[15]

In either case – with a watershed plan or using available watershed information – the rules outlines several considerations the permitting agency should take into account when making compensatory mitigation decisions. These considerations include – among others – the landscape position, resource type, habitat requirements of important species, habitat loss or conversion trends, the requirements of other regulatory and non-regulatory programs, and surrounding land uses.[13] Additionally, a watershed approach should include consideration of inventories of historic and existing aquatic resources, "including identification of degraded aquatic resources, and identification of immediate and long-term aquatic resource needs within watersheds…"[14] and planning efforts should identify and prioritize aquatic resource restoration, establishment, enhancement activities, and preservation sites with as much specificity as possible.[16]

Finally, a watershed approach may lead to a decision to locate compensatory mitigation sites either on-site, off-site, or to a combination of on-site and off-site compensatory mitigation to offset the permitted impacts.[17] For example, a project to replace water storage or sediment sequestration functions on or near the impact site may not support the full range of habitat functions lost by the impact. In this case, additional mitigation may be required at a location off-site where a wetland or stream project is more likely to provide sustainable habitat functions.

Making decisions using a watershed approach

A watershed approach is used to inform decisions, it does not make decisions. Therefore, this handbook does not focus on issues such as the design or application of crediting schemes or weighting of factors that the permitting agencies or Interagency Review Teams may develop. It is important for readers to keep in mind that ultimately, it is up to the staff of the permitting agency to determine whether a watershed plan is appropriate for use.[18] The use of approaches, techniques, or tools outlined in this handbook does not guarantee that the end product will be deemed appropriate by the permitting agency or other regulatory agencies. However, using these approaches and working in partnership with these agencies increases the likelihood that the outputs will meet the needs of a range of regulatory and non-regulatory programs. Like so much in the environmental resource management field, partnership and collaboration are keys to success.

A watershed approach is used to inform decisions, it does not make decisions.

14 33 C.F.R. § 332.3(c)(3).
15 33 C.F.R. § 332.3(c)(2)(iv).
16 33 C.F.R. § 332.3(c)(2)(iv).
17 33 C.F.R. § 332.3(c)(2)(iii).
18 33 C.F.R. § 332.3(c)(1).

Using the Watershed Approach to Achieve Regional Goals: Southeastern Virginia Watershed Area Management Plan

Perhaps one of the best examples demonstrating the value of the watershed approach is the work from southeast Virginia undertaken as part of the Southern Watershed Area Management Program, otherwise known by its very appropriate acronym, "SWAMP." This effort includes all five key elements of the watershed approach. In particular, this is a good example of the value of being as specific as possible in defining watershed-scale desired outcomes.

The SWAMP was a multi-faceted effort initiated by Hampton Roads Planning District Commission and had five goals:

- Protect and enhance water quality for water supplies and natural resources conservation;
- Preserve open lands to help protect and enhance water quality;
- Ensure compatibility of recreational activities and commerce with natural resource protection;
- Retain the rural character of the Southern Watershed while providing for rural residential development; and
- Sustain and encourage agriculture and silviculture activities in the Southern Watershed Area.[19]

The Conservation Plan developed by the Virginia Department of Conservation and Recreation's Division of Natural Heritage (DCR) focuses on retaining and restoring intact natural ecosystems and open-space as part of the local communities.[20] In particular, the plan identifies the need to establish conservation corridors within this area. As stated in the plan:

> Scattered, unconnected natural areas representing remnants of once-continuous natural habitats have limited potential to provide diverse ecosystem services. One alternative that allows growing human communities and natural systems to coexist is to provide connections between remnant patches of habitat by means of a system of linear open spaces called *conservation corridors*. Corridors and greenways restore some of the previous landscape connectivity, providing habitat connections for wide-ranging animals as well as the gene flow necessary to maintain healthy, viable populations of plants and animals. In addition to providing wildlife habitat connections and protecting ecosystems, conservation corridors have been used to promote and enhance local parks, recreational, and educational interests.

To help implement the conservation plan, a more technical document was developed that includes a set of watershed profiles and GIS information to identify areas suitable for restoration and protection of wetland and stream resources. The document also provides a "decision tree" to help guide use of the information to inform wetland and stream mitigation decisions.[21]

19 LandMark Design Group, Inc. (July 2001). *Multiple Benefits Conservation Plan*. Prepared for the Hampton Roads Planning District Commission.
20 Virginia Department of Conservation and Recreation, Division of Natural Heritage. (February 2001). *Conservation Plan for the Southern Watershed Area*. Natural Heritage Technical Report 00-12.
21 Hampton Roads Planning District Commission. (July 2001). *SWAMP Multiple Benefits Conservation Plan Report*.

The results of this watershed approach have been impressive. The plan also helped to galvanize funding from multiple sources, as documented in Table 1. And mitigation, while not the largest contributor to the establishment of the conservation corridor, played a significant role. The entire SWAMP planning effort (as outlined above) was a more comprehensive effort to also assure other community values in the area helped to demonstrate how this conservation effort supports other regional social and economic goals.

Southern Watershed Area Management Plan Results			
		Preservation	Restoration
Northwest River	15,888	11,487	4,401
North Landing	24,847	24,647	206
Total acres:	40,746	36,128	4,607
Acres by Funding Sources			
State:	31%	Mitigation:	15%
TNC:	23%	Other Fed:	6%
USFWS:	22%	Local:	3%

Table 1: Southern Watershed Area Management Plan Results and Funding Sources

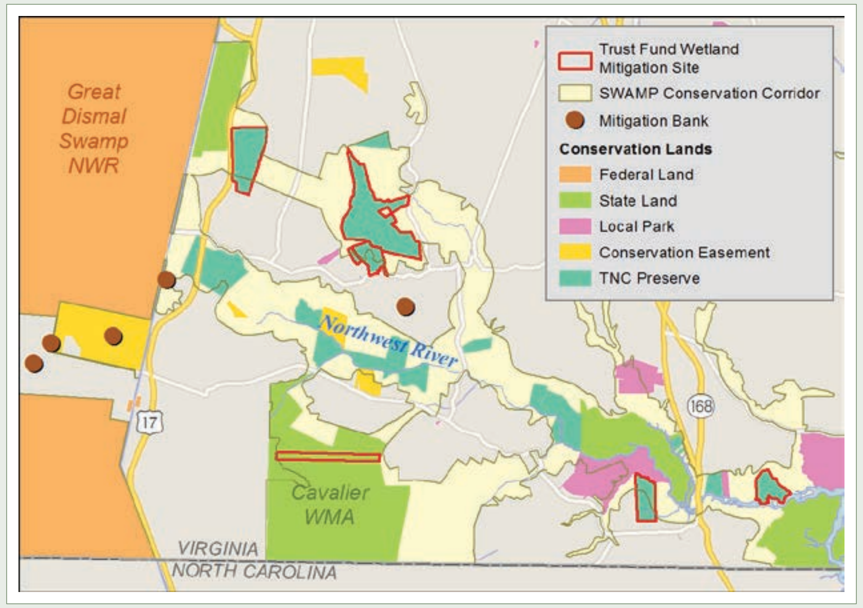


Figure 1: Mitigation and Other Funding of Protected Lands in the Southern Watershed.

Prepared by the Landmark Design Group, p. 117.

Why Use a Watershed Approach?

A watershed approach is critical to improving the outcomes of wetland and stream protection and restoration projects. As with other planning and analysis approaches, it requires a certain level of effort and resources to undertake a watershed approach. Yet, if done effectively, such efforts can provide a wealth of benefits. While the watershed approach does not require the development of a formal plan or use of a formal planning process, a collaborative effort to use a watershed approach or develop a watershed plan can be instrumental in developing a shared understanding of conservation priorities across decision-makers and stakeholders that can greatly facilitate future decision-making.

This section summarizes a variety of ecological, economic and social benefits afforded by the use of a watershed approach and how these benefits accrue to a range of stakeholders. Of course, the level of effort exerted in any instance will be determined, in large part, by the availability of resources.

Definition: Watershed Approach

This handbook provides guidance on how to use a watershed approach to improve outcomes associated with wetland and stream mitigation projects. Though not limited to projects related to compensatory mitigation projects, for the purposes of this handbook we use the definition of the watershed approach provided in the USACE/EPA 2008 mitigation rule. However, though we use this definition, the information included in this handbook is intended for use and therefore in some cases is different from what is required or described under the rule. We note in several places where this is the case.

Definition:

Watershed approach means an analytical process for making compensatory mitigation decisions that support the sustainability or improvement of aquatic resources in a watershed. It involves consideration of watershed needs, and how locations and types of compensatory mitigation projects address those needs. A landscape perspective is used to identify the types and locations of compensatory mitigation projects that will benefit the watershed and offset losses of aquatic resource functions and services caused by activities authorized by [Department of the Army (DA)] permits. The watershed approach may involve consideration of landscape scale, historic and potential aquatic resource conditions, past and projected aquatic resource impacts in the watershed, and terrestrial connections between aquatic resources when determining compensatory mitigation requirements for DA permits.

1.2: Why Use a Watershed Approach?

Improving environmental return on investment

Wetland and stream restoration and protection projects in general provide a wide range of benefits. When undertaken using a watershed approach, they can improve the number, type and scale of these benefits. We briefly discuss a few of these benefits.

Water quality

Over 41,000 water bodies in the United States are categorized as impaired under federal clean water programs. While these water bodies are affected for a range of reasons, many are impaired by pollutants that could be addressed by wetland and stream restoration and protection projects. For example, almost 6,900 waterbodies are impaired due to excess nutrients, over 6,100 by excess sediment, and over 3,100 by temperature.[22] As a case in point, in Oregon, communities along the Tualatin River near Portland determined that the most cost effective means to address a temperature problem was to plant trees in riparian areas rather than invest in expensive water treatment upgrades. The local wastewater and soil and water districts spent about $22 million on restoration projects rather than an estimated $60 - $100 million on refrigeration for its wastewater discharge. In addition, these new riparian plantings have helped filter water and improved other water quality impairments of the Tualatin River.[23]

Flood attenuation

The costs of flood damage are increasing and changing climatic conditions are making more extreme events more common. In a basin with flooding issues, stream and wetland restoration projects can be designed to help alleviate such conditions. A watershed approach can not only help identify the most effective locations for restoration projects upstream of flood-prone areas, but can also highlight the need for certain types of projects. For example, projects that seek to reconnect streams to their floodplains can increase water storage and might be deemed relatively better able to meet flood control needs than restoration of a wetland that does not significantly increase upstream storage.

Habitat improvement

In 2012, the United States had 1,437 federally listed endangered or threatened plant and animal species and 592 distinct active recovery plans to protect and restore these endangered or threatened species.[24] Many of these species might benefit from wetland and stream restoration and protection efforts. Clearly, depending on the proximity of such work to the habitats of these species, great care must be taken to not have unintentional impacts. In some instances, wetland and stream projects can be aligned with species recovery plans to yield beneficial outcomes for at-risk species. For example, in east Tennessee, The Nature Conservancy established a wetland

22 U.S. Environmental Protection Agency. (April, 2014). *National Summary of Impaired Waters and TMDL Information*. Retrieved April 11, 2014, from: http://iaspub.epa.gov/waters10/attains_nation_cy.control?p_report_type=T
23 U.S. Environmental Protection Agency. (March, 2013). *Oregon: Tualatin River Basin, Watershed Approach Reduces Pollution in the Tualatin River.* Retrieved April 11, 2014, from: http://water.epa.gov/polwaste/nps/success319/or_tualatin.cfm
24 U.S. Fish and Wildlife Service. Environmental Conservation Online System. (October, 2012). *Summary of Listed Species Listed Populations and Recovery Plans.* Retrieved October 31, 2012, from: http://www.fws.gov/ecos/ajax/tess_public/pub/boxScore.jsp

mitigation bank to help protect and restore over 200 acres of habitat for the bog turtle. The bank is part of a larger protected site that, at over 700 acres, is large enough to improve the likelihood that viable populations will have long-term success.

Recreation

Wetland and stream projects can also improve recreational opportunities. In 2011, over 33 million individuals 16 and older spent one or more days fishing. These sportsmen and women spent almost $90 million on fish, hunting and wildlife watching, including almost $42 billion on recreational fishing, including travel, equipment, licenses, and other items.[25] Wetland and stream mitigation projects can help protect and restore important sport fishery populations and thereby enhance recreational opportunities. For example, along the western shore of Green Bay, extensive restoration of streams and wetlands has helped to re-establish important spawning areas for northern pike – an important recreational species – by reconnecting streams to low-lying floodplains.

Improving the economic return on investment

The development and use of a watershed approach provides the ability to facilitate environmental review and permitting associated with major infrastructure and other development projects. Delays and uncertainty associated with permitting are often cited as significant causes of increased infrastructure project costs. Watershed analyses and plans that identify watershed needs and potential compensatory mitigation project sites that can meet these needs can support permitting, development project planning, and the approval of compensatory mitigation projects.

> *Advance mitigation projects may … be especially useful for planning for multiple future projects or large infrastructure projects.*

First, a watershed approach, including suitable watershed plans, can identify high value and irreplaceable resources – information that is useful in identifying areas to be avoided during the project planning stage. Second, a watershed approach can identify the relative ability of sites to support different functions and can therefore help identify compensatory mitigation projects that are suitable for replacing specific functions lost at impact sites. Third, a watershed approach can identify potential compensatory mitigation sites where there is already agreement by stakeholders and decision-makers on the relative value of the sites in meeting watershed needs – and therefore the likelihood of these sites being favorably considered as appropriate mitigation projects.

Finally, watershed analyses or plans can serve as key resources to support advance mitigation projects. Advance mitigation projects are implemented in advance of permitted impacts and therefore may help facilitate more timely permit reviews, and, if they have already met their performance standards, reduce risk and uncertainty.

25 U.S. Fish and Wildlife Service and U.S. Census Bureau. September 2013. "2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation., p. 4" FHW/11-NAT (RV).

Advance mitigation projects may take a landscape approach to the characterization of projected impacts and to the identification of appropriate compensation for those impacts, and may be especially useful for planning for multiple future projects or large infrastructure projects. For example, transportation departments have undertaken advance mitigation projects to facilitate the development of large, regional transportation projects. While advanced mitigation efforts have often proven to be cost-effective for such large regional projects, the existence of a watershed plan that identifies key resources and key watershed needs can bring similar benefits to a range of smaller projects that might not be able to afford undertaking such a planning effort on their own.

Facilitating project implementation

North Carolina

The North Carolina Department of Environment and Natural Resource's Ecosystem Enhancement Program (NCEEP) has not only embraced watershed planning but has done so at the statewide scale. This program emerged from concern over delays with implementing transportation projects in the 1990s and has evolved into a program that can meet the compensatory mitigation needs of any project. Since 2003, there have been no delays in the construction of transportation projects due to the need to identify compensatory mitigation projects.

The program has provided the needed compensatory mitigation and thereby helped facilitate the implementation of over $14 billion in transportation projects. This success is a result of both the watershed planning approach and the close coordination between the transportation agency and NCEEP. The state department of transportation provides NCEEP with an annually updated list of projects scheduled to go to construction over a seven-year period. This forward planning helps ensure that NCEEP can work to meet the compensatory mitigation requirements of these future projects.[26]

Michigan Department of Transportation

The Michigan Department of Transportation (MDOT) realized substantial savings in time and money through two watershed-based planning efforts. First, MDOT sought the approval of compensatory mitigation for multiple projects simultaneously, rather than on a project-by-project basis. Second, the agency developed a mitigation site selection tool that helped it evaluate the restoration potential of prospective sites. Mitigation costs in the state subsequently dropped from about $75,000-150,000 per acre on average to about $25,000-30,000 per acre and dramatically improved the rate of compensatory mitigation project approval.[27]

26 North Carolina Department of Environment and Natural Resources. *North Carolina Ecosystem Enhancement Program. End of Year (FY 2010-11) Program Fund Status.* Retrieved April 11, 2014, from: http://portal.ncdenr.org/web/eep/2984-ncdot-streamandwetland

27 Venner, M. (September 2010). *The Case for an Ecosystem Approach to Transportation Decision Making: A More Effective and Efficient Environmental Review & Permitting Process.*

Increasing state and federal agency program transparency and efficiency

Rattlesnake master (Eryngium yuccifolium) in restored mesic prairie - Kankakee Sands Prairie Restoration, Indiana. Credit © Chis Helzer/TNC

The watershed approach also benefits the agencies charged with implementing the regulatory review and approval process. The watershed approach can improve the efficiency of agency review processes and help to maintain or improve the degree of rigor and fairness in permit and mitigation decisions.

A watershed approach, particularly when it involves development of a watershed plan, can provide a high degree of scientific rigor and an avenue for stakeholder input. Well-informed plans or watershed approaches supported by strong data and broad consensus on desired outcomes can increase the confidence of agencies in making decisions and making them in a timely manner. By providing a vision for potential compensatory mitigation opportunities outside the context of individual permit decisions, a watershed plan for stream and wetland restoration and protection activities provides a forum and framework for scientific rigor outside of regulatory timelines – but the resultant plan, analyses, and definition of goals and other desired outcomes can then be efficiently included in the decision-making process.

The compensatory mitigation program at the federal and state levels already includes mechanisms, such as crediting schemes, that can be used to provide incentives for mitigation providers to align compensatory mitigation projects with an agreed upon watershed plan. For example, some crediting schemes require different ratios of credits depending on the extent and type of impact or likelihood of achieving the desired ecological outcomes of the mitigation. When such alignment occurs, the approval of compensatory mitigation can be accelerated and help achieve larger program goals for the agency as well as the goals of the permit applicant.

A watershed approach can also help regulatory agencies make decisions about when and how to allow or encourage out-of-kind mitigation, when it is appropriate to allow a broader geographic separation between the impact site and the compensatory mitigation site, and when functional replacement can and should be met at more than one compensatory mitigation site. For example, a watershed approach or suitable watershed plan may identify wetland types that are relatively more important to a particular watershed or have previously suffered greater proportional losses than other more common types. These tools can provide regulators with greater clarity on when it is therefore appropriate to encourage the restoration or protection of another, more valuable wetland type to offset permitted impacts.

Similarly, a watershed approach or watershed plan may identify areas in the landscape that can provide high levels of habitat functions and those that can provide high levels of water storage functions. If a project proposes to impact both functions, a watershed approach or watershed plan can help the permitting agency determine whether it may be more appropriate to replace these functions through different compensatory mitigation projects in separate areas in the watershed. Such an approach may more effectively offset the lost functions and help ensure a high “rate of return” on the investments made in compensatory mitigation.

Meeting existing environmental goals

A watershed approach offers a concrete mechanism for considering various existing agency plans and goals and making them relevant to wetland and stream restoration projects. By explicitly considering these goals – such as water quality goals or habitat protection goals – the watershed approach provides the ability to have multiple programs work together to achieve multiple goals.

> *A watershed approach offers a concrete mechanisms for considering various existing agency plans and goals...*

The benefits flow in both directions. A watershed approach may allow wetland protection programs to directly contribute to achieving the goals of other state and federal programs – like state water quality programs and state and federal endangered species programs. For example, siting a wetland or stream restoration so as to connect to, abut, buffer or otherwise contribute to the habitat for a threatened or endangered species can support fish and wildlife conservation goals.

The alignment of different programs is a constant struggle for agencies where different legal mandates, different agencies, and different cultures prevent easy collaboration. A watershed approach provides the opportunity for joint planning and analysis, for agencies to share data and information, and for this information to inform compensatory mitigation decisions. The resulting analysis or plan based on shared data, analyses, plans, and outcomes has the potential to significantly align agency actions to sustain and improve ecosystem functions and services in a watershed and more effectively achieve desired outcomes in places where they have been defined. For example, the watershed approach might facilitate synergy between Clean Water Act §319 programs (focused on non-point sources), with municipal stormwater permitting, with wetland protection programs, and with state wildlife action plan programs to collectively contribute to improving watersheds and aquatic resources.

Benefits for communities

A watershed approach also offers the ability to improve outcomes for local communities across the country. The use of a transparent, science-based, and stakeholder-informed process to identify priority watershed needs and project sites that contribute to meeting those needs can help address issues of importance to local communities. For example, the re-establishment of northern pike spawning areas along the western shoreline of Green Bay, Wisconsin helps support a highly valued recreational fishery. Similarly, the strategic placement of these projects can help protect important wildlife species and support the tourism industry. For example, projects that contribute to protection of sandhill cranes in Mississippi by connecting two existing wildlife refuges also support a species that is valued for attracting visitors and tourists. Finally, projects can help communities reduce costs and meet water quality goals, such as the work to restore riparian areas to reduce stream temperatures along the Tualatin River in Oregon. In this instance, the community found that it was less expensive to restore streamside habitat than it was to reduce temperatures at the treatment plant through technological improvements. These outcomes not only result in measurable benefits in the watershed but also help increase the perceived effectiveness of the various programs, agencies, and entities involved in these efforts.

Benefits for project proponents

The watershed approach offers benefits to project proponents who need to implement a compensatory mitigation project to offset unavoidable impacts to wetlands and streams. A watershed approach greatly increases the likelihood that a compensatory mitigation project will achieve the desired ecological results because the approach facilitates the selection of sites that are more likely to meet project objectives and regulatory requirements. The watershed approach can also provide information about the type and location of projects according to a plan or analysis around which consensus has been developed, thereby reducing costs and facilitating compliance with permit conditions. In addition, if a good restoration site is selected through a watershed approach, there will likely be less need for adaptive management and remediation, which would result in cost savings to the project proponent over time.

Benefits for mitigation providers

A watershed approach also can benefit mitigation providers, including private mitigation bankers and administrators of in-lieu fee programs. For mitigation providers, use of a watershed approach to identify and design proposed wetland or stream compensatory mitigation projects can increase the likelihood of those proposed projects being approved and being approved more quickly. Well-sited projects also have the potential to produce more credits than a project proposed in the absence of a watershed approach, because a watershed approach or watershed plan can identify sites or projects that result in higher level of functional gains based on watershed needs. To the extent that suitable watershed plans include analysis of future development trends and locations, they can also provide valuable information to mitigation providers about future credit demand.

> *Well-sited projects also have the potential to produce more credits than a project proposed in the absence of a watershed approach...*

Benefits for scientists

A watershed approach can help to frame and highlight gaps in current scientific knowledge and can be used to frame and provide direction for research and monitoring programs. For example, as use of a watershed approach grows, there may be more demand for higher quality data and better understanding of wetland and stream functions. This demand will help guide areas of research for public and private researchers and help target public funding dollars to the most

pressing needs. In addition, a watershed approach and the identification of watershed-scale needs helps define outcomes.

Identifying and tracking system-scale outcomes has long been recognized as a growing need. Similarly, documenting the ecological outcomes of restoration projects is also a recognized need. Using a watershed approach to first identify watershed needs and then to identify the types and locations of potential restoration and protection projects can help scientists both frame their work to meet these needs by providing clear desired outcomes and then measure whether the projects implemented help to achieve these desired outcomes, both at the site and watershed scale. The watershed approach may foster a new generation of watershed studies to help define desired watershed outcomes, quantify the benefits of understanding watershed needs, and prioritize actions to achieve outcomes. Such studies may include paired watershed studies that help to document the added value and benefits of using a watershed approach and studies on how the watershed approach can inform the selection of the type and location of wetland and stream restoration and protection projects.

Entity	Environmental protection outcomes	Economic outcomes	Regulatory outcomes	Non-regulatory Outcomes
Agency/regulator	Improves ability to meet public/agency program goals		Saves time in regulatory review process	Achieves goals of multiple programs
Community	Improves environmental condition in community	Improves community quality of life		Achieves goals shared by community
Development project proponents	Increases likelihood of successfully offsetting unavoidable permitted impacts	Saves time and money	Saves time in the regulatory review process Improves predictability and transparency	Improves public perception and confidence in agency
Mitigation/wetland and stream project providers	Improves likelihood of achieving desired/ required ecological outcomes	Saves time and money	Saves time in the regulatory review process Improves predictability and transparency	Achieves goals shared by community

Table 2: Environmental protection, economic, regulatory, and non-regulatory benefits of a watershed approach for different parties.

Protecting the Pascagoula River through mitigation

Mitigation has played an important role in The Nature Conservancy's efforts to help conserve the Pascagoula River watershed in Mississippi. This watershed has long been identified as a conservation priority for The Nature Conservancy and natural resource agencies. As the largest (by volume of water) unmanaged river in the continental U.S., the watershed supports a tremendous diversity of aquatic and terrestrial habitats from pine-dominated hills to marine marshes. Since the 1970s, TNC has worked with partners to develop conservation plans and apply a variety of conservation tools to protect critical lands in the area. This effort has resulted in over 70,000 acres of protected habitat within an 80-mile river corridor. Mitigation projects have protected and restored over 6,500 of these acres and filled important gaps in existing conservation areas, connected blocks of once disjunct habitats, and enabled much-needed habitat management. Specifically:

- The 2,000-acre Old Fort Bayou Mitigation Bank (OFBMB) was established by TNC in 1997 to bridge a large and critical gap in the Mississippi Sandhill Crane National Wildlife Refuge. The now near-contiguous block of several thousand acres in two watersheds has helped facilitate the continued use of prescribed fire, an ecological process needed to maintain open wetland savanna habitat for the cranes and other species such as the critically endangered Dusky Gopher Frog (Lithobates sevosus). The Dusky Gopher Frog is considered by many to be the most endangered amphibian in the U.S. With only one known viable population, this species has been introduced by the USFWS to a natural pond on the OFBMB site in hopes of establishing another self-sustaining, viable population. This effort has resulted in preliminary success. In this rapidly developing area along the coast, a subsequent partnership with an adjacent golf course increased the acreage of land in conservation, allowing for improved smoke management while accommodating compatible uses.

- The 3,300-acre TNC Charles M. Deaton Preserve/Mitigation Bank Unit was added to the Old Fort Bayou Mitigation Bank in 1999 to conserve extensive hardwood forests where two primary tributaries merge to form the Pascagoula River. This part of the river is critical for a variety of species of high conservation concern, including gulf sturgeon, a rare migratory fish of ancient origins that lives in marine waters and spawns in freshwater, the endemic yellow-blotched sawback turtle, and the swallow-tailed kite, a declining raptor that prefers large areas of swamp forests. Both the original 2,000 acre OFBMB and the area in the Deaton Preserve provided the Mississippi Department of Transportation (MDOT) with significant credits for their highway improvement projects.

- The Red Creek Consolidated Mitigation Bank is a 1,200-acre stream and wetland mitigation bank established by The Nature Conservancy and MDOT in a larger 3,000-acre longleaf pine preserve supporting the rare gopher tortoise. The bank includes over 12 miles of preserved, enhanced, and restored streams and 350 acres of wetland on a major tributary to the Pascagoula. The bank is adjacent

1.2: Why Use a Watershed Approach?

to a state wildlife management area and county lands and serves to reduce sediment inputs to the stream and provide another linkage of conservation lands in the watershed.

- Two additional properties were conserved and restored by TNC to provide compensation for impacts from a settlement through an EPA Supplemental Environmental Project. This includes TNC's 1,312-acre Robbie Doak Fisher Preserve and 90 acres within the Herman R. Murrah Preserve. These sites help link the Deaton Preserve/Mitigation Bank Unit to existing state conservation lands.

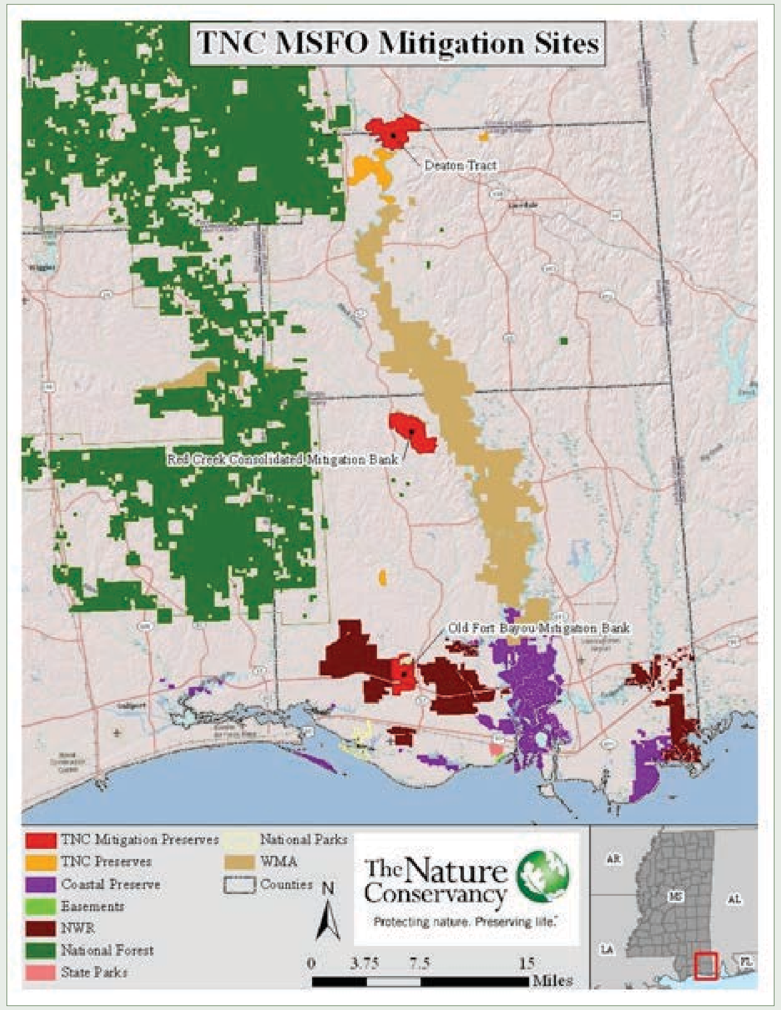


Figure 2: The Nature Conservancy, Mississippi Field Office's Mitigation sites in Mississippi

What's so special about a watershed?

Freshwater systems are highly dynamic bio-physical systems in which the movement of water over and through the land acts as the "master variable" for the form and functions of wetlands and streams. The contours of the land form a self-organizing framework for the movement of water. Much of our understanding of how freshwater and estuarine systems function is based on our understanding of the dynamic processes that occur across the landscape, including the movement of water, materials, and energy, as well as associated ecological processes. The interconnected and highly interdependent nature of these processes requires that they be analyzed and managed as systems rather than as separate and distinct components.

Estuarine wetlands and tidal streams are also highly dynamic bio-physical systems in which the movement of water is generally the most significant factor for determining form, functions, and value as it interacts with the geologic features of the coast. Here, the catchment or watershed is also important, but often the interaction of the land with estuarine and marine waters is the primary driver of these systems. In areas near coastlines and shorelines, delineation of watersheds may only provide part of the context for identifying key issues important to the decisions about the most appropriate type and location for projects. In these cases, a combination of regional analysis based on nearshore features and dynamics such as embayments, shoreline currents, or near-shore features combined with watersheds of rivers and streams may be more appropriate. As with freshwater systems, a regional or landscape-scale analysis is important to understanding how these systems are influenced by surrounding uplands and how they may be related to each other through along-shore processes. For simplicity sake, the term watershed may be used in the context of estuarine and tidal systems, but it is used with the understanding that these concepts apply to these systems in a manner that is somewhat different from inland watersheds.

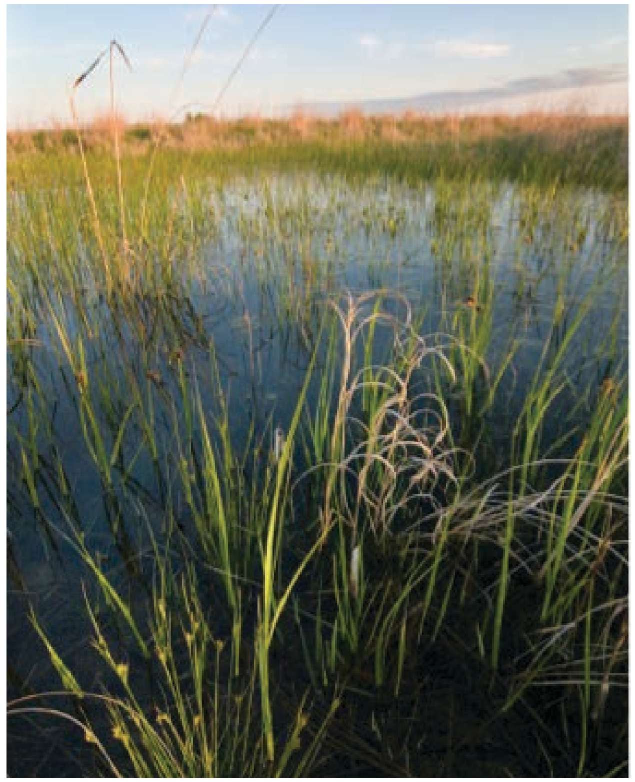
The importance of the watershed-based and interdependent nature of aquatic systems and the surrounding landscape is recognized in the 2008 mitigation rule, which states:

> "A watershed approach to compensatory mitigation considers the importance of landscape position and resource type of compensatory mitigation projects for the sustainability of aquatic resource functions within the watershed."[28]

Of course, watershed processes are not the only attributes that determine the type of wetland or stream that are present. Some wetland types, such as bogs and those that exist in karst environments, may be more dependent on groundwater or other features. But even for these systems, understanding the broad watershed and landscape context is important for informing the type and location of wetland and stream restoration and protection projects.

28 33 C.F.R. § 332.3(c)(2).

1.3: Watersheds 101



Restored wetland at The Nature Conservancy's Derr Tract. Central Platte River, Nebraska. Credit © Chris Helzer/TNC

Dominant physical and ecological processes within a watershed

This section provides a brief overview of key watershed processes and attributes that are relevant to developing wetland and stream restoration and protection plans. Key drivers of wetlands, rivers, and streams can be thought of as collection dominant processes, as described in the Active River Area Framework.[29]

Hydrology and Fluvial Action: Often described as the master variable for aquatic systems, the levels and movement of water across the landscape influence the physical processes and attributes of aquatic ecosystems. Natural water flows vary broadly, from floods to droughts. These natural variations are critical to preserving or restoring the health of these systems, as species and natural communities have adapted to use or take advantage of both extreme conditions and more average conditions. For example, the reproductive timing and strategies of various species are often timed to such natural variations, such as the migration of fish to spawning areas during certain seasons and flow conditions. The functional attributes of wetland, riparian, and coastal systems, as well as groundwater-dependent wetlands, are highly dependent on water and its natural range of variation. For example, vernal pools and coastal plain ponds are characterized by communities that are dependent on the seasonal nature of water levels. The characteristics of flows are determined, in large part, as a result of the slope, form, and composition of the lands through which the water flows.

Movement of Sediment, Sand, and Debris: Sediment, including sand, and how it moves through freshwater and nearshore systems is an important driver and determinant of system type and evolution. Sediment transport and hydrology collectively determine the "dynamic equilibrium" of river and stream channels. As sediment moves downstream it is sorted by size, with different particle sizes determining habitat types and other conditions. For wetlands, sediment or the lack of sediment directly influences the development of different wetland types. Some wetlands types, for example, are characterized by minimal sediment contributions, such as fens, and others, like floodplain forests, receive regular contributions of sediment. Debris flows are closely associated with hydrology and sediment transport. Some of these materials, such as large woody debris, have profound physical effects on river processes, such as sediment transport, local hydraulics, and dominant feeding mechanism of aquatic organisms. Debris piles also play important habitat roles for terrestrial and avian species within riparian

29 Smith, M.P., R. Schiff, A. Olivero & J. MacBroom. (April 2008). The Active River Area: A Conservation Framework for Protecting Rivers and Streams. Boston, MA: The Nature Conservancy.

The Nature Conservancy's Old Fort Bayou Mitigation Bank in Jackson County, Mississippi. Credit © Erika Nortemann/TNC

areas. For nearshore areas, the movement of sand off-shore, on-shore, and along shore is a critical part of these systems.

Ecological processes and biotic interactions: In streams, ecological processes convert organic materials into forms that can used by plants and animals. Soluble organic compounds are transformed physically and biologically as they move downstream from headwaters. The energy flow in headwater streams is dominated by primary production fed by terrestrial inputs of organic material while the energy flow in medium and large rivers is distinguished by longer food chains and higher levels of secondary production fed by processed organic inputs from upstream. Deposition areas, such as riparian wetlands and floodplains, accumulate organic materials and support high levels of productivity. Likewise, nearshore systems, particularly estuaries, are important areas of primary production for marine systems. They often have a direct link to the energy and materials of nearshore areas, including inputs from freshwater systems.
Biotic actions and interactions help determine the structure of ecological communities. A primary action is the ability for species to move between habitat types in both longitudinal and lateral directions to fulfill their life cycle, including accessing spawning and nursery habitats and seeking refuge from predators or adverse conditions. Biotic interactions, including population controls such as competition, predation, parasitism, and the spread of disease are also closely tied to the movement of water within river and stream systems.

Watershed position

The interaction and relative importance of physical processes, ecological processes, and key attributes can be more specifically understood in the context of their position within the watershed. Generally, a river system and its watershed can be thought of as having three parts -- headwater/source areas, mid-watershed/transfer areas, and lower-watershed/deposition areas. These divisions provide an idealized way to understand hydrology, sediment transport, biotic actions and interactions, energy flow, and movement of debris.

Of course, river systems often deviate from this idealized model of steep headwaters, declining slope through mid and lower watershed areas, and decreasing confinement from headwaters to low-gradient deposition areas. However, the model is appealing because it helps systematically frame the dominant processes, attributes, and disturbance regimes under different settings to provide a general understanding of these dynamics.

Understanding the dominant physical and ecological process and their relation to watershed position can be useful in explicit ways when undertaking a watershed approach to wetland and stream mitigation. For wetlands, the type and direction of water flows are a dominant feature used by well-known classification frameworks.

For example, the HGM assessment approach identifies five basic types of wetlands:

> **Fringe wetlands** (lacustrine or estuarine) exist on the shores of permanent open water and the primary water movement is from this body of water horizontally into and out of the wetland.
>
> **Slope wetlands** have water flowing through the wetland in one direction without being impounded.
>
> **Riverine wetlands** are in a valley or stream channels that are inundated generally in one direction by water from the stream or river and can be inundated frequently, but at least once every two years.
>
> **Depressional wetlands** are in topographic depressions that are fed by groundwater or through water ponding constantly or at some times of the year.
>
> **Soil flats wetlands** (mineral or organic) are flat areas where water originates primarily from precipitation or groundwater.

Each of these wetland types speaks to watershed position and movement of water through the system. Such a classification is helpful in understanding overall distribution of wetlands types and can provide a framework for evaluating the relative condition of these different wetland types.

Why watersheds matter for wetland restoration and protection projects

The landscape context and position of a restoration or protection project in the watershed are critical determinants of the successful establishment and sustainability of wetland protection and restoration projects. For example, many of the key characteristics of wetlands, such as wetland type and condition, are influenced by the hydrology, geology, and a variety of abiotic and biotic factors in the watershed or catchment in which the wetland or stream exists. Similarly, water quality and quantity are greatly influenced by the upstream and surrounding lands within the watershed or catchment of the wetland or stream.

Therefore, a key aspect of ensuring appropriate and sustainable hydrology relates to understanding the position of the wetland within the watershed. For example, trying to restore a small wetland at the bottom of a large drainage area may lead to the site being repeatedly overwhelmed by an excessive amount and velocity of water, with sediment and debris moving across or along a site, thus causing damage to, or destruction of, the project altogether.

Why watersheds matter for stream restoration and protection projects

Watershed position and landscape context are also critical to the successful restoration and protection of streams. Hydrologic processes are influenced by factors occurring at the watershed scale and directly impact the functions of streams and therefore the services and values they produce for society. Many key stream characteristics, such as streambed type and condition, are influenced by sediment transport from upstream. Similarly, water quality is greatly influenced by the adjoining uplands and the land use and condition upstream in the watershed. By understanding the processes that occur at the watershed scale, the role and function of rivers and streams are better understood and taken into account in the site selection and project design process. In addition, the condition of the watershed upstream from specific sites can greatly influence the types of impairments that exist – and influence the ability and potential to restore a stream reach or segment.

Therefore, the position in the watershed and stream type are critical aspects of stream restoration site selection. The areas upstream and upslope from the restoration or protection project site are critical to both the current and long-term conditions of the site. The area downstream from the site can also be key to achieving desired biological outcomes, just as connectivity within the stream network is important for re-colonization of a restored area. The success of a stream restoration project to result in the desired ecological and physical outcomes often depends as much on its watershed context as it does on site conditions or the quality of the restoration work itself.

Focusing on key functions will help ensure project achieve their desired outcomes by building an understanding of each of these elements and how they work together in the context of stream restoration or protection. As with wetlands, understanding these elements in the context of watershed position is key to project success. For example, restoring a stream segment lower in a watershed without understanding the hydrology, hydrologics, and geomorphology upstream may result in the site being washed out by a large storm event. Or an appropriately sized restoration project may function hydraulically under a normal range of conditions, but if upstream and downstream biological factors are not considered the effort may result in little or no restoration of the desired biological or ecological functions.

1.3: Watersheds 101

In addition, the condition of surrounding and upstream uplands within the watershed is also critical factors in the overall condition of a wetland and stream and are critical to particular functions associated with these resources. Uplands immediately surrounding wetlands and streams serve as important buffer areas, helping filter, trap, and hold sediment, nutrients and other pollutants that travel through surface run-off and near surface water flows. These surrounding areas and their connections to other intact habitat areas also provide important habitat, travel corridors and refuge for species of birds, mammals, amphibians, and reptiles that use these water resources for part of or all of their life cycle. In addition, the condition and use of uplands upstream of, but not immediately adjacent to, these resources have a significant effect on the condition and functions of the wetlands and streams. The watershed approach provides a way to take the conditions of these lands into account when designing restoration and protection projects. And, the approach can inform the design of restoration and protection projects so they include the protection of upland areas that are important to achieve the desired outcomes and effectively address watershed needs.

Watersheds matter!

Watersheds are important because the lands and waters within the watershed physically, chemically, and biologically determine functions and services of wetlands and streams and therefore provide a critical framework for helping to ensure the desired ecological and other outcomes of restoration or protection projects. They are equally important because watersheds provide the context within which restoration and protection projects can be evaluated and selected based on their ability to meet human needs, offset new or previous impacts, and help achieve desired future conditions.

As our country has developed, lands have been changed from natural areas to farms, cities, and suburbs. Levees, dams, seawalls, and jetties have been built to protect these areas from floods and to control natural flows. Wetlands have been drained and streams realigned to accommodate human needs. And our rivers and marine waters continue to be used to dispose of our sewage and other wastes. Understanding how these activities affect desired future conditions for both environmental quality and human uses is critical to informing what wetland and stream restoration and protection projects should seek to accomplish. Highly functional wetlands and streams can help meet these human needs. Wetlands can help improve water quality, store floodwaters, and mitigate storm surges. While regulatory programs often focus on the restoration of lost acres and functions to compensate for unavoidable impacts, the watershed approach allows restoration and protection projects to be evaluated in a watershed context and should address identified watershed needs. They should also take into consideration, to the extent possible, future conditions and needs likely to be increasingly important with a changing climate, like storage of flood waters, improved buffers for rivers and streams to increase shade, or improved migration corridors to facilitate movement of species.

In the context of the watershed approach, watersheds provide the frame of reference through which aquatic resources and the natural processes on which they depend, impacts to these resources and processes, and desired outcomes can be viewed. By bringing these three elements together, a watershed approach helps to ensure that these projects are not only successful in a physical sense, but also that they achieve functional outcomes and provide the desired ecosystem.

Longleaf pine restoration: protecting and restoring valuable wetlands through mitigation banking

The Nature Conservancy has employed wetland mitigation as a conservation tool to protect and restore high-quality examples of longleaf pine-dominated habitats in St. Tammany Parish, Louisiana. Longleaf pine ecosystems contain some of the most species-rich habitat types in North America. Many species that occur in longleaf pine habitats occur nowhere else, including many globally and regionally rare plant and animal species. Money Hill includes community types that support more rare plant and animal species than any habitat in the state – over 36 to date – and is an important migratory bird conservation area.

Much of TNC's wetland mitigation work has been focused within an area referred to as the Money Hill Conservation Area (MHCA). TNC owns and operates several bank units (approximately 4,000 acres) within the MHCA, and worked with private entities to establish two entrepreneurial banks within the conservation area. Together, about 12,000 acres within the MHCA is conserved in wetland mitigation banks and TNC is currently working with a private group to establish yet another bank within the conservation area. The Money Hill Conservation Area includes two watersheds that were identified as priority areas for compensatory mitigation because of their extensive and diverse, but degraded wetlands; relatively large, undeveloped blocks that would allow for the use of prescribed fire; and inclusion as priority areas in TNC's East Gulf Coast Ecoregional Plan.

The following is a summary of banking activities in the Money Hill Conservation Area to date:

1996 – 1998: TNC establishes two wetland mitigation banks totaling 4,000 acres, Abita Creek Flatwoods and Talisheek Pine Wetlands.

2001: The 2,700-acre Bayou Lacombe Mitigation Bank is established by St. Tammany Mitigation Services, LLC.

2008 – 2011: TNC encourages Weyerhaeuser, a timber management company, to establish compensatory mitigation projects on their property adjacent to TNC's Talisheek Bank. Weyerhaeuser established two projects, Talisheek Swamp Mitigation Area, a 300-acre permittee-responsible mitigation site, and the 1,500-acre Dolly-T Wetland Mitigation Bank. TNC helps conduct the prescribed burning on these tracts.

2009 – 2010: TNC partners with Ecosystem Investment Partners, a private equity firm, to establish a bank on a tract of land south of the Dolly-T bank that contains a significant area of pine wetlands. The result is the 2,000-acre Mossy Hill Mitigation Bank, an area contiguous with the Bayou Lacombe Wetland Mitigation Bank.

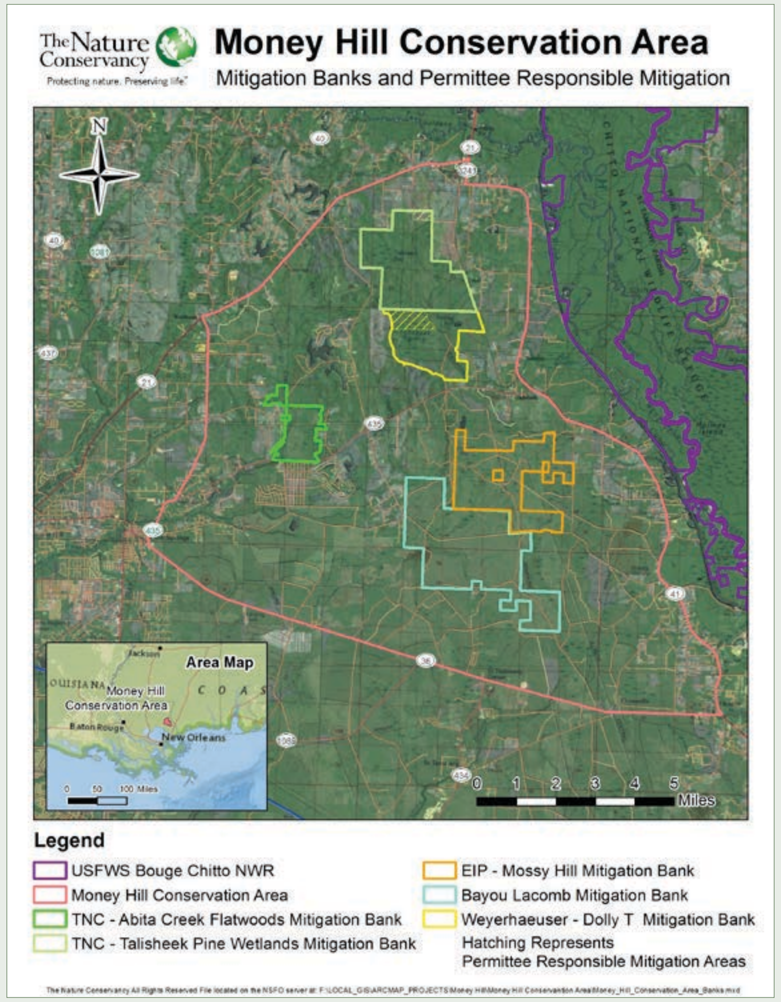


Figure 3: Money Hill Conservation Area, Louisiana

The Spectrum of Watershed Approaches

The goal of a watershed approach is the identification of the types and locations of wetland and stream restoration and protection projects that can best support the sustainability and improvement of aquatic resources and their functions and services in a watershed. A watershed approach is defined by its consideration of watershed needs and how locations and types of wetland and stream restoration projects address these needs. An understanding of the effects of watershed processes (e.g., water and sediment runoff, storage, and deposition) on wetland and stream functions is also critical to the sustainability of existing and restored wetlands and streams.

A watershed perspective requires more than just consideration of replacing lost wetland and stream acres and linear feet. It requires an understanding of landscape- and watershed-scale processes and provides the opportunity to define how protection and restoration projects can contribute to addressing aquatic resource-related needs and desired outcomes within the watershed.

There are a variety of approaches to using watershed characteristics and needs to identify appropriate types and locations of wetland and stream restoration and protection. These approaches span a spectrum from simple watershed informed decision-making to fully developed watershed plans with well-defined watershed goals, objectives, and expected outcomes clearly articulated.

Five elements of the watershed approach

There are five elements generally included when taking a watershed approach to wetland and stream restoration and protection. These are:

1. *Identification of watershed needs,* including a determination of how watershed needs identified by various regulatory and non-regulatory programs can inform the watershed approach.
2. *Identification of desired outcomes,* or the specific and usually measurable results desired in the future. An outcome is a stated desired future condition that will result from undertaking a variety of projects within the watershed. Desired outcomes (e.g., meet water quality standards) provide the goals by which to align and prioritize many types of projects and actions, including wetland and stream restoration projects.
3. *Identification of potential project sites,* generally based on the ability of wetlands and streams to develop and persist in a particular location. This element focuses on identifying suitable sites that have a high likelihood of providing the desired ecological functions on a sustainable basis, including both intact areas that may warrant protection and degraded areas that may warrant restoration.
4. *Assessment of the potential of sites to meet watershed needs,* generally through ranking the relative ability of potential protection and restoration sites to support particular ecosystem functions and services that help address one or more established watershed needs.
5. *Prioritization of project sites,* based on their relative ability to sustain wetland characteristics, address watershed needs, and/or contribute to achieving desired watershed outcomes. Generally, project sites that are more likely to produce more functions and address specific watershed needs should be prioritized over project sites that will provide smaller incremental results.

As discussed below, depending on the how the watershed approach is undertaken not all of these elements will addressed in every case. However, as discussed in section 1.7, to the extent that all of these elements are addressed at some level, the more likely the approach will achieve substantial improvements to watershed outcomes.

Watershed needs

As highlighted by the National Research Council (NRC),[30] a watershed approach is intended to improve the outcome of wetland and stream restoration projects by improving their sustainability over time. In addition, a watershed approach allows such projects to be strategically undertaken so the type and location of restoration and protection projects can be strategically selected so they contribute to one or more broader desired outcome. For example, projects may improve habitat for species of plants and animals particularly important for that watershed or contribute to improved water quality of a stream not meeting water quality standards. Therefore, using a watershed approach helps ensure both projects achieve their desired outcomes and helps provide a high return on the investment by contributing to broader needs and desired outcomes.

Watershed needs may be specific ecological functions or ecosystem services that have been identified as necessary for the improvement or sustainability of a watershed and for which a future desired condition has or can be identified. These may include *problems or impairments* of aquatic resources that need to be fixed (e.g., improve water quality or restore habitat condition), *threats* to aquatic resources that need to be reversed or prevented (e.g., prevent fragmentation of habitat, protect upland buffers), or *opportunities* to improve, sustain, and preserve aquatic resources and associated upland areas (e.g., preserve existing habitat areas, maintain habitat corridors). To be considered a *watershed* need, such a problem, threat, or opportunity must be recognized as a priority within, and often at the scale of, the watershed or subwatershed, rather than solely at an individual site or reach within the watershed. The more specifically defined a watershed need is, the more helpful it will be in guiding the selection of types and locations of restoration and protection projects.

Watershed needs often are identified in existing state, local, or regional plans that contain goals for the restoration or protection of aquatic resources.

Watershed needs often are identified in existing state, local, or regional plans that contain goals for the restoration or protection of aquatic resources. While most of these plans don't go so far as to identify potential restoration or protection sites, they often identify priorities that can be used to identify and prioritize such sites. These plans may include water quality plans, flood management

30 National Research Council. (2001). Compensating for Wetland Losses Under the Clean Water Act. Washington, DC: The National Academies Press.

plans, and wildlife habitat conservation plans. Watershed needs may also be identified in federal plans, such as Special Area Management Plans, Advance Identification efforts, or species recovery and Habitat Conservation Plans developed pursuant to the Endangered Species Act. The identification of watershed needs may also be informed by input from stakeholders, through data analysis, and using both quantitative and qualitative methods.

The 2008 Compensatory Mitigation Rule encourages, but does not require, such an alignment with broader watershed needs. However, at its full potential, the watershed approach can align projects with broader societal, community, and other natural resource program goals and desired outcomes.

Importance of site suitability

While the identification of watershed needs is a primary component of a watershed approach, these needs are not, by themselves, sufficient for identifying and selecting wetland and stream projects. The 2001 NRC report and other studies have clearly explained the importance of selecting wetland and stream restoration and protection sites that are suitable for supporting a wetland or stream.

Therefore, a watershed approach should also include a determination of the relative suitability of a site according to its capacity to develop and sustain desired conditions. Site suitability is defined as the ability of wetlands and streams to develop and persist in a particular location. Suitability assessments generally include consideration of factors such as local hydrology, soil characteristics, and/or compatibility of desired resources with surrounding natural resources and land uses. Site suitability assessments also can assess current or future threats, such as planned development, changes to hydrology from water withdrawals or diversions, and the expected impacts of climate change.

Connecting ecosystem functions to watershed needs and desired outcomes

Finally, a watershed approach requires an understanding of the ability of the wetlands and streams being restored or protected to support particular ecosystem functions and services, particularly those relevant to an identified watershed need and larger desired outcomes (that is, larger than restoration or protection of a particular site). These include habitat, biogeochemical, water storage, and other hydrology regulating functions. The factors that can influence ecosystem functions include watershed position, wetland type, water source, hydrodynamics, adjacency to existing protected lands and wetlands, and surrounding land uses.

... a watershed approach requires an understanding of the ability of the wetlands and streams being restored or protected to support particular ecosystem functions and services ...

By understanding the relative ability of different sites or projects to provide certain functions and associated services, one can then identify project locations and types that can most efficiently and effectively contribute to meeting watershed needs.

The spectrum of watershed approaches

Watershed approaches come in many forms. The range of approaches is best portrayed as spanning a spectrum, from simple and general logic frameworks to more comprehensive and specific analyses and planning efforts.

Watershed approaches can be characterized along a spectrum of categories. The three basic categories of watershed approaches are:

- Watershed informed decisions
- Watershed analyses with non-prescribed outcomes
- Watershed plans with prescribed outcomes

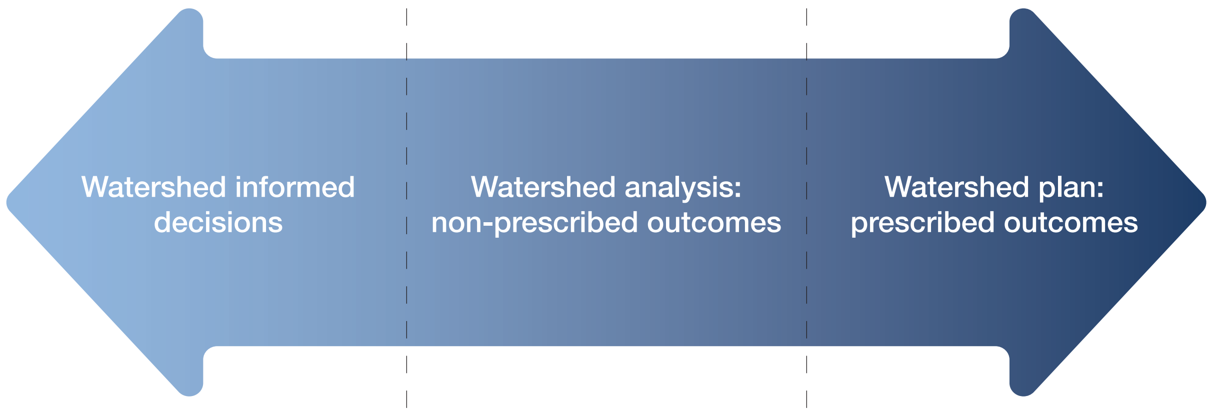
Where along the spectrum an effort resides depends largely on if and how it addresses the five elements of the watershed approach outlined above (see Figure 4). For example, the more rigorous and specific an approach is in defining watershed needs and potential sites for fulfilling those watershed needs, the further it may reside toward one end of the spectrum. Similarly, how broadly site suitability is considered relative to specific functions and how prescribed and specific the intended outcomes for the watershed have been articulated will affect where an approach is on the spectrum.

The three categories of the spectrum are not strict categories that neatly define very different watershed approaches. Rather, they are useful distinctions along a continuum that can help users understand the range of approaches to strategic identification of wetland and stream restoration and protection projects that can be considered "watershed approaches." The spectrum captures the reality that in many cases a suitable watershed plan may not be available or sufficient resources may not be available for developing a formal watershed plan; the spectrum recognizes the role and value of watershed analyses or even watershed informed decision-making as important steps that can improve project outcomes at the site and watershed levels.

In practice, efforts to undertake a watershed approach may include aspects of more than one category. Therefore, the spectrum broadly describes and groups the possible characteristics of approaches – from the a fundamental consideration of watershed needs, to explicit analyses to inform decision-making, to the articulation of specific desired outcomes for the wetland and stream restoration or protection projects identified through a watershed approach. It is also important to note that the spectrum does not suggest that each type of approach will yield equally effective outcomes or be equally successful in aligning restoration and protection projects to meet watershed needs. However, the spectrum is a useful tool to help understand the different range of approaches and levels of effort that at least minimally meet our definition of a watershed approach.

... the spectrum broadly describes and groups the possible characteristics of approaches ...

Watershed Approach Spectrum



Decision-tree or some consideration of watershed factors.	Identifies watershed need(s).	Identifies watershed need(s).
Includes some consideration of watershed need(s).	No or little translation of watershed needs (s) into specific desired watershed outcome(s}.	Describes specific, measurable desired watershed outcomes.
Potential of site to develop and persist is determined through individual site assessments.	Includes analysis of the potential of sites to develop and persist in a particular location.	Includes analysis of the potential of sites to develop and persist in a particular location.
No assessment of the potential of sites to meet watershed needs.	Assesses the potential of sites to meet watershed needs.	Assesses the potential of sites to meet watershed needs.
No comparison of the relative ability of sites to sustain desired characteristics and to address watershed needs.	Compares sites to evaluate their relative ability to sustain desired characteristics and to address watershed needs.	Compares sites to evaluate their relative ability to sustain desired characteristics, address watershed needs, and contribute to desired outcomes.
Examples: • WA Dept. of Ecology approach (esp. flow charts 2 and 3) • DU VT ILF Compensation Planning Framework (prioritization strategy)	Examples: • Duck-Pensaukee Watershed Approach Pilot, WI (TNC/ELI) • MD Watershed Resources Registry (Corps/EPA pilot) • MO DNR Wetland Potential Screening Tool • Sunrise River, MN Watershed Approach Pilot (Corps)	Examples: • NC Ecosystem Enhancement Program Local Watershed Plans • CA Regional Advance Mitigation Plan

Figure 4: Watershed Approach Spectrum

Watershed-informed decisions

Watershed-informed decision-making is an approach that utilizes watershed and landscape factors to guide decision-making. This approach sometimes is based on formal decision-trees or series of questions. This requires stepping through a logic framework to select sites for wetlands or stream restoration or protection projects that will provide functions and services and that address watershed needs. This approach often includes a review of existing plans, information, and analyses that may be relevant to these decisions. Although these frameworks do not result in any new detailed analysis of a watershed or its needs, they may suggest such an analysis be used.

Watershed-informed decision-making often includes questions to determine whether a particular site or location has been evaluated for its suitability to sustain a wetland or stream, including the functions and services the wetland or stream is expected to provide. However, this approach is limited it its ability to evaluate the relative suitability of different sites on a watershed-scale. In large part, the ability of a decision framework to meet watershed needs or help achieve identified watershed outcomes will depend on the availability of existing plans and documents that define such needs and outcomes. These frameworks help project sponsors consider various watershed factors as they select sites for restoration or protection projects.

Watershed analyses: non-prescribed outcomes

Watershed analyses with non-prescribed outcomes are GIS and other analyses of watershed attributes to help inform site selection for wetland and stream projects. These watershed-scale analyses generally seek to determine the suitability of sites for wetland and stream projects and then assess the relative ability of different sites to provide functions that address one or more watershed needs. Identification of watershed needs is a key step of these analyses. Even if the plan does not get to the level of detail of identifying specific places to do restoration or protection projects, by clearly describing specific watershed needs and providing relevant spatial analyses the plan can provide information useful to others who can then identify the types and locations of restoration and protection projects that will help address these needs.

Undertaking only a spatial analysis of the suitability of sites that will support the development and persistence of wetlands or streams can improve ecological outcomes and may meet the requirements of 2008 rule. However, this approach does not realize all the benefits possible with a watershed approach because, by itself, such analysis does not specifically relate these functions and locations to their ability to address a watershed need.

Watershed plans: prescribed outcomes

Watershed plans with prescribed outcomes include watershed analyses as described above but they also seek to define more specific, desired watershed outcomes. Watershed outcomes are the specific desired results of actions taken to address a watershed need. Watershed outcomes are specific, measurable goals that can be assessed. For example, watershed outcomes could be the attainment of water quality standards in a particular stream/river segment, reduction

Pelicans in prairie pothole. Credit © Ronald F. Fischer/TNC

of nitrate export from a watershed to achieve a target loading or concentration, restoration of specific acreage of a particular habitat type in particular habitat corridors, or recovery of the population of a particular species to a certain level. These plans may be done for purposes other than wetland and stream restoration and protection, such as meeting water quality standards and may not evaluate sites for wetland and stream restoration and protection projects. However, by clearly describing specific desired outcomes they provide information useful in identifying the types and locations of restoration and protection projects that will support the outcomes of these watershed plans. Some watershed plans with prescribed outcomes may also specifically compare the relative ability of different sites to support achievement of a prescribed watershed outcome. This may lead to selection of particular areas in which to focus projects, and perhaps even explicitly the types of projects at these locations.

To prescribe or not prescribe specific outcomes

When undertaking a watershed approach there is often a decision about whether and how specific and prescriptive outcomes should be defined. For examples, should a plan identify specific sites for restoration or just provide a relative ranking of all sites? Should a specific outcome be defined, such as "meet water quality standards" or "establish a 2 km wide corridor between point A and point B," or more broadly state an outcome for improved connectivity with analysis of a variety options? There are often good reasons why a less prescriptive approach may be desired for watershed plans and other such efforts for advance identification of potential wetland or stream restoration or protection sites. For example, those involved in acquiring sites for protection and restoration often resist identifying particular locations or parcels as the desirability of the location can increase acquisition costs and can lead to resistance from landowners and land managers whose properties may be identified through such a process. Or being too specific about a particular outcome – like water quality, might limit engagement of other stakeholders with other interest.

1.4: The Spectrum of Watershed Approaches

Often watershed analyses will often result in lists or maps showing the relative ability of different suitable locations to meet various watershed needs. However, while such an approach may improve overall outcomes, being less specific in identifying priority areas or project sites could mean that implemented projects may be spread throughout the watershed, potentially diminishing their cumulative ability to address a specific need.

Being specific about desired outcomes does not necessarily mean watershed plans need to be specific or overly prescriptive about particular sites for wetland and stream projects. In some cases, specificity is needed, as when a rare wetland type is the only one that can provide certain habitat features or is the only place to restore or maintain connectivity with existing habitat areas within a watershed. In other cases, such as when water quality is a concern, there may be a number of places where stream and wetland projects can help improve the water quality of the watershed and while understanding the relative importance of difference sites will be important to project selection, it may be less necessary to identify a specific subset to be targeted.

There is no one correct answer to how prescribed a watershed approach should be. The better defined the desired outcomes at the watershed or landscape scale, the more agencies and others can meaningfully contribute to these outcomes. Therefore, the more information that can be provided about watershed goals and objectives, as well as specific sites that may contribute to fulfilling those goals and objectives, the more powerful and useful a contribution will be made as a result of using a watershed approach.

The better defined the desired outcomes at the watershed or landscape scale, the more agencies and others can meaningfully contribute to these outcomes.

The spectrum as building blocks

The spectrum is also a useful framework to help decision-makers think about which watershed approach best meets their needs. All plans need to have a basic logic framework to help define what they hope to accomplish. This framework can inform data gathering and analysis and can yield a comprehensive watershed analysis that identifies potentially restorable wetlands and streams. In addition, planners can use the spectrum to identify where along the spectrum their approach is located and determine whether they want to enhance their existing efforts by adopting more watershed-based analysis and more prescribed outcomes.

Watershed-Informed Decisions

While much of the potential of the watershed approach is best realized by undertaking watershed-scale analyses and developing watershed plans, often resources and time limitations preclude these more in-depth approaches. In such cases, decision-makers may determine that watershed-informed decisions are the best possible route. Using such an approach will help ensure that projects address watershed needs and yield improved outcomes at both the project- and watershed-scale. Otherwise, projects may be selected primarily based on costs, availability of land, and technical feasibility - criteria that are important but which may lead to projects with fewer benefits.

Because watershed informed-decisions are likely to be used in many situations and in many parts of the country, we devote this chapter to several types of information that are generally readily available and can support watershed-informed decisions. This includes a few rules of thumb that can be used to support watershed-informed decisions and some general watershed needs that can be informed with existing data and can therefore be used to guide watershed-informed decisions.

This generic approach to considering watershed issues will likely improve project outcomes and may help to meet the requirements as described in the 2008 Compensatory Mitigation Rule. However, unless an existing watershed analysis exists or is created and the five basic elements outlined in Chapter 4 generally followed, the protection or restoration projects are not likely to achieve the potential outcomes and return on investment that would otherwise be possible. Such approaches, depending on their rigor lie on the very edge of the Spectrum of Watershed Approaches we describe in section 1.4.

This section was developed using information provided from a variety sources: The Washington state mitigation policy;[31] the Washington state guide Selecting Wetland Mitigation Sites Using a Watershed Approach;[32] the Virginia Off-Site Mitigation Guidelines,[33] developed by the Norfolk District of USACE; and a presentation on Ecological Considerations for Mitigation Bank Site Selection and Design – Emphasis on the Watershed Approach,[34] by Jae Chung of the U.S. Army Corps of Engineers. All of these, in one way or another, built upon the recommendations included in the 2001 National Resources Council Study.[35]

31 Washington State Department of Ecology, U.S. Army Corps of Engineers Seattle District & U.S. Environmental Protection Agency Region 10. (March 2006). Wetland Mitigation in Washington State – Part 1: Agency Policies and Guidance (Version 1). Washington State Department of Ecology Publication #06-06-011a. Olympia, WA.
32 Hruby, T., K. Harper & S. Stanley. (2009). Selecting Wetland Mitigation Sites Using a Watershed Approach. Washington State Department of Ecology Publication #09-06-032. Olympia, WA.
33 U.S. Army Corps of Engineers, Norfolk District. (March 5, 2008). Virginia Off-Site Mitigation Location Guidelines. Norfolk, VA.
34 Chung, J. (June 2012). Ecological Considerations for Mitigation Bank Site Selection and Design – Emphasis on the Watershed Approach. U.S. Army Corps of Engineers.
35 National Research Council. (2001). Compensating for Wetland Losses Under the Clean Water Act. Washington, DC: The National Academies Press.

Existing plans and data to support watershed-informed decisions

Existing watershed plans

Existing state and local plans may provide important insights into watershed needs, degraded functions, and current and future watershed conditions.

Existing state and local plans may provide important insights into watershed needs, degraded functions, and current and future watershed conditions. Therefore, seeking out and consulting such plans should be a priority when developing wetland and stream restoration and protection projects.

Projects should be consistent with and, where appropriate, help to achieve goals associated with local planning documents (e.g. comprehensive and long-term plans, zoning overlays, etc.). The types of information that would be most valuable to glean from existing plans include:

Areas that have been identified and/or prioritized for wetland restoration and preservation in the appropriate hydrologic unit.

- The location of existing mitigation sites in or near priority conservation areas.
- Functions and services considered critical in the watershed.
- Watershed processes that have been altered and therefore highlight restoration needs.

Watershed and landscape data

If there are no existing plans, other existing watershed and landscape data may help identify the major landscape-scale problems (i.e., alterations to processes, not structure) that exist in the watershed. Appendix B includes a list of many of the potentially relevant national-scale data sets and information sources. This section briefly describes some other factors to consider when using a watershed approach, particularly when developing a specific plan for wetland and stream restoration and protection projects is not possible.

For example, the 2008 Compensatory Mitigation Rule lays out several considerations, information needs, and site selection guidelines that should be taken into account when taking a watershed approach. These include:

- Habitat requirements of important species
- Sources of watershed impairments
- Habitat loss/conversion trends
- Current trends in development
- Cumulative impacts of past development activities
- Requirements of regulatory and non-regulatory programs (Habitat Conservation Plans under the Endangered Species Act, stormwater programs)
- Terrestrial resources, such as non-wetland riparian resources
- Contribute to or improve the overall ecological functioning of aquatic resources in the watershed.

- Chronic environmental problems such as flooding and poor water quality
- Suite of functions (not just habitat, water quality)
- Other relevant factors including, but not limited to, development trends, anticipated land use changes, habitat status and trends, the relative locations of the impact and mitigation sites in the stream network, local or regional goals for the restoration or protection of particular habitat types or functions (e.g., re-establishment of habitat corridors or habitat for species of concern), water quality goals, floodplain management goals, and the relative potential for chemical contamination of the aquatic resources.

Rules of thumb to guide watershed-informed decisions

Work where wetlands and streams exist or previously existed

In the absence of appropriate, existing plans and data, one rule of thumb for selecting restoration and protection sites is to choose sites where wetlands previously existed, such as those in prior converted cropland. Restoration of wetlands is more feasible and sustainable than creation of wetlands or streams where none previously existed. Converted wetland areas are likely to have hydric soils and proper substrate, seed sources on-site or nearby, and the appropriate hydrological conditions, all of which may contribute to more successful projects. For more information on this type of information, see “Identifying Wetland Restoration Opportunities” in Chapter 2.1.

Provide adequate buffers and connectivity

Buffers surrounding wetlands and streams and providing connectivity between these resources and other protected areas are important for protecting a wide variety of ecological functions. Buffers and corridors reduce the adverse impacts of adjacent land uses and provide important habitat for wildlife. Existing guidance, such as the *Virginia Off-Site Mitigation Location Guidelines*[36] on stream mitigation, recommend that riparian areas be protected on both sides of streams to maintain and improve water quality and should include 3 zones of vegetative cover, including trees, shrubs, and herbaceous zones. The guidelines also suggest that stream restoration opportunities should be evaluated for their potential to also include the preservation of associated intact streams and associated riparian buffers. Stream preservation (rather than only looking for restoration sites) should be considered for exemplary systems.

Build on existing wetland and upland systems

If possible, mitigation sites should be located to take advantage of refuges, buffers, green spaces, and other preserved aspects of the landscape. Project sites can be designed to utilize natural processes and energies, such as the potential water and energy from streams and other adjacent water bodies. Mitigation sites should also, where possible, be located contiguous with

36 U.S. Army Corps of Engineers, Norfolk District. (March 5, 2008). Virginia Off-Site Mitigation Location Guidelines. Norfolk, VA.

and/or connected to other aquatic and protected areas. See examples of data to identify existing resources in Chapter 2.1 (e.g., National Hydrologic Dataset, NWI and NWIPlus in the discussion of elements).

General watershed needs to guide watershed-informed decisions

Addressing watershed needs is key to using a watershed approach – but understanding watershed needs can be difficult if no existing plan exists and time or resources prevent a more in-depth planning or analysis effort. Yet, some general types of goals or needs can be identified using existing data. For example:

1. Restore, enhance, or preserve aquatic resources and/or associated riparian areas identified as a priority in an approved Federal, state, or local watershed management plan or in conservation plans prepared by nonprofit conservation organizations such as The Nature Conservancy.
2. Abut or adjoin an existing reserve or conservation area or create or contribute to a corridor linking existing reserves, conservation areas, or large wetland or aquatic resource systems to other habitats. Such corridors should provide for wildlife movement through urban or agricultural landscapes.
3. Conserve or restore habitat and buffer areas for one or more state or federal-listed species, including federally designated critical habitat or State designated areas, rare or imperiled natural communities, species identified as rare by State Natural Heritage programs, and Species of Greatest Conservation Need identified in the State Wildlife Action plans.
4. Contribute to improved water quality through wetland or stream restoration associated with identified/designated impaired waters (with an emphasis on implementation of TMDL restoration plans for degraded waters).
5. Contribute to improved flood management through projects that help address recognized flooding problems.
6. Remove barriers to fish passage, particularly in priority conservation areas.
7. Conserve and/or restore the entire watershed associated with stream systems.
8. Remediate inputs of substantial amounts of sediments or pollutants to downstream waters (as part of wetland or stream restoration activities).

Consider compatibility with adjacent land uses

Consider any potentially conflicting land uses on the mitigation site or adjacent properties, including but not limited to drainage easements, utility easements and rights-of-way, lines, timber and mineral rights, and rights of ingress/egress.

Consider the source of water

Water is the most critical environmental variable in selecting and designing a wetland mitigation site. Available information on the source of water should therefore be used when selecting and designing mitigation projects. Failure to establish an adequate and self-sustaining source of water is a major reason for wetland mitigation project under performance.

Consider a changing landscape

When identifying appropriate sites for wetland and stream protection and restoration projects, decision-makers should consider both current and future watershed hydrology and location. If possible, take into account surrounding land use and future plans for the land. Select sites that are, and will continue to be, resistant to disturbance from the surrounding landscape. For example, mitigation projects can be sited in areas that have existing large, buffers and are connected to other aquatic resources and protected areas.

Restoration and protection project areas should not be sited in areas with future foreseeable upstream or up-gradient activities, including activities on adjacent properties, that are likely to cause adverse effects to the mitigation area. Areas likely to be developed in the foreseeable future include areas adjacent to existing development and areas currently zoned or identified for future development in a locality's comprehensive plan, long-range plan, or zoning overlay. See examples of future threats analysis in the discussion of elements in Chapter 2.1.

Identify appropriate wetland types

Wetland and stream mitigation sites are sustainable only if the type of wetland or stream being proposed is appropriate for its position in the landscape. Several existing sources of information provide decision-makers with valuable input on the appropriate wetland and stream types based on their position in the landscape. For example, the Hydrogeomorphic Methodology (HGM)[37] for classification of wetlands is based on characteristics of water movement and position in a landscape and can be used to identify appropriate wetland types for different locations in a hydrologic unit. Some specific questions that decision-makers can ask to determine if proposed project types are suitable based on their landscape position are:

- Will the mitigation activities result in a wetland of the appropriate HGM class in that landscape setting?
- Will the primary source of water to the mitigation site be appropriate for the HGM class?
- Will the site have an adequate supply of water to maintain a wetland without engineering a system to deliver water that requires long-term control or maintenance?
- Will the mitigation activities maintain hydric soils, if they exist, at the site?
- Can the mitigation be designed to control aggressive plant species?

See the overview of HGM in the discussion of elements in Chapter 2.1.

37 Brinson, M.M. (August 1993). A hydrogeomorphic classification for wetlands. Prepared for U.S. Army Corps of Engineers. Technical report WRP-DE-4.

Montsweag Brook, Maine. Credit © Brian Peters

Consider complications associated with projects located at seriously degraded or disturbed sites

A seriously degraded wetland or stream, surrounded by an extensively developed landscape, may achieve its maximal function only with active, ongoing management.[38] It should be recognized, however, that the functional performance of some degraded sites may be optimized by mitigation, and these considerations should be included if the goal of the project is to address a watershed need or objective best served by locating a wetland in a disturbed landscape position.

Focus on ecological processes rather than physical structure of the environment

Wetland and stream restoration and protection sites should be planned to accommodate natural, biological systems. The system of plants, animals, microbes, substrate, and water flows should be developed for self-maintenance and self-design.

Restore or develop naturally variable hydrological conditions

Restoration and protection projects should be designed to allow for naturally variable hydrology, with an emphasis on enabling fluctuations in water flow and level and duration and frequency of change, and should be representative of other comparable wetlands in the same landscape setting. Preferably, natural hydrology should be allowed to become reestablished rather than finessed through active engineering devices designed to mimic a natural hydro-period.

Avoid over-engineered structures in the project design

Wetland and stream restoration and projection projects should be designed, whenever possible, to avoid approaches that are heavily engineered and require continual maintenance. Such projects should favor the use of passive devices that have a higher likelihood of successfully sustaining the desired hydro-period over the long-term. Hydraulic control and other engineered structures are vulnerable to chronic failure and require on-going maintenance and replacement. If necessary to design projects with such structures, such as to prevent erosion until the wetland has developed soil stability, decision-makers should strive to use natural features, such as large woody debris.

38 National Research Council. (2001). Compensating for Wetland Losses Under the Clean Water Act. Washington, DC: The National Academies Press.

Examples of Different Watershed Approaches

The spectrum of watershed approaches is a useful way to understand the range of what constitutes a watershed approach as discussed in the *Chapter 1.4*. The distinctions across the spectrum can best be illustrated by short case studies from each category along the spectrum. These summaries provide a sense of some typical watershed approaches that can illustrate what might be most appropriate in a given situation. These case studies were selected to demonstrate the three basic categories of watershed approaches: 1) Watershed informed decisions; 2) Watershed analyses without prescribed outcomes; and 3) Watershed plans with prescribed outcomes. Some of these cases studies, however, include elements of other categories. As discussed in the overview of the spectrum, the spectrum is a useful construct through which to understand different ways of implementing a watershed approach, but is not meant to describe strict or specific categories of watershed approaches.

Category 1: Watershed-informed decisions

Washington Department of Ecology decision frameworks

In 2009 and 2010, respectively, the Washington State Department of Ecology published frameworks to guide users in evaluating potential wetland compensatory mitigation sites in the western and eastern portions of the state.[39] The handbooks include decision trees containing yes/no questions, instructions, and recommendations. The questions help the user to evaluate the ecological functions/values supported by a potential wetland mitigation site and then provide users with specific recommendations based on some consideration of watershed needs and benefits. Each series of yes/no questions is contained in a flow chart and throughout the process of assessing a potential mitigation site the user will reference various charts depending on a site's geomorphic setting. Thus, the tool does not require thorough comparison of the relative ability of many or all potential mitigation sites in the watershed to address watershed needs; instead, a single site or a limited number of sites are considered in the context of watershed stressors and needs.

If an appropriate watershed plan does not exist for the area of the impact site, the decision framework charts first prompt the user to decide the specific hydrologic unit in which the mitigation site will be located. This determination is based on the need to maintain some ecological functions near the impact site or in the same watershed (e.g., local water storage functions), the possibility that off-site or out-of-watershed mitigation may better replace some functions (e.g., habitat), and the ability of wetlands to develop and persist in a watershed. The tool then guides the user to evaluate which watershed functions/values should be targeted at the mitigation site and to assess whether wetland mitigation functions at the site will persist over time. The decision framework charts advise the user to "identify the major landscape-scale problems that could be addressed by mitigation for the hydrologic unit where your site

39 Hruby, T., K. Harper & S. Stanley. (2009). Selecting Wetland Mitigation Sites Using a Watershed Approach. Washington State Department of Ecology Publication #09-06-032; Hruby, T., K. Harper & S. Stanley. (November 2010). Selecting Wetland Mitigation Sites Using a Watershed Approach (Eastern Washington). Publication #10-06-007. Olympia, WA: Washington State Department of Ecology.

1.6: Examples of Different Watershed Approaches

is found" by selecting from a list of possible ecological processes that have been historically altered within the watershed. This list of landscape-scale ecological stressors prompts at least general consideration of watershed needs and how a potential mitigation site addresses those needs. Examples of historic alterations to watershed functions/values that the user is asked to consider include flooding, water quality, and habitat fragmentation.

Ducks Unlimited Vermont In-Lieu Fee Program Compensation Planning Framework

The prioritization strategy for compensatory mitigation site selection used by the Ducks Unlimited Vermont In-Lieu Fee Program (DU VT ILF)[40] provides a second example of a decision tree that guides assessment of wetland compensatory mitigation sites under a watershed approach. The DU VT ILF program uses a set of questions that prompt consideration of how a particular mitigation site addresses watershed needs, with or without a watershed plan; sites are scored based on varying site-specific and watershed- or landscape-scale criteria. For mitigation sites in areas without a watershed plan, the DU VT decision questionnaire guides assessment of factors indicative of a wetland mitigation project's ability to develop and persist into a good condition aquatic resource. For instance, the questionnaire prompts users to evaluate the site relative to National Wetlands Inventory maps, state wetlands data, priority conservation areas, Vermont TNC natural areas, and agricultural lands, among other factors. For all mitigation sites under consideration, this decision tree also includes some consideration of watershed habitat needs by considering the presence of threatened and endangered, species identified in the Vermont State Wildlife Action Plan, or exemplary wetland natural communities as defined by the Vermont Non-Game Natural Heritage Program. This DU questionnaire also prompts users to address watershed needs by considering state agency conservation goals.

Category 2: Watershed analysis—non-prescribed outcomes

Maryland Watershed Resources Registry

The Maryland Water Resource Registry (WRR)[41] provides a watershed-scale platform for various federal, state, and local agencies to address aquatic resource regulatory and non- regulatory restoration and conservation in a collaborative fashion. It establishes maps to support decision-making by regulators, planners, non-governmental organizations, permit applicants, and others. The system facilitates identification of aquatic resource restoration and conservation efforts that can support multiple functional benefits. The WRR applies to Clean Water Act (CWA) regulatory programs under §§303(d), 305(b), 401, 402, 404 and supports Maryland's Green Infrastructure Assessment and land use planning. The WRR can also be used to identify priority projects for funding under CWA §319, guide transportation planning efforts under federal transportation legislation, and support the U.S. Fish and Wildlife Service's Partners for Fish and Wildlife Program. The WRR combines consideration of a suite of watershed needs, such as water quality

40 Ducks Unlimited. (December 7, 2010). Ducks Unlimited, Inc. – Vermont In-lieu Fee Program. Ann Arbor, MI: Ducks Unlimited, Inc.
41 For information on the Maryland Water Resources Registry see: Watershed Resources Registry. *About Us.* Retrieved April 11, 2013, from: http://watershedresourcesregistry.com/overview.html; Bradley, J.J., J. Lemly, M.G. Nepstad, T. Smith, K.B. Copes & E. Bryson. (2010). Incorporating the Watershed Approach for Wetland Compensatory Mitigation. *National Wetlands Newsletter,* 32(6), 11-13; Bryson, E., S. Hertz, R. Spagnolo & W. Seib. (2013). Rollout of the Watershed Resources Registry in Maryland. *National Wetlands Newsletter, 35(1), 30-31.*

The Nature Conservancy's Old Fort Bayou Mitigation Bank in Jackson County, Mississippi. Credit © Erika Nortemann/TNC

improvements, stormwater management, forests, habitat networks, and other needs based on the data that it uses to assess and compare site suitability. This pilot project includes eight separate analyses that compare the relative suitability of potential compensatory mitigation sites throughout entire watersheds to provide eight maps ranking site suitability for the following efforts: wetlands preservation, wetlands restoration, riparian zone preservation, riparian zone restoration, upland preservation, upland restoration, natural stormwater infrastructure preservation, and stormwater infrastructure restoration.

However, while the WRR uses input data that incorporate consideration of watershed-scale needs (e.g., §303(d) impaired waters, green infrastructure maps), it does not conduct unique, thorough analytic, or stakeholder-driven processes to construct a watershed profile or perform multi- criteria decision-making to prioritize among these needs. Instead, the WRR relies primarily on the U.S. Environmental Protection Agency's "Surf Your Watershed" tool for watershed-scale information. This results in a less prescriptive product that allows users of the WRR to identify sites that meet their individual interests and that support their own desired outcomes.

Missouri Department of Natural Resources: Little Chariton/Paddy Creek Watersheds Wetland Potential Screening Tool

In 2008, the Missouri Department of Natural Resources (MDR) published a report on headwater wetlands in the state. The project sought to identify areas with "the greatest potential for the restoration or creation of sustainable wetlands" at a landscape scale.[42] The specific goals of the project were to select sites that could improve water quality and provide habitat for wetland

42 Weller, M.S. (June 2008). Headwater Wetlands in Agricultural Areas in Missouri. Final Report to the U.S. Environmental Protection Agency, Region 7. Missouri Department of Natural Resources.

1.6: Examples of Different Watershed Approaches

species and to evaluate land for enrollment in the Wetland Reserve Program (WRP). The GIS-based model combines data on wetland functionality and persistence, slope, flow accumulation, hydric soils, flooding frequency and duration, land use/land cover, distance from first and second order streams, and distance from existing wetlands. It considers surrounding land uses and average slope to calculate the size of each restorable area.

These three functions/factors—improving water quality, providing habitat for wetland species, and evaluating land for WRP enrollment—are general watershed needs that can be addressed through wetland restoration or creation. While these watershed needs are less specific than those identified by the Maryland program discussed above, or other more prescribed case studies, the Wetland Potential Screening Tool (WPST) developers selected these three general watershed needs based on their universal nature to make their model more transferable to other watersheds. The GIS site suitability analysis utilized by the WPST compares the potential of all sites (30 m resolution) in these watersheds for wetland restoration/creation based on these three needs. The WPST developers do not set outcomes for wetland restoration/creation in these two watersheds (e.g., acreage targets for restoration, water quality improvement goals), instead leaving setting of outcomes to users of the model results.

Sunrise River Watershed Approach Pilot Project

The U.S. Army Corps of Engineers' St. Paul District completed a watershed approach pilot project to identify priority wetland restoration sites "for the express purpose of making compensatory mitigation decisions more responsive to the needs of the [Sunrise River] watershed's stakeholders."[43] The objective of the project was to develop a GIS-based tool to assist regulators and stakeholders in the identification, prioritization, and ultimately, the selection of compensatory mitigation sites in a holistic, proactive manner. The Sunrise River Watershed Approach Pilot conducted a watershed profile-like assessment to characterize watershed needs and also incorporated a thorough and systematic stakeholder review process to weight/prioritize the relative importance of these watershed needs and site-specific factors. These stakeholder-generated weightings are then used for a GIS comparison of site suitability for wetland mitigation across the watershed. As with the Maryland WRR and Missouri WPST, however, specific watershed outcomes of wetland restoration or enhancement are not specified in the Sunrise River Pilot Project.

The pilot project includes four key phases: baseline assessment of watershed conditions (vulnerability assessment), stakeholder input on watershed priorities, development of a GIS-based decision support system, and development of implementation strategies and plan implementation. A particularly unique portion of this pilot is the multi-criteria decision-making method—the Analytic Hierarchy Process (AHP)—used to gather stakeholder input and utilize it in prioritization. This stakeholder process uses a "sieve-mapping approach" that gives stakeholders the opportunity to assign ratings and weightings of importance to the criteria in combination and to conduct 'what if' scenario analyses.

The Sunrise River spatial decision support system includes several different spatial layers, including current and historical extent of wetlands, water quality, extent of impervious surfaces, tributary hydrologic impairment and, areas of high/significant biodiversity. The pilot uses ten

43 Smith, T. (March 10, 2010). Integrating Watershed-Based Mitigation Planning in the Section 404 Permitting Program. U.S. Army Corps of Engineers [PowerPoint Slides].

criteria to select sites: 1) Hydrologic connectivity to tributaries; 2) Land costs: 3) Potential to reconnect riparian buffers; 4) Potential beneficial effects on fisheries; 5) Threats from urban growth; 6) Adjacency to public lands; 6) Opportunities to improve or protect areas of significant biodiversity; 8) Distance from roads and population centers; 9) Locations within the floodplain of a tributary; and 10) Opportunities to improve water quality impairments. The systematic stakeholder input process (AHP) translated general watershed needs (e.g., improve water quality impairments) into site suitability maps for the Sunrise River watershed.

Duck-Pensaukee Watershed Approach Pilot Project

Led by The Nature Conservancy and Environmental Law Institute, The Duck-Pensaukee Watershed Approach Pilot brought together agencies and partners in a Great Lakes basin of Wisconsin to identify the top tier of wetland conservation sites based on their potential to provide ecosystem services and to meet watershed needs. Both preservation and restoration opportunities were considered for application in both regulatory and non-regulatory contexts. Several factors were used to identify suitable sites, including current wetland coverage, historic wetland coverage, and current land use. Sites were ranked based on their potential to provide individual or multiple ecosystem services (i.e., flood abatement, water quality protection, surface water supply, shoreline protection, carbon storage, fish habitat, and wildlife habitat). Wildlife habitat received special focus in this approach and the analysis used priorities identified in Wisconsin's Wildlife Action Plan to make those priorities spatially explicit.

Watershed needs were established by conducting a watershed profile, based on U.S. Fish and Wildlife Service's NWIPlus methods. The profile identified the relative loss of wetland ecosystem services by sub-watershed since pre-settlement times.

The Duck-Pensaukee plan is intentionally non-prescriptive, instead providing a flexible environment in which plan users may set individual ecosystem service-based goals, identify sub-watersheds in which to collaboratively address the collective goals of partners, and select specific sites within these sub-watersheds at which to work. Partners were engaged throughout the process to ensure accuracy and relevance of the plan, and to help define objectives, develop methods, and refine outputs. Partners included watershed stakeholders, wetland-focused agencies (including Wisconsin DNR, St. Paul District of the Corps, and EPA Region 5), government (tribes, counties, municipalities), conservation organizations, and academic researchers.

Category 3: Watershed plan—prescribed outcomes

North Carolina Ecosystem Enhancement Program

North Carolina Ecosystem Enhancement Program (NCEEP), a program of the North Carolina Department of Environment and Natural Resources, uses a rigorous watershed planning process to identify priority sites where wetland and stream compensatory mitigation projects can best be used to support watershed needs and outcomes. To prioritize coarse-scale priorities, NCEEP conducts a River Basin Restoration Priorities (RBRPs) analysis using GIS to rank individual hydrologic unit codes (HUCs), specifically HUC-14 watersheds within HUC-8 service areas, based on watershed needs (problems, assets, and opportunities). The HUC-14 watersheds that NCEEP identifies using this process are

1.6: Examples of Different Watershed Approaches

then targeted for extensive local-scale analysis, documented in Local Watershed Plans (LWPs). The LWPs identify watershed-scale functional outcomes that can be achieved through wetland or stream compensation at certain sites. The specificity of LWP outcomes varies by watershed and the methods and data used for prioritization and development of the watershed management plan (e.g., modeling, GIS, qualitative methods).

To ascertain watershed needs and set desired watershed outcomes, NCEEP's LWP process includes a four-step detailed needs assessment for the relevant HUC-14. The four steps of the needs assessment are: 1) Characterization of current watershed conditions; 2) Detailed watershed assessment; 3) Development of a watershed management plan and project atlas; and 4) Implementation of the watershed management plan and project atlas.

In the characterization of current watershed conditions and detailed watershed assessment, NCEEP conducts thorough assessments of existing data and collects monitoring data to evaluate water quality, habitat, and hydrologic functions to identify stressors to these functions. NCEEP then designs watershed management plans and project atlases that evaluate management strategies and conducts on-the-ground project evaluations to find "projects and management strategies that address identified stressors and have the best opportunity for bringing about functional improvement to the watershed."[44] Finally, NCEEP implements priority projects and develops management plans to achieve desired outcomes of the LWP process. The projects are often selected based on their ability to meet desired conditions for watershed functionality.

California Regional Advance Mitigation Planning

California Regional Advance Mitigation Planning (RAMP) is a planning process that identifies mitigation needs for specific habitat types by overlaying footprints of projected infrastructure projects with natural resource maps. RAMP planners then systematically identify top parcels for ecological mitigation using Marxan, a conservation planning software.[45] RAMP was developed by a workgroup of 14 agencies and organizations, organized under the FloodSAFE Environmental Stewardship and Statewide Resources Office in the California Department of Water Resources. RAMP uses Marxan in two stages: the regional conservation assessment and the mitigation portfolio. Conservation targets, which are set by habitat type by conservation organizations or academic researchers, incorporate watershed needs and desired outcomes for multiple habitat types. The result is a regional greenprint that limits where mitigation may occur. Mitigation obligations for infrastructure impacts then determine the habitat types that are replaced within this greenprint. Marxan allows conservationists and transportation planners to set very prescribed outcomes for restoration or conservation of particular habitat types (e.g., restoring a certain percentage of a watershed and achieving certain restoration targets for particular habitat types within that greenprint). RAMP also estimates parcel acquisition costs and constructs a portfolio of mitigation parcels that best achieves the desired habitat outcomes based on parcels' cost-effectiveness, as determined by their price, size, boundary area, habitat types, and other ecological values, such as their location within wildlife corridors.

44 North Carolina Ecosystem Enhancement Program. (August 8, 2012). *NC Ecosystem Enhancement Program Local Watershed Planning Manual: Version 1*. Retrieved April 11, 2014, from: http://portal.ncdenr.org/c/document_library/get_file?uuid=07477766-468b-44f0-a379-e0274c75f4bb&groupId=60329

45 Watts, M.E., I.R. Ball, R.S. Stewart, C.J. Klein, K. Wilson, C. Steinback, R. Lourival, L. Kircher & H.P. Possingham. (2009). Marxan with Zones: Software for optimal conservation based land-and sea-use zoning. *Environmental Monitoring & Software, 24(12), 1513-1521* .

Using a Watershed Approach

For an organization, agency, or individual about to embark on using a watershed approach to inform decisions related to the type and location of wetland and stream restoration and preservation projects, this handbook can help guide the way. The handbook provides a framework – or logical process – for assessing which tools and information are right for implementing a watershed approach that helps fulfill desired goals and outcomes. The first step will be to understand the level of effort and technical capacity that can be dedicated to the effort. Will this be a planning process involving many stakeholders? Or a less structured effort that generally considers certain watershed-related factors? How specific are the desired outcomes and at what scale? How confident do you want to be in identifying projects best able to contribute to outcomes that help improve or sustain the watershed? How specific do you want to be in identifying sites? What types of resources, time, and expertise is available to help in the effort? These are all questions that will influence how to implement and use a watershed approach.

The next step will be to align that selected approach with the elements necessary for carrying out that approach. You will determine which methods are necessary to incorporate a specific element into the analysis. Below is some additional guidance to help evaluate the tradeoffs inherent in these choices.

Finally, all of these considerations need to be weighed against opportunities and constraints in the particular watershed you're working in and the available financial and staff resources, technical capacity, and data availability. The spectrum also provides the ability to weigh the relative complexity and the commitment of time and resources each approach requires against what they can reasonably achieve.

Using the spectrum

The Watershed Approach Spectrum (see Chapter 4) describes the range of approaches that can be used to inform the type and location of wetland and stream restoration and protection projects. The watershed approach requires using at least a basic logic framework describing, at least in general terms, the desired outcomes and then identifies the decision points necessary to for this desired outcome to be achieved. These steps should then inform data gathering and analysis. Across the spectrum, there are five elements that characterize a watershed approach and form the basis of such a logic framework. Even when the ability to identify watershed needs is limited, outlining the desired project outcomes and how to identify potential sites will likely improve project outcomes. The five elements are:

- Identification of watershed needs
- Identification of desired outcomes
- Identification of potential project sites
- Assessment of the potential of sites to meet watershed needs
- Prioritization of project sites that meet watershed needs

Where along the spectrum the work lies will affect the kinds of returns that can be expected. *Table 3* below provides a summary of the ecological, economic, stakeholder, and other outcomes that can be achieved by the different approaches along the spectrum.

	Watershed informed decisions	Watershed analyses	Watershed plan
Ecological return on investment	Helps improve ecological outcomes, especially at site level. Can help address watershed needs depending on availability of information and data.	Superior because more analysis involved, more factors are considered.	Greater potential for watershed benefits because of stakeholder informed definition of needs and desired outcomes. Likely more repeatable and reproducible.
Economic return on investment	Improved likelihood of achieving desired ecological outcomes and sustainability likely to result in lower costs (less need for remediation and adaptive management).	Greater likelihood of achieving desired ecological outcomes and sustainability likely to result in lower costs (less need for remediation and adaptive management).	Greatest likelihood to provide economic return on investments (less need for remediation, increased predictability of mitigation project approvalsand streamlining).
Stakeholder	Usually not involved.	Involvement of stakeholders helps improve analysis and coordination. Depends on on the extent of stakeholder involvement.	Plans with strong stakeholder engagement help improve coordination and secure buy-in. More collaborative.
Clarity	Case-by-case.	Case-by-case, depends on type and rigor of analysis.	Plans define desired outcomes and potentially high priority types and locations of projects. Superior clarity due to specific analysis and description of desired outcomes.
Learning, monitoring, reporting	Can be improved through user feedback.	Can be improved through user feedback.	Plans may set clear outcomes to monitor, and provide lessons-learned for future watershed planning efforts.

Table 3: Return on investment for different watershed approaches along the spectrum.

Before going too far along the path of a specific approach, decision-makers should also consider the barriers that may lie ahead. The barriers to undertaking such planning include competing demands; varying authorities among the federal, state, tribal, and local regulatory and non-regulatory agencies involved in aquatic resource protection and management; and lack of resources, incentive, or leadership necessary to overcome the inertia needed to undertake such efforts.

In general, greater specificity and clarity about watershed-scale needs – such as improvements in water quality, habitat, or flood attenuation – and how potential wetland and stream restoration and protection projects can help fulfill those needs will better guide the selection of the types and locations of projects that will produce desired outcomes in the watershed. Over time as a range of agencies and organizations undertake projects, individual projects identified and implemented under a watershed approach may add up to advancing desired outcomes within a watershed. This is the power and potential of the watershed approach – the alignment of the work, energy, and skill that will add up to more than the sum of their parts.

Finally, as discussed in Chapter 1.4, when determining which approach to take, decision-makers should consider how prescriptive they would like the final results to be. A less prescriptive approach may be appropriate in cases where there are limited resources available to undertake new analysis or develop a watershed plan. On the other hand, when specific desired outcomes have or can be identified, such as establishment of connectivity between protected areas, an approach with more prescriptive project types, locations, and desired outcomes may be best.
Selecting the right methods to address watershed elements

As discussed in Chapter 1.6, there are five categories, or elements, of a watershed approach. There are a wide variety of planning, mapping, and analytical techniques that can be adopted in each of the five element categories. There are tradeoffs when deciding which elements to tackle and which methods to adopt to carry out the element. *Table 4* below depicts the relationship between the approach, which elements to incorporate into the effort, and the likelihood of achieving the desired outcomes.

	Watershed informed decisions	Watershed analyses	Watershed plan
Identify watershed needs	X	X	X
Identify potential protection and restoration sites	X (by site)	X	X
Assess the potential of sites to meet watershed needs		X	X
Prioritize sites , areas, and desired outcomes	Somewhat		X
Achieve watershed significant outcomes	Maybe	Likely	Most Likely

Table 4: Watershed Approach and Meeting Outcomes

1.7: Using a Watershed Approach

Evaluating opportunities and constraints

As with any process, there are an array of factors that should be considered when deciding which approaches and elements should be used. Five such factors include:

- Stakeholder engagement
- Data availability, collection, and processing
- Scientific and technical expertise
- Data analysis
- Communicating results
- Stakeholder engagement

It is very clear from a long history of planning in general and watershed and water resource planning and decision-making in particular that stakeholder engagement is one of the most important factors in determining the success of a project. Successful stakeholder engagement, however, takes time and requires a clear planning and decision-making process. For a watershed approach, this requires engagement of both those who are expected to use the results, such as regulatory and resource agencies, project sponsors, and citizens, as well as stakeholders in the watershed who can help identify needs and desired watershed outcomes. There are also formal techniques that can be used to collect and analyze stakeholder input. These techniques can help to document the range of interests and how they were used to inform the project and desired outcomes. One of the factors that should be weighed in consideration of stakeholder involvement is how to determine the number of stakeholders to engage and how to determine the appropriateness of stakeholders. While including non-technical stakeholders (i.e., citizens) may be appropriate to ensure that the desired outcomes reflect community values, including these stakeholders in the identification of priority sites – as distinct from priority outcomes – can dilute the scientific basis of site selection.

Data availability, collection, and processing

Geographic information systems (GIS) and other tools have made planning at the watershed scale possible with relative ease. However, as any GIS analyst can attest, a significant amount of time needs to be devoted to collecting relevant data sets, aligning them, and otherwise making them ready for analysis. The level of effort needed for this work depends on the goals and objectives of the plan or analysis, data availability, the quality of data, and the extent and number of analyses planned for the project. In general, working with stakeholders and project managers to define the scope and intended analyses required for the project early can help focus data collection on only those datasets necessary for the intended analysis. Frequently, the tendency is to collect all available data as a first step – some or much of which will not play a significant role in the final watershed analysis or plan.

Scientific and technical expertise

Stakeholder engagement and appropriate data and information provide the raw material for undertaking a watershed approach. Important to a successful effort is having the people with the appropriate scientific and technical expertise to ensure the information is used in a manner that produces credible results that meet the needs of the project. Whether undertaking a full planning process or using watershed information to inform decisions about the types and locations of projects having people who understand key aspects of wetlands and stream hydrology, biology, geology and how issues such as watershed position, condition and connectivity affect the likely success of a project and its ability to address watershed needs is critical. In addition, sufficient expertise in the tools or models necessary to conduct appropriate analysis is important to the success of these efforts. Finally, working effectively with stakeholders requires its own type of expertise, including knowledge of the appropriate stakeholders to be engaged, relevant views and information to be collected, and how the results of analysis should be interpreted. Ensuring appropriate scientific and technical expertise is available is an important part of using a watershed approach.

Data analyses

Data analyses methods can range from simple overlay of spatial data to the use of complex statistical models that require significant time to calibrate and verify. There is no "right" answer to what level of analysis will help achieve the most effective results. As discussed earlier, effectiveness of the watershed approach effort is more likely related to involvement of stakeholders and the understanding and acceptance of the work and its use by the intended decision-makers than the complexity or depth of the data analysis.

Clearly, the scientific and technical rigor of data anlyses must be commensurate with the questions one is trying to answer and the skills and capabilities of the staff responsible for the analyses. More rigor is often necessary to understand complex situations. On the other hand, many rigorous studies go unused because the analysis is not understood by the intended users. Avoiding the fatal "black-box" syndrome – where analysis or models are used that only the modeler sees or understands -- can be key for securing the support and trust of important stakeholders, which may be crucial determinants of whether the plan and analysis are embraced and used when complete.

Communicating results

The effectiveness of a watershed approach may be determined not by the completeness or rigor of the analysis or decision criteria, but rather by whether the work informs decisions made by those that undertake wetland and stream restoration and protection projects. Certainly written reports summarizing the planning process, analysis, and outcomes are important for documenting methods and will be critical for encouraging people to use and understand the work that was done.

Increasingly, data, information, and results are being made available through web-based portals and interactive websites. These sites allow users to not only view the results, but also increasingly offer the ability to manipulate some of the data to highlight information related to the user's particular interest. Again, the level of effort related to communicating results spans a spectrum from simply making a report widely available in both printed in electronic forms to the development of interactive websites that promote use and understanding of the results, analyses, and underlying data.

1.8: Other Watershed Planning Guides

Other Watershed Planning Guides

This handbook focuses on the spectrum of approaches available to take a watershed approach to wetland and stream restoration and protection projects and an overview of key steps and elements that can inform such approaches. A number of other handbooks, guides, and guidance produced by federal agencies focus more broadly on watershed planning, which can be used to support a watershed approach to identifying and selecting wetland and stream restoration and protection projects. A formal watershed plan is not necessary to take a watershed approach to wetland and stream restoration and protection activities. Other ways of implementing a watershed approach can include analytical frameworks, advance identification efforts, watershed evaluation tools, watershed studies, as well as watershed plans.

This handbook describes approaches and techniques that are consistent with these other planning guides. Each resource for watershed evaluation or planning has its own focus given the mission of the agency or organization that developed it, but many of the key concepts and approaches are similar. Many of these other guides and handbooks provide useful guidance for undertaking a watershed approach. These guides and handbooks may include information on how to structure the planning process and the importance of engaging key stakeholders during the planning process; topics that we do not address in detail within this handbook. This handbook, however, is unique in its focus on using a watershed approach and developing watershed plans specifically to identify and prioritize wetlands and streams for restoration and protection. As previously discussed, a watershed plan is not required by the 2008 rule to implement a watershed approach for wetland and stream restoration and protection activities, but such plans can significantly enhance the benefits and values achieved by the investments in such projects. Below are summaries of some other valuable watershed planning guides and how they relate to the watershed approach for wetland and stream restoration and protection projects.

Center for Watershed Protection: Watershed Planning Guide

In 2006 the Center for Watershed Protection (CWP) published an EPA-funded document, *Using Local Watershed Plans to Protect Wetlands*. Like this handbook, CWP's guide provides a strong overview of the steps involved in a good planning process and how these processes can be tailored to integrate wetland protection and restoration into watershed plans. This handbook complements the CWP guide by identifying a range of watershed approaches that might be taken and by providing a range of examples of different watershed approaches and different types of analysis that might be useful in such an approach. Although this handbook does not focus on the steps of a planning process, the CWP guide, as well as others, does provide guidance about the steps of watershed planning generally (See *Table 5*).

Principles of Watershed Planning for Wetlands[46]	
Watershed Planning Principles to Protect Wetlands	**Specific Methods**
1. Compile Wetland Information on a Watershed Basis	1.1 Review existing plans 1.2 Compile additional data
2. Assess Local Wetland Protection Capacity	2.1 Conduct Needs and Capabilities Assessment 2.2 Conduct 8 Tools Audit
3. Identify Wetland Partners and Roles	3.1 Involve wetland partners in stakeholder process 3.2 Consult with wetland partners for technical support 3.3 Form partnerships for implementation
4. Define Wetland Goals and Objectives for the Watershed	4.1 Define wetland goals 4.2 Define specific wetland objectives
5. Create an Inventory of Wetlands in the Watershed	5.1 Update existing wetland maps 5.2 Estimate historic wetlands coverage 5.3 Delineate wetland contributing drainage areas 5.4 Estimate wetland functions 5.5 Estimate wetland condition 5.6 Estimate effects of future land use changes on wetlands
6. Screen Wetlands for Further Assessment	6.1 Screen for priority subwatersheds using wetland metrics 6.2 Screen wetland inventory for conservation sites 6.3 Screen wetland inventory for sensitive wetlands 6.4 Screen wetland inventory for restoration sites
7. Evaluate Wetlands in the Field	7.1 Conduct rapid assessment of wetland impacts 7.2 Conduct detailed wetland assessments
8. Adapt Watershed Tools to Protect Wetlands	8.1 Review 8 Tools Audit 8.2 Make specific recommendations for each tool
9. Prioritize Wetland Recommendations	9.1 Compile list of wetland recommendations 9.2 Rank recommendations to identify priorities
10. Coordinate Implementation of Wetland Recommendations	10.1 Implement changes to local programs and regulations 10.2 Coordinate with wetland regulatory agencies 10.3 Implement projects with wetland partners
11. Monitor Progress Toward Wetland Goals	11.1 Update the wetland inventory 11.2 Track implementation of wetland projects 11.3 Conduct wetland monitoring

Table 5: Principles of Watershed Planning for Wetlands. The Center for Watershed Protection outlined eleven watershed principles to protect wetlands in its document Using Local Watershed Plans to Protect Wetlands.

46 Cappiella, K., A. Kitchell & T. Schueler. (2006). Using Watershed Plans to Protect Wetlands. Ellicott City, MD: Center for Watershed Protection. Wetlands & Watersheds Article #2, p. 6.

1.8: Other Watershed Planning Guides

The CWP guide also supports the focus of this handbook, namely the need to link wetland goals and objectives to the goals and objectives of the watershed plans. In addition, the document includes a good crosswalk about how watershed-planning tools can be used to protect wetlands.

Adapting the Eight Tools of Watershed Protection for Wetlands		
Watershed Protection Tool	**Description**	**How the Tool is Used to Protect Wetlands**
1. Land Use Planning	Use land use planning techniques to redirect development, preserve sensitive areas, and maintain or reduce impervious cover in a given portion of the watershed	Use land use planning techniques to direct growth away from wetlands
2. Land Conservation	Apply land conservation techniques to permanently protect critical resources from being developed	Identify wetlands as priority lands for conservation
3. Aquatic Buffers	Provide special protection, in the form of a buffer, to the aquatic corridor to physically protect and separate water resources from future disturbance	Establish vegetated buffers around all wetlands
4. Better Site Design	Foster site design that protects watersheds by reducing the amount of impervious cover, and increasing conservation of natural areas	Design developments to minimize impacts to wetlands on the site
5. Erosion and Sediment Control	Mitigate impacts of sediment during the construction process by restricting clearing, requiring erosion and sediment controls, and enforcing these regulations	Modify ESC regulations to provide stricter controls in areas draining to wetlands
6. Stormwater Management	Install stormwater treatment practices to compensate for the hydrological changes caused by new and existing development	Outline special criteria to protect downstream wetlands from stormwater runoff
7. Non-Stormwater Discharges	Reduce pollutant discharges from non-stormwater sources, such as septic systems, illicit discharges, and spills	Establish restrictions on activities that have high potential for pollutant discharges in areas draining to wetlands
8. Watershed Stewardship	Increase public understanding and awareness about watersheds, promote better stewardship of private lands, and develop funding to sustain watershed management efforts	Ensure that wetlands are a key component of all watershed stewardship activities

Table 6: Adapting the eight tools of watershed protection for wetlands (Center for Watershed Protection)

The work of the Center for Watershed Protection and this handbook together provide a solid overview of the planning process and substantive elements that can inform a watershed approach to wetland and stream restoration and protection.

U.S. Environmental Protection Agency: Watershed Planning Handbook

In 2008, EPA issued its *Handbook for Developing Watershed Plans to Restore and Protect Our Waters*, which provides broad guidance on how to undertake a watershed plan to address point sources and nonpoint sources of pollutants. The handbook identifies six steps to watershed planning:

- Build partnerships
- Characterize the watershed to identify problems
- Set goals and identify solutions
- Design and implementation program
- Implement the watershed plan
- Measure progress and make adjustments

Though the handbook focuses on issues related to water quality impairments, the overall framework provided is helpful for a broad range of watershed-based planning efforts.

U.S. Environmental Protection Agency: Region 5 Watershed Planning Handbook – Wetland Supplement

In 2013, EPA Region 5 issued a supplement to the watershed planning handbook titled: *Wetlands Supplement: Incorporating Wetlands into Watershed Planning*[47]. The purpose of the supplement is to:

> *… is to encourage the inclusion of proactive wetland management into watershed plans because wetlands play an integral role in the healthy functioning of the watershed. This Supplement promotes using a watershed approach that not only protects existing freshwater wetlands but also maximizes opportunities to use restored, enhanced, and created freshwater wetlands to address watershed problems such as habitat loss, hydrological alteration, and water quality impairments*.

The supplement includes the following summary of its content.

> **Chapter 1** includes an overview of the purpose and intent of the document, background on why it is valuable or important to include wetlands in watershed planning, and a brief overview of the historical and current protection of wetlands.

47 U.S. Environmental Protection Agency. (February 2013). EPA Region 5 Wetlands Supplement: Incorporating Wetlands into Watershed Planning. Retrieved April 11, 2014, from: http://www.epa.gov/region5/agriculture/pdfs/wetlands-in-watershed-planning-supplement-region-5-201302.pdf

> **Chapter 2** provides the regulatory definition of wetlands, an overview of wetland types, and a review of wetland classification schemes.
>
> **Chapter 3** outlines the basic watershed planning steps and highlights the watershed planning considerations when incorporating wetlands. The chapter also provides general information on wetland restoration, enhancement, and creation techniques and discusses the consideration one should offer in selecting options.
>
> **Chapter 4** contains four case studies summarizing approaches for identifying existing and former wetlands for restoration or enhancement, as well as possible sites for wetland creation within a watershed context. The case studies also summarize approaches for prioritizing amongst potential sites based on wetlands having the greatest restoration potential and wetlands whose restored functions would address key watershed goals such as improved hydrology, improved water quality, and increased habitat.

U.S. Army Corps of Engineers: Watershed Planning Guidance

The Army Corps has embraced watershed planning and is working to take an integrated approach to water management. The agency issued guidance on watershed planning and the preparation of watershed plans in 2010[48].

The guidance highlights planning at the watershed scale as an important aspect of an integrated water management approach. As stated in the circular:

> *Watershed perspective* is the viewpoint which requires that all activities be accomplished within the context of an understanding and appreciation of the impacts of those activities on other resources in the watershed. The watershed perspective encourages the active participation of all interested groups and requires the use of the full spectrum of technical disciplines in activities and decision making. This viewpoint takes into account (1) the interconnectedness of water and land resources, (2) the dynamic nature of the economy and environment, and (3) the variability of social interests over time. It recognizes that watershed activities are not static, and that the strategy for managing the resources of the watershed needs to be adaptive.

The circular also includes four specific considerations to take into account when engaging in watershed planning:

> **Systems Approach:** Within watersheds, there are many competing demands for available water resources. In utilizing a systems approach within a watershed, the planning effort should identify and characterize the systems of interest to the current and future needs of the watershed.

48 U.S. Army Corps of Engineers. (January 15, 2010). Watershed Plans. Circular No. EC 1105-2-411.

Public Involvement, Collaboration and Coordination. Public involvement, collaboration and consultation with Federal, tribal, state, interstate, and local government entities are a keystone of the USACE watershed approach and are essential to the success of watershed planning. The goal of public involvement, collaboration and coordination is to open and maintain channels of communication in order to give full consideration to the views of others in the planning process.

Leveraging of Resources During Implementation: Watershed planning should include strategies for implementation, both Federal and non-Federal, to allow programs to work together over time. Federal, State, Tribal and local government entity missions, goals, objectives, funding requirements, and timeframes should be fully understood so that efforts can be accomplished by various entities in an integrated way in accordance with a collaboratively developed plan.

Study Area: Watershed planning addresses resource conditions in the watershed, land uses, and multiple stakeholder interests. By definition, watershed planning focuses on a watershed, a geographic area that is defined by a drainage basin.

Many of the Corps' watershed principles are reflected in this handbook.

U.S. Forest Service: Watershed Condition Classification Guide

The U.S. Forest Service has also developed a guide, *Watershed Condition Classification Technical Guide.*[49]

This guide explains the value and need for a watershed approach this way:

> The most effective way to approach complex ecological issues is to consider them at the watershed level, where the fundamental connection among all components of the landscape is the network of streams that defines the watershed (Heller 2004, National Research Council 1999, Newbold 2002, Ogg and Keith 2002, Reid et al. 1996, Sedell et al. 2000, Smith et al. 2005, Williams et al. 1997). Watersheds are easily identified on maps and on the ground, and their boundaries do not change much over time (Reid et al. 1996). Watersheds are also readily recognized by local communities and resonate with members of the public as a logical way to address resource management issues.

49 U.S. Department of Agriculture. Forest Service. (July 2011). Watershed Condition Classification Technical Guide. FS-987. Retrieved April 11, 2014, from: http://www.fs.fed.us/restoration/Watershed_Restoration/overview.shtml.

1.8: Other Watershed Planning Guides

The guide also provides a six-step watershed condition framework:

Step A: Classify the condition of all 6th-level watersheds in the national forest by using existing data layers, local knowledge, and professional judgment.

Step B: Prioritize watersheds for restoration: establish a small set of selected watersheds for targeted improvement equivalent to a 5-year program of work.

Step C: Develop watershed restoration action plans that identify comprehensive project- level improvement activities.

Step D: Implement integrated suites of projects in select watersheds.

Step E: Track restoration accomplishments for performance accountability.

Step F: Verify accomplishment of project activities and monitor improvement of watershed and stream conditions.

The watershed planning guides discussed above include several consistent themes. These include:

- Engage stakeholders throughout the planning process
- Work at the watershed scale
- Use a systems approach
- Set goals
- Monitor and evaluate outcomes
- Measure progress
- Make adjustments based on evaluations and progress to desired outcomes

Part 2: Watershed Approach Techniques and Data Sources

Introduction

Numerous planning tools and methods have been developed that are useful for informing a watershed approach to wetland and stream restoration and protection. These various efforts yield a rich diversity of experiences, methods and models on which to base a watershed approach to stream and wetland restoration and protection projects. Over 65 case studies were identified and analyzed to capture a variety of different tools and methods for carrying out a watershed approach. This analysis allowed us to identify five categories, or elements of a watershed approach to wetland and stream restoration and protection activities. Of course such a list cannot, nor is it intended to, be definitive. Rather, the elements are meant to be illustrative and to help minimize the necessity for every watershed approach effort to reinvent the wheel when thinking about these questions.

The five elements of a watershed approach for wetland and stream restoration and protection that were identified are:

> **Element 1:** *Identify watershed needs,* including a determination of how watershed needs defined by other regulatory and non-regulatory programs can inform a watershed approach.
>
> **Element 2:** *Identification of desired watershed outcomes,* or the measurable results anticipated from undertaking protection and restoration projects.
>
> **Element 3:** *Identify potential project sites,* generally based on the ability of wetlands and streams to develop and persist in a particular location. This generally includes consideration of such factors as local hydrology, soil characteristics, and/or compatibility of desired resources with surrounding land uses.
>
> **Element 4:** *Assess the potential of sites to meet watershed needs*, generally through analysis of the ability of the potential wetland and stream project sites identified in Element 3, above, to support particular ecosystem functions and services relevant to identified watershed need(s).
>
> **Element 5:** *Prioritize sites and areas* based on their relative ability to sustain wetland and stream characteristics and functions, and their relative ability to address watershed needs and help meet desired watershed goals and outcomes.

There are a variety of planning, mapping, and analytical techniques that can be used in each of the element categories. In other words, each of these watershed approach elements can be carried out using a variety of technical tools or approaches. These techniques range from the highly technical to more easily applied qualitative approaches. Recognizing that staff capacity, funding, and technical abilities will vary widely, a variety of examples are provided for each of the five elements.

All five of the elements are part of an effective watershed approach; however, the assessment of case studies made it clear that the first element, the identification of watershed needs, is often overlooked. Identifying watershed needs will increase the likelihood that investment in multiple projects across a watershed will collectively produce results relevant at a watershed scale. Although the five elements have been listed in a logical order, analyses need not follow this exact sequence.

Element 1: Identify watershed needs

- Existing plans, reports, or analyses
- Analysis of historical loss of aquatic resources in the watershed
- Analysis of current condition of aquatic resources in the watershed
- Analysis of trends and future threats within the watershed
- Stakeholder input

Element 2: Identify desired outcomes

Element 3: Identify potential sites

- Identify areas with appropriate hydrology and soils
- Determine potential for persistence of sites

Element 4: Assess the potential of sites to sustainably meet watershed needs

- Function and condition assessments
- Ecosystem service assessments
- Wildlife and habitat assessments

Element 5: Prioritize sites, areas, and desired outcomes

- Identify priority hydrologic units
- Prioritize sites

These categories of analytic methods are not mutually exclusive. For example, a watershed-wide assessment of current wetland and stream condition may be conducted to inform the decisions of stakeholder groups as they establish watershed needs. Specific methods may be selected based on a number of criteria, which may vary among watersheds, such as data availability, available resources for planning, and regulatory consideratoins. The level and breadth of stakeholder engagement needed to ensure acceptance and implementation of a watershed plan may also play an important role.

The examples of elements described below were selected based on several criteria, including representation of a range of: 1) Technical requirements: 2) Financial resources; 3) Regulatory and non-regulatory contexts; 4) Natural resources addressed (e.g., streams, wetlands): and 4) Physio-geographic contexts (e.g., nearshore vs. inland). These case studies come from a variety of sources and may constitute an entire watershed planning

Part 2: Watershed Approach Techniques and Data Sources

effort, be selected from a broader approach or suite of methods, have been created for another regulatory program (e.g., §319 planning), or be the product of academic research.

Element 1: Identify Watershed Needs

Existing plans, reports, or analyses

Water quality standards and implementation plans[50]

Clean Water Act Section 303(d) requires each state to list the waters of the state that are not attaining their established water quality standards. This list is updated on a regular basis and generally includes waters that are currently non-attaining water quality standards, waters for which TMDLs (Total Maximum Daily Loads, pollution reduction plans that outline how much pollutant may be released) are being or have been created, and formerly listed waters that have reached their water quality goal. These plans can be useful in determining watershed needs in terms of water quality and its impact on associated aquatic habitat. They also can provide a broader context for wetland and stream restoration activities by setting specific water quality-related goals.

Maryland Water Resource Registry. Recognizing water quality as a primary goal, or watershed need, Maryland's Watershed Resources Registry[51] uses 303(d) listed waters as one layer of information in its multi-metric approach. Areas that are closer to 303(d) listed waters are identified as areas in need of water quality improvement.

U.S. Army Corps of Engineers watershed assessments

Section 729 of the Water Resources Development Act of 1986 authorizes the U.S. Army Corps of Engineers (USACE) to undertake watershed planning. These Corps' assessments generally include sections with information on the current physical, ecological, hydrologic, economic, and demographic conditions of the larger watershed.

The Monongahela River Watershed Assessment. The Monongahela River Initial Watershed Assessment[52] is a Corps "reconnaissance level report." The report was funded through section 729 and identifies current existing conditions within the watershed and details the major water resource problems of the watershed. The Monongahela is a large watershed and the information contained in this report can directly apply to watershed approaches in smaller basins in the drainage.

Special Area Management Plans[53]

The Coastal Zone Management Act (CZMA), established in 1972, provides the basis for cooperation in the management and usage of our areas near the coast. The CZMA creates a funding mechanism for the development of Special Area Management Plans (SAMPs), which are comprehensive plans

50 For more on water quality standards and implementation plans, see: U.S. Environmental Protection Agency. Impaired Waters and Total Maximum Daily Loads. http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/index.cfm
51 The Maryland Watershed Resources Registry is available at http://watershedresourcesregistry.com/home.html with additional information on the tool available on the History, Methods and FAQ tabs.
52 U.S. Army Corps of Engineers. (September 2011). Monongahela River Watershed Initial Watershed Assessment.
53 For more on Special Area Management Plans, see: National Oceanic and Atmospheric Administration. Ocean & Coastal Resource Management. Coastal Issues: Special Area Management Plans.

that consider natural resource protection, coastal-dependent economic use, and provide detailed guidance for the public and private uses of lands and waters within a state defined 'coastal zone'. Special Area Management Plans may also be developed by the U.S. Army Corps of Engineers Regulatory Program, for use with a variety of aquatic resource types to protect aquatic resources and provide predictability in permitting for development projects. Guidance in the use of SAMPs in the Corps Regulatory Program is provided by Regulatory Guidance Letter 05-09.

Rhode Island Salt Pond Special Area Management Plan. The Rhode Island Salt Pond Region Special Area Management Plan[54] includes information on water quality, living resource and critical habitat, and cumulative and secondary impacts.

State Wildlife Action Plans[55]

State comprehensive wildlife action plans, developed by each state and U.S. territory, identify species of greatest conservation need (SGCN) and assess the condition of their populations and habitats. These plans then identify threats to SGCNs, and present possible strategies to protect their populations and habitats over the long term. State fish and wildlife agencies have developed these plans by working with a broad array of partners, including conservation organizations, researchers, sportsmen, and members of the community. The methodologies used by each state vary widely, however the data and descriptive information in these plans can be used to determine the needs of wildlife at watershed scales, including the types of aquatic resources various wildlife species might utilize.

Idaho Wetland Conservation Prioritization Plan. The Idaho Division of Fish andGame (IDFG) "Wetland Conservation Prioritization Plan"[56] uses information and data from the IDFG Comprehensive Wildlife Plan in its multi-metric assessment. The plan assesses a wetland habitat function by analyzing the capacity of a wetland to support vertebrate and invertebrate Species of Greatest Conservation Need (SGCN) and special status vascular and non-vascular plants. These data were mapped and buffered and converted to 30 m square pixel raster layers and then combined into one rare species habitat function layer (see *Figure 5*).

54 Ernst, L.M., L.K. Miguel & Jeff Willis. (April 12, 1999). Rhode Island's Salt Pond Region: A Special Area Management Plan. Prepared for the Rhode Island Coastal Resources Management Council. Retrieved April 11, 2014, from: http://www.crmc.ri.gov/regulations/SAMP_SaltPond.pdf
55 For more on State Wildlife Action Plans, see: http://www.wildlifeactionplan.org.
56 Murphy, C., J. Miller & A. Schmidt. (2012). Idaho wetland conservation prioritization plan – 2012. Prepared for Idaho Department of Parks and Recreation. Boise, ID: Idaho Department of Fish and
Game, p. 29 & appendix.

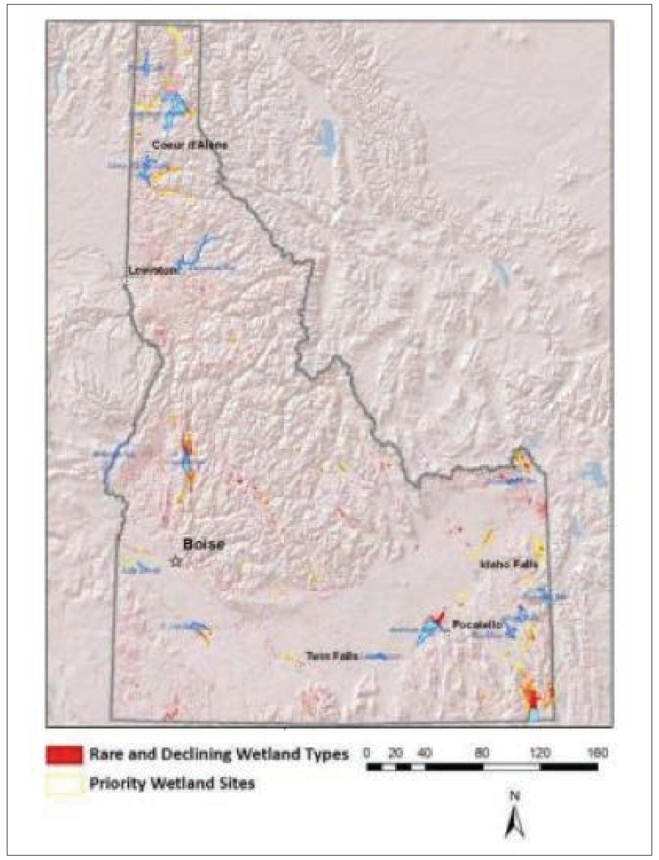


Figure 5: Wetlands supporting rare, sensitive, or declining ecological systems. Used with permission from Chris Murphy, Idaho Department of Fish and Game.

ESA Habitat Conservation Plans

Etowah Habitat Conservation Plan. The Etowah Habitat Conservation Plan (HCP) strives to enhance the Etowah watershed in Northwest Georgia through protection of aquatic species and water resources, while simultaneously allowing the region to continue to grow and develop. The basis for the development and implementation of the HCP is a series of scientific studies conducted throughout the Etowah watershed and peer reviews of the best available scientific information from similar regions. To ensure the best potential for a restoration project to succeed the Etowah Restoration analysis only included areas that contain less than 5% impervious surface and greater than 50% forest cover. Impervious surface and forest cover play a key role in the survival of biodiversity within an area. Once impervious surface exceeds 5% within an area the aquatic biodiversity falls drastically.[57 58] Forested area below 50% within a catchment was assumed to lower the ability of streams to support biodiversity.[59]

57 Walters, D.M., D.S. Leigh & A.B. Bearden. (2003). Urbanization, Sedimentation and the Homogenization of Fish Assemblages in the Etowah River Basin, USA. Hydrobiologia, 494, 5-10.
58 Wenger, S. & M. Freeman. (2007). Stressors to Imperiled Fishes in the Etowah Basin: Mechanisms, Sources and Management under the Etowah HCP. Retrieved April 11, 2014, from: http://www.rivercenter.uga.edu/publications/pdf/stressors_2007.pdf
59 Long, J. & M.S. Schorr. (2005). Effects of Watershed Urban Land Use on Environmental Conditions and Fish Assemblages in

Flood management plans[60]

Certain plans relating to specific ecosystem services may also provide valuable information on identified aquatic resource needs within a watershed. State and local flood management and flood hazard mitigation plans can illustrate the amount and location of flooding impact that can be used with other ecological information to create comprehensive watershed plans.

New Hampshire Flood Protection Tool. The New Hampshire Department of Environmental Services (NHDES) Wetland Restoration Assessment Model (WRAM) Flood Protection Tool assesses the potential for each wetland site to act as a natural flood control buffer based on a number of factors, including the percentage of the site located within a FEMA floodplain.[61]

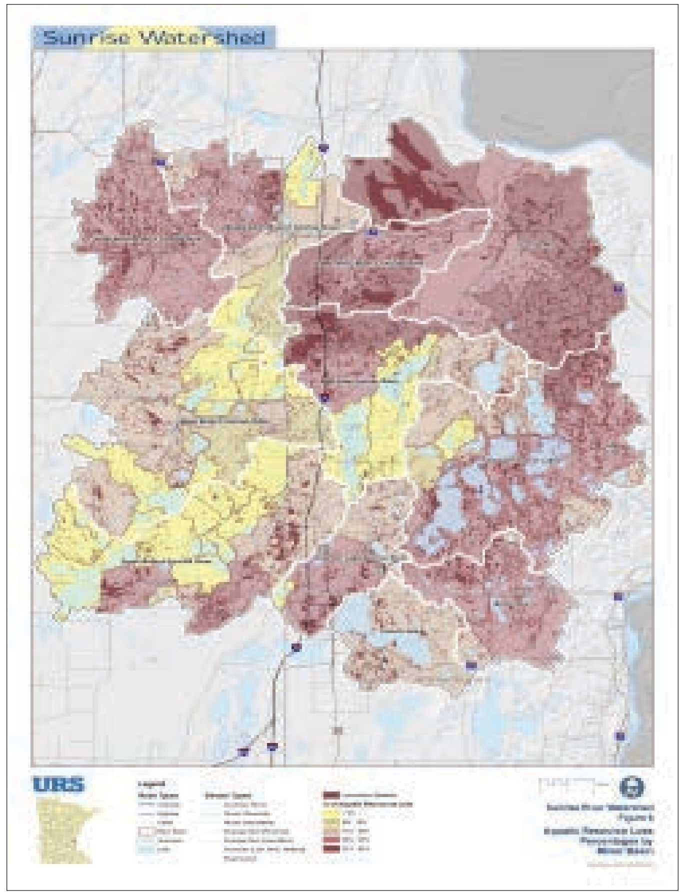


Figure 6: Cumulative impact assessment for wetlands, St. Paul District Sunrise River watershed. Used with permission from Tim Smith, St. Paul Corps.

Chattanooga Area Streams (Tennessee-Georgia). *Journal of Freshwater Ecology,* 20(3), 527-537.
60 For more on flood management plans, see: Association of State Floodplain Managers. http://www.floods.org
61 Vanasse Hangen Brustlin, Inc. (2009). Merrimack River Watershed Wetland Restoration Strategy. Prepared for New Hampshire Department of Environmental Services.

Analysis of historical losses

Quantity (area) of historical losses

Assessment of cumulative aquatic resource losses over time can help to identify watershed needs by noting particular areas within a watershed that have been heavily impacted by losses of those aquatic resources and the functions and services those aquatic resources provided.

Minnesota Sunrise River Watershed-Based Mitigation Pilot. The St. Paul Corps District's Sunrise River watershed approach pilot project conducted a baseline assessment of watershed conditions, including a comparison of historical wetland coverage with current wetland coverage (2008) to ascertain cumulative losses of wetlands. Two data layers were produced: one that displayed historical wetland losses throughout the watershed, and one that displayed the percentage of historical wetlands lost for each of ten subbasins (see *Figure 6*).

Type of historical losses: permitted

Watershed needs for restoration or protection of particular wetland or stream types may be identified through analysis of historical permitted losses by type in a watershed, with the ultimate objective of restoring wetland or stream types that have suffered the most permitted losses.
Minnesota Sunrise River Watershed-Based Mitigation Pilot. The St. Paul Corps District's Sunrise River watershed approach pilot project provide data on permitted losses of aquatic resources under CWA section 404 (see *Figure 7*).

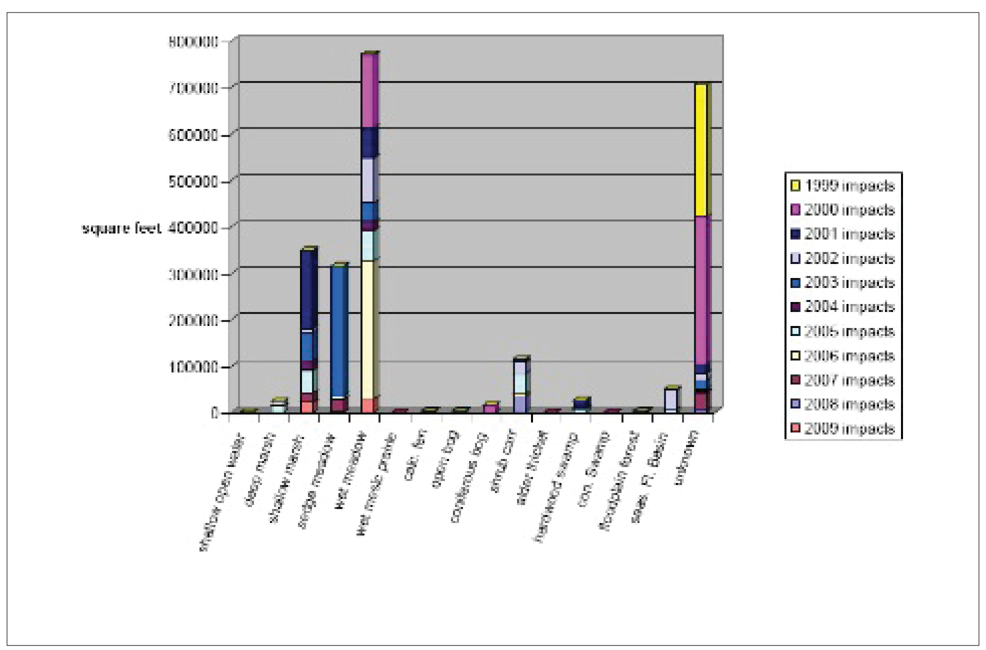


Figure 7: CWA 404 permitted wetland impacts by type, 1999-2009, St. Paul Corps District Watershed Approach Baseline Assessment. Used with permission from Tim Smith, St. Paul Corps.

Functional impacts of historical losses

National Wetlands Inventory Plus (NWIPlus)

Where historical estimates of wetland extent and characteristics can be generated alongside current estimates, changes in the extent of wetland service provision (functions) over time can be assessed at watershed or subwatershed scales. Aggregate statistics for functional losses in a watershed can help environmental managers target restoration or conservation activities that restore particularly scarce or damaged wetland functions. For example, in the Nanticoke River watershed[62] in Delaware/Maryland and in the Duck-Pensaukee watershed in Wisconsin,[63] NWIPlus has been used to generate statistics for wetland functional loss since settlement times. NWIPlus enhances standard NWI data by adding hydrogeomorphic (HGM) descriptors for each mapped wetland. Scientists then correlate combinations of HGM and NWI descriptors with various wetland functions, allowing for the categorization of each site as "high potential" or "moderate potential" for each function of interest. The additional HGM characteristics fall under four categories: landscape position, landform, water flow path, and waterbody type. Aggregation of NWIPlus results at a watershed scale can be very useful for comparing how the extent of wetland loss and degradation translates into functional changes (see *Figure 8*).

Function	Potential Significance	Pre-settlement Area (% of total area)	1998 Area (% of total)	% Change in Area
Surface-water Detention	High	20,380.5 (21.9)	15,870.7 (27.6)	−22.1
	Moderate	70,814.5 (76.0)	39,847.7 (69.2)	−43.7
	Total	91,195.0 (97.9)	55,718.4 (96.8)	−38.9
Streamflow Maintenance	High	72,971.2 (78.4)	9,586.2 (16.7)	−86.9
	Moderate	546.4 (0.6)	33,332.4 (57.9)	+600.0
	Total	73,517.6 (79.0)	42,918.6 (74.6)	−41.6
Nutrient Transformation	High	39,009.7 (41.9)	14,476.2 (25.2)	−62.9
	Moderate	54,115.5 (58.1)	40,864.3 (71.0)	−24.5
	Total	93,125.2 (100.0)	55,340.5 (96.2)	−40.6
Retention of Sediments and Other Particulates	High	20,380.1 (21.9)	15,627.2 (27.2)	−23.3
	Moderate	20,365.2 (21.9)	1,920.1 (3.3)	−90.6
	Total	40,745.3 (43.8)	17,547.3 (30.5)	−56.9
Shoreline Stabilization	High	20,448.2 (22.0)	15,798.1 (27.5)	−22.7
	Moderate	-0-	0.4 (−)	+negligible
	Total	20,448.2 (22.0)	15,798.5 (27.5)	−22.7
Coastal Storm-surge Detention	High	13,587.7 (14.6)	10,415.1 (18.1)	−23.3
Fish/Shellfish Habitat	High	10,670.0 (11.5)	7,133.4 (12.4)	−33.1
	Moderate	-0-	572.3 (1.0)	+significant
	Shading*	6,787.6 (7.3)	5,349.1 (9.3)	−21.2
	Total	17,457.6 (18.8)	13,054.8 (22.7)	−25.2
Waterfowl/Waterbird Habitat	High	10,686.9 (11.5)	7,337.0 (12.8)	−31.3
	Moderate	-0-	486.4 (0.8)	+significant
	Wood Duck	8,025.7 (8.6)	5,453.0 (9.5)	−32.1
	Total	18,712.6 (20.1)	13,276.4 (23.1)	−29.1
Other Wildlife Habitat	High	90,559.4 (97.2)	52,648.5 (91.5)	−41.9
	Moderate	2,565.8 (2.8)	2,699.1 (4.7)	+5.2

Figure 8: Functional loss in Nanticoke River watershed, DE/MD, from presettlement to 1998. Used with permission from Ralph Tiner, U.S. Fish and Wildlife Service.

62 Tiner, R. W. (2005). Assessing cumulative loss of wetland functions in the Nanticoke River watershed using enhanced National Wetlands Inventory data. *Wetlands*, 25, 405–19.
63 Miller, N., T. Bernthal, J. Wagner, M. Grimm, G. Casper, & J. Kline. (2012). The Duck-Pensaukee Watershed Approach: Mapping Wetland Services, Meeting Watershed Needs. Madison, WI: The Nature Conservancy & Washington, DC: Environmental Law Institute.

NWIPlus data are more widely available for current assessments of wetland functions.[64] While not a standard NWI product, these data are available for many areas including a few states via an online mapping tool posted on the Association of State Wetland Managers website: "Wetlands One-Stop" (http://aswm.org/wetland-science/wetlands-one-stop-mapping). Landscape-level wetland functional assessments are available for two states – DE and CT and in progress for MA, NJ and RI plus many other geographic areas including Long Island (NY), several watersheds in New York, southern Vermont, coastal New Hampshire, James River watershed (VA), Lake Erie watershed and Delaware River coastal zone (PA), much of Maryland (Potomac River east), Horry and Jasper County (SC), the coast of Mississippi, Corpus Christi area (TX), Shirley Basin area (WY), and Ventura River watershed (CA). Several states - including Michigan, Minnesota, Montana, New Mexico, and Oregon - are also creating or planning to create NWIPlus databases on a watershed basis.[65]

Historical ecology analysis to inform wetland restoration priorities

San Gabriel River Watershed Historical Analysis. Researchers analyzed multiple, historical documents and maps in the San Gabriel River watershed in southern California, a landscape with heavily modified geomorphology and hydrology from the development of dams, infiltration areas, and channelization.[66] The product of this analysis is a depiction of wetland extent and classifications with a confidence rating for the historical presence of these features throughout this watershed. A map of average wetland conditions from 1850-1890 was constructed based on primary sources, such as historical land grant sketches, soil survey maps, and irrigation maps, and secondary sources, such as oral histories of floods. When compared with current wetland maps, this historical ecological analysis reveals wetland change by type throughout the watershed. This detailed historical analysis can correct misconceptions regarding the historical representation of certain wetland types and subsequent restoration or conservation goals that are based on these misconceptions. The historical ecological analysis can "provide a template for restoration and conservation by illuminating the areas most conducive to reestablishment of wetland and riparian habitats; identifying where the greatest losses have occurred, both geographically and in terms of specific habitat types; providing an understanding of factors affecting local habitats and how they have adapted to changes in the landscape; and highlighting historical wetland areas with significant, often unrecognized, potential for restoration and enhancement."[67] (see *Figure 9*)

64 Tiner, R.W., K. McGuckin, L.D. Roghair, S. Weaver & J. Christie. (2013). Wetlands One-Stop Mapping: providing easy online access to geospatial data on wetlands and soils and related information. *Wetland Science and Practices*, 30(1), 22-30.
65 Tiner, R.W., K. McGuckin, L.D. Roghair, S. Weaver & J. Christie. (2013). Wetlands One-Stop Mapping: providing easy online access to geospatial data on wetlands and soils and related information. Wetland Science and Practices, 30(1), 22-30.
66 Stein, E.D., A. Dark, T. Longcore, R. Grossinger, N. Hall & M. Beland. (2010). Historical ecology as a tool for assessing landscape change and informing wetland restoration priorities. *Wetlands*, 30(3), 589–601.
67 *Ibid.*

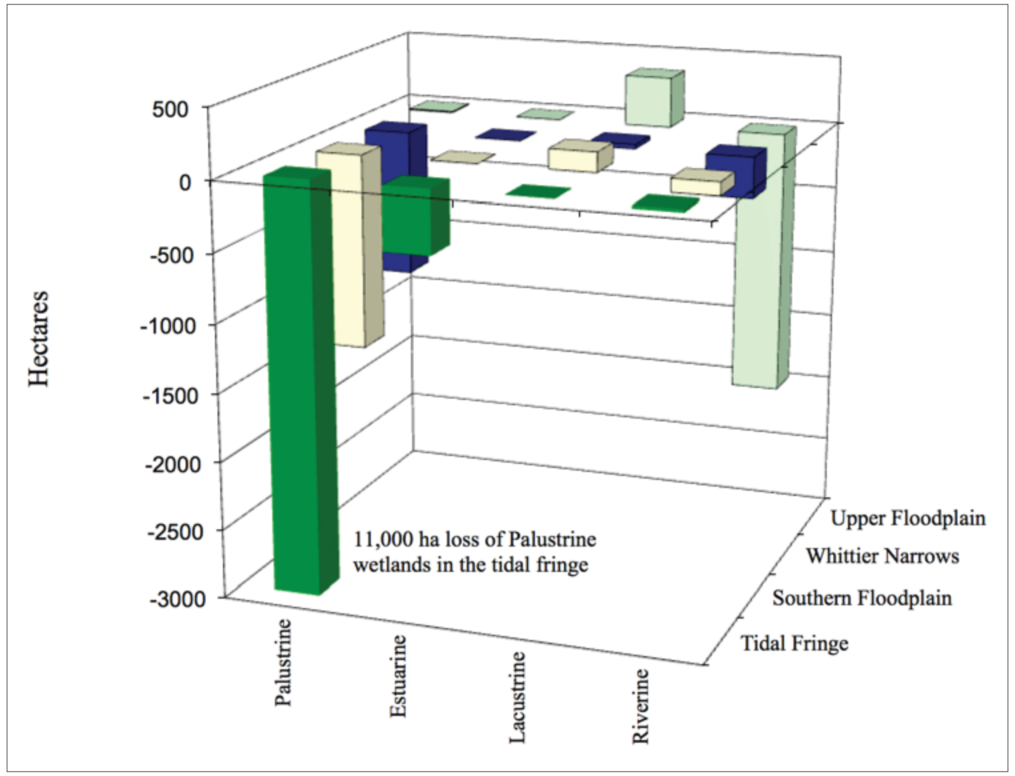


Figure 9: Wetland loss (or gain) by Cowardin class in San Gabriel River watershed, California. Stein, E. D., Dark, S., Longcore, T., Grossinger, R., Hall, N., & Beland, M. (2010). Historical ecology as a tool for assessing landscape change and informing wetland restoration priorities. Wetlands, 30(3), 589-601.

Analysis of current condition

Use of watershed metrics

There are several approaches that use indicators of aquatic resource health or impairment to compare or relatively rank the current state of the resources in a watershed. These approaches rate condition of a given resource relative to other similar resources within the watershed, and may not measure the absolute condition of a given planning unit or quantify the resource's functionality or composition.

North Carolina EEP River Basin Restoration Priority Methodology. In order to gauge the natural resource value of each watershed, the North Carolina Ecosystem Enhancement Program (NCEEP) considers the amount of forested land, land in public or private conservation, riparian buffer condition, high and outstanding quality resource waters, and natural heritage elements (see *Figure 10*). This information is then combined with impairments and opportunities to identify in which subwatersheds to focus management activities.[68]

68 For more information on this methodology, see: EEP River Basin Restoration Priority Methodology. http://portal.ncdenr.org/web/eep/methodology

Targeted Local Watershed Summary Table

Major Streams	14-digit Hydrologic Unit	Area (sq mi)	Land Cover: % Developed Area	Land Cover: % Agriculture	Stream Miles on Draft 2008 303(d) List	HQW & ORW Stream Miles	WSW Stream Miles	% of Streams with Trout Classification	# of NHEOs	% of Land in Conservation	% of Streams with Forested Buffer	Land Cover: % Forest & Wetland
Hiwassee R, Sweetwater Cr	06020002080010	27	9	20	0	0	72	0	6	1	66	71
Brasstown Cr	06020002080010	36	5	16	0	0	164	0	4	6	76	78
Unnamed tributaries to Hiwassee R	06020002090020	2	6	19	0	0	8	0	6	6	74	74
Upper Valley R	06020002100010	42	5	3	0	15	0	58	13	56	69	92
Middle Valley R	06020002100020	62	7	8	~5 miles of the Valley R	3	18	48	16	32	65	85
Lower Valley R	06020002100030	16	15	8	~3 miles of the Valley R	0	4	45	9	15	77	77
Peachtree Cr	06020002100040	22	6	14	0	0	7	0	9	23	78	79
Mission Cr	06020002100050	4	9	22	0	0	18	0	8	15	71	69
Martins Cr	06020002170010	12	8	14	0	0	0	0	3	6	68	77
Persimmon Cr	06020002180010	80	4	5	~6 miles of Persimmon Cr	0	0	47	12	38	78	85
S. Shoal, N. Shoal, Camp Cr	06020002180020	50	3	4	0	0	0	43	5	28	85	90

*2001 TLW=targeted local watershed in 2001 plan; LWP=local watershed plan
Other table acronyms: WSW=DWQ Water Supply Watershed; HQW=DWQ High Quality Water; ORW=DWQ Outstanding Resource Water; NHEO=Natural Heritage Element Occurrence, as maintained by the NC Natural Heritage Program

Figure 10: North Carolina Ecosystem Enhancement Program watershed metrics. Used with permission from Tim Baumgartner, North Carolina Ecosystem Enhancement Program.

EPA Recovery Potential Screening Tool. The EPA Recovery Potential Screening Tool is a method for comparing the relative restorability of large numbers of water bodies. The method measures, for each water body or watershed, several ecological, stressor, and social context indicators that are associated with the likelihood that a restoration effort may succeed. The planning framework, applicable throughout the U.S., includes a list of indicators from which partners can choose a suite of indicators relevant to their watershed.[69]

Puget Sound Characterization Project. The Puget Sound Characterization Project evaluates the current condition of water resources (both water flow and water quality) and fish and wildlife habitats over the entire drainage area of Puget Sound. The assessments provide a watershed-scale perspective on the relative importance of small watersheds (~ 1–10 square miles or up to a few tens of square kilometers) for the protection and restoration of water resources and habitats that is not generally provided by other available tools. Water flow condition incorporates the current ability of the watershed to move water by assessing the watershed in its current impacted state (Level of importance), in contrast with the how the watershed would move water without considering current human impacts (Level of impact). This allows mapping of the assessment units relative to one another within a land use potential matrix (see *Figures 11 and 12*).[70]

69 For more information on this methodology, see: EPA Watershed Recovery Potential Screening. http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/recovery/overview.cfm

70 For more information on this methodology, see: Puget Sound Characterization Project. http://www.ecy.wa.gov/puget_sound/characterization/index.html

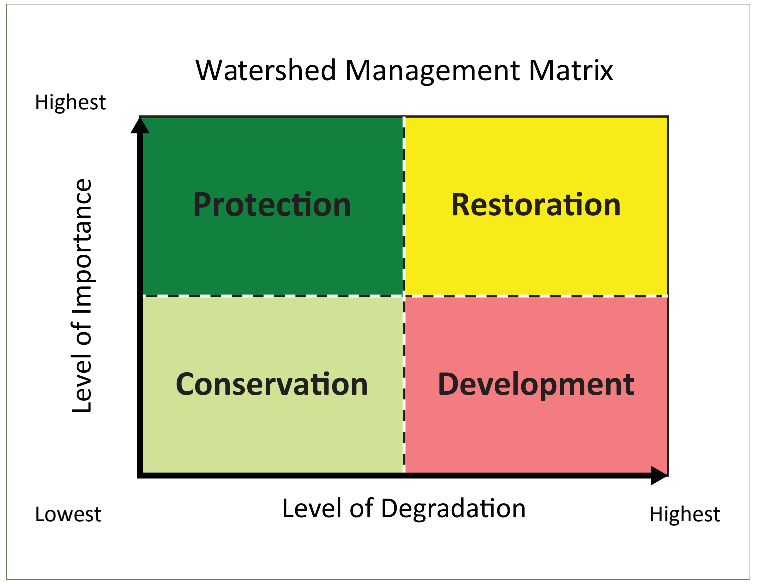


Figure 11: Puget Sound Characterization Watershed Management Matrix. Washington Department of Ecology. 2010. Puget Sound Watershed Characterization: Introduction to the Water Flow Assessment for Puget Sound. Publication No. 10-06.014. www.pointblue.org/sfbayslr

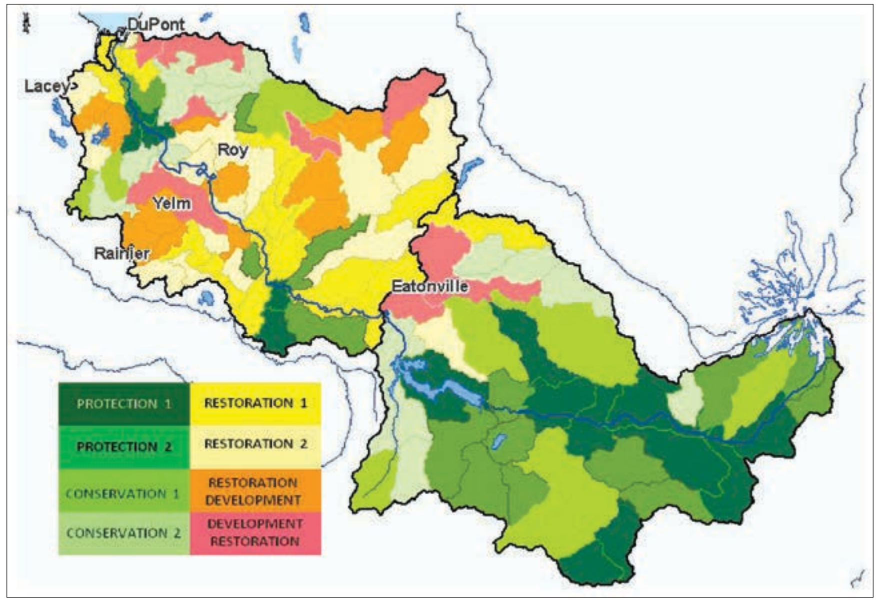


Figure 12: Puget sound characterization watershed map. Washington Department of Ecology. 2010. Puget Sound Watershed Characterization: Introduction to the Water Flow Assessment for Puget Sound. Publication No. 10-06.014. www.pointblue.org/sfbayslr

Kentucky In-Lieu Fee Compensation Planning Framework. The Kentucky In-Lieu Fee Compensation Planning Framework includes a section on Resource Status, which covers historic impacts, current condition, and threats. The majority of the current condition information comes from an analysis of the state 305 and 303(d) reports. There is an assessment for each watershed on how many miles of waters are attaining their aquatic life use criteria and a summary of the most common types of impairments. The repair/removal of these impairments is then the focus of mitigation projects in the watershed. The state wildlife action plan and the location of federal and state listed endangered and threatened species are also considered in assessing the current condition of the target watershed.[71]

Use of watershed metrics

Natural Habitat Integrity Indices. The following is an example of watershed condition indices developed for Maryland's Nanticoke and Coastal Bays watersheds (Tiner 2004) and applied to the Hackensack River watershed (Tiner and Bergquist 2007). They were also later used by the U.S. Fish and Wildlife Service to produce a regionwide watershed assessment for the Midwest Region and adapted by the State of Virginia in their watershed integrity model for a statewide analysis (Ciminelli and Scrivani 2007) and the State of Montana for watershed assessments (e.g., Vance and Stagliano 2007).

<u>Natural Habitat Integrity Indices</u>. These indices were designed to meet four of the following requirements: 1) be derived from air photointerpretation and/or satellite image processing for contemporary data and from maps for historical data, 2) be suitable for frequent updating and rapid assessment, 3) consist of metrics that could efficiently and cost effectively be updated for large geographic areas, 4) present a broad view of the condition of "natural habitat," and 5) provide a historic perspective on the extent of wetlands and open waterbodies. Such indices represent coarse-filter variables for assessing the overall condition of watersheds. They were intended to augment, not supplant, other more rigorous, fine-filter approaches for describing the ecological condition of watersheds (e.g., Index of Biological Integrity for instream macroinvertebrates and fish, and the extent of invasive species) and for examining relationships between human impacts and natural resources.

The variables chosen for indexing included: 1) extent of "natural" habitat, 2) condition of river and stream corridors, 3) condition of wetland buffers, 4) condition of pond and lake buffers, 5) present extent of wetlands relative to historic area, 6) present extent of standing waterbodies relative to historic area, 7) amount of stream channelization, 8) extent of river/stream damming, 9) the amount of wetland disturbance (e.g., drained, excavated, impounded, and farmed wetlands), and 10) the degree of habitat fragmentation by roads. These variables represent features important to natural resource managers attempting to lessen the impact of human development on the environment.

Based on these variables, eleven indices were created: six addressing habitat extent (i.e., the amount of natural habitat occurring in the watershed and along wetlands and waterbodies), four dealing with habitat disturbances (emphasizing human-induced alterations to streams, wetlands, and terrestrial habitats), and one composite index.

71 For more information on this methodology, see the Kentucky In-Lieu Fee Program Agreement. http://fw.ky.gov/pdf/inlieumitigationfeeagreement.pdf

The six "natural" habitat extent indices are "natural" cover, river-stream corridor integrity, vegetated wetland buffer integrity, pond and lake buffer integrity, wetland extent, and standing waterbody extent. The four "habitat disturbance indices" involve dammed stream flowage, channelized stream flowage, wetland disturbance, and habitat fragmentation by roads. The last index - "composite natural habitat integrity index" - is comprised of the weighted sum of all the other indices, with the disturbance indices subtracted from the habitat extent indices to yield an overall natural habitat integrity score for a watershed or subbasin. All indices have a maximum value of 1.0 and a minimum value of zero. For the habitat extent indices, the higher the value, the more habitat available. For the disturbance indices, the higher the score, the more disturbance.

Watershed profiling to characterize the abundance, types, and condition of aquatic resources

Watershed profiling is a method that creates a balance sheet of the abundance, distribution, and condition of wetlands and water resources in a watershed. This tabular information can then be used to paint a picture of what is abundant and what is missing in a watershed.

Colorado Blue River Watershed. In the Blue River Watershed in Colorado, researchers mapped the abundance, distribution and location of different types of water resources and created a tabular accounting of this information. Graphs were created that depict the abundance of the different classes of wetlands within three different landscape types present in the watershed. The planners then compared the graphs from areas with high development impact and reference areas with little impact. Mitigation could then focus on more heavily impacted wetland types in a given landscape.[72]

Water quality analysis and modeling

The current condition of water quality of every waterbody within an entire watershed can be difficult to collect and assess. Site-specific water quality monitoring of the chemical composition of even a network of waterbodies can only give a small picture of the current condition of a watershed. There are a number of different models available that can characterize the water quality of a watershed based on a suite of currently available data.

USGS SPARROW. The USGS has developed SPARROW (Spatially Referenced Regressions on Watershed attributes), a model designed to allow users to interpret water-quality monitoring data. "The model relates in-stream water-quality measurements to spatially referenced characteristics of watersheds, including contaminant sources and factors influencing terrestrial and aquatic transport. SPARROW empirically estimates the origin and fate of contaminants in river networks and quantifies uncertainties in model predictions."[73] To make the results of SPARROW usable, USGS has created an interactive mapping tool and online interactive decision support system for six regions of the United States. The interactive mapping tool that provides detailed modeled information on the point and non-point loads of nitrogen and phosphorus in catchments, as well as the source of the loads (see *Figure 13*). The outputs are useful in characterizing the water quality of basins that are around 1500 sq. km. or greater in size.[74]

72 Sumner, R., J.B. Johnson & J. Lemly. (2010). Demonstrating Use of the Watershed Approach for Wetland Compensatory Mitigation in Colorado. National Wetlands Newsletter, 32(6), 11-13.
73 Robertson, D. M. & D.A. Saad. (2011). Nutrient Inputs to the Laurentian Great Lakes by Source and Watershed Estimated Using SPARROW Watershed Models. *Journal of the American Water Resources Association*, 47(5), 1011–1033.
74 For more information on SPARROW, see: USGS. SPARROW Surface Water-Quality Modeling: SPARROW Frequently Asked

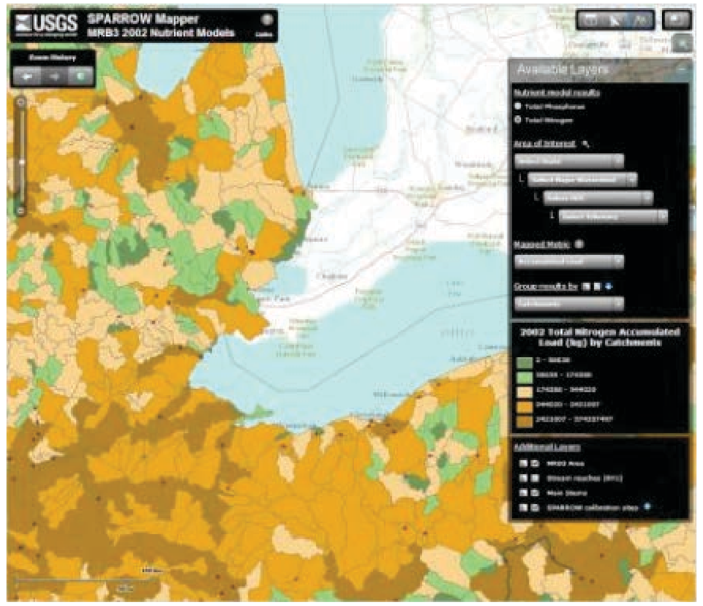


Figure 13: SPARROW Mapper Nutrient Model. Robertson, D.M. and Saad, D.A., 2011, Nutrient inputs to the Laurentian Great Lakes by source and watershed estimated using SPARROW watershed models: Journal of the American Water Resources Association. v. 47, p. 1011-1033, DOI: 10.1111/j.1752-1688.2011.00574.x.

Habitat and ecological functions modeling

There are many data sets that can be incorporated into a watershed plan that identify locations of certain species of plants and animals. However, many of these datasets, such as statewide herpetology atlases or plant atlases, only identify the location of certain taxa. Others, such as the state natural heritage programs, only identify the locations of at-risk species and threatened ecosystems.[75] These programs also only identify the location of these species in areas that have been inventoried. They do not predict where these species may occur in areas not yet inventoried.

Milwaukee River Basin Wildlife Tool. In the Milwaukee River Basin, a Wildlife Tool was developed to identify areas in the landscape that are needed by certain "umbrella" wildlife species that, based on their habitat and life history requirements, are representative of the habitats in the watershed.[76] The approach is built around a "wildlife matrix" (see *Figure 23*), in which species experts 1) identify the correct umbrella species to represent the critical habitats in the watershed, and 2) rank all of the mapped habitat types in the watershed for their suitability as habitat for each umbrella species.

Questions.http://water.usgs.gov/nawqa/sparrow/FAQs/faq.html#21

75 For more on natural heritage programs, and links to the state programs, see: NatureServe. http://www.natureserve.org

76 Kline, J., T. Bernthal, M. Burzynski & K. Barrett. (2006). Milwaukee River Basin Wetland Assessment Project: Developing Decision Support Tools for Effective Planning. DRAFT Final Report to the U.S. Environmental Protection Agency, Region V. Retrieved April 11, 2014, from: http://dnr.wi.gov/topic/wetlands/documents/Mukwonago_Version_MRPWAP_August_17.pdf

Analysis of future threats

Identifying watershed needs based on analysis of future threats

California Road Impact Footprint Analysis. State departments of transportation often conduct detailed planning to identify projects, impacts, and potential compensatory mitigation projects well into the future. These plans can provide information on potential future threats that could be incorporated into a watershed planning effort. The California Department of Transportation (Caltrans), for example, created a Road Impact Footprint Analysis[77] tool to forecast mitigation needs for state road projects. Through this analysis, proposed projects are identified and the tool provides information on the biological resources expected to exist in the area, as well as the potential impacts to these resources from the proposed Caltrans projects (see *Figure 14*).

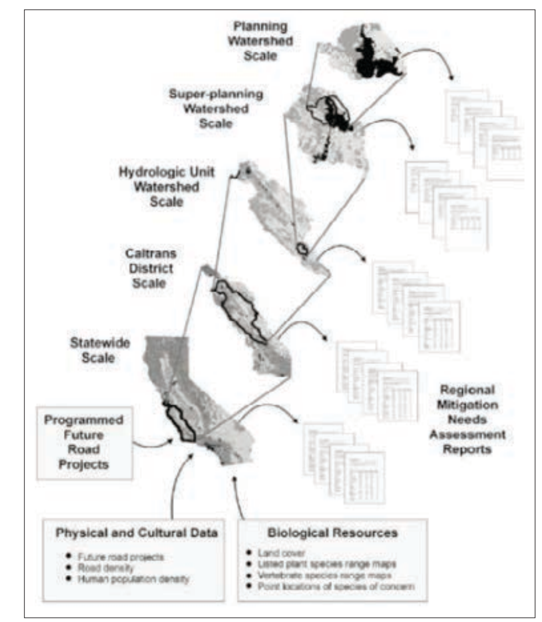


Figure 14: CalTrans Road Impact Footprint Analysis. Used with permission from Dr. Jim Thorne, U.C. Davis.

Tennessee Stones River Watershed Analysis. In Tennessee, The Nature Conservancy and the Environmental Law Institute developed a watershed analysis of the Stones River Watershed that takes into account future anticipated development trends. This analysis relied upon land use zoning information, as well as population growth and land conversion trajectories, to develop a map of the projected land cover change in the watershed. The results were used to evaluate whether potential restoration sites were likely to be sustainable and persist over time, based on the likelihood that the surrounding landscape would be developed.

77 Thorne, J.H., E.H. Girvetz & M.C. McCoy. (2007). A Multi-Scale and Context Sensitive State-Wide Environmental Mitigation Planning Tool for Transportation Projects in California. University of California-Davis: John Muir Institute of the Environment. Retrieved April 11, 2014, from: http://escholarship.org/uc/item/9bh201bp#

Stakeholder input

Expert/stakeholder collaboration to identify watershed needs

North Carolina EEP Watershed Needs Assessment Team. The North Carolina Ecosystem Enhancement Program (NCEEP) solicited input from its multi-agency Watershed Needs Assessment Team (WNAT) to identify and define ecosystem functions that should serve as the basis of efforts to screen and select priority watersheds in which to focus mitigation resources in North Carolina.[78] The outcome of this collaboration was the identification of water quality, hydrology, and habitat as important functions to consider as part of its River Basin Restoration Priorities screening process (see *Table 7*). For this screening process, NCEEP evaluates HUC-14s in terms of these target functions in addition to watershed problems, assets, and opportunities.

78 North Carolina Department of Environment and Natural Resources, Ecosystem Enhancement Program. (2010). Report from the Watershed Needs Assessment Team to the Mitigation Coordination Group. Retrieved April 16, 2014, from: http://www.nceep.net/news/reports/WNAT Mit Group Final.pdf

2.1: Identify Watershed Needs

Water Quality	Hydrology	Habitat
Element Cycling and Spiraling Abiotic and biotic processes that convert elements from one form to another within a watershed.	**Subsurface Water Storage** Availability of water storage beneath the surface.	**Definition** Habitat is all of the physical, biological and chemical characteristics necessary to maintain an organism's viability.
Removal and Transport Of nutrients, contaminants, sediment and/or other elements or compounds.	**Moderation of Groundwater Flow or Discharge** Capacity of a watershed to moderate rate of groundwater flow or discharge from upgradient sources.	**Maintain Characteristics Plant Distribution and Abundance** The emphasis is on dynamics, structure, species composition and physical characteristics of the plan community (upland, wetland and aquatic).
Retention Of nutrients, contaminants, sediment and/or other elements or compounds.	**Surface Water Flow or Discharge** Capacity of a watershed to moderate surface water flow and energy from upgradient sources.	**Maintain Characteristic Animal Distribution and Abundance** The emphasis is on the dynamics, spatial distribution and species composition of the animal communities (terrestrial, semi-aquatic, aquatic).
Thermal Regulation Absorption, storage and dissipation of thermal energy.	**Dynamic Surface Water Storage** Capacity of a watershed to detain moving water from overbank flow for a short duration when flow is out of the channel; associated with moving water from overbank flow and/or upland surface water inputs by overland flow or tributaries.	**Physical Habitat Characteristics** Maintain interspersion, connectivity, temporal dynamics and spacial structure of the physical habitat.
	Long-term Surface Water Storage The capability of a watershed to temporarily store (retain) surface water for long durations; associated with standing water not moving over the surface. Water sources may be overbank flow, overland flow and/or channelized flow from uplands or direct precipitation.	

Table 7: EEP's multi-agency Watershed Needs Assessment Team collaborated to identify and define the above watershed functions. These functions would be used as the basis for identifying watershed needs across HUC-14 watersheds.

Georgia GIS Watershed-Based Planning Tool. In Georgia, under the direction of the Georgia Environmental Protection Division, a stakeholder input was used to identify watershed objectives that would inform development of a GIS-based tool for locating mitigation banks. In the first stage of this process, a technical steering committee identified prioritization objectives to be targeted for compensatory wetland mitigation based on regulatory, planning, and management considerations. The committee, which was composed of representatives from state and federal agencies, non-governmental organizations, and forest product industry groups, identified nine total objectives. These included water quality and quantity, flood control and flow regulation, biodiversity conservation, connectivity, ease of restoration, education, recreation, scenic value, wildlife habitat. The group then developed a GIS-based modeling tool that generated a map that ranked areas across the landscape in terms of their ability to achieve these objectives.[79]

The Nature Conservancy's (TNC) Aquatic Ecoregional Assessment method. As part of The Nature Conservancy's Aquatic Ecoregional Assessment method, TNC staff identified landscape needs for the Central Appalachian Forest Ecoregion at the scale of the Ecological Drainage Unit (EDU). TNC developed EDUs by aggregating HUC-8 watersheds sharing a common zoogeographic history and local physiographic and climatic characteristics. For each EDU, TNC staff identified a set of "conservation targets" composed of priority ecosystems, communities, and species identified at both fine scales (e.g., rare and endangered species) as well as coarse scales (e.g., large river systems) (see *Figure 15*). TNC then evaluated the "viability" of each conservation target by assessing its size, condition, and landscape context using various GIS datasets. It also held workshops to solicit input from experts familiar with each ecoregion to obtain data for target occurrences that were not readily available. These included data on stocking, channelization, invasive species, non-point source pollution, dam operation, and local water withdrawals.[80] One application of this approach is the identification of service areas and the development of the compensation planning framework for the VA Aquatic Resources Trust Fund, a state-wide In Lieu Fee program in VA.

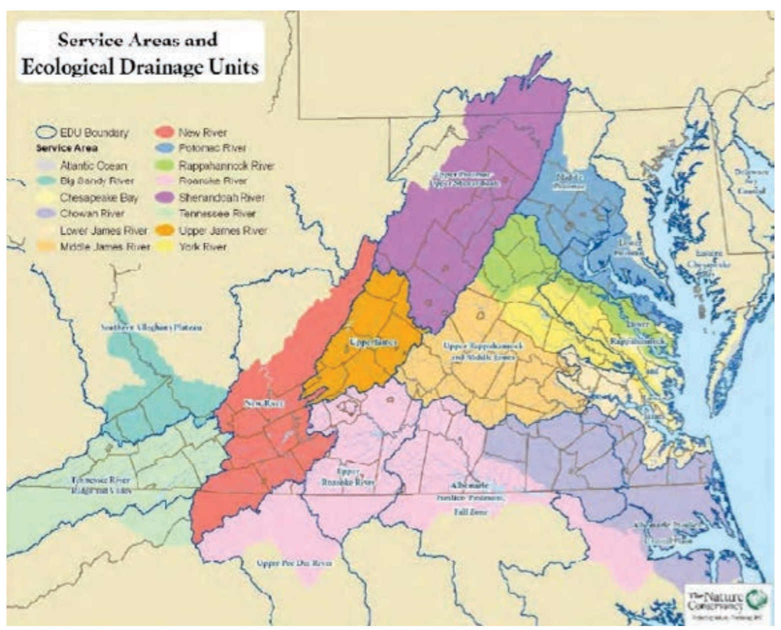


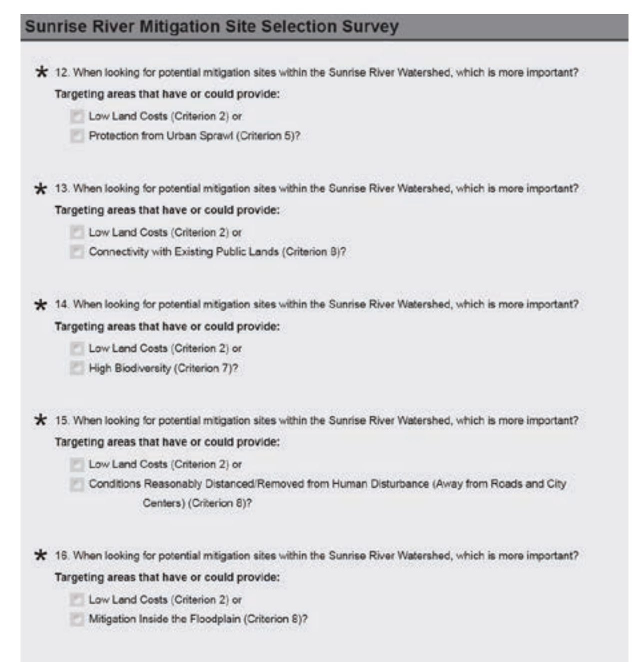
Figure 15: TNC's Aquatic Ecoregional Assessment solicited expert input to identify conservation targets within EDUs and assess their viability. Used with permission from Karen Johnson, The Nature Conservancy.

79 Kramer, E.A. & S. Carpenedo. (2009). A statewide approach for identifying potential areas for wetland restoration and mitigation banking in Georgia: An ecosystem function approach. *Proceedings of the 2009 Georgia Water Resources Conference.* Retrieved April 11, 2014, from: http://www.gwri.gatech.edu/sites/default/files/files/docs/2009/2.6.1_Kramer.pdf
80 See the chapter on standard methods for aquatics: Olivero, A.P. (author) and M.G. Anderson, and S.L. Bernstein (editors). (2003). Planning methods for ecoregional targets: Freshwater aquatic ecosystems and networks. The Nature Conservancy, Conservation Science Support, Northeast & Caribbean Division, Boston, MA.

Multi-Criteria Decision Analysis

Minnesota Sunrise River Watershed-Based Mitigation Pilot. As part of its Sunrise River Watershed-Based Mitigation Pilot, the U.S. Army Corps of Engineers used stakeholder input obtained from workshops and web-based surveys to inform the development of a GIS-based tool for identifying priority sites for wetland mitigation projects. Central to this approach was the Corps' application of the Analytic Hierarchy Process (AHP), a form of Multi-Criteria Decision Analysis (MCDA), which analyzes stakeholder responses to a series of pair-wise comparisons. MCDA methods such as AHP provide a transparent, structured decision-making process for identifying stakeholder preferences based on complex, disparate, and conflicting preference data.

In a series of workshops, the stakeholder team collaborated to develop a framework for selecting mitigation sites that would best meet watershed needs. As part of this process, the stakeholder team selected criteria that it considered to be most important for targeting wetland compensation mitigation efforts within each subwatershed. Ten criteria important for evaluating watershed needs were identified, including hydrologic connection to tributaries, land costs, and potential to reconnect riparian buffers. Following the workshops, stakeholders completed a web-based survey in which they ranked selected criteria against one another in a series of pairwise comparisons (see *Figure 16*). Using the AHP, the Corps analyzed survey results to determine overall importance values for each criterion, which were in turn used to determine the weightings for each criterion in the Corps' Spatial Decision Support System GIS-based prioritization model. The survey was completed online, rather than as a group, to minimize bias and avoid concerns related to "groupthink."[81]


Sunrise River Mitigation Site Selection Survey

* 12. When looking for potential mitigation sites within the Sunrise River Watershed, which is more important?
Targeting areas that have or could provide:
- Low Land Costs (Criterion 2) or
- Protection from Urban Sprawl (Criterion 5)?

* 13. When looking for potential mitigation sites within the Sunrise River Watershed, which is more important?
Targeting areas that have or could provide:
- Low Land Costs (Criterion 2) or
- Connectivity with Existing Public Lands (Criterion 8)?

* 14. When looking for potential mitigation sites within the Sunrise River Watershed, which is more important?
Targeting areas that have or could provide:
- Low Land Costs (Criterion 2) or
- High Biodiversity (Criterion 7)?

* 15. When looking for potential mitigation sites within the Sunrise River Watershed, which is more important?
Targeting areas that have or could provide:
- Low Land Costs (Criterion 2) or
- Conditions Reasonably Distanced/Removed from Human Disturbance (Away from Roads and City Centers) (Criterion 6)?

* 16. When looking for potential mitigation sites within the Sunrise River Watershed, which is more important?
Targeting areas that have or could provide:
- Low Land Costs (Criterion 2) or
- Mitigation Inside the Floodplain (Criterion 8)?

Figure 16: The Corps used web-based surveys to solicit the stakeholder team for weightings to apply in the SDSS prioritization model for each criterion identified by the team in the workshops. Used with permission from Tim Smith, St. Paul Corps.

81 Smith, T. & T. Mings. Watershed Based Identification and Evaluation of Compensatory Mitigation Site [webinar]. U.S. Army Corps of Engineers, St. Paul District. See also; Smith, T.J. & K.A. Burks-Copes. (2010). Development of a GIS-Based Spatial Decision Support System to Target Potential Compensatory Mitigation Sites in Minnesota. *National Wetlands Newsletter*, 32(6), 14-15.

Element 2: Identify desired outcomes

Defining watershed outcomes sets the stage for achieving measurable conservation results. By clearly defining a set of conservation outcomes, stakeholders have a clear idea of the goals of a watershed plan and can understand how their project can contribute to achieving that vision.

Southeastern Virginia, Southern Watershed Area Management Plan (SWAMP). This effort includes all five elements of the approach (see Chapter 6). SWAMP is a particularly good example of the value of being as specific as possible in defining watershed desired outcomes.

Southern Watershed Area Management Plan Results			
		Preservation	Restoration
Northwest River	15,888	11,487	4,401
North Landing	24,847	24,647	206
Total acres:	40,746	36,128	4,607
Acres by Funding Sources			
State:	31%	Mitigation:	15%
TNC:	23%	Other Fed:	6%
USFWS:	22%	Local:	3%

Table 8: SWAMP summary of conservation outcomes[82]

An element of the SWMAP, the Conservation Plan[83] developed by the Virginia Department of Conservation and Recreation's Division of Natural Heritage (DCR) and at the request of the Hampton Roads Planning District Commission focused on retaining and restoring intact natural ecosystems and open space, with an emphasis on identifying and protecting conservation corridors. Subsequently a MOU among the parties identified a specific corridor and corridor size as the desired outcome.

Following release of the Conservation Plan, the Planning Commission released a multiple benefits plan, which focuses explicitly on wetlands and stream mitigation approaches. This plan includes a set of watershed profiles and displays GIS information that identifies areas suitable for the development and persistence of wetlands and riparian resources. It also provided a 'decision tree' to guide wetland and stream mitigation decision-making.[84]

The project also helped to galvanize other funding from multiple sources, including compensatory mitigation, to help achieve the conservation vision created by this planning effort. The widely

82 This table is a summary of Steve Martin's analysis of outcomes as of 2010 and was not specified in the plan. Data was first presented at the 2008 SWS conference & then updated for a presentation on a national webinar on the Eco-Regional approach sponsored by FHwA in July 2010

83 Virginia Department of Conservation and Recreation, Division of Natural Heritage. (February 2001). Conservation Plan for the Southern Watershed Area. Natural Heritage Technical Report 00-12.

84 LandMark Design Group, Inc. (July 2001). Multiple Benefits Conservation Plan. Prepared for the Hampton Roads Planning District Commission. Figure 7, "Site Search Process."

collaborative process, which was part of a larger effort to protect a variety of community values, demonstrates how a conservation effort can fit within the other social and economic goals of an area.

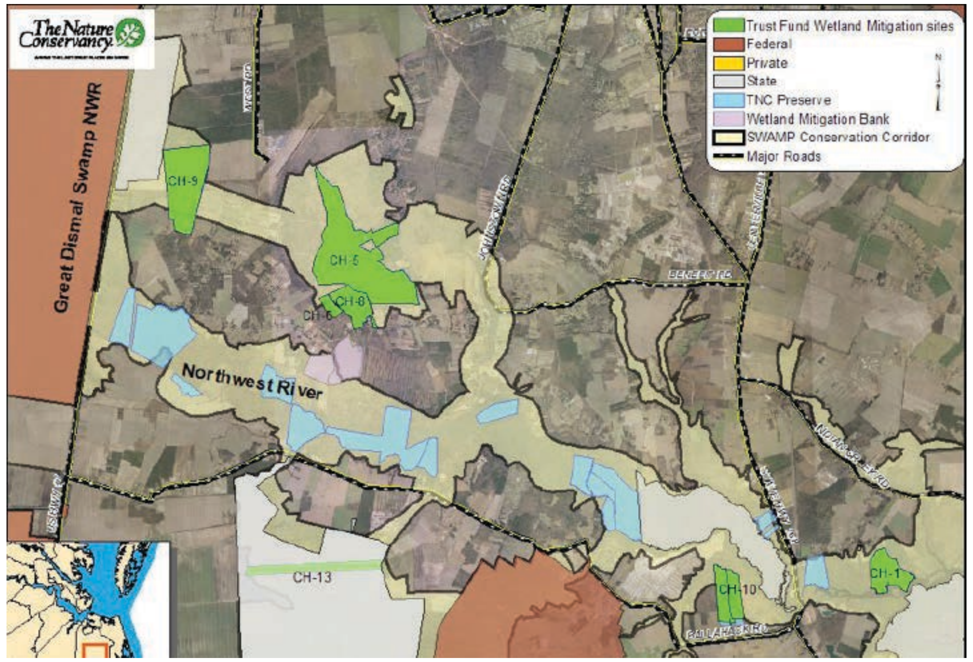


Figure 17: Portion of the "Moderate" SWAMP Conservation Corridor showing many of the conservation projects within the corridor (from VA ARTF 2007 Annual Report, (Attachment B, Conservation Corridor). Used with permission from Karen Johnson, The Nature Conservancy.

Element 3: Identify potential sites

Identify hydrologically sustainable restoration and protection opportunities

Identifying wetland restoration and protection opportunities

Wetland inventories generated by the U.S. Fish and Wildlife Service (FWS) or state, tribal, territorial, or local governments often provide a first resource for identifying existing wetland sites that may be suitable for protection, rehabilitation, or enhancement projects.

National Wetlands Inventory. Since 1974, FWS has administered the National Wetlands Inventory (NWI), which displays the extent, distribution, and types of the nation's wetlands and deepwater habitats. NWI uses the Cowardin classification system[85] to categorize wetlands and deepwater habitats into different systems, classes, and subclasses; this classification system also includes descriptors to indicate water regime, water chemistry, soil, and special modifiers (e.g., partially drained) (see *Figure 18*). NWI maps are generated through photointerpretation of aerial imagery, which may be compared with other data sources such as soil survey maps and the National Hydrography Dataset (NHD), to delineate wetlands, streams, and rivers. NWI maps presently cover about 89% of the contiguous U.S., though maps may be outdated or inaccurate in some regions (e.g., arid western U.S.). NWI does not specifically provide information on functions or quality of the wetland, so is generally used in connection with other data, including data provided in NWIPlus.

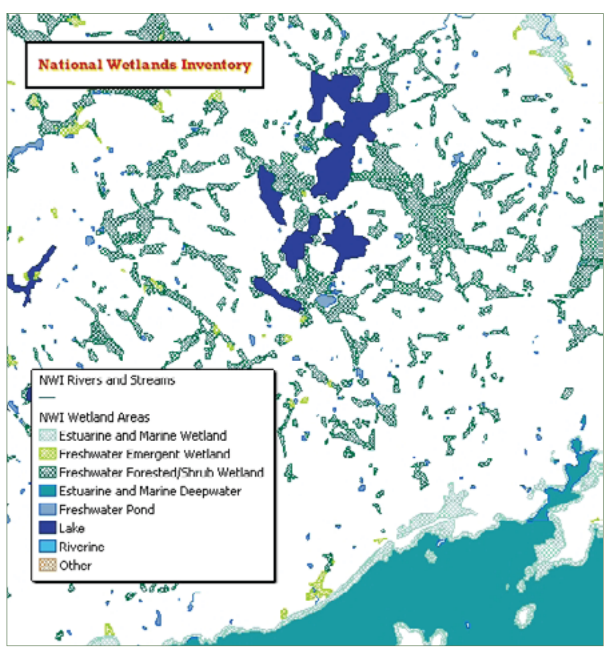


Figure 18: NWI Map from Massachusetts. Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, Information Technology Division

85 Cowardin, L. M., V. Carter, F. C. Golet, & E. T. LaRoe. (1979). Classification of wetlands and deepwater habitats of the United States (Version 04DEC98). Washington, D.C.: U. S. Department of the Interior, Fish and Wildlife Service, Jamestown, ND: Northern Prairie Wildlife Research Center Home Page.

Regional and State Wetland Inventories. Some areas, states, tribes, territories, or local governments may produce their own wetland inventory maps using similar methods, such as the Wisconsin Wetland Inventory (WWI).[86] Some of these inventories may incorporate field data.

National Land Cover Dataset. Beyond wetland-specific inventories, land use/landcover maps may also provide valuable information on the presence of wetlands. For example, the National Land Cover Dataset (NLCD), derived from Landsat imagery, indicates wetland presence and spans the entire nation.[87]

Inventories of Potential Wetland Restoration Sites. These inventories identify potential wetland restoration sites using a combination of aerial imagery, National Wetlands Inventory geospatial data, and USDA soil survey data. Two general wetland restoration categories are classified: type 1 restoration sites (re-establishment, former wetlands that may be restorable given current land use) and type 2 restoration sites (rehabilitation; existing wetlands with some impairment). The former may include effectively drained hydric soils that are in agricultural use, filled wetlands (e.g., dumps and dredge material disposal sites), and former wetlands that are now deepwater habitats. The latter sites include tidally restricted wetlands, farmed wetlands, and wetlands affected by ditches, excavation, or impoundment. The results of these inventories are available via the Association of State Wetland Managers website – "Wetlands One-Stop" (http://aswm.org/wetland-science/wetlands-one-stop-mapping, *Figure 19*).

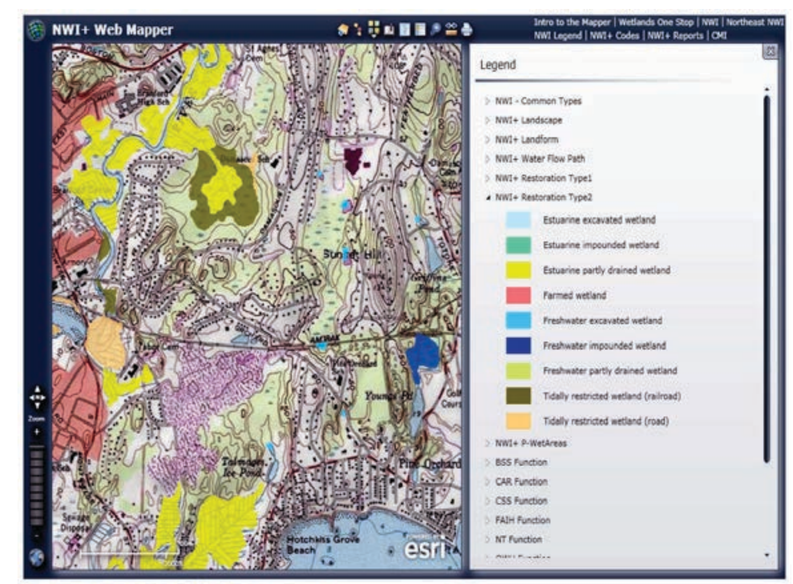


Figure 19: Sample of webmap showing potential type 2 restoration sites (and accompanying legend) for an area in Connecticut. Association of State Wetland Managers.

86 For more information on the Wisconsin Wetland Inventory see: http://dnr.wi.gov/topic/wetlands/inventory.html
87 For more on National Landcover Dataset see the USGS Land Cover Institute at: http://landcover.usgs.gov/natllandcover.php

Identifying stream restoration and protection opportunities

National Hydrography Dataset. The U.S. Geological Survey (USGS) produces National Hydrography Dataset (NHD) maps that provide information on potential stream restoration or conservation sites. NHD maps may be used to separate stream segments for subsequent analysis of their suitability for stream restoration or conservation projects.[88] While NWI includes stream and river maps, NHD provides a network, allowing users to conduct basic analyses of flow downstream or upstream from certain stream segments. This enables users to view hydrologic connectivity between restoration or conservation sites and other parts of the network.[89]

USGS Aquatic Gap Program. The USGS Aquatic Gap Program also produces – in some areas of the country – useful data on aquatic biological diversity and aquatic habitats using spatial analysis and habitat suitability models.[90] This approach generally focuses on watersheds or drainage units and uses physical and biological features to identify unique river and stream species and communities types and then use landscape and other condition data to describe how well protected, or threatened, different community types may be. Such information may be useful to identify areas that are rare or of very high quality and should be considered for protection type projects, help identify stressors to aquatic systems that might be mitigated by wetland and stream restoration projects, and identify areas where specific functions or desired outcomes are likely to be achieved.

Updating or creating new wetland or stream data layers

Where existing wetlands inventories or hydrography datasets are outdated, inaccurate or otherwise insufficient, remote sensing data may be used to identify areas where wetlands or streams are likely to exist.

Playa Lake Joint Venture. In the Midwest, playa lakes are often too small to be represented by NWI. In response to this data gap, the Playa Lakes Joint Venture (PLJV) has conducted GIS analyses[91] to compile its own data layer that displays where playas are likely to occur (see *Figure 20*). PLJV identified probable playas with wet-season Landsat imagery and added soil playas that were evident in the U.S. Department of Agriculture (USDA) Soil Survey Geographic Database (SSURGO) maps.[92] These wetlands types can then be considered for restoration, enhancement, or preservation depending on their condition and whether doing so would help address a watershed need.

Digital Elevation Models. Digital Elevation Models (DEMs) may also be particularly helpful for identifying existing wetland or stream resources not captured in NWI, NHD, or other similar inventories. At a national scale, USGS distributes DEM maps that can be analyzed with GIS to identify hydrologic sinks indicative of wetlands or to identify surface hydrologic flow patterns

88 Strager, M.P., J. T. Anderson, J.D. Osbourne & R. Fortney. (2011). A three-tiered framework to selection, prioritize, and evaluate potential wetland and stream mitigation banking sites. *Wetlands Ecology and Management,* 19(1), 1-18.
89 For more on the National Hydrography Dataset see: http://nhd.usgs.gov
90 For more on The Aquatic Gap Program see the USGS Aquatic Gap Program site at: http://gapanalysis.usgs.gov/aquatic-gap/
91 For more information on the Playa Lakes Joint Venture GIS methodology see: http://www.pljv.org/about/23-partners/partners-gis-tools
92 For more on the Soil Survey Geographic Database see: http://soils.usda.gov/survey/geography/ssurgo/

indicative of streams. At the local level, such as county or city level, higher-resolution elevation data may be available, such as that captured using LiDAR. Using these data, DEMs can be created that more accurately locate existing wetlands and streams.[93] Finding such areas that are not shown as wetland as streams can provide information on sites that can be considered for restoration or protection.

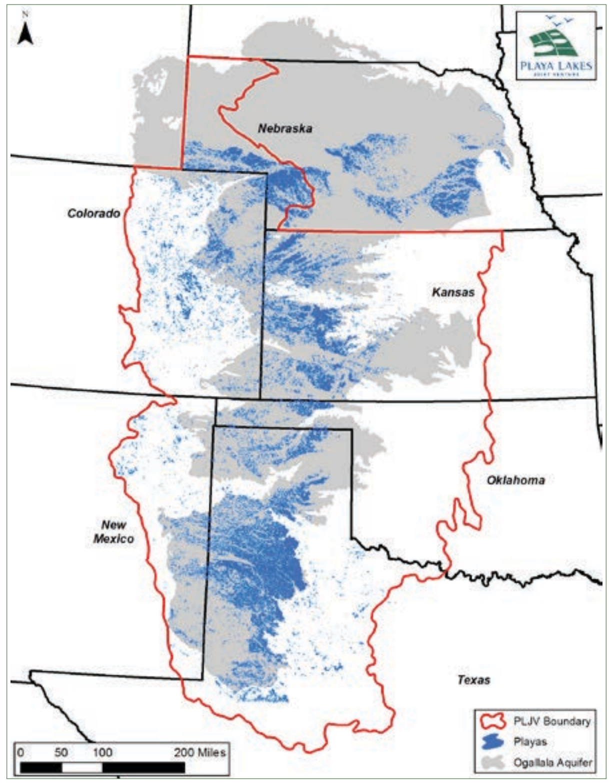


Figure 20: Probable playas in Ogallalla Aquifer region, Playa Lakes Joint Venture. Used with permission from Alex Daniels, Playa Lakes Joint Venture.

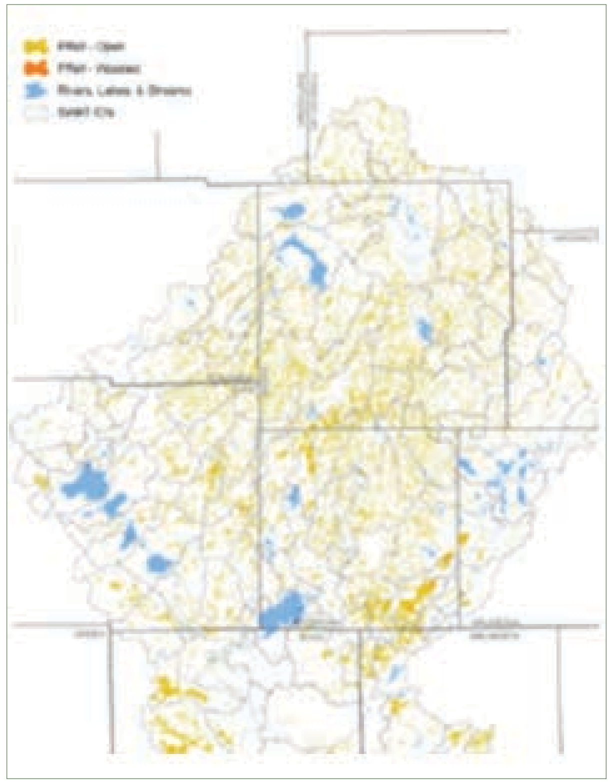


Figure 21: PRW map, Rock River Basin, WI. Used with permission from Tom Bernthal, Wisconsin Department of Natural Resources.

Identifying wetland restoration opportunities

Wetlands restoration projects may be more readily established, restored and sustained in former wetlands that have been drained or filled, since, barring major landscape alterations or substantial changes to local hydrology (such as groundwater withdrawal for agricultural or urban use), these sites offer the best chance for reestablishing appropriate wetland hydrology. Previously drained wetlands or other topographic depressions suitable for wetland restoration may be identified by combining multiple GIS data sources in processes termed “vector overlays” (using datasets made up of points, lines, and polygons such as NWI) or “raster stacking” (using pixelated imagery such as Landsat data).

93 For more on USGS Digital Elevation Model data see: http://data.geocomm.com/dem/

Wisconsin Potentially Restorable Wetlands. To screen locations suitable for wetland reestablishment, the Wisconsin Department of Natural Resources identified Potentially Restorable Wetlands (PRW)[94] using a vector overlay analysis. The PRW analysis uses GIS to identify areas that SSURGO maps identify as having greater than 85% hydric soils, WWI does not identify as existing wetlands, that are not located in existing wetlands restoration sites, and that are not located in areas that land cover maps label as "heavy urban" (see *Figure 21*).

Maryland Water Resources Registry. In Maryland, the Maryland Watershed Resources Registry (WRR)[95] uses raster stacking to identify potential wetlands restoration projects by locating areas on poorly drained soils, without forested land cover, and without wetlands land cover.

Missouri Wetland Potential Screening Tool. The Missouri DNR has used the Wetland Potential Screening Tool[96] to identify areas with the greatest potential for the restoration or creation of wetlands. It is also, in part, an overlay tool that uses ten different data layers to identify sites. Each layer receives a user-defined weighting, allowing for the customization of the tool to different goals and geographic settings. Additionally, the tool uses a neighborhood analysis to characterize potential sites and an additional analysis to calculate the size of the potential site.

Reestablishing aquatic resources: Identifying stream restoration suitability

Stream Channel and Riparian Channel Indices. Meixler and Bain 2010[97] compiled the first-ever GIS categorization of in-stream and riparian habitat condition and prioritized restoration actions at the stream reach scale with a GIS-based multimetric assessment tool for the East Credit subwatershed in Ontario, Canada. The stream channel condition index (SCCI) was calculated based on land use composition of a reach's drainage basins, road and railroad density within 200 meters of the reach, and stream sinuosity to indicate channelization. The riparian channel index (RCI) was calculated based on convexity fragmentation metrics, patch density, and percent forest in the reach's drainage basin. After calculating the SCCI and RCI metrics and categorizing in-stream and riparian habitat for each reach as poor, fair, or good, the authors merged the SCCI and RCI with data on riparian zone slope (ideally 1-10%), public lands, adjacency to high-quality habitat, and subwatershed position (e.g., headwater tributary) to identify reaches that were generally most suitable for stream restoration. Stream restoration suitability for each reach was determined by categorizing each reach's restoration potential as high, medium, or low; "[f]air quality stream channels on public land, adjacent to high-quality habitat or in the tributary headwaters were ranked to receive special priority, with extra special priority given to reaches meeting two or more of these criteria." The authors compared the SCCI/RCI model to prioritized

94 Bernthal, T. (2001). Integrating Wetland Data Into Watershed Reporting and Management: WDNR Final Report to USEPA. Wetland Grant CD00E50601.
95 For more on the Maryland Resources Registry see: http://watershedresourcesregistry.com/home.html. See also: Bryson, E., R. Spagnolo, M. Hoffmann & W. Seib. (2010). Achieving Ecosystem Health Using a Watershed Approach: The Watershed Resources Registry Pilot Project in Southwestern Maryland. *National Wetlands Newsletter*, 32(3), 8-11; Sumner, R., J.B. Johnson, J. Lemly, M.G. Nepstad, T. Smith, K. Burks-Copes & E. Bryson. (2010). Incorporating the Watershed Approach for Wetland Compensatory Mitigation. *National Wetlands Newsletter*, 32(6), 11-13; and Bryson, E., S. Hertz, R. Spagnolo & W. Seib. (2013). Rollout of the Watershed Resources Registry in Maryland. *National Wetlands Newsletter*, 35(1), 30-31.
96 Weller, M.S. (2008). Headwater Wetlands in Agricultural Areas in Missouri: Final Report to the U.S. EPA Region 7. Missouri Department of Natural Resources Water Resources Center.
97 Meixler, M.S. & M.B. Bain. (2010). Landscape scale assessment of stream channel and riparian habitat restoration needs. *Landscape and Ecological Engineering,* 6(2), 235–245.

rankings generated with field-based rapid geomorphic assessment and rapid stream assessment technique data and found 86% agreement between the two methods.

Arkansas Multi-Agency Wetland Planning Team. The Arkansas Multi-Agency Wetland Planning Team (MAWPT)[98] identified riparian wetlands and associated streams for protection and restoration. They devised a polygon overlay method for identifying floodplain wetlands and areas for potential wetland and stream restoration. By using existing stream, hydric soils, landcover and floodplain layers, they were able to identify stream sections with intact floodplain areas for protection, and adjacent areas for possible restoration (see *Figure 22*).

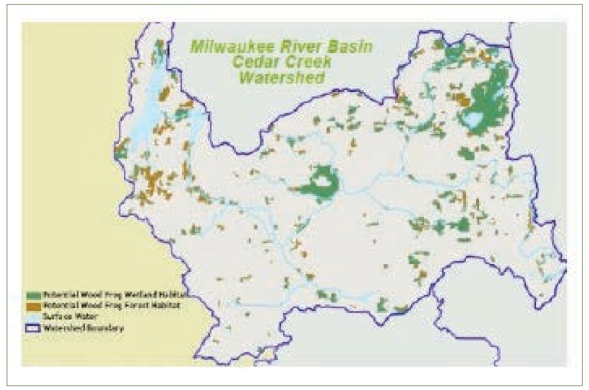


Figure 22: (L) Arkansas MAWPT wetland protection and restoration map. Used with permission from Jennifer Sheehan, Arkansas Game and Fish Commission.
Figure 23: (R) Milwaukee River basin wildlife tool important. Used with permission from Tom Bernthal, Wisconsin Department of Natural Resources

Identifying adjacent uplands important to wetland wildlife

Wisconsin Wildlife Tool. The Wisconsin Department of Natural Resources[99] developed a Wildlife Tool that includes an overlay analysis using hydric soils, wetlands, and an upland landcover layer. This tool identifies not only wetland protection and restoration opportunities, but also upland habitat critical to wetland-dependent species identified as important in the watershed (see *Figure 23*).

98 Layher, W.G. & J.W. Phillips. (2002). Bayou Bartholomew Wetland Planning Area Report. Prepared for the Arkansas Multi-Agency Wetland Planning Team, p. 75.
99 Kline, J., T. Bernthal, M. Burzynski & K. Barrett. (2006). Milwaukee River Basin Wetland Assessment Project: Developing Decision Support Tools for Effective Planning. DRAFT Final Report to the U.S. Environmental Protection Agency, Region V. Retrieved April 11, 2014, from: http://dnr.wi.gov/topic/wetlands/documents/Mukwonago_Version_MRPWAP_August_17.pdf

Determine potential for persistence of sites

Future development trends: Impact of new infrastructure on protection and restoration sites

California Regional Advance Mitigation Planning. Caltrans developed a GIS-based approach for estimating habitat-specific “footprints” of multiple planned government infrastructure projects (e.g., roads) as part of its Regional Advance Mitigation Planning (RAMP) initiative.[100] This method estimates future habitat impacts resulting from planned road projects by applying buffer distances to planned road corridors reflecting the ecologically-relevant spatial extent of impact for each road classification (e.g., a road 30.5m wide impacted a 10m buffer). Caltrans RAMP sums the total area affected for each habitat type across all projects in the study region. This assessment of future impacts is used together with anticipated mitigation ratios for each habitat type to estimate Caltrans’ future mitigation needs. The project combines this information with a compilation of regional conservation goals (termed a “greenprint”), and applies spatial modeling (MARXAN) to identify a portfolio of land parcels that could cost-effectively be acquired to meet compensatory mitigation obligations in advance of the projected impacts (see *Figure 24*).

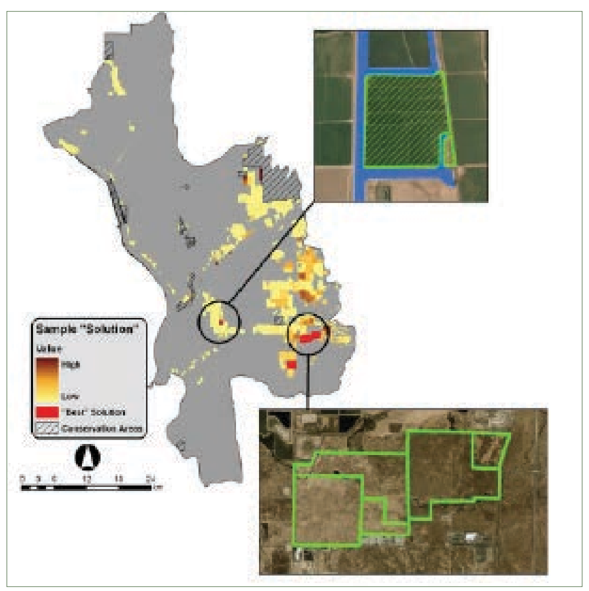


Figure 24: RAMP applies MARXAN to identify priority parcels for mitigation of agency infrastructure projects. Dark brown colored parcels represent those most likely to meet Caltrans’ mitigation needs, while red parcels are “best” solutions that meet mitigation needs at low cost. Used with permission from Dr. Jim Thorne, U.C. Davis.

Georgia GIS Watershed-Based Planning Tool: Human Development Index. Another approach to analyzing future development trends is provided by the Human Development Index (HDI).[101] This tool quantifies the presence of current and future threats within each HUC-12 by reclassifying eight datasets, each representing aquatic resource threats, on a scale of one to nine and adding them to obtain a final HDI score. Examples of threats used to calculate the HDI included percent of impaired streams in each HUC-12 and the change in wetland density between 1974 and 2008.

100 Rivera-Monroy, V.H., B. Branoff, M. Dortch, A. McCorquodale, E. Meselhe & J. Visser. (2012). Nitrogen Uptake Model (Potential for) Technical Report Appendix D-22, Louisiana’s Comprehensive Master Plan for a Sustainable Coast. Baton Rouge, LA: Coastal Protection and Restoration Authority of Louisiana. Retrieved April 11, 2014, from: http://www.lacpra.org/assets/docs/2012 Master Plan/Final Plan/appendices/Appendix D22 - Nitrogen Uptake Potential for Technical Report.pdf

101 Kramer, E.A. & S. Carpenedo. (2009). A statewide approach for identifying potential areas for wetland restoration and mitigation banking in Georgia: An ecosystem function approach. *Proceedings of the 2009 Georgia Water Resources Conference.* Retrieved April 11, 2014, from: http://www.gwri.gatech.edu/sites/default/files/files/docs/2009/2.6.1_Kramer.pdf

Future development trends: Impact of population growth

Tennessee Stones River Watershed Analysis. To help understand the likely future condition of wetlands and streams, the Watershed Planning Approach for the Stones River, Tennessee[102] uses a statewide population growth model to construct a statewide development suitability model, based on land cover type, topographic slope, FEMA flood ratings, land protection status, and accessibility to roads and existing urban centers. This model was then used to spatially allocate projected population changes within the planned growth areas. The result is a spatially explicit projection of future population growth and distribution at 5-year time steps out to the year 2030. Population densities were then calculated from the projections and, using a formula published by the EPA, converted to estimates of percent total impervious area (%TIA). %TIA projections for the year 2030 were then subtracted from those for the year 2000 to give estimates of total projected change in %TIA. *Figure 25* shows areas of the Stones River watershed where increased permit activity may be anticipated, as well as areas where lower degrees of land use change may occur. Both pieces of information are useful in avoidance and minimization analyses, as well as in choosing mitigation sites likely to be more sustainable in the future.

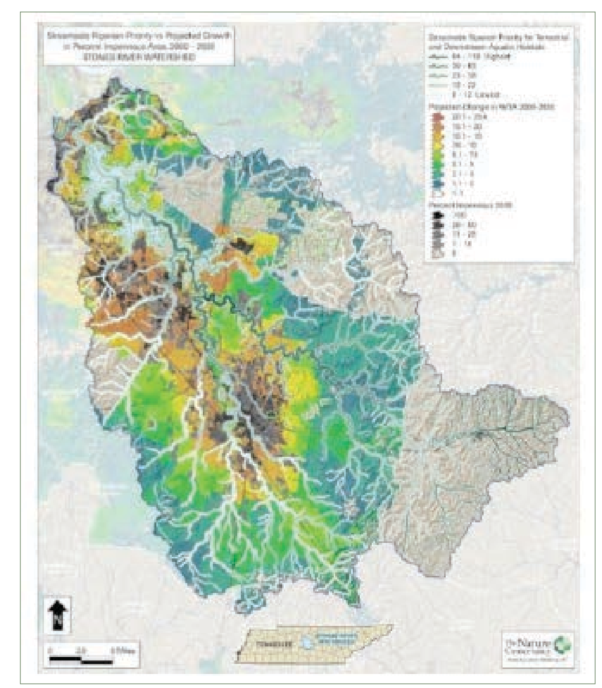


Figure 25: Streamside Priority Areas in relation to areas of projected population growth, Stones River Watershed. Used with permission from Sally Palmer, The Nature Conservancy.

Adaptation to climate change: Sea level rise

Understanding how climate change may impact wetlands and streams through changes in hydrology, land uses, or natural communities, can help determine the likely persistence of a site

102 Palmer, S.R. & J.P. Wisby. (December 2011). Linking Conservation Priorities to Wetland and Stream Mitigation Decisions: A watershed planning approach for the Stones River, Tennessee. Tennessee: The Nature Conservancy. See also: Palmer, S.R. (2013). Linking Conservation Priorities to Wetland and Stream Mitigation Decisions: A Watershed Planning Approach for the Stones River Watershed, Tennessee. *National Wetlands Newsletter,* 35(1), 18-21.

and its desired functions under expected future conditions. For example, understanding potential sea level rise is critical to investing in projects that are likely to be viable under future conditions and not investing in areas that are highly likely to be fully submerged in the foreseeable future. *Future San Francisco Bay Tidal Marshes: a Climate Smart Planning Tool.* In California, a conservation planning tool has been developed that uses a hybrid approach to model tidal marsh inundation and creation based on a range of predicted sea level change.[103] Tidal marsh persistence is dependent on sediment delivery to an area and the accumulation of the organic matter to create areas with the correct elevation in relationship to the tidal water elevation. The tool uses a model to predict this marsh-building process under different sea level rise scenarios. The results of the modeling are mapped at a high spatial resolution for a large number of scenarios combining two sea level rise curves, two sediment assumptions, and two organic accumulation assumptions. The resulting tool (see *Figure 26*), made available through an interactive online map, provides a means to identify the likely sustainability or persistence of a site for protection or restoration on the San Francisco Bay.

Figure 26: Screen capture of the Future San Francisco Bay Tidal Marshes - a Climate-Smart Planning Tool (http://data.prbo.org/apps/sfbslr/). Used with permission from Sam Veloz, Point Blue Conservation Science.

103 Stralberg D, M. Brennan, J.C. Callaway, J.K. Wood, L.M. Schile, et al. (2011). Evaluating Tidal Marsh Sustainability in the Face of Sea-Level Rise: A Hybrid Modeling Approach Applied to San Francisco Bay. *PLoS ONE*, 6(11), 1.

Adaptability to climate change: Changes in species composition

A changing climate will influence factors (e.g., water temperature, water quality, hydroperiod) that determine site suitability for a variety of stream and wetland-dependent species. Understanding these changes can help identify sites that will be viable and provide the expected functions not only today, but also into the future.

Wisconsin Climate Prediction Change Model. Wisconsin Department of Natural Resources developed a model that predicts the change in distribution of 50 different fish species in Wisconsin under several climate scenarios.[104] This modeling included three steps: 1) current fish occurrence and environmental data (landscape position, topography and geology, climate, landcover/land use) were used to create accurate predictive models of occurrence for 50 fish species in Wisconsin; 2) the fish model was used to predict distribution of fish in the state under current climate conditions; and 3) the model was then re-run for three alternate climate scenarios. For watershed planners, this output can provide guidance on the likely persistence of specific biotic assemblages in streams and rivers that may be considered for protection or restoration (see *Figure 27*).

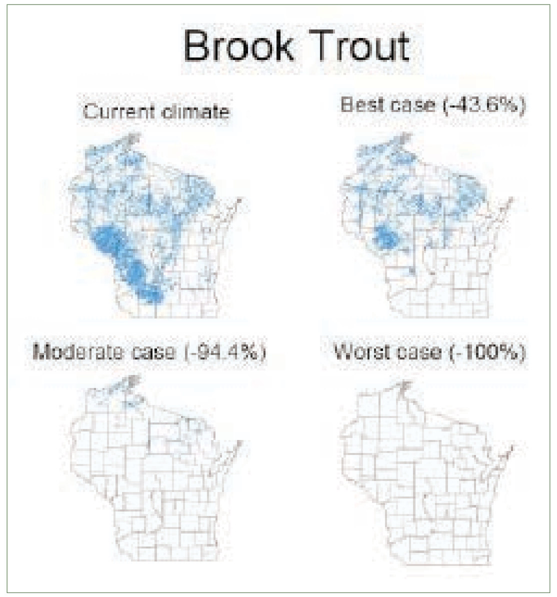


Figure 27: Impact to brook trout distribution in Wisconsin under current climate and three alternate climate scenarios. Used with permission from John Lyons, Wisconsin Department of Natural Resources.

Considering sustainability within the social context

EPA Social Context Indicators. EPA has developed a Social Context Indicator tool that prioritizes sites for sustainability of restoration, among other objectives, by scoring each user-defined hydrologic unit based on several factors known to influence restoration success. These include: leadership; organization and engagement; protective ownership or regulation; information availability; certainty; planning; restoration cost, difficulty, or complexity; socioeconomic considerations; and human health, beneficial uses, recognition and incentives.[105]

104 Lyons, J., J.S. Stewart & M. Mitro. (2010). Predicted effects of climate warming on the distribution of 50 stream fishes in Wisconsin, U.S.A. *Journal of Fish Biology*, 77(8), 1867-1898.
105 For more on EPA's Social Context Indicators see: U.S. Environmental Protection Agency. Water: Recovery Potential. Social

Element 4: Assess the potential of sites to meet watershed needs

Function and Condition assessments

Assessment based on landscape metrics informed by professional judgment

Virginia Wetland Condition Assessment Method. Some tools evaluate wetland condition based on landscape metrics calculated for buffer regions surrounding each wetland, accounting for stressors resulting from surrounding land uses such as roads, urbanization, or agriculture. For example, Virginia Institute of Marine Science's (VIMS) Wetland Condition Assessment Method[106] scores each wetland in Virginia in terms of overall stress level based on factors that included land use type, road density, wetland size, and wetland type.[107] VIMS makes results from its method available as part of its web-based Non-tidal Wetlands Viewer, which allows users to visualize wetland condition for individual wetlands and apply a variety of map overlay and spatial analysis (see *Figure 28*).

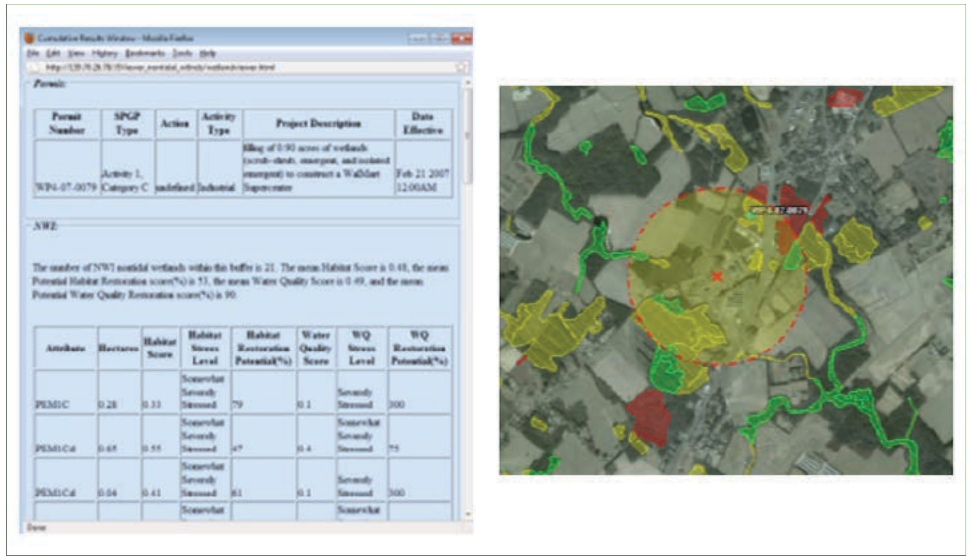


Figure 28: Using the VIMS Non-tidal Wetlands Viewer Tool, users can visualize wetland condition scores obtained using its Wetland Condition Assessment Tool, with color codes used to represent different stress levels (left). It also includes geoprocessing tools, such as a cumulative effects analysis, that reports stress levels for wetland habitat and water quality within a 1km radius, in addition to point source impairments (e.g., DEQ General Permit locations indicated by blue dots above). CCRM/Virginia Institute of Marine Science.

Context Indicators. http://owpubauthor.epa.gov/lawsregs/lawsguidance/cwa/tmdl/recovery/indicatorssocial.cfm

106 Center for Coastal Resources Management, Virginia Institute of Marine Science, College of William and Mary. (2007). Development of a nontidal inventory and monitoring strategy for Virginia – completion of phase II (coastal plain and piedmont physiographic provinces): Final report to the Environmental Protection Agency Region III. Retrieved April 11, 2014, from http://ccrm.vims.edu/publications/projreps/wetland_assessment_final_rpt_06-07.pdf

107 *Ibid.*

Colorado Landscape Integrity Model for Wetlands. Colorado Natural Heritage Program's (CNHP) Landscape Integrity Model[108] (LIM) ranks wetlands in terms of their "overall landscape integrity," an indicator of the overall stress on each wetland derived by combining four stressor categories comprising 13 total stressors within buffer regions surrounding each wetland. The tool models the decline in the effect of each stressor across space using distance-decay functions, which was parameterized for each stressor using best professional judgment. Using the distance-decay curve, the team had the ability to describe the effect of stressors in a variety of ways, ranging from having a high impact (i.e., high weight) but declining rapidly with distance to having a low impact (i.e., low weight) but decaying gradually.

Aquatic Freshwater Analysis Method. The Nature Conservancy developed a freshwater analysis method to identify the most intact and functional stream networks and aquatic lake/pond ecosystems in such a way as to represent the full variety of freshwater diversity present within an ecoregion. The method calculates wetland condition based on landscape metrics for hydrologic units. The tool identifies the most intact HUC-12s within Ecological Drainage Units by ranking each watershed in terms of land cover and road impacts (impacts due to roads, urbanization, and agriculture), dam and drinking water supply impacts (impacts caused by altered hydrologic regimes and creation of migration barriers due to dams), and point source impacts (potential chemical threats due to point sources).[109]

Assessment of landscape metrics derived from the strength of correlation between prospective metrics and field measures

Other tools select metrics and weightings for evaluating wetland or stream condition based on the strength of correlation between prospective landscape metrics and field indicators of wetland or stream condition (e.g., Rapid Assessment Method scores). Those metrics that are most significantly correlated with field indicators are incorporated into landscape models that predict wetland or stream condition as $30m^2$ resolution raster datasets.

Nanticoke Landscape Indicators of Wetland Condition. In the Nanticoke watershed, a team correlated landscape metrics derived from readily-available raster datasets (e.g., percent impervious surface coverage, distance to nearest stream, etc.) one-by-one with nine field-derived Functional Capacity Index (FCI) scores. For each FCI dataset, landscape indicators for which the correlations were most significant were selected to form the basis of a multivariate model, resulting in the selection of nine sets of landscape indicators for each of the nine FCI datasets. The researchers found that these multivariate models produced a strong relationship between landscape variables and FCI scores, with even the poorest performing models explaining nearly 50% of the variability.[110]

108 Lemly, J., L. Gilligan & M. Fink. (2011). Statewide Strategies to Improve Effectiveness in Protecting and Restoring Colorado's Wetland Resource. Fort Collins, CO: Colorado Natural Heritage Program, Colorado State University. Retrieved April 11, 2014, from: http://www.cnhp.colostate.edu/download/documents/2011/Statewide_Wetland_Strategies_Report_-_FINAL.pdf

109 See the chapter on standard methods for aquatics: Olivero, A.P. (author) and M.G. Anderson & S.L. Bernstein (eds). (2003). Planning methods for ecoregional targets: Freshwater aquatic ecosystems and networks" Boston, MA: The Nature Conservancy, Conservation Science Support, Northeast & Caribbean Division, Retrieved April 11, 2014, from: http://science.natureconservancy.ca/centralinterior/docs/ERAtoolbox/7/Aquatic_Methods_ECS.pdf

110 Weller, D.E., M.N. Snyder, D.F. Whigham, A.D. Jacobs & T.E. Jordan. (2007). Landscape indicators of wetland condition in the Nanticoke River watershed, Maryland and Delaware, USA. *Wetlands*, 27(3), 498-514.

Idaho Landscape-Scale Wetland Condition Assessment Tool. The Idaho Department of Fish and Game (IDFG) developed a landscape-scale wetland condition assessment tool that relies upon field-based data that is correlated with a wide variety of potential landscape metrics (69 total). IDFG largely derives field data sources from existing level 2 datasets, with some additional rapid assessment data obtained to ensure that the final field dataset represented the variety of wetland environments across the landscape. Based on the correlations of the field data and landscape metrics, the IDFG tool produced two level 1 models, one composed of 19 metrics and representing a northern region and the other composed of 41 metrics and representing a southern study site (see *Figure 29*).[111]

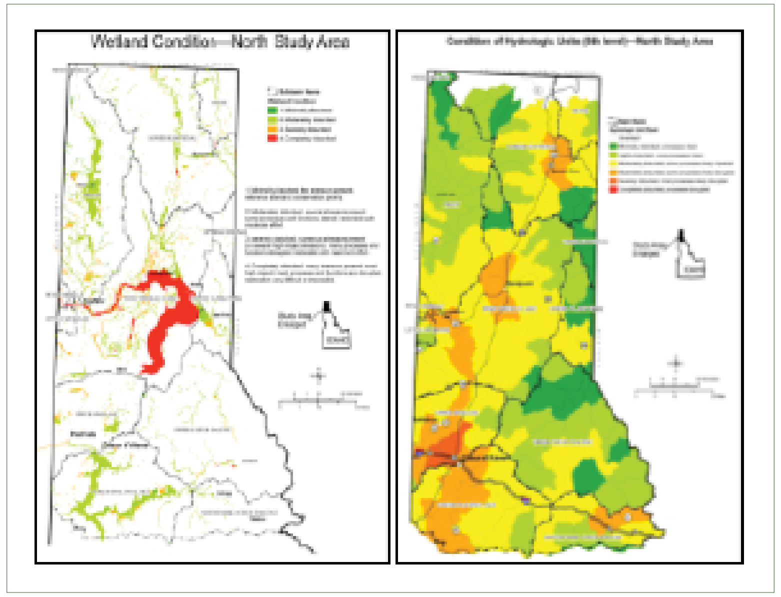


Figure 29: In the north study site, IDFG's landscape assessment tool ranked individual wetland polygons (left) and HUC-12 watersheds (right) in terms of overall landscape disturbance. A similar analysis was also completed for the southern study site. Used with permission from Chris Murphy, Idaho Department of Fish and Game.

111 Idaho Department of Fish and Game. (2010). Development of a landscape-scale wetland condition assessment tool for Idaho.

Analyzing datasets for rapid assessment or intensive data at the watershed level

Rapid assessment (e.g., RAM scores) or intensively-collected data may be used to summarize wetland condition at the watershed level.

Nanticoke Watershed-Scale Wetland Assessment. In the Nanticoke River Watershed, a team of researchers demonstrated that site-specific and reference-based approaches to wetland assessment can be effectively applied at watershed scales using EPA's Environmental Monitoring and Assessment Program (EMAP) survey design.[112] Using this method, the group drew a random tessellation stratified (RTS) sample of sites at which to complete Functional Capacity Index (FCI) rapid assessments (a type of hydrogeomorphic assessment). Scores obtained for this sample were used as the basis for the development of the level 1 tools used in the Nanticoke, discussed above.

Florida Uniform Mitigation Assessment Method (UMAM) Florida has developed a uniform method to assess the potential of mitigation sites to provide the functions associated with mitigation projects. The approach is divided into three parts: Location and Landscape Support, which provides an assessment of the ecological context within which the system exists; the Water Environment, which includes rapid assessment of hydrologic alteration and water quality impairment, and Community Structure, including assessments for both emergent vegetative and submerged benthic sites (See http://www.dep.state.fl.us/water/wetlands/mitigation/umam/index.htm).

Colorado Identification of Wetlands of High Biodiversity Significance. As part of its conservation planning program, the Colorado Natural Heritage Program applies field-based assessments that are used to rank wetlands in terms of their biodiversity significance by conducting surveys at the county level (see: http://www.cnhp.colostate.edu/cwic/cons/surveys.asp). However, the method can also be used to rank wetlands at the watershed, planning area, and ecoregional scale. CNHP stores survey data in its Biotics database.[113] The biodiversity significance rank ranks wetlands on a scale of 1-5, with wetlands receiving a rank of 'B1' considered to have "outstanding significance" and those receiving a rank of 'B5' having only "general significance." The B-rank is obtained by combining a "global rarity rank," ranging from G1 ("critically imperiled") to G5 ("very common"), with an "element occurrence rank," ranging from A ("relatively large, pristine, defensible, and viable") to D ("too degraded or not viable"). CNHP plans to use results from its LIM tool (discussed above) as a coarse filter for identifying high and low quality wetlands, within which it will seek funding to apply its field-based targeted assessment methods.

112 Whigham, D.F., A.D. Jacobs, D.E. Weller, T.E. Jordan, M.E. Kentula, S.F. Jensen & D.L. Stevens. (2007). Combining HGM and EMAP Procedures to Assess Wetlands at the Watershed Scale – Status of Flats and Non-tidal Riverine Wetlands in the Nanticoke River Watershed Delaware and Maryland (USA). *Wetlands,* 27(3), 462–478.
113 Colorado Natural Heritage Program. (2010). Colorado Natural Heritage Program Wetland Program Plan: A Vision for Building Comprehensive Wetland Information for the State of Colorado. Planning Years 2011-2015. Retrieved April 11, 2014, from: http://www.cnhp.colostate.edu/download/documents/2010/CNHP_Wetland_Program_Plan_-_2011-2015_-_revised.pdf

Ecosystem service assessments

Hydrologic and Water quality functions and services: Sediment trapping, nitrogen uptake, and multiple criteria

Some GIS-based tools evaluate watershed units for their ability to trap and store sediment and nutrients.

New Hampshire Sediment Trapping and Nutrient Attenuation Tool. The New Hampshire Department of Environmental Services developed a Wetland Restoration Assessment Model (WRAM) Sediment Trapping and Nutrient Attenuation Tool[114] that scores each NWI wetland in terms of its ability to improve water quality based on the opportunity to capture pollutants (e.g., average slope of contributing watershed), potential to capture sediment (e.g., riparian buffer width of the site), potential for nutrient attenuation (e.g., dominant wetland class), and sediment loading potential (e.g., soil erodibility of upslope drainage).

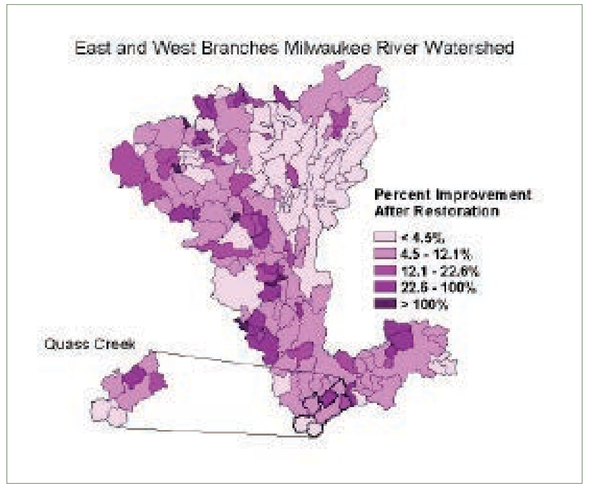


Figure 30: WDNR's water quality tool can be used to determine the potential percent improvement in sediment trapping function of HUC-14 watersheds following wetland restoration. Used with permission from Tom Bernthal, Wisconsin Department of Natural Resources.

Wisconsin Wetland Water Quality Assessment Tool. The Wisconsin Department of Natural Resources (WDNR) has developed a Wetland Water Quality Assessment Tool[115] that assesses the relative increase in sediment trapping function that could be gained in a catchment (HUC-14) following wetland restoration through modeling and a variety of data inputs (e.g., elevation, hydrography, and land use) (see *Figure 30*).

114 Vanasse Hangen Brustlin, Inc. (2009). Merrimack River Watershed Wetland Restoration Strategy. Prepared for New Hampshire Department of Environmental Services.

115 Kline, J., T. Bernthal, M. Burzynski & K. Barrett. (2006). Milwaukee River Basin Wetland Assessment Project: Developing Decision Support Tools for Effective Planning. DRAFT Final Report to the U.S. Environmental Protection Agency, Region V. Retrieved April 11, 2014, from: http://dnr.wi.gov/topic/wetlands/documents/Mukwonago_Version_MRPWAP_August_17.pdf

Louisiana Nitrogen Uptake Spatial Statistical Approach. The Louisiana Coastal Protection and Restoration Authority's (LACPRA) Nitrogen Uptake Spatial Statistical Approach, developed as part of a Coastal Master Plan, estimates nitrogen removal due to denitrification resulting from wetland protection or restoration projects by combining raster datasets for saline, brackish, intermediate, and freshwater habitat vegetation. The tool adjusts denitrification rates for vegetation using salinity and temperature data for each project site to calculate benthic rates of denitrification.[116]

Wisconsin Duck-Pensaukee Watershed Approach. The Duck-Pensaukee Watershed Approach[117] evaluates the capacity of sites to improve water quality based on three types of criteria: "opportunity" criteria (e.g., point source discharge upstream or directly into the site), "effectiveness" criteria (e.g., site has seasonally fluctuating water levels), and "social significance" criteria (e.g., wetland occurs in or above a catchment containing 303d waters).

Flood management and mitigation

New Hampshire Flood Protection Tool. The New Hampshire Department of Environmental Services developed a Wetland Restoration Assessment Model, which includes a Flood Protection Tool that is used to determine the potential of individual NWI wetlands to act as natural flood control buffers. The tool relies on a series of factors, including storage (the amount of water that the wetland can hold), outlet flow rate, percentage of the site located within a Federal Emergency Management Agency (FEMA) floodplain, and the dominant wetland class.

Georgia GIS Watershed-Based Planning Tool: Water Quality and Quantity Index. The Water Quality and Quantity Index evaluates the capacity of wetlands to limit flooding using 30m^2 raster datasets representing the proportion of runoff following a large storm event that a wetland could store and the ability of potential restoration sites to limit non-point source pollution based on landscape position.[118]

Louisiana Storm Surge/Wave Attenuation Potential Suitability Index and Coastal Louisiana Risk Assessment. The Louisiana Coastal Protection and Restoration Authority's (LACPRA) Comprehensive Master Plan (CMP) includes a Storm Surge/Wave Attenuation Potential Suitability Index that estimates the beneficial effects of potential wetland projects in terms of flood mitigation for 500m^2 cells within 100- and 500-year flood zones using data on wetland location, percent land, vegetation type, and elevation.[119] In addition, for each of the approximately 35,500 census

116 Rivera-Monroy, V.H., B. Branoff, M. Dortch, A. McCorquodale, E. Meselhe & J. Visser. (2012). Nitrogen Uptake Model (Potential for) Technical Report Appendix D-22, Louisiana's Comprehensive Master Plan for a Sustainable Coast. Baton Rouge, LA: Coastal Protection and Restoration Authority of Louisiana. Retrieved April 11, 2014, from: http://www.lacpra.org/assets/docs/2012 Master Plan/Final Plan/appendices/Appendix D22 - Nitrogen Uptake Potential for Technical Report.pdf

117 Miller, N., T. Bernthal, J. Wagner, M. Grimm, G. Casper & J. Kline. (2012). The Duck-Pensaukee Watershed Approach: Mapping Wetland Services, Meeting Watershed Needs. The Nature Conservancy & Environmental Law Institute. See also: Miller, N., J. Wagner & T. Bernthal. (2013). An Ecosystem Service-Based Watershed Approach to Wetland Conservation in the Great Lakes Basin. *National Wetlands Newsletter,* 35(1), 14-17.

118 Kramer, E.A. & S. Carpenedo. (2009). A statewide approach for identifying potential areas for wetland restoration and mitigation banking in Georgia: An ecosystem function approach. *Proceedings of the 2009 Georgia Water Resources Conference.* Retrieved April 11, 2014, from: http://www.gwri.gatech.edu/sites/default/files/files/docs/2009/2.6.1_Kramer.pdf

119 Reed, D. (2012). Storm surge/wave attenuation (potential for) technical report. Appendix D-23. Louisiana's Comprehensive Master Plan for a Sustainable Coast. Coastal Protection and Restoration Authority of Louisiana. Baton Rouge, LA. Retrieved April 16, 2014, from: http://www.lacpra.org/assets/docs/2012 Master Plan/Final Plan/appendices/Appendix D23 - Surge Wave Attenuation Potential for Technical Report.pdf

blocks that make up coastal Louisiana, the LACPRA CMP Coastal Louisiana Risk Assessment (CLARA) estimated the effect of wetland restoration projects on total economic damage and risk resulting from storm events of category three or higher.

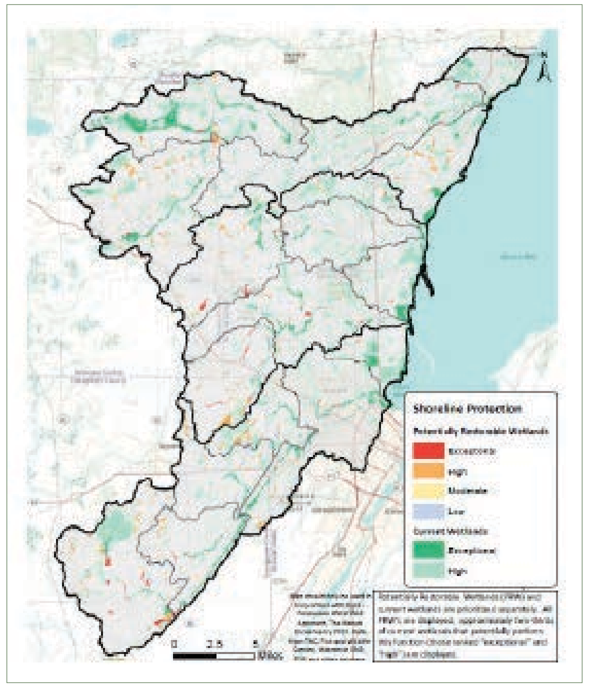


Figure 31: The TNC-ELI DPWAP Shoreline Protection Tool promotes the watershed approach to mitigation within the Duck-Pensaukee watershed by prioritizing wetland restoration and preservation sites for shoreline protection. Used with permission from Nick Miller, The Nature Conservancy.

Shoreline Protection

Wisconsin Duck-Pensaukee Watershed Approach. The Duck-Pensaukee Watershed Approach evaluated the ability of riverine wetlands to protect shorelines from flooding based on criteria such as river adjacency and presence of densely-rooted vegetation (see *Figure 31*).[120]

Other functions and services: Carbon storage, surface water and groundwater supply, social values

A variety of additional tools seek to evaluate other functions and services. For example, there are tools that prioritize wetland conservation sites based on carbon storage potential (see *Wisconsin Duck-Pensaukee Watershed Approach* below), surface water retention (see *Washington State's Water Delivery and Surface Storage Models* below), groundwater supply services, and social factors (see *Louisiana Nature Based Tourism Suitability Index* below).

Wisconsin Duck-Pensaukee Watershed Approach. The Duck-Pensaukee Watershed Approach factors in the prevalence of high biomass vegetation, organic substrates, and the potential of wetlands to serve as carbon sinks (based on water flow path) to evaluate the potential for wetland restoration and preservation sites to store carbon.[121]

120 Miller, N., T. Bernthal, J. Wagner, M. Grimm, G. Casper & J. Kline. (2012). The Duck-Pensaukee Watershed Approach: Mapping Wetland Services, Meeting Watershed Needs. The Nature Conservancy & Environmental Law Institute.
121 Miller, N., T. Bernthal, J. Wagner, M. Grimm, G. Casper & J. Kline. (2012). The Duck-Pensaukee Watershed Approach:

2.4: Assess the Potential of Sites to Meet Watershed Needs

Washington State's Water Delivery and Surface Storage Models. The Washington State Department of Ecology's (WSDOE) Chehalis Basin Watershed Assessment includes a water delivery model that assigns high "importance" ranks to user-defined hydrological units that have higher annual precipitation and larger coverage by rain-on-snow and snow-dominated zones.[122] The assessment also includes a surface storage model that assigns high importance ranks to hydrologic units containing a high percentage of depressional wetlands and larger coverage of unconfined and moderately confined floodplains. Both models score hydrologic units in terms of "impairment" of surface water supply – for example, the surface storage model ranks those hydrologic units as highly impaired that contain a higher acreage of storage wetlands lost to urban and agricultural land use and a higher mileage of channelized stream in unconfined and moderately unconfined floodplain.

Washington State Groundwater Recharge and Discharge Models. WSDOE's Chehalis Basin Watershed Assessment includes a groundwater recharge model that uses spatial factors such as soil permeability and annual average precipitation to assess the importance of hydrologic units for groundwater recharge. The Assessment also includes a groundwater discharge model that ranks hydrologic units in terms of their importance for groundwater *discharge* based on factors such as miles of stream crossing areas containing unconfined floodplain (see *Figure 32*).[123]

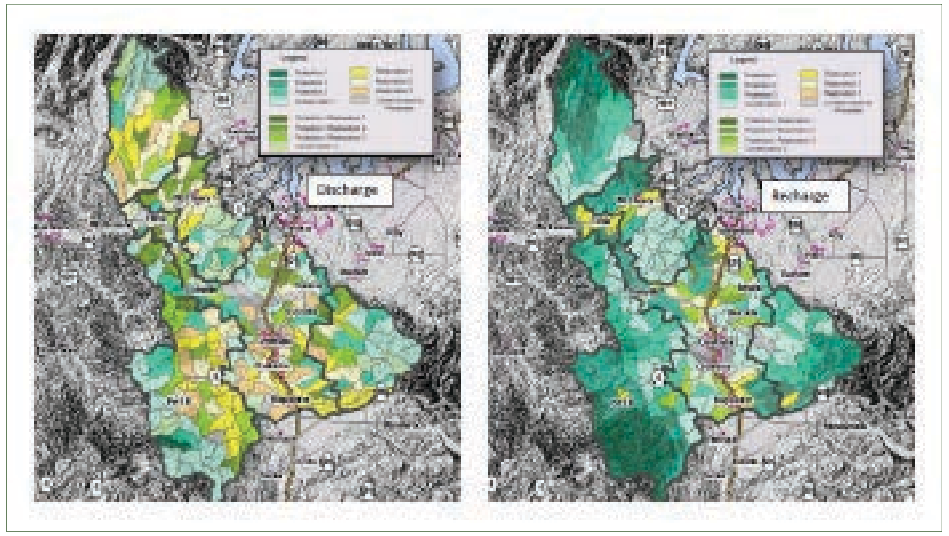


Figure 32: Output maps from the WSDOE Watershed Characterization Tool prioritizing ground water discharge (left) and recharge (right) for the Upper and Lower Chehalis Basins showing priorities. Priorities are identified for aquatic resource restoration (yellow), protection (green), and conservation (light yellow/light green), in addition to areas in which future disturbances are likely to have less impact (orange). Stanley S., S. Grigsby, T. Hruby & P. Olson. (2010). Chehalis Basin Watershed Assessment: Description of Methods, Models and Analysis for Water Flow Processes. Olympia, WA: Washington State Department of Ecology. Publication #10-06-006.

Mapping Wetland Services, Meeting Watershed Needs. The Nature Conservancy & Environmental Law Institute.
122 Stanley S., S. Grigsby, T. Hruby & P. Olson. (2010). Chehalis Basin Watershed Assessment: Description of Methods, Models and Analysis for Water Flow Processes. Olympia, WA: Washington State Department of Ecology. Publication #10-06-006.
123 *Ibid.*

Maryland Water Resource Registry Natural Stormwater Infrastructure Model. The Maryland Water Resource Registry Natural Stormwater Infrastructure Preservation model ranks sites that have well-drained soils and are currently forested as the highest.[124]

Louisiana Nature Based Tourism Model. One example of a tool that evaluates the potential effect of wetland conservation on social values is the LACPRA Nature Based Tourism model.[125] This model estimates the ability of a given wetland project to provide habitat suitable for nature-based tourism by assigning higher ranks to sites located closer to points of interest (e.g., wildlife refuges), closer to beaches, and more than 90% developed or under agricultural land cover.

Georgia GIS Watershed-Based Planning Tool: Connectivity to Existing Conservation Lands. In Georgia, a team working on watershed-based planning evaluated social values through the measure of "connectivity to existing conservation lands," a method that prioritizes potential wetland conservation sites in terms of recreation, education, and scenic value. The tool uses an "area-weighted connectivity function" to rank areas higher that lie in closer proximity to conservation areas identified in the Georgia Conservation Lands Database.[126]

Wildlife and habitat assessments

Assessment of habitat quality for wetland species

While some tools prioritize habitat areas for individual species (see *Louisiana Habitat Suitability Index* below), others do so for groups of related species (see *USGS Forest Breeding Bird Decision Support Model and Playa Lakes Decision Support System* below), while still others prioritize habitat areas for broader species groups (see *Milwaukee River Basin Watershed Plan's Wildlife Tool* below).

Louisiana Habitat Suitability Index. As part of its Coastal Master Plan, the Louisiana Coastal Protection and Restoration Authority (LACPRA) calculated Habitat Suitability Index (HSI) scores representing the effects of wetland projects on 14 individual species known to inhabit the Louisiana coast.[127] HSI scores are calculated for 500m^2 landscape units based on habitat factors known to align with habitat preferences of each species evaluated. For example, LACPRA ranked 500m^2 landscape units higher for American Alligator habitat that contained larger amounts of edge habitat (an indicator of more plentiful prey) and lower salinity (the American alligator is a freshwater species).[128]

124 Maryland Water Resources Registry. Preservation of Natural Stormwater Infrastructure Suitability Analysis Summary. Retrieved April 11, 2014, from http://watershedresourcesregistry.com/detailsHp.html
125 Reed D. (2012). Nature based tourism (potential for) technical report. Appendix D-21. Louisiana's Comprehensive Master Plan for a Sustainable Coast. Baton Rouge, LA: Coastal Protection and Restoration Authority of Louisiana. Retrieved April 11, 2014, from: http://www.lacpra.org/assets/docs/2012 Master Plan/Final Plan/appendices/Appendix D21 - Nature Based Tourism Potential for Technical Report.pdf
126 Kramer, E.A. & S. Carpenedo. (2009). A statewide approach for identifying potential areas for wetland restoration and mitigation banking in Georgia: An ecosystem function approach. *Proceedings of the 2009 Georgia Water Resources Conference.* Retrieved April 11, 2014, from: http://www.gwri.gatech.edu/sites/default/files/files/docs/2009/2.6.1_Kramer.pdf
127 Louisiana Coastal Protection and Restoration Authority. *Appendix D – Decision Support Tools – Predictive Models.* Louisiana's Comprehensive Master Plan for a Sustainable Coast. Retrieved April 11, 2014, from: http://www.lacpra.org/assets/docs/2012MP/Appendix_D-Decision_Support_Tools_Models_DRAFT.pdf
128 Nyman, JA. (2012). *Appendix D-5: American alligator habitat suitability index technical report.* Louisiana's Comprehensive Master Plan for a Sustainable Coast. Baton Rouge, LA: Coastal Protection and Restoration Authority of Louisiana. Retrieved April 11, 2014, from http://www.lacpra.org/assets/docs/2012MP/Appendix_D-Decision_Support_Tools_Models_DRAFT.pdf

USGS Forest Breeding Bird Decision Support Model. The USGS Forest Breeding Bird Decision Support Model rates 30m^2 raster cells throughout the Mississippi Alluvial Valley in terms of their ability to benefit forest-breeding birds through restoration of bottomland hardwood forest habitat.[129]

Playa Lakes Decision Support System. The Playa Lakes Joint Venture (PLJV) Playa Lakes Decision Support System (PLDSS) Landscape-Scale Model prioritizes migratory waterfowl habitat highest where playa complexes existed containing multiple, densely-distributed playas as well as fewer, larger, isolated playas based on known relationships between dabbling duck abundance and playa density.[130]

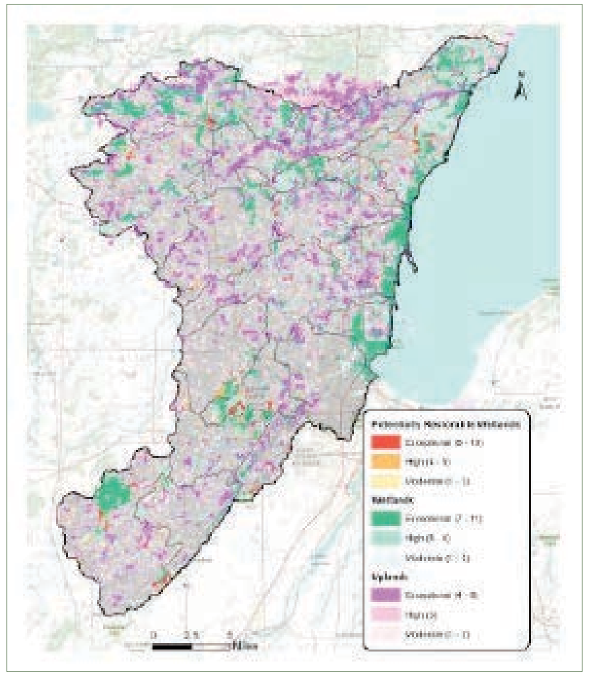


Figure 33: The TNC-ELI Duck Pensaukee Watershed Approach Pilot identified wetland and upland habitat best suited for preserving and restoring wetland-associated wildlife of this watershed. Used with permission from Nick Miller, The Nature Conservancy.

Milwaukee River Basin Watershed Plan's Wildlife Tool. The Wildlife Tool, developed in the Milwaukee River Basin[131] and applied in the Duck-Pensaukee watershed,[132] prioritizes wetland and upland areas for protecting and restoring wetland-associated Species of Greatest Conservation Need (SGCN), as identified in Wisconsin's Wildlife Action Plan (WWAP).[133] Rankings were based on expert evaluation of the strength of association between WWAP-designated target habitats specific to a watershed (e.g., evergreen forested wetland) and SGCNs representative of those habitats in the watershed (e.g.,

129 Twedt DJ, W.B. Uihlein, & A.B. Elliot. (2005). A spatially explicit decision support model for restoration of forest bird habitat. *Conservation Biology,* 20(1), 100-110.
130 Playa Lakes Decision Support System, from http://www.pljv.org/playa-dss.
131 Kline, J., T. Bernthal, M. Burzynski & K. Barrett. (2006). Milwaukee River Basin Wetland Assessment Project: Developing Decision Support Tools for Effective Planning. DRAFT Final Report to the U.S. Environmental Protection Agency, Region V. Retrieved April 11, 2014, from http://dnr.wi.gov/topic/wetlands/documents/Mukwonago_Version_MRPWAP_August_17.pdf
132 Miller, N., T. Bernthal, J. Wagner, M. Grimm, G. Casper & J. Kline. (2012). The Duck-Pensaukee Watershed Approach: Mapping Wetland Services, Meeting Watershed Needs. The Nature Conservancy & Environmental Law Institute. See also: Miller, N., J. Wagner & T. Bernthal. (2013). An Ecosystem Service-Based Watershed Approach to Wetland Conservation in the Great Lakes Basin. *National Wetlands Newsletter,* 35(1), 14-17.
133 Wisconsin Department of Natural Resources. (2005). Wisconsin Strategy for Wildlife Species of Greatest Conservation Need. Madison, WI. Retrieved April 11, 2014, from: http://dnr.wi.gov/topic/WildlifeHabitat/documents/WWAP.pdf

northern flying squirrel). This information, along with landscape-scale considerations (e.g., habitat size and juxtaposition), was used to generate maps of habitat suitability for representative species. Resulting maps were stacked to identify potential restoration and protection sites with the greatest potential to conserve a broad array of wetland-associated wildlife in the watershed (see *Figure 33*).

Assessment of habitat quality in terms of wetland condition

New Hampshire Ecological Integrity Method. The New Hampshire Dept. of Environmental Services (NHDES) Wetland Restoration Assessment Model (WRAM) Ecological Integrity Method scored each wetland in terms of the capacity of surrounding upland to buffer each wetland from human activity.[134]

Massachusetts Conservation Assessment and Prioritization System: Index of Ecological Integrity. The University of Massachusetts, Amherst's Conservation Assessment and Prioritization System (CAPS) developed an Index of Ecological Integrity that uses raster processing to score each 30m^2 area in terms of its potential to support biodiversity in the long-term. The Index scores 22 different aquatic community types by drawing upon indicators of ecological condition such as nutrient loading, intensity of nearby road traffic, and effects of development on habitat connectivity.[135]

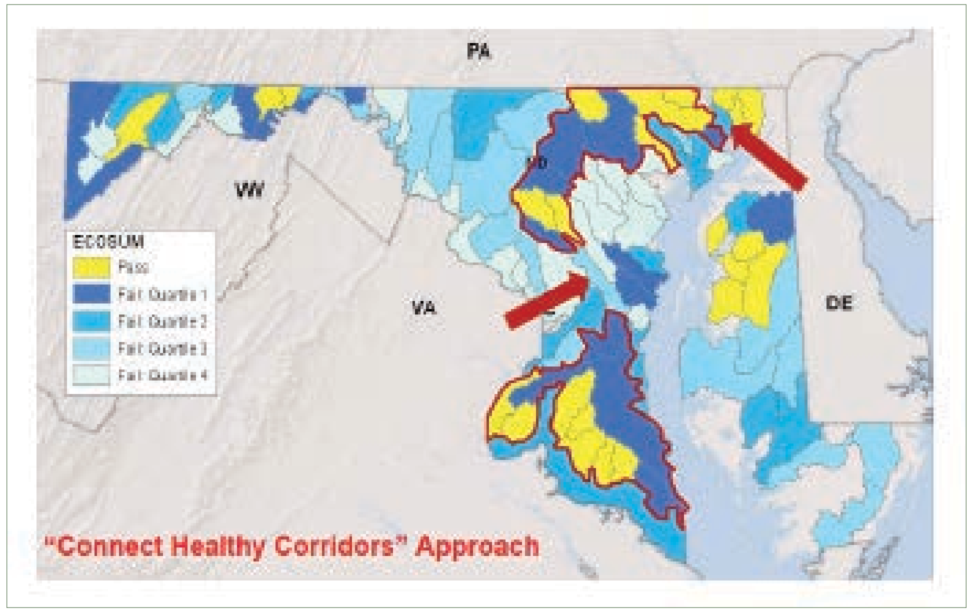


Figure 34: Output scores from EPA's Recovery Screening Tool. This map shows "passing" watersheds (yellow) as well as those that "failed" in field-based assessments (blue) but display varying degrees of recovery potential (darker blue = better recovery potential). Used with permission from Douglas Norton, U.S. Environmental Protection Agency.

134 Vanasse Hangen Brustlin, Inc. (2009). Merrimack River Watershed Wetland Restoration Strategy. Prepared for New Hampshire Department of Environmental Services.
135 McGarigal, K., B. Compton, S. Jackson, E. Plunkett, K. Rolih, T. Portante & E. Ene. (2012). Conservation Assessment and Prioritization System (CAPS) Statewide Massachusetts Assessment: November 2011. Amherst MA: University of Massachusetts, Amherst, Department of Environmental Conservation, Landscape Ecology Program. Retrieved April 11, 2014, from: http://www.masscaps.org/pdf/CAPS2011MassachusettsAssessment.pdf

EPA Recovery Potential Screening Tool. The EPA's Recovery Potential Screening (RPS) Tool evaluates the ecological condition of hydrologic units in terms of their physical/biotic structure and key natural processes, accounting for factors such as watershed natural structure, corridor and shoreland stability, flow and channel dynamics, biotic community integrity, aquatic connectivity, and ecological history. The approach enables users to identify watersheds in which restoration may be most effective in increasing the size of contiguous healthy watershed patches and connecting healthy patches into large-scale corridors by targeting impaired but restorable watersheds in key locations (see red arrows in *Figure 34*).[136]

Assessment of habitat quality in terms of wetland connectivity

USGS Forest Breeding Bird Decision Support Model. The USGS Forest Breeding Bird Decision Support Model (discussed above) incorporates connectivity into its analysis by scoring potential restoration areas based on their proximity to forest core areas, with proximity scores weighted based on core area size (see *Figure 35*).[137]

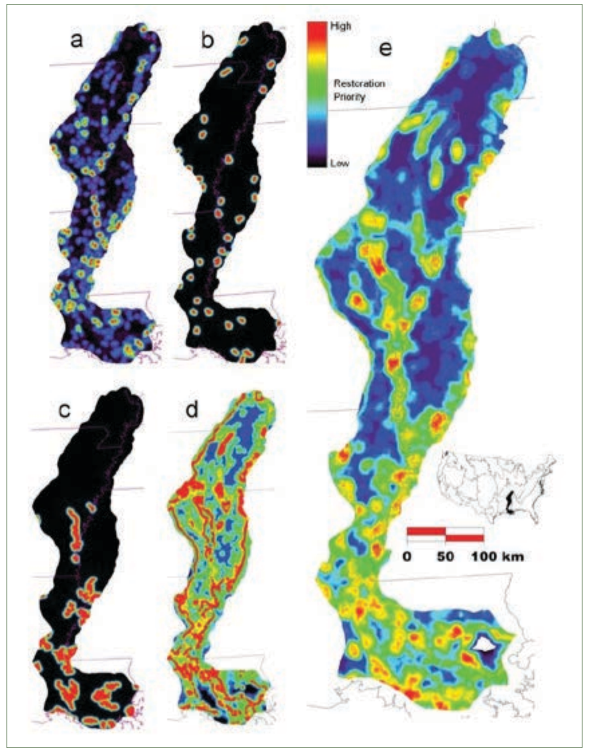


Figure 35: The prioritization outputs of the Forest Breeding Bird Decision Support Model rate areas for their ability to enhance regional habitat connectivity. These include: (a) creating forest patches with >2000 ha core area, (b) creating forest patches with > 5000 ha core area, (c) adding to forest core areas already >5000 ha, (d) increasing percentage forest cover in local landscapes to >60%, and (e) combining scores for all of these criteria and emphasizing higher-elevation sites. U.S. Geological Survey.

Georgia GIS Watershed-Based Planning Tool: Natural Upland Habitat Surrounding Wetlands. The Georgia watershed-based planning effort may be used to assess the locations in the landscape potential wetland restoration sites will provide the greatest benefit to wildlife, increase

136 U.S. Environmental protection Agency. (February 22, 2012). *Recovery Potential Screening: A tool for comparing impaired waters restorability.* Washington, DC: D. Norton and T. DiMascio. Retrieved April 11, 2014, from: http://water.epa.gov/learn/training/wacademy/archives.cfm - w20120222
137 Twedt, D.J., W.B. Uihlein, III & A.B. Elliott. (2006). A Spatially Explicit Decision Support Model for Restoration of Forest Bird Habitat. *Conservation Biology*, 20(1), 100–110.

connectivity, and maintain water quality and quantity based on the amount of natural upland habitat surrounding wetlands. The analysis ranks 30m² raster cells in terms of their connectivity to vegetated upland habitats, which provide important benefits to wetland-dependent wildlife. The tool evaluates sites in terms of percentage of upland vegetation within a 500-meter radius to account for amphibian movement and dispersal requirements.[138]

Georgia GIS Watershed-Based Planning Tool: Connectivity to Existing Conservation Lands. The Georgia watershed planning effort also evaluated the connectivity of sites to existing conservation lands by using an area-weighted connectivity function to rank areas higher where they were located in closer proximity to conservation areas identified in the Georgia Conservation Lands Database. This was done for several conservation area layers, which were summed so that higher ranks indicated potential sites that would enhance connectivity among multiple conservation areas.[139]

Assessment of habitat quality for streams and riparian buffers

Alabama Prioritized Watersheds for River and Stream Restoration. In collaboration with several partners, the team developed a Habitat Priority Planner (HPP), which includes the Prioritized Watersheds for River and Stream Restoration data layer. Developed in collaboration with stakeholders, the layer identifies a set of parameters that would effectively prioritize watershed units for river and stream conservation. Stakeholder-derived parameters included impervious surface coverage and presence of impaired streams.[140]

Framework to Select, Prioritize, and Evaluate Potential Wetland and Stream Mitigation Banking Sites. A group of researchers in West Virginia developed a framework to select, prioritize, and evaluate potential wetland and stream mitigation banking sites that delineates subwatershed boundaries around individual stream segments between stream confluences and tributaries.[141] Stream segments identified as mitigation priorities had drainage areas ranging from 1 to 130 km² and were biologically impaired due to sedimentation, temperature, or animal waste runoff (i.e., listed on West Virginia Dept. Environmental Protection's 303(d) list of impaired waters).

Maryland Water Resource Registry Riparian Zone Restoration Suitability Model. The Maryland Watershed Resource Registry (WRR) developed a Riparian Zone Restoration Suitability model that rates the suitability of each 30m² area throughout the state for riparian zone restoration by scoring and combining data layers representing a variety of relevant factors (e.g., ''in a Biological Restoration Initiative watershed"). This final score for the model is converted to a ranking of 1-5, which can be queried as part of an interactive map on WRR's website. The model substitutes factors more specific to riparian zone preservation such as "area is located in a Chesapeake Bay Commission Critical Area."

138 Kramer, E.A. & S. Carpenedo. (2009). A statewide approach for identifying potential areas for wetland restoration and mitigation banking in Georgia: An ecosystem function approach. *Proceedings of the 2009 Georgia Water Resources Conference.* Retrieved April 11, 2014, from: http://www.gwri.gatech.edu/sites/default/files/files/docs/2009/2.6.1_Kramer.pdf
139 *Ibid.*
140 The Nature Conservancy, National Oceanic and Atmospheric Administration & Mobile Bay National Estuary Program. (2009). Prioritization guide for coastal habitat protection and restoration in Mobile and Baldwin counties, Alabama. Retrieved April 11, 2014, from: http://habitats.disl.org/HabitatMapperGuide.pdf
141 Strager, M.P., J. T. Anderson, J.D. Osbourne & R. Fortney. (2011). A three-tiered framework to selection, prioritize, and evaluate potential wetland and stream mitigation banking sites. *Wetlands Ecology and Management,* 19(1), 1-18.

Alabama Prioritized Riparian Buffers Model. An Alabama team (also discussed above) included a riparian buffers model as part of the Habitat Priority Planner. The model prioritizes riparian buffer restoration using stakeholder-identified metrics that include buffer width, buffer vegetation, and buffer length. In addition, this tool scores buffers higher that have 50% or more of their area lying inside watersheds prioritized for river and stream conservation using the data layer discussed above: Prioritized Watersheds for River and Stream Restoration (see *Figure 36*).[142]

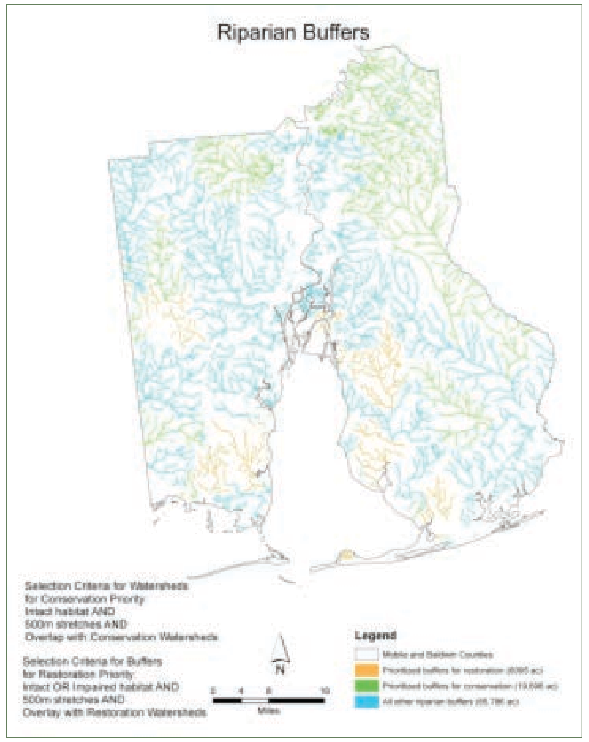


Figure 36: The Alabama Habitat Priority Planner model prioritizes riparian buffer restoration using stakeholder-identified metrics. Mobile Bay National Estuary Program.

142 The Nature Conservancy, National Oceanic and Atmospheric Administration & Mobile Bay National Estuary Program. (2009). Prioritization guide for coastal habitat protection and restoration in Mobile and Baldwin counties, Alabama. Retrieved April 11, 2014, from: http://habitats.disl.org/HabitatMapperGuide.pdf

Assessing site suitability for water quality functions

Water quality assessment using field assessments

Rapid or intensive field assessments may be used to evaluate the potential for wetland or stream restoration or protection sites to improve water quality functions in a watershed. A national review of rapid assessment methods (RAMs) for wetland condition found that of 16 RAMs, eight included scoring categories for water quality function at restoration or protection sites.[143] More intensive assessments, such as hydrogeomorphic (HGM) functional assessments or indices of biological integrity (IBI), are also used to assess water quality functions at individual wetland or stream restoration or protection sites. These site assessments can then be linked to watershed needs for water quality. Field assessments can also be used to characterize water quality functions for stream restoration and protection projects.

Water Quality Assessment Using Raster Stacking

A number of relatively simple GIS models add multiple data layers to rank site suitability across watersheds or ecoregions.

Maryland Watershed Resources Registry. The Maryland Water Resources Registry (WRR) incorporates at least one data layer related to restoration or conservation sites' potential to improve water quality in impaired waters. GIS data is divisible into two types of data sources: raster data and vector data. Raster data is pixelated spatial imagery, and can be added together by layering pixels from different data sources on top of each other and summing values to generate an aggregate score for restoration or conservation value; this process is termed "raster stacking." Raster stacking is used in the Maryland WRR to score potential wetland, riparian zone, upland, and natural stormwater infrastructure sites for restoration and preservation; five of the eight GIS analyses conducted by the WRR assign points based on the proximity of a site to CWA §303(d) impaired waters. For example, the wetlands restoration output generated by the WRR assigns one point for sites that are 100 feet from a §303(d) impaired stream and a half-point for sites that are between 100 and 500 feet from an impaired stream.[144]

Water quality assessment using WET-based methods

A number of water quality assessment methods draw from Wetland Evaluation Technique or "WET" based methods[145]

Duck-Pensaukee Watershed Approach. The Duck-Pensaukee Watershed Plan uses GIS analyses to determine whether several water quality improvement criteria were met at both existing wetlands and potential restoration sites. (Note that these same methods were also used to assess other services, such as flood abatement and shoreline protection.) Each criterion is categorized as "opportunity," "effectiveness," or "social significance." Opportunity criteria indicate whether a wetland has the chance to improve water quality. In general, opportunity criteria evaluate the context of wetlands and their

143 Fennessy, M.S., A.D. Jacobs & M.K. Kentula. (2004). Review of rapid methods for assessing wetland condition. EPA/620/R-04/009. Washington, D.C: U.S. Environmental Protection Agency.
144 Watershed Resources Registry. *About Us*. Retrieved April 11, 2013, from: http://watershedresourcesregistry.com/overview.html
145 Adamus, P. et al. (1987). Wetland evaluation technique (WET); Volume II: Methodology. NTIS No. AD A189 968. Vicksburg, MS: U.S. Army Engineer Waterways Experiment Station.

catchments, such as impervious surfaces, land use, and proximity to nutrient sources. Effectiveness criteria assess the capacity of a site to improve water quality, based on the site's inherent or internal characteristics. For example, wetlands with dense, persistent vegetation that occur in topographic depressions slow floodwaters and allow contaminated sediments to drop out of suspension. Social significance criteria indicate whether improvement of water quality at a particular site would have clear benefits to society. For example, sites that interact hydrologically with drinking water reservoirs or wells have particular significance for water quality. To compare the relative potential for sites to improve water quality, scores were generated on a scale of 0 to 1, based on the number of criteria met divided by the total number of criteria. Sites were then ranked in tiers of "Exceptional," "High," and "Moderate".[146]

Water quality site suitability

Optimization of Wetlands for Nitrogen Removal. A 2005 combined hydrologic simulation and landscape design model prioritizes portfolios of wetlands restoration sites to maximize nitrogen removal under given budget constraints for four watersheds in the Central Valley of California. The GIS-based hydrologic model estimates reduced nitrogen loads in surface runoff from individual wetland restoration sites. It uses a "greedy" algorithm to optimize nitrogen removal through wetlands restoration under budget constraints. Optimization algorithms inherently acknowledge that selection of one aquatic resource restoration or conservation site changes the relative benefits of subsequent sites—a standard principle of reserve design. This example suggests that environmental managers use optimization simulations such as these to supplement existing methods to target priority wetland restoration sites, and that use of optimization could improve the cost-effectiveness, structure, and reproducibility of processes that target restoration activities.[147]

Georgia GIS Watershed-Based Planning Tool – Water Quality and Quantity Index. In Georgia, a group developed a Water Quality and Quantity Index (WQQI) that combines a Potential Runoff Index (PRI) and Distance to Impairment Index (DII) to evaluate "where potential wetland restoration sites may have the greatest positive effect on non-point source impairments to water quality."[148]

146 Miller, N., T. Bernthal, J. Wagner, M. Grimm, G. Casper & J. Kline. (2012). The Duck-Pensaukee Watershed Approach: Mapping Wetland Services, Meeting Watershed Needs. The Nature Conservancy & Environmental Law Institute. See also: Miller, N., J. Wagner & T. Bernthal. (2013). An Ecosystem Service-Based Watershed Approach to Wetland Conservation in the Great Lakes Basin. *National Wetlands Newsletter,* 35(1), 14-17.
147 Newbold, S. (2005). A combined hydrologic simulation and landscape design model to prioritize sites for wetlands restoration. *Environmental Modeling and Assessment,* 10(3), 251-263.
148 Kramer, E.A. & S. Carpenedo. (2009). A statewide approach for identifying potential areas for wetland restoration and mitigation banking in Georgia: An ecosystem function approach. *Proceedings of the 2009 Georgia Water Resources Conference.* Retrieved April 11, 2014, from: http://www.gwri.gatech.edu/sites/default/files/files/docs/2009/2.6.1_Kramer.pdf

Element 5: Prioritize sites and areas

Identify priority hydrologic units

Identifying relative need and opportunity for wetland restoration by subbasin

Wisconsin Potentially Restorable Wetlands. Based on its analysis and delineation of potentially restorable wetlands, the Wisconsin Department of Natural Resources (WDNR) ranks relative need and opportunity for wetlands restoration for individual subbasins. The results can then be compared to prioritize among subbasins. "Relative Need" is defined as "the degree to which wetland restoration in a sub-basin has the potential to make an improvement in wetland functions." It is expressed as the ratio of lost wetland acres to remaining wetland acres, multiplied by the percent of the sub-basin that was originally a wetland. The agency then evaluates Relative Potential Opportunity based on Relative Need, but only counts lost wetlands that are not currently in urban use (i.e., not restorable) (see *Figure 37*).[149]

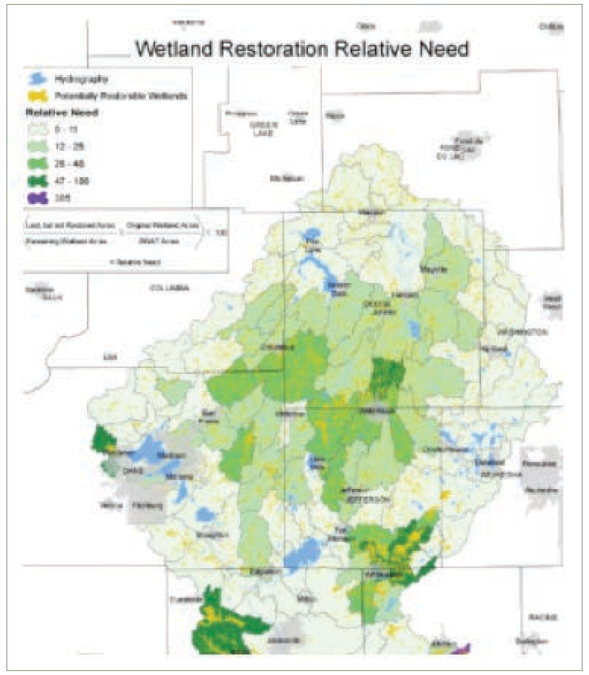
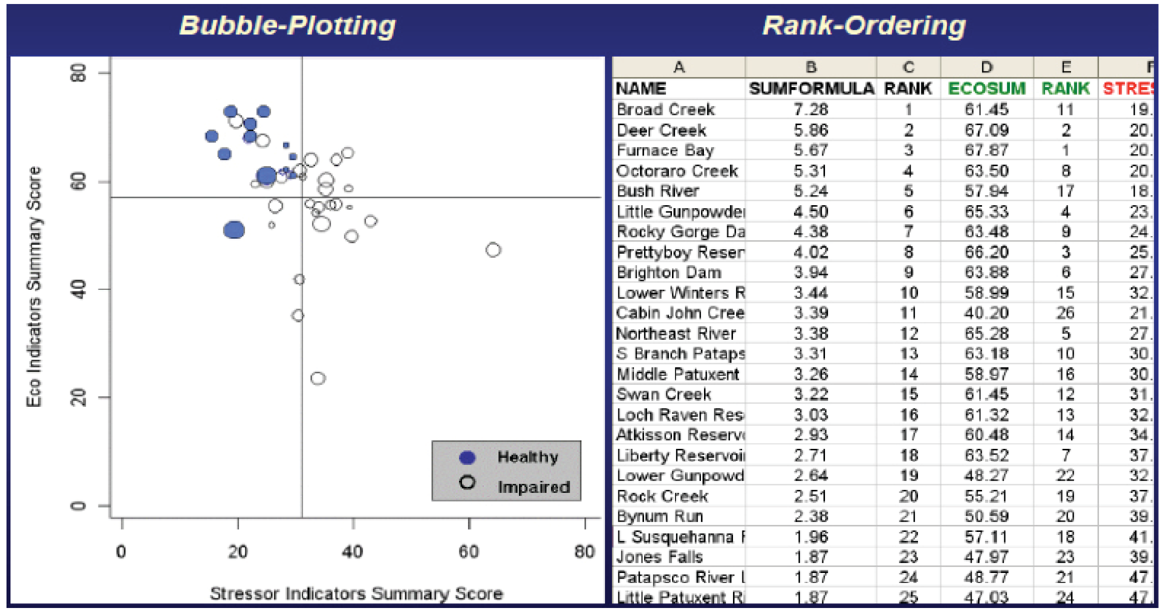


Figure 37: Wetland restoration relative need by subbasin of the Rock River watershed, Wisconsin. Used with permission from Tom Bernthal, Wisconsin Department of Natural Resources.

Hydrologic unit summary statistics to select priority basins, watersheds, or subwatersheds

North Carolina EEP River Basin Restoration Priorities. North Carolina Ecosystem Enhancement Program (NCEEP) compiles River Basin Restoration Priorities using watershed summary statistics to rank 14-digit hydrologic unit codes (HUC-14s) within each HUC-8 based on measures of watershed problems (e.g., percent impervious surface), assets (e.g., percent conservation land), and opportunities (e.g., number existing NCEEP projects). Problem and asset measures are weighted by water quality, flood retention, and aquatic and riparian habitat functions, while opportunity measures receive no weighting. Based on the HUC-14 measures and weightings, final scores are obtained for each category (problems, assets, and opportunities). The categories are weighted and added together to obtain final ranks for each HUC-14. Top HUC-14(s) within each HUC-8 are then designated targeted local watersheds, which become targets for compensatory mitigation projects and for the potential development of detailed local watershed plans.[150]



A	B	C	D	E	F
NAME	SUMFORMULA	RANK	ECOSUM	RANK	STRES
Broad Creek	7.28	1	61.45	11	19.
Deer Creek	5.86	2	67.09	2	20.
Furnace Bay	5.67	3	67.87	1	20.
Octoraro Creek	5.31	4	63.50	8	20.
Bush River	5.24	5	57.94	17	18.
Little Gunpowder	4.50	6	65.33	4	23.
Rocky Gorge Da	4.38	7	63.48	9	24.
Prettyboy Reser	4.02	8	66.20	3	25.
Brighton Dam	3.94	9	63.88	6	27.
Lower Winters R	3.44	10	58.99	15	32.
Cabin John Cree	3.39	11	40.20	26	21.
Northeast River	3.38	12	65.28	5	27.
S Branch Pataps	3.31	13	63.18	10	30.
Middle Patuxent	3.26	14	58.97	16	30.
Swan Creek	3.22	15	61.45	12	31.
Loch Raven Res	3.03	16	61.32	13	32.
Atkisson Reserv	2.93	17	60.48	14	34.
Liberty Reservoi	2.71	18	63.52	7	37.
Lower Gunpowd	2.64	19	48.27	22	32.
Rock Creek	2.51	20	55.21	19	37.
Bynum Run	2.38	21	50.59	20	39.
L Susquehanna I	1.96	22	57.11	18	41.
Jones Falls	1.87	23	47.97	23	39.
Patapsco River I	1.87	24	48.77	21	47.
Little Patuxent R	1.87	25	47.03	24	47.

Figure 38: Bubble plots and rank-ordered scores for ecological, stressor, and social context indicators for each HUC-12 watershed generated by EPA RPS. Stanley, S., S. Grigsby, T. Hruby, and P. Olson. 2009. Puget Sound Watershed Characterization Project: Description of Methods, Models and Analysis. Washington State Department of Ecology. Publication #10-06-005. Olympia, WA.

EPA Recovery Potential Screening Tool. EPA has developed a watershed prioritization approach related to a potential restoration site's likely ability to recover from current degradation, known as the Recovery Potential Screening Tool (RPS). Originally developed to support the prioritization of restoration under the Total Maximum Daily Load (TMDL) and impaired waters listing programs, the tool may also be applied to support a variety of other programs including nonpoint source control, healthy watersheds protection planning, fisheries management, and potentially aquatic resource compensatory mitigation. RPS compares differences in the likelihood of impaired watersheds and waters to return to a desired condition by calculating three multi-metric indices: ecological capacity, stressor exposure, and social context. Each of these indices can be used independently, but users also obtain an overall recovery potential score for each unit by adding each watershed's 'ecological capacity' score with its 'social context' score and dividing by its 'stressor exposure' score. RPS calculates the indices for each

149 Bernthal, T. & B. Hatch. (2008). Mapping Potentially Restorable Wetlands in the Rock River Basin. Final Report to the U.S. Environmental Protection Agency, Region V, Wetland Grant # CD 96544501-0. Wisconsin Department of Natural Resources. Retrieved April 11, 2014, from: http://dnr.wi.gov/topic/wetlands/documents/RockRiverPRW.pdf

150 Ecosystem Enhancement Program. (2010). EEP River Basin Restoration Priority Methodology. Raleigh, NC: North Carolina Department of Environment and Natural Resources.

unit based on standard types of indicators, which are tailored to the state or region based on data availability and user objectives. The results are comparative across the units being assessed. Users visualize recovery potential scores using bubble plots, maps of restorability by subwatershed, and rank-ordered tables for each index (see *Figure 38)*. Among other uses, screening results have been used by Massachusetts to revise statewide strategies for applying CWA §319 nonpoint source funding to watersheds, Maryland (in conjunction with other sources) to inform priorities for TMDL and CWA §319 programs, and Pennsylvania to successfully advocate for fisheries restoration proposals.[151]

Identifying and prioritizing watershed management strategies for hydrologic units for overall and specific watershed functions

Watershed statistics and models can be used to classify watersheds or subwatersheds based on the management strategies that should be used in these areas and then subsequently identify priority watersheds for each management strategy. Management strategies can be identified and prioritized for different categories of hydrologic functions (e.g., water flow, water storage, groundwater recharge).

Washington State Watershed Characterization Tool. The Washington Department of Ecology's (WSDOE) Watershed Characterization Tool is a method for assessing and understanding watershed processes at a broad scale.[152] Using the tool, the state ranks user-defined hydrological units relative to others in terms of their importance and impairment for specific and overall watershed processes. It then uses both rankings to determine the extent to which management actions within the unit should focus on restoration, conservation, or protection (see *Figure 39*).

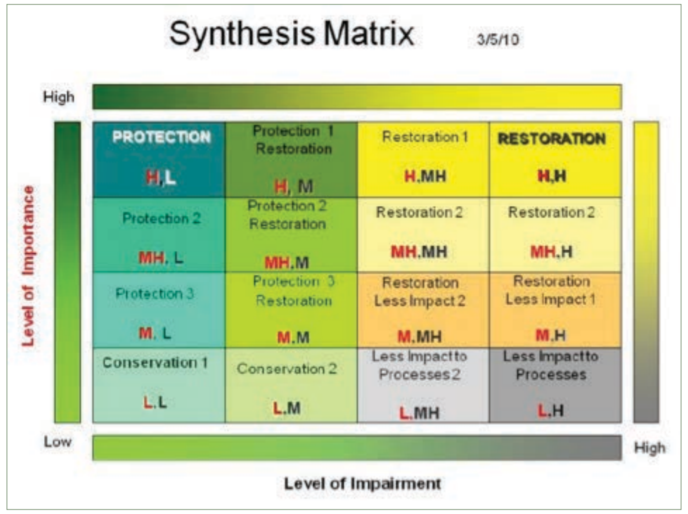


Figure 39: WSDOE synthesis matrix for identifying and prioritizing watershed management strategies. Used with permission from Douglas Norton, U.S. Environmental Protection Agency.

151 Norton, D.J., J.D. Wickham, T.G. Wade, K. Kunert, J.V. Thomas & P. Zeph. (2009). A Method for Comparative Analysis of Recovery Potential in Impaired Waters Restoration Planning. *Environmental Management*, 44(2), 356-368.
152 Washington State Department of Ecology. (January 2009). Summary of Watershed Characterization and Analysis Project for Clark County. Ecology Publication No. 09-06-003.

WSDOE's most developed and applied watershed characterization model to date is its water flow process model.[153] In the process model, WSDOE ranks all analysis units relative to each other in terms of their status as "important areas," reflecting their ability to help maintain specific watershed processes relative to other analysis units. WSDOE first ranks each analysis unit in terms of individual component watershed processes (e.g., groundwater recharge) before summing the individual component rankings to obtain an overall ranking for that watershed process (e.g., overall water flow ranking). For example, in a watershed characterization of the Chehalis basin, WSDOE used a water flow process model to determine important areas for water delivery, water storage, groundwater discharge, and groundwater recharge. The rankings obtained for each of these component importance analyses were then added to produce rankings for overall importance. WSDOE also ranks analysis units in each landscape group by their "impairment level," a relative ranking of the level at which human activities are likely damaging watershed processes. In the Chehalis study, WSDOE ranked analysis units relative to each other in terms of impairment for the water flow processes of delivery, storage, discharge, and recharge. Importance and impairment for overall watershed processes and more specific, component processes are each ranked as low, medium, medium-high, or high. These two sets of rankings are then combined to identify and prioritize watershed management strategies for overall watershed processes and the specific, component processes based on a synthesis matrix.

Identifying top subwatersheds for wetland restoration with water quality modeling

Rock River Basin Soil and Water Assessment Tool. Modeling may also be used to identify hydrologic units with the most potential for restoring particular aquatic resource functions. In its Rock River Basin TMDL, WDNR used the Soil and Water Assessment Tool (SWAT) water quality model to estimate load reductions in total suspended solids (TSS) and total phosphorus (TP) with restoration of various percentages of restorable wetlands area (20%, 40%, 60%, and 80%) by subbasin. The modeled pollutant reductions can then be used to target wetlands restoration in high-priority areas of the larger Rock River watershed with the objective of reducing TSS or TP pollution.[154]

153 Stanley, S., S. Grigsby, T. Hruby & P. Olson. (2010). Chehalis Basin Watershed Assessment: Description of Methods, Models and Analysis for Water Flow Processes. Publication #10-06-006. Olympia, WA: Washington State Department of Ecology. Retrieved April 11, 2014, from: https://fortress.wa.gov/ecy/publications/publications/1006006.pdf
154 The Cadmus Group, Inc. (2011). Total Maximum Daily Loads for Total Phosphorus and Total Suspended Solids in the Rock River Basin. Prepared for Wisconsin Department of Natural Resources and U.S. Environmental Protection Agency, Region V. Retrieved April 11, 2014, from: http://dnr.wi.gov/topic/TMDLs/RockRiver/FinalRockRiverTMDLReportWithTables.pdf

Prioritize sites

Analysis of sites as raster cells within a watershed or landscape

Raster cells are a GIS-based analysis unit for representing individual "sites." If the landscape is considered as a grid, then the individual "square" units making up the grid are considered the raster "cells." Raster cells used to identify priority wetland sites for wetland restoration or protection are generally $30m^2$ in size. Many methods use readily available ArcGIS tools, such as raster calculator or ModelBuilder, to score individual raster cells in terms of their capacity to achieve some watershed objective.

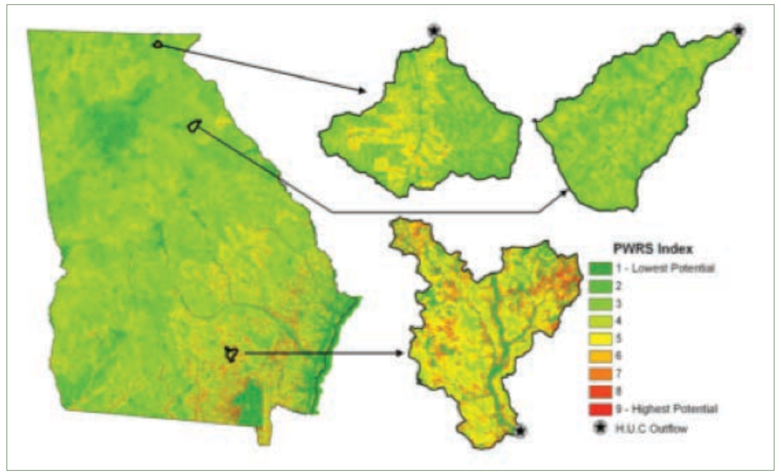


Figure 40: Potential Wetland Banking Site Index scores $30m^2$ raster cells in terms of their ability to support wetland creation for mitigation based on nine watershed objectives. Used with permission from Elizabeth Kramer, University of Georgia.

Georgia GIS Watershed-Based Planning Tool: Potential Wetland Banking Site Index. The Potential Wetland Banking Site Index (PWBSI) values each $30m^2$ raster cell in terms of its suitability for mitigation banking based on nine watershed objectives identified by a technical steering committee (see *Figure 40)*.[155] Inputs for the PWBSI included restorable land cover and hydric soils layers, which accounted for the 'ease of restoration' objective, with the eight other watershed objectives accounted for by seven other metrics, such as a "water quality and quantity index" (which accounts for water quality and flood control values) and "connectivity to existing conservation lands" (which accounts for connectivity, recreation, education, and scenic values). These metric were combined to obtain a final PWBSI score for each raster cell.

Massachusetts Conservation Assessment and Prioritization System: Index of Ecological Integrity. The Conservation Assessment Prioritization System (CAPS), developed by the University of Massachusetts, Amherst, uses a "rescaling" process to convert absolute values for individual submetrics (e.g., habitat loss) to new values ranging between zero and one that are readily compared

155 Kramer, E.A. & S. Carpenedo. (2009). A statewide approach for identifying potential areas for wetland restoration and mitigation banking in Georgia: An ecosystem function approach. *Proceedings of the 2009 Georgia Water Resources Conference.* Retrieved April 11, 2014, from: http://www.gwri.gatech.edu/sites/default/files/files/docs/2009/2.6.1_Kramer.pdf

across individual cells (i.e., "sites"). Groups of submetrics are then weighted and combined in various ways to calculate Index of Ecological Integrity (IEI) scores for a variety of aquatic community types.[156] For example, as applied by the "marsh" community type, the best 10% of marshes for a certain metric receive an IEI value ≥ 0.90. By rescaling submetrics, CAPS is able to account for differences in units of measurement and ranges of values among metrics and identify the "best" of each community type by eliminating bias in metric scores caused by more dominant communities (i.e., forest). The geographic extent for which metrics are rescaled before calculating the IEI score is critical for prioritizing different community types for conservation. In *Figure 41*, metric values for individual cells are rescaled relative to the boundaries of major watersheds, so that darker green cells represent those areas likely to provide the highest ecological value over time within their respective watershed.

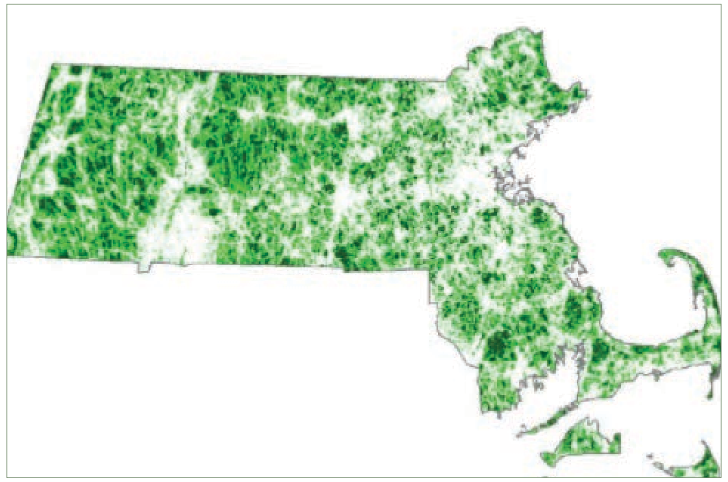


Figure 41: CAPS IEI scores rescaled by major watershed. Used with permission from Scott Jackson, University of Massachusetts Amherst.

California Regional Advance Mitigation Planning. Optimization approaches use algorithms to identify areas throughout the landscape in which conservation resources can be most effectively targeted given some constraint (e.g., cost). In California, the Department of Transportation's (Caltrans) Regional Advance Mitigation Planning (RAMP) program uses the MARXAN landscape optimization algorithm to identify a portfolio of habitat restoration and protection sites to serve as compensatory mitigation in advance of future road infrastructure impacts. As applied by Caltrans, the MARXAN optimization procedure uses GIS spatial data inputs for stakeholder conservation values, location of parcels within wildlife corridors (habitat connectivity), and parcel costs to identify a cluster of parcels ("regional greenprint") that provides maximum benefits in terms of some factors (achievement of stakeholder habitat values) while minimizing costs in terms of others (parcel cost). Caltrans further incorporates habitat mitigation needs derived based on an analysis of the expected habitat "footprint" of anticipated infrastructure impacts to establish a final mitigation portfolio.[157]

156 McGarigal, K., B. Compton, S. Jackson, E. Plunkett, K. Rolih, T. Portante & E. Ene. (2012). Conservation Assessment and Prioritization System (CAPS) Statewide Massachusetts Assessment: November 2011. Amherst MA: University of Massachusetts, Amherst, Department of Environmental Conservation, Landscape Ecology Program. Retrieved April 11, 2014, from: http://www.masscaps.org/pdf/CAPS2011MassachusettsAssessment.pdf

157 Thorne, J.H., P.R. Huber, E.H. Girvetz, J. Quinn & M.C. McCoy. (2009). Integration of regional mitigation assessment and

Analysis of sites as polygons within a watershed/landscape

Wetland polygons are represented in GIS as the "vector" data type and generally derived from data sources such as the National Wetlands Inventory that interpret wetland polygon boundaries using aerial photography.

Wisconsin Duck-Pensaukee Watershed Approach. The Duck-Pensaukee Watershed Approach Pilot project, completed by The Nature Conservancy and Environmental Law Institute in 2012, identified individual wetland polygons as Potentially Restorable Wetlands (PRWs) that had a strong potential to support successful wetland reestablishment.[158] The resulting plan identifies existing wetland polygons from the Wisconsin Wetland Inventory and National Wetland Inventory as wetland preservation opportunities. Individual PRW and preservation wetland polygons were scored in terms of their ability to provide various functional benefits by analyzing their ability to satisfy various opportunity, effectiveness, and social significance criteria. For example, the plan assesses the ability of PRWs and preservation wetlands to provide flood abatement benefits by evaluating whether each polygon had the opportunity (e.g., "impervious surfaces cover > 10% of the site's catchment") to abate flooding, would be effective at abating flooding (e.g., "the site is in a topographic depression or floodplain"), and would provide socially significant flood abatement benefits (e.g., "developed flood-prone areas occur within 5 miles downstream") (see *Figure 42*).

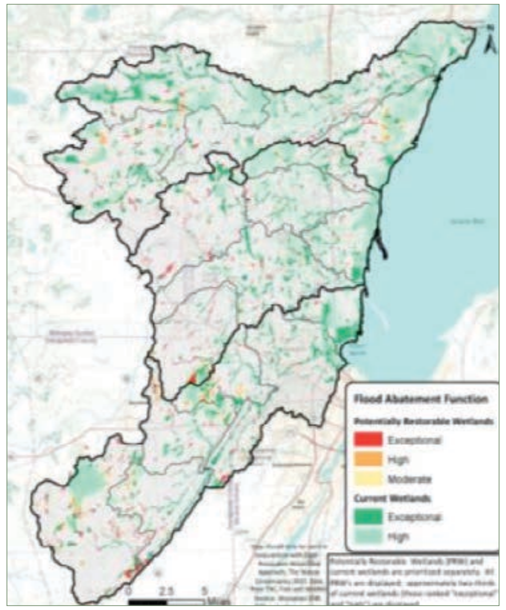


Figure 42: The Duck-Pensaukee Watershed Approach Pilot evaluated wetland polygons in terms of their ability to support various functions. The project ranked wetlands in terms of their ability to support flood abatement functions, as shown above. Used with permission from Nick Miller, The Nature Conservancy.

conservation planning. *Ecology and Society,* 14(1), 47.

158 Miller, N., T. Bernthal, J. Wagner, M. Grimm, G. Casper & J. Kline. (2012). The Duck-Pensaukee Watershed Approach: Mapping Wetland Services, Meeting Watershed Needs. The Nature Conservancy & Environmental Law Institute.

Evaluation of sites in the field to assess value for a watershed/landscape

Washington State Wetland Mitigation Site Selection Approach. The Washington State Department of Ecology (WSDOE) has developed a field-based approach for selecting mitigation sites based on a series of decision trees containing yes/no questions, instructions, and recommendations. The questions relate to the ecological functions/values supported by potential mitigation sites in a watershed and guide users to specific action recommendations that will provide the largest watershed-scale benefit given the project criteria. Each series of yes/no questions is contained in a "chart" and throughout the process of assessing a potential mitigation site users reference a variety of these charts depending on the geomorphic setting of the site. For example, the chart shown in *Figure 43* is used by field practitioners to determine whether hydrologic functions can be enhanced at a particular site and provides specific recommendations for how those functions can be enhanced. WSDOE created two versions of the approach – one for Eastern Washington[159] and the other for Western Washington[160] – to account for major hydrologic and geomorphic differences throughout the state that affect decision-making regarding the selection of mitigation sites. Additionally, each version of the approach may use different charts where hydrologic units differ substantially.

159 Hruby, T., K. Harper & S. Stanley. (November 2010). Selecting Wetland Mitigation Sites Using a Watershed Approach (Eastern Washington). Olympia, WA: Washington State Department of Ecology. Publication #10-06-007.

160 Hruby, T., K. Harper & S. Stanley. (2009). Selecting Wetland Mitigation Sites Using a Watershed Approach. Washington State Department of Ecology Publication #09-06-032.

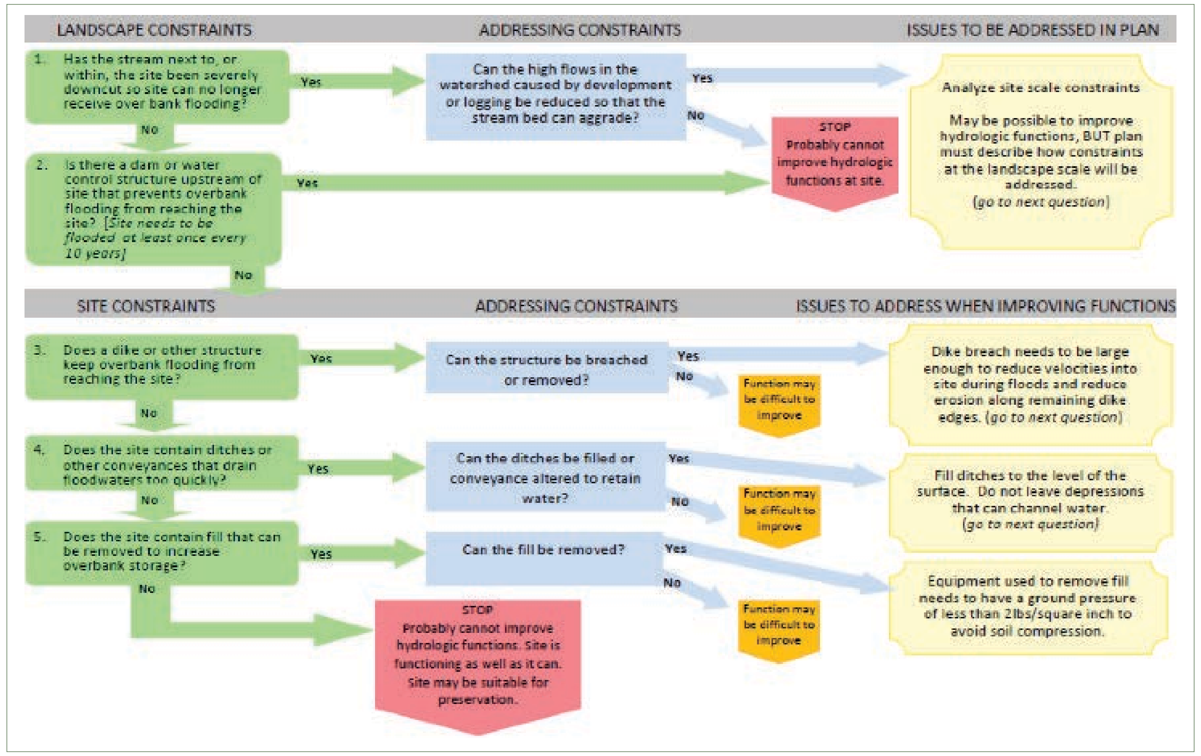


Figure 43: WSDOE's flowchart-based approach to selecting mitigation sites in the field using a watershed approach is based on a series of decision trees containing yes/no questions, instructions, and recommendations. Hruby, T., K. Harper & S. Stanley. (November 2010). Selecting Wetland Mitigation Sites Using a Watershed Approach (Eastern Washington). Olympia, WA: Washington State Department of Ecology. Publication #10-06-007.

Data Sources to Support the Watershed Approach

National Meeting on the Watershed Approach: Satisfying Data Needs

On December 18, 2009, the Environmental Law Institute convened a full-day workshop in Washington, D.C. to develop a list of nationally consistent, readily available sources of data that can fulfill most or all of the "information needs" and "considerations" outlined in the "watershed approach."

- During the meeting, participants (see below) reviewed those information needs and considerations and were asked to:
- Identify nationally-consistent, readily available sources of data that can fulfill the "information needs" and "considerations" outlined in the watershed approach;
- Discuss the strengths and limitations of these data (i.e., resolution, availability gaps); and
- Discuss whether these data are easy to access, easy to upload, and available in a format (e.g., GIS-ready) that would allow for easy analysis.

This section provides readers with the results of the workshop and additional research carried out by ELI (see table of contents below). The data list primarily includes geospatial data, although it also covers relevant non- spatial data sources. The majority of the list consolidates information on data that is publically available and freely accessible; as such, the list is intended for use by any parties interested in advancing a watershed basis for locating aquatic resource compensatory mitigation.

The Rule sets out specific types of data that district engineers should consult to guide identification and prioritization of potential aquatic resource compensation or preservation sites. These include: 1) chronic environmental problems, 2) cumulative impacts of past development activities, 3) current development trends, 4) the presence and needs of sensitive species, 5) site conditions that favor or hinder the success of compensatory mitigation projects, and 6) current trends in habitat loss or conversion. Our data list is organized according to these categories (see table of contents below).

Appendix B contains more information on the datasets we collected that may be useful for a watershed approach to compensatory mitigation. Datasets are grouped by identified project needs and their potential relevance to watershed-based mitigation analysis is noted.[161]

161 An additional searchable spreadsheet of the data sources is available on our website - http://www.eli.org/compensatory-mitigation.

Dataset Table of Contents

Chronic environmental problems

- National Water Information System (USGS)
- Repetitive loss dataset (FEMA)
- Insurance claims (FEMA)
- Floodmaps (FEMA)
- National Integrated Drought Information System (NIDIS)
- Climate Wizard (TNC)
- North American Regional Climate Change Assessment Program (NARCCAP)
- 303(d) list (EPA)
- 305(b) report (EPA)
- Assessment, TMDL Tracking and ImplementatioN System (ATTAINS) (EPA)
- NPDES permits (EPA)
- Fish Consumption Advisories (NLFA) (EPA)
- Beaches Environmental Assessment, Closure, and Health (BEACH) (EPA)
- Clean Watershed Needs Survey (EPA)
- EPA Water Monitoring Stations (STORET)

Cumulative impacts of past development activities

- National Estuarine Eutrophication Assessment (NEEA)
- National Coastal Conditions Report (EPA)
- National Coastal Assessment (EPA)
- Mussel Watch Program (NOAA)
- National Fish Habitat Action Plan/National Fish Habitat Assessment (NFHA)
- 303(d) list (EPA)
- 305(b) report (EPA)
- Floodmaps (FEMA)
- Minnesota Population Center National Historical GIS (NHGIS)

Current development trends

- National Hydrographic Dataset (NHD) (USGS)
- National Agricultural Imagery Program (NAIP) (USDA)
- 5 year projection data on census blocks
- American Community Survey (Census Bureau)
- Decennial Census (Census Bureau)
- Topologically Integrated Geographic Encoding and Referencing system (TIGER)
- (Census Bureau)

Current trends in habitat loss or conversion

- GAP Analysis
- National Land Cover Dataset (NLCD) (MLRC)
- National Land Cover Pattern Database (USGS)

2.6: Data Sources to Support the Watershed Approach

Landsat Data Archive (USGS)

- Coastal Change Analysis Program (C-CAP) (NOAA)
- National Wetlands Inventory (NWI) (FWS)
- USGS-NPS Vegetation Characterization Program (National Vegetation
- Classification System (NVCS))
- Satellite imagery (Google)
- National Aquatic Resource Surveys (EPA)
- Wadeable Stream Assessment
- National Lakes Assessment
- National Rivers and Streams Assessment
- National Wetland Condition Assessment
- National Coastal Conditions Report (EPA)
- National Coastal Assessment (EPA)
- National Resources Inventory (NRI) (NRCS)
- National Agricultural Statistical Service (NASS) (USDA)
- Forest Inventory and Analysis National Program (FIA) (USFS)
- National Insect and Disease Risk Map (USFS)
- LANDFIRE
- Fire Regime Condition Class (FRCC)
- TNC Ecological Drainage Units (EDU) map
- EDDMaps (Invasive Species Monitoring/Early Detection)

Immediate and long-term aquatic resource needs within watersheds that can be met through compensatory mitigation projects

- USGS database of invasive species: USGS Nonindigenous Aquatic Species database; National Institute for Invasive Species Science (NIISS)
- State nonpoint source management plans (CWA 319 plans) (EPA)
- Invasive Species Mapping Project (IMAP) (Princeton)
- Coastal zone management plans/programs (CZMPs) (NOAA)

Inventories of historic and existing aquatic resources

- Essential Fish Habitat (EFH) (NOAA)
- Estuarine Living Marine Resources database (NOAA)
- National Benthic Inventory (NBI) (NOAA)

Other information sources that could be used to identify locations for suitable compensatory mitigation projects in the watershed

- National register of historic places (since 1966) (NPS)
- Historic American Landscape Survey (NPS)
- Historic American Engineering Record (NPS)
- Historic American Building Survey (NPS)
- Statewide inventories of historic properties
- Wetlands Reserve Project (WRP) sites (NRCS)
- Ducks Unlimited Habitat Projects locations, Focus Areas, Flyways, International
- Conservation Planning Regions
- Watershed Notebook (EPA Watershed Approach Handbook)

Site conditions that favor or hinder the success of compensatory mitigation projects

- Marine Protected Areas (MPA) Inventory (NOAA)
- CBRA (Coastal Barrier Resources Act) CBRS (Coastal Barrier Resources System) (FWS)
- National Estuarine Restoration Inventory (NERI) (NOAA)
- Sea Level Affecting Marshes Model (FWS)
- Protected Areas Database of the United States (PAD-US): Conservation Biology
- Institute
- National landscape condition map (LANDFIRE)
- National Assessment of Coastal vulnerability to Sea-Level Rise (USGS)
- Hydric soils survey, Soil Survey Geographic Database (SSURGO) (USDA)
- US General Soils Map (STATSGO2) (USDA)
- USGS Fisheries: Aquatic and Endangered Resources Program (FAER)
- Critical habitat designations under ESA for marine species (NMFS)
- Critical habitat designations under ESA for terrestrial species (FWS)

The presence and needs of sensitive species/Information on rare, endangered and threatened species and critical habitat

- TNC Ecoregional Assessments – portfolios for terrestrial assessments
- TNC Conservation Action Plans
- Statewide assessments of forest resources
- State wildlife action plans

SSURGO soils

- Natural heritage databases (states, NatureServe)
- NatureServe national coverage at HUC-10/HUC-8 of freshwater fish, snails, mussels
- Environmental Conservation Online System (ECOS) (FWS)
- Information, Planning, and Consultation system (IPaC)
- Recovery Online Activity Reporting System (ROAR)
- Candidate Notice of Review (FWS)
- North American Bird Conservation Initiative (NABCI)
- Waterfowl management plans/Joint Ventures
- Important Bird Areas (IBA) Program (Audubon)

U.S. Geological Survey topographic and hydrologic maps

- Digital Raster Graphics (DRG)
- New US topography (US Topo)
- National Hydrographic Dataset (NHD)
- NHDPlus
- National Elevation Dataset (NED)
- Orthophoto/orthoimagery theme of the National Map
- Coastal Assessments Framework (CAF) – estuaries
- FEMA watershed approach (flood insurance studies)
- Watershed Boundary Dataset (WBD)

ArcGIS extensions

ArcGIS is a GIS software package developed by Esri. The following list does not represent an exhaustive search for ArcGIS extensions, but does list some tools that seemed particularly relevant for a watershed approach to wetland and stream restoration and protection projects. As noted by Esri, extension products are tools that let the user perform extended tasks such as raster geoprocessing, three-dimensional analysis, and map publishing.[162] In contrast to datasets, extensions are tools that process existing data to produce a desired data output. A list of such extensions is also included in this section.

- Integrated Climate and Land Use (ICLUS) tool
- Impervious Surface Analysis Tool (ISAT)
- Nonpoint-Source Pollution and Erosion Comparison Tool (N-SPECT)
- MapTite: marshland elevation tool

162 *See* www.esri.com/software/arcgis/arcgis-for-desktop/extensions

Appendix A: Definitions

These definitions come from the 2008 Mitigation Rule.

Enhancement means the manipulation of the physical, chemical, or biological characteristics of an aquatic resource to heighten, intensify, or improve a specific aquatic resource function(s). Enhancement results in the gain of selected aquatic resource function(s), but may also lead to a decline in other aquatic resource function(s). Enhancement does not result in a gain in aquatic resource area.

Establishment (creation) means the manipulation of the physical, chemical, or biological characteristics present to develop an aquatic resource that did not previously exist at an upland site. Establishment results in a gain in aquatic resource area and functions.

Preservation means the removal of a threat to, or preventing the decline of, aquatic resources by an action in or near those aquatic resources. This term includes activities commonly associated with the protection and maintenance of aquatic resources through the implementation of appropriate legal and physical mechanisms. Preservation does not result in a gain of aquatic resource area or functions.

Restoration means the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former or degraded aquatic resource. For the purpose of tracking net gains in aquatic resource area, restoration is divided into two categories: reestablishment and rehabilitation.

Re-establishment means the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former aquatic resource. Re-establishment results in rebuilding a former aquatic resource and results in a gain in aquatic resource area and functions.

Rehabilitation means the manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural/historic functions to a degraded aquatic resource. Rehabilitation results in a gain in aquatic resource function, but does not result in a gain in aquatic resource area.

Watershed means a land area that drains to a common waterway, such as a stream, lake, estuary, wetland, or ultimately, the ocean.

Watershed approach means an analytical process for making compensatory mitigation decisions that support the sustainability or improvement of aquatic resources in a watershed. It involves consideration of watershed needs, and how locations and types of compensatory mitigation projects address those needs. A landscape perspective is used to identify the types and locations of compensatory mitigation projects that will benefit the watershed and offset losses of aquatic resource functions and services caused by activities authorized by DA permits. The watershed approach may involve consideration of landscape scale, historic and potential aquatic resource conditions, past and projected aquatic resource impacts in the watershed, and terrestrial connections between aquatic resources when determining compensatory mitigation requirements for DA permits.

Watershed plan means a plan developed by federal, tribal, state, and/or local government agencies or appropriate non-governmental organizations, in consultation with relevant stakeholders, for the specific goal of aquatic resource restoration, establishment, enhancement, and preservation. A watershed plan addresses aquatic resource conditions in the watershed, multiple stakeholder interests, and land uses. Watershed plans may also identify priority sites for aquatic resource restoration and protection. Examples of watershed plans include special area management plans, advance identification programs, and wetland management plans.

Appendix B: Data Sources for Applying a Watershed Approach

The Rule sets out specific types of data that district engineers should consult to guide identification and prioritization of potential aquatic resource compensation or preservation sites. These include: 1) chronic environmental problems, 2) cumulative impacts of past development activities, 3) current development trends, 4) the presence and needs of sensitive species, 5) site conditions that favor or hinder the success of compensatory mitigation projects, and 6) current trends in habitat loss or conversion.

Chronic environmental problems

Section 303(d) list: Pursuant to Section 303(d) of the Clean Water Act, states are required to compile and submit to EPA a list ("303(d) list") of all rivers, lakes, and estuaries not attaining their designated water quality standard. States are then required to develop TMDLs for these impaired waters. However, 303(d) lists do not contain a State's entire Integrated Report (305(b), see below); impaired waters with an EPA-approved TMDL, impaired waters where existing pollution control measures are expected to achieve water quality standards, or "waters impaired as a result of pollution and is not caused by a pollutant" are excluded from 303(d) lists. After state water quality agencies submit Integrated Reports to EPA, EPA utilizes the NHD (see below) to digitize 303(d) or 305(b) lists into geospatial data. Some states also submit geospatial 303(d)/305(b) lists to EPA. State agencies generally are the best source for the most current and detailed 303(d) or 305(b) shapefiles.

Section 303(d) report: States submit Integrated Reports (IR) on the assessed water quality of state rivers, lakes and estuaries, and subsequent compliance with state water quality standards, to EPA on a biennial basis. 305(b) reports include the status of all assessed waters in a state. After approval, EPA subsequently compiles geospatial databases of impaired waters included in IRs, typically via the NHD. State water quality agencies generally are the best source for the most current and detailed 303(d) or 305(b) shapefiles. Also available through EPA EnviroMapper.

US EPA HQ
http://epamap32.epa.gov/radims/

National Water Information System: USGS collects surface-water data from field installations across the Nation, relaying real-time or daily stream levels, streamflow (discharge), reservoir and lake levels, surface-water quality, and rainfall. Surface-water data is available in real-time for 9,144 stream gauge and on a daily basis from 25,270 sites, and data is collected either through automatic recorders or manual measurements. USGS similarly collects water-quality characteristics nationwide from a subset of surface-water and groundwater stations, recording pH, specific conductance, temperature, dissolved oxygen, and percent dissolved-oxygen saturation. 1,541 water-quality sites relay data in real-time and 3,787 sites relay data on a daily basis.

National Water Information System
http://waterdata.usgs.gov/nwis
EPA Water Monitoring Stations (STORET): "The STORET Data Warehouse is EPA's repository of the water quality monitoring data collected by water resource management groups across the country. These organizations, including states, tribes, watershed groups, other federal agencies, volunteer groups and universities, submit data to the STORET Warehouse in order

to make their data publicly accessible. Data can then be re-used for analysis. Each sampling result in the STORET Warehouse is accompanied by information on where the sample was taken (latitude, longitude, state, county, Hydrologic Unit Code and a brief site identification), when the sample was gathered, the medium sampled (e.g., water, sediment, fish tissue), and the name of the organization that sponsored the monitoring. In addition, the STORET Warehouse contains information on why the data were gathered; sampling and analytical methods used; the laboratory used to analyze the samples; the quality control checks used when sampling, handling the samples, and analyzing the data; and the personnel responsible for the data."

storet@epa.gov
http://www.epa.gov/storet/
http://epamap32.epa.gov/radims/

National floodmaps: FEMA distributes floodmaps and associated geodata through its Map Service Center. FIRMs depict flood risk in particular areas as determined by results of FEMA engineering analyses. FIRMs typically include common physical base data, Special Flood Hazard Areas (SFHAs), base flood elevation/depth (1% annual chance), flood insurance risk zones, areas subject to flooding by a 0.2% annual chance flood, regulatory floodways, undeveloped coastal barriers, and floodplain boundaries. DFIRMs include information depicted in FIRMs and, when available, may include more detailed data layers relevant to local hydrology/engineering. NFHL data, which may be downloaded separately from a DFIRM, is part of DFIRM map data. NFHL data is available by request, via web map service, and in a Google Earth tool. FEMA is currently in the process of digitizing much of its geospatial data, and as such, DFIRM data appears to be not as widely available as the original FIRMs.

FEMA Map Service Center
mscservices@riskmapcds.com
http://www.msc.fema.gov/webapp/wcs/stores/servlet/FemaWelcomeView?storeId=10001&catalogId=10001&langId=-1&userType=G

Clean Watershed Needs Survey: "CWNS provides combined sewer overflow data and combined sewer overflow features respectively. The CWNS is a comprehensive assessment of the capital needs to the water quality goals set in the Clean Water Act. Every four years, the states and EPA collect information about: -Publicly owned wastewater collection and treatment facilities -Stormwater and combined sewer overflows (CSOs) control facilities -Nonpoint source (NPS) pollution control projects -Decentralized wastewater management -Estuary management projects. Information collected about these facilities and projects includes: -Estimated needs, including costs and technical information, to address a water quality or water-related public health problem -Location and contact information for facilities and projects -Facility populations served, flow, effluent, and unit process information -NPS best management practices. Additionally, under "Data Downloads" on CWNS website (see "link" cell), Access databases for every survey point (not just combined sewer overflow features) can be downloaded. These Access databases include latitude/longitude data for each survey point, which can be used to geospatially reference all capital needs project types (see above) and data on flow, discharge, effluent, etc.).

Appendix B: Data Sources for Applying a Watershed Approach

waters_support@epa.gov
http://epamap32.epa.gov/radims/
http://water.epa.gov/scitech/datait/databases/cwns/index.cfm

Assessment TMDL Tracking and Implementation System (ATTAINS): EPA also distributes shapefiles of impaired waters with developed TMDLs, which can be georeferenced to the implementation status of the TMDL as reported in the EPA Water Quality Assessment and Total Maximum Daily Loads Information (ATTAINS) database. Layers include point data, linear data, and polygon data. Again, state water quality agencies are generally the best source for the most up-to-date and detailed TMDL attainment geospatial data. Also available through EPA EnviroMapper.

US EPA HQ
http://epamap32.epa.gov/radims/

NPDES permits: "The Permit Compliance System Image datasets contain layers of facilities that discharge to water and provides locations of and information on sites within EPA's Permit Compliance System (PCS). The PCS is a national computerized management information system that automates entry, updating, and retrieval of NPDES data and tracks permit issuance, permit limits and monitoring data, and other data pertaining to facilities regulated under NPDES. PCS was developed in 1974 and records water-discharge permit data on more than 64,000 facilities nationwide. PCS provides information on when a permit was issued and expires, how much the company is permitted to discharge, and the actual monitoring data showing what the company has discharged." NPDES database information for a number of states is being migrated to the ECHO platform (in place of PCS); NPDES shapefiles are generally also available from state water quality agencies and may be more current. Also available through EPA EnviroMapper.

waters_support@epa.gov
http://epamap32.epa.gov/radims/
http://www.epa.gov/enviro/html/pcs/adhoc.html
http://www.epa-echo.gov/echo/compliance_report_water.html

NOAA droughts, with USGS: See drought indices below.

National Integrated Drought Information System (NIDIS): The U.S. Drought Monitor is compiled weekly based on a combination of quantitative drought indices and the judgments of a rotating panel of around 250 climatology experts. Experts work for USDA, NOAA, and NDMC (National Drought Mitigation Center). One lead author generally compiles the weekly map, which is subsequently reviewed by the national panel. Weekly U.S. Drought Monitor maps, which are released every Thursday morning, denote the perceived severity, extent, and impacts of drought across the nation. Other drought indicators, such as the PDSI or SWSI, are based on stricter, numeric formulations (though often tweaked to regional characteristics). SWSI is an index designed for regions highly dependant upon snowmelt and resultant runoff, and accordingly is primarily only calculated in Western states. Some formulations weigh terms to favor depiction of long-term drought, while others are designed to depict short-term drought. Drought indices based on a longer temporal scale are generally more indicative of chronic drought.

US Drought Monitor Data:
National Drought Mitigation Center (NDMC)
http://www.drought.gov/portal/server.pt/community/drought.gov/202//contact_us
http://www.drought.gov/portal/server.pt/community/drought_gov/202;jsessionid=D5EDDE78D664F1EB4F66E770BC8396FE

Climate Wizard: ClimateWizard maps average temperatures and precipitation in the U.S. and globally as observed over the last 50 years and as predicted by a 16-GCM (General Circulation Model) ensemble for 2050 and 2080. Users may specify the desired IPCC GHG emissions scenario for the model ensemble and may also choose climate projections from individual models. Historical climate data for the U.S. is available at 4 km resolution and projected U.S. climate data is available at 12 km resolution.

http://www.climatewizard.org

North American Regional Climatic Change Assessment Program (NARCCAP): NARCCAP runs regional climate models (RCMs) which are informed by underlying coupled atmospheric-ocean GCMs to produce high-resolution projections of climate change impacts in North America. NARCCAP's research runs combinations of applicable RCMs and GCMs, which are forced by the IPCC A2 emissions scenario (high emissions). Data is available for the individual RCM-GCM combinations that have been completed to date. RCMs output a spatial resolution of 50 km data, and outputs from RCM-GCM combinations produce extensive data layers (see http://www.narccap.ucar.edu/data/data-tables.html).

http://www.narccap.ucar.edu/

Fish Consumption Advisories (NLFA): "The Fish Consumption Advisories dataset contains information on Fish Advisories events that have been indexed to the National Hydrography Dataset (NHD) Reach Addressing Database (RAD). Fish consumption advisories and fish tissue sampling stations are reported to EPA by the states. Sampling stations are the locations where a state has collected fish tissue data for use in advisory determinations. In addition to NHD reach indexed data there may also be custom events (point, line, or polygon) that are not associated with NHD and are in an EPA standard format that is compatible with EPA's Reach Address Database. These custom events are used to represent Fish consumption advisory locations that are not represented well in NHD." "These waters can be linked to the fish consumption advisories and fish tissue sampling stations locations stored in the EPA National Listing of Fish and Wildlife Advisories (NLFWA) database for query and display. The ENTITY_ID field in the event table/shapefile can be linked to the ADVNUM in EPA's NLFWA database." The NLFWA database can identify the fish types/contaminants associated with an FCA. Also available through EPA EnviroMapper.

US EPA
http://epamap32.epa.gov/radims/
http://map1.epa.gov/scripts/esrimap.dll?name=Listing&Cmd=Map
Beaches Environmental Assessment Closure and Health (BEACH): "The Beaches Environmental Assessment and Coastal Health (BEACH) Program focuses on the following five areas to meet the goals of improving public health and environmental protection for beach goers and providing

Appendix B: Data Sources for Applying a Watershed Approach

the public with information about the quality of their beach water: strengthening beach standards and testing, providing faster laboratory test methods-predicting pollution, investing in health and methods research, informing the public. Under the BEACH Act Grant Program states (including tribes and territories) are required to submit their beach monitoring (water quality), notification (advisory and closing), and beach location data to EPA."

BEACH geospatial data provides hyperlinks to BEACON (Beach Advisory and Closing On-line Notification), EPA's online beach health database, which provides "a list of §406 waters, pollution occurrence data, monitoring data, and data collected through BEACH Act Grants Program."

U.S. EPA, Office of Water
http://epamap32.epa.gov/radims/
http://iaspub.epa.gov/waters10/beacon_national_page.main

Insurance claims: NFIP's Bureau and Statistical Agent (contractor), Computer Sciences Corp. (CSC), maintains the NFIP policy database. The NFIP policy database records properties with flood insurance policies, totaling over 5 million nationwide, and additionally maintains information on policy claims/losses due to flooding.

http://www.fema.gov/business/nfip/statistics/pcstat.shtm (data aggregated by state)

Repetitive Loss Dataset: FEMA distributes Severe Repetitive Loss (SRL) grants to lessen or prevent long-term flood risk for qualifying structures insured under the National Flood Insurance Policy (NFIP). The SRL program is designed to reduce claims expenditures by NFIP and is reserved for residential properties that meet the following criteria: "(a) Have at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or (b)For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building. For both (a) and (b) above, at least two of the referenced claims must have occurred within any ten-year period, and must be greater than 10 days apart." In addition, FEMA also maintains the Repetitive Flood Claims (RFC) program to distribute $10 million annually to States and communities. RFC funding may be targeted to any NFIP-insured property that has submitted at least one flood claim. Theoretically, properties funded through the SRL or RFC programs would be identifiable in NFIP's Policy database.

http://www.fema.gov/government/grant/srl/index.shtm
http://www.fema.gov/government/grant/rfc/index.shtm

Table 1: Datasets documenting chronic environmental problems						
Dataset	Specifics of interest	Spatial?	Category	Format	Scope	Currentness
303(d) list	Impaired waters	Spatial	abiotic	Download (GIS data), web map	National, Nationally by state or by cataloging unit	National file updated 1/8/2010; some state data may be substantially older. States required to submit 303(d) list to EPA every two years, but this does not necessarily include GIS data.
305(b) report	Assessed water quality	Spatial	abiotic	Download (GIS data), web map	National, Nationally by state or by cataloging unit	National file updated 1/8/2010; some state data may be substantially older. States required to submit 305(b) list to EPA every two years, but this does not necessarily include GIS data.
National Water Information System	USGS surface water and water quality data	spatial	abiotic	Download	National	Subset of sites have data available in real-time; others available daily
EPA Water Monitoring Stations (STORET)	Water quality monitoring station data	spatial	abiotic	For download (tabular, GIS format), web map	National, national by state, national by cataloging unit	7/1/2010 (nationwide metadata)
Floodmaps	Flood Insurance Rate Maps (FIRMs), Digital FIRMs, National Flood Hazard Layer (NFHL)	spatial	abiotic	Web map; web map service (for GIS software); partial download (GIS format); by request (DVD, GIS format)	Nationally by community (county subset). Also may download "kits" by county or request kits by state.	Varies by county/ community

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Clean Watershed Needs Survey	Combined Sewer Overflow events; also capital needs asessments for publicly owned wastewater collection and treatment facilities, stormwater and combined sewer overflows (CSOs) control facilities, nonpoint source (NPS) pollution control projects, decentralized wastewater management.	spatial	abiotic	For download (GIS format), web map, WMS	National, National by state, national by cataloging unit	Latest report in 2008; CWNS conducted every 4 years
Assessment, TMDL Tracking and ImplementatioN System (ATTAINS)	Specifically interested in 303(d), 305(b), and TMDL status	Spatial	abiotic	Download (GIS data), web map	National, Nationally by state or by cataloging unit	National file updated 1/8/2010; some state data may be substantially older. States required to submit 305(b) list to EPA every two years, but this does not necessarily include GIS data.
NPDES permits	Locations for point-source discharge facilities	Spatial	abiotic	Download (GIS format), web map	National, national by state Note: 26 states + DC, PR have frozen input to PCS database and are migrated to ECHO database (see lower web link).	1/8/2010 (date cited in metadata); from briefly downloading a couple of datasets, it appears some maybe more recent.
NOAA droughts, with USGS	see drought indices below		abiotic			

National Integrated Drought Information System (NIDIS)	US Drought Monitor, Standardized Precipitation Index (SPI), Palmer Drought Severity Index (PDSI), Modified PDSI, Palmer Hydrological Drought Index (PHDI), Palmer Z-Index, Surface Water Supply Index (SWSI), Crop Moisture Index, Soil Moisture	Spatial	abiotic	Map Viewer, Download (GIS format)	National	Ongoing updates (US Drought Monitor: weekly; SPI: daily and monthly; PDSI: weekly; modified PDSI: weekly; PDHI: weekly; Palmer Z-Index: monthly;SWSI: varies by state; CMI: weekly; Soil Moisture: Daily)
Climate Wizard	Modeled 21st century temperature/ precipitation trends, temperature/ precipitation trends in past 50 years	spatial	abiotic	Download (GIS data)	National	Based on downscaled climate projections from Maurer, et al. 2007
NARCCAP (North American Regional Climate Change Assessment Program)	Surface Air Temperature, Precipitation, Surface Evaporation of Condensed Water, Surface Latent Heat Flux, Surface and Subsurface Runoff, Total Soil Moisture Content, Specific/ Relative Humidity	spatial	abiotic	Download (GIS data)	National	Varies by GCM-RCM model run; see http://www.narccap.ucar.edu/data/status.html to see which model runs are complete and which are ongoing
Fish Consumption Advisories (NLFA)	Waters with contaminated fish samples	spatial	abiotic	For download (GIS format), web map	National, National by state, national by cataloging unit	2/1/2010 (date included with national metadata) States/ territories/ tribes submit FCA data to EPA annually
Beaches Environmental Assessment, Closure, and Health (BEACH)	Beach advisories and closings	spatial	abiotic	For download (GIS format), web map	National, National by state (only for Great Lakes/ coastal states), National by cataloging unit	6/16/2010; Coastal/Great Lakes states/ territories/ tribes appear to submit beach notification data annually

Insurance claims	NFIP Policy Payouts database with quantity of losses	Spatial-locational data would be redacted for use by a nonprofit; however, federal agencies could get access to this. Nonprofits could get access to aggregate data; specific scale not determined, would have to go through data acquisition process.	other	Available by request	National	Some aspects of database updated annually; some updated as new policies are inserted
Repetitive loss dataset	Severe repetitive loss properties, repetitive flood claims	Spatial-locational data would be redacted for use by a nonprofit; however, federal agencies could get access to this. Nonprofits could get access to aggregate data; specific scale not determined, would have to go through data acquisition process.	other	Available by request	National	Some aspects of database updated annually; some updated as new policies are inserted

Cumulative impacts of past development activities

National Estuarine Eutrophication Assessment (NEEA): The NEEA is a national collaborative project between the NOAA National Centers for Coastal Oceans and Science (NCCOS) and the University of Maryland Integration and Application Network (IAN) to assess the eutrophic condition of the Nation's estuaries. NEEA initially surveyed the status of estuaries nationwide in 1999 and provided an updated evaluation of estuarine eutrophic status in 2007. The overall eutrophic condition of the Nation's estuaries is assigned based on five factors: chlorophyll a, macroalgae, dissolved oxygen, submerged aquatic vegetation, and nuisance/toxic blooms. NEEA also examines the effectiveness of various estuarine management approaches on reducing eutrophication. Quantitative data for the "specifics of interest" are available, as aggregated by estuary, through the online data viewer and qualitative assessments of the five determinant factors of eutrophic condition are included in regional summaries in the report.

Contact (by region): http://ian.umces.edu/neea/contact.php
http://ian.umces.edu/neea/siteinformation.php

Impaired Waters List: 303(d)/305(b) listed waters (see above).

FEMA floodplain data: See "Floodmaps" above.

National Coastal Conditions Report(s): The NCCR series of reports, now in its third iteration, assesses the environmental condition of all U.S. coastal waters and the Great Lakes, including evaluations of the status of all of the nation's estuaries. The NCCR III report provides ratings of the overall condition of the nation's coastal waters and the condition of individual coastal waters. NCCR III ratings are divisible into three main data types: coastal monitoring data, offshore fisheries data, and assessment and advisory data. Coastal monitoring data is largely influenced by monitoring data from the EPA National Coastal Assessment (NCA; see below), and is ranked as good, fair, or poor based on five common indices of environmental condition. Indices for water quality, sediment quality, benthic community condition, coastal habitat loss, and fish tissue contaminants inform the coastal monitoring ranking (for information on formulation of indices, see NCCR III Ch. 1). Offshore fisheries data, principally from NOAA National Marine Fisheries Service (NMFS), was introduced into the NCCR series for the first time in NCCR III; this data charts long-term trends in fisheries monitoring data. Assessment and advisory data is rated based on data supplied by states or other regulatory agencies, such as state CWA 305(b) reports, Fish Consumption Advisories, and Beaches, Environmental Assessment, Closure, and Health (BEACH). Geospatial data is available for the various indices and the overall ratings given by the NCCR reports by request.

http://www.epa.gov/owow/oceans/nccr3/downloads.html

National Coastal Assessment: "The EMAP National Coastal Database contains estuarine and coastal data that EMAP and Regional-EMAP have collected since 1990 from thousands of stations along the U.S. coasts. These data include water column data, sediment contaminants and toxicity data, and benthic macroinvertebrate and demersal fish community and contaminant data."

http://www.epa.gov/emap/nca/

National Fish Habitat Action Plan/National Fish Habitat Assessment (NFHA): The first iteration of the NFHA, to be released in 2010, will assess the condition of fish habitat in inland and coastal/nearshore habitat across the contiguous 48 states and parts of Hawaii and Alaska. The NFHA is systematically evaluated in a geospatial framework which utilizes watershed, water body, and ecosystem boundaries, and each resultant geospatial unit is given a score to denote the level of landscape disturbance. Disturbance is determined by integrating anthropogenic factors (e.g. land use, dams, point source discharge, population density) with the degree of eutrophication in the geospatial unit, assuming that highly disturbed habitat will correlate with areas in poor ecological condition, and vice-versa. NFHA uses PCA (principal components analysis) to differentiate the factors that explain the most variation in assessments, with an emphasis on differentiating local and regional causes of habitat degradation. The NFHA intends to utilize more field data collected in future reports.

http://fishhabitat.org/index.php?option=com_content&view=article&id=234:national-fish-habitat-assessment-and-support-decision-document-&catid=42:science-data&Itemid=61
Data: http://fishhabitat.org/index.php?option=com_content&view=article&catid=42:science-data&id=315:nfhap-science-and-data-national-stpatial-framework-database&Itemid=61

Minnesota Population Center National Historical GIS (NHGIS): As part of its NHGIS project, the Minnesota Population Center distributes geospatial data depicting historical Census data across the United States, as available. Census data is available within state and county boundaries from 1790-2000, census tract-level data is available after 1910, and metropolitan area-level data is available after 1950. Data is available in both tabular and GIS formats.

Minnesota Population Center
http://www.nhgis.org/mapping

Mussel Watch Program: Mussel Watch, a project of the NOAA Center for Coastal Monitoring and Assessment (CCMA), evaluates biological and chemical contaminant trends in bivalve tissue and sediment at over 280 coastal monitoring sites from 1986 to the present. Mussel Watch regularly records concentrations in sediment and bivalve tissue of "over 100 organic and inorganic contaminants; bivalve histology, and pathogen concentrations. This project regularly quantifies PAHs, PCBs, chlorinated pesticides including DDT and its metabolites, TBT and its metabolites, and trace elements." The Mussel Watch Project is designed to assess the ecological condition of the Nation's estuaries and coastal waters, assess temporal changes in environmental quality of these waters, and provide data to inform ecosystem-based management objectives. Site monitoring data is available in GIS format with georeferenced contaminant readings.

http://ccma.nos.noaa.gov/about/coast/nsandt/musselwatch.html; for data: search geodata.gov for "Mussel Watch" or see http://ccma.nos.noaa.gov/about/coast/nsandt/download.html

Table 2: Datasets documenting cumulative impacts of past development activities

Dataset	Specifics of interest	Spatial?	Category	Format	Scope	Currentness
National Estuarine Eutrophication Assessment (NEEA)	Physical characteristics, landuse and population, hydrology, climate, oceanic details, sediment & nutrient loads	Spatial (Very limited; only contains latitude/ longitude centroid for each estuary and catchment assessed)	abiotic	Web map viewer (satellite image of applicable estuary), online viewer (data by estuary; no map), for download (reports)	Nationally by estuary	2004 assessment; released 2007
Impaired Waters List	303(d)/305(b) listed waters--see above					
FEMA floodplain data	See "Floodmaps" above					
National Coastal Conditions Report(s)	Coastal Monitoring Data: Water Quality Index, Sediment Quality Index, Benthic Index, Coastal Habitats Index, Fish Tissue Contaminants Index; Offshore Fisheries Data; Assessment and Advisory Data.	Spatial and non-spatial	abiotic and biological	Download (document), Available by request (Monitoring Station location/rating, also various indices) engle.virginia@epa.gov	Coastal Monitoring, Assessment/Advisory data: National by region; Offshore Fisheries Data: National by LME (Large Marine Ecosystem)	2006* Data from NCCR III report is only from surveying through 2002; NCCR IV report is in draft phase currently and they have data through 2006 for this report.
National Coastal Assessment	Coastal monitoring data, i.e. water column data, sediment contaminant/toxicity data, benthic macroinvertebrate and demersal fish community and contaminant data	spatial	abiotic and biological	For download (tabular), web map	National by EMAP biogeographical regions	2006
National Fish Habitat Action Plan/National Fish Habitat Assessment (NFHA)	Index of watershed/ water body/ecosystem disturbance	Spatial	biological & abiotic (input data is abiotic, but output is designed to display effects on fish-see dataset summary)	Local/network disturbance index data available for download (.dbf); NHD+ catchments/flowlines (shapefile) for download, Fish Habitat Partnerships for download (shapefile)	National by fish habitat partnership, by state, and by hydrologic region (HUC-2)	First NFHA (disturbance index) will be completed in 2010
Minnesota Population Center National Historical GIS (NHGIS)	US Census Data 1790-2000	spatial	other	Web map, for download (GIS format, tabular)	National	10/10/2006
Mussel Watch Program	Bivalve tissue: trace elements, organic compounds; sediment: trace elements, organic compounds	spatial	biological	Web map service (geodata.dov), download (GIS format; via CCMA website)	National (including HI, AK, PR; NS&T via geodata.gov); National by region (CCMA site)	CCMA site data (2009); National Status & Trends Mussel Watch Data (via geodata.gov)-03/12/2007

Current development trends

National Agricultural Imagery Program (NAIP): The NAIP collects and disseminates orthophoto data of agricultural lands in support of Federal agriculture initiatives and natural resource conservation, along with maintenance of Common Land Unit (CLU) boundaries. Orthophotos are captured during the agricultural growing season of the surveyed area. The objective of NAIP is to obtain 1-meter resolution imagery for the entire contiguous United States. From 2003-2008, NAIP data was reacquired on a 5-year cycle; beginning in 2009, NAIP data is obtained on a 3-year cycle.

http://www.fsa.usda.gov/FSA/apfoapp?area=home&subject=prog&topic=nai

National Hydrographic Dataset (NHD): The NHD is a comprehensive geospatial dataset portraying surface waters throughout the United States. NHD is designed for integration into a GIS as either a base layer for general topology or as an analysis layer for scientific inquiries into surface-water characteristics. NHD's flow direction network allows GIS users to trace water flow upstream or downstream of a point, and NHD features can also be readily georeferenced to a wealth of other hydrological information on water quality, discharge, and fish population. The StreamStats tool developed for utilization with NHD also allows GIS users to predict streamflow at user-defined locations along a water body based on nearby streamgauge measurements, search for dams or point source pollution sources in the vicinity of a user-defined location, perform stream traces, and create stream/land elevation profiles. NHD data is separated into point data (dams, gauges), linear data (streams, rivers, flow direction through polygons), and polygon data (estuaries, lakes).

nhd@usgs.gov; 1-888-275-8747
http://nhd.usgs.gov/

Topologically Integrated Geographic Encoding and Referencing system (TIGER): TIGER shapefiles contain common base map data, such as roads, railroads, and rivers, along with legal/statistical boundary areas used for Census tabulation. While TIGER shapefiles do not actually house Census demographic data, they can readily be georeferenced to Census tables.

geo.tiger@census.gov
http://www.census.gov/geo/www/tiger/

Decennial Census: The Census Bureau surveys the American population every ten years to record population size and detailed demographic information. Data is available at different scales, beginning at the block level.

factfinder@census.gov; 301-763-INFO(4636)
http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=DEC&_submenuId=&_lang=en&_ts=

American Community Survey: The American Community Survey is an ongoing effort to sample local populations and develop annual estimates of population size and demographic characteristics at the Census blockgroup and tract levels.

cmo.acs@census.gov; 1-888-456-7215
http://www.census.gov/acs/www/Products/

5 year projection data on census blocks: Nielsen and GeoLytics provide demographic projections at the Census tract and blockgroup level for clients interested in local marketing data. Nielsen and GeoLytics use local data to estimate current population and projects five-year changes in local demographics.

http://en-us.nielsen.com/contact
questions@geolytics.com
http://enus.nielsen.com/content/nielsen/en_us/expertise/segmentation_and_targeting/demographics/what_tools_should_i_use.html
http://www.geolytics.com/USCensus,Estimates-Projections,Products.asp

Table 3: Datasets documenting current development trends

Dataset	Specifics of interest	Spatial?	Category	Format	Scope	Currentness
National Agricultural Imagery Program (NAIP)	Very high resolution areal imagery	spatial	other	For download, web map service (http://gis.apfo.usda.gov/arcgis/services), web order	National by county, state, place, bounding rectangle, bounding rectangle, custom AOI (via NRCS Geospatial Data Gateway)	Nationally variable; from 2003-08, NAIP obtained on a 5-year rotating basis; from 2009-present obtained on a 3-year rotating basis
National Hydrographic Dataset (NHD)	Flow direction network, StreamStats (calculate streamflow volume; see dataset summary)	spatial	abiotic	For download (GIS format), web map	National, national by state	High-resolution (24k): 2008; Medium-resolution (100k): 2006
Topologically Integrated Geographic Encoding and Referencing system (TIGER)	GIS shapefiles of Census delineations (block, blockgroup, tract etc.), infrastructure, rivers	spatial	other	For download (GIS format)	National	2009
Decennial Census	Population and demographics comprehensively surveyed nationally at blockgroup/tract level	spatial	other	For download (tabular)	National	2000 (Census processing 2010 data)
American Community Survey	Population and demographic characteristics at blockgroup/tract level annually	spatial	other	For download (tabular)	National, national by state/county/county subdivisions	2008
5 year projection data on census blocks	High accuracy population projections	spatial	other	Available by request ($)	National	Present

Current trends in habitat loss or conversion

National Wetlands Inventory (NWI): "The U.S. Fish and Wildlife Service is the principal Federal agency that provides information to the public on the extent and status of the Nation's wetlands. Through the National Wetlands Inventory, the agency has developed a series of topical maps to show wetlands and deepwater habitats. These maps have been used extensively to make resource management decisions at the federal, state and local government levels. As of October of 2009, the wetland geospatial data layer provides on-line map information for 82 percent of the conterminous U.S., 31 percent of Alaska and 100 percent of Hawaii. Currently, efforts are underway to complete and maintain a seamless digital wetlands data set for the Nation. This effort constitutes the Wetlands Data Layer of the National Spatial Data Infrastructure." FWS, under lead author Tom Dahl, has also produced a series of "Status and Trends" reports describing national and regional patterns in wetlands losses and gains. Wetlands Status and Trends reports are available for the following time periods: 1780s-1980s, 1950s-1970s, mid-1970s-mid-1980s, 1986-1997, 1998-2004.

http://www.fws.gov/wetlands/

GAP Analysis: The objective of the GAP Analysis project is to protect common species ("those not threatened with extinction") by recognizing floral and faunal communities that are not adequately present on conservation lands. GAP Analysis proceeds by utilizing three data layers for this evaluation: land cover data, the predicted spatial distribution of vertebrate communities, and land stewardship data. GAP National Land Cover Data displays geographic patterns in vegetation and land use, applying the NatureServe Ecological System classification scheme to create up to 590 land use classes. Ecological Systems may be denoted at three different levels of specificity depending on project needs, delineating 8 classes in Level 1, 43 classes in Level 2, and 590 classes in Level 3. GAP Analysis uses vegetative land cover data, along with "known, probable, and possible" distributions of all "terrestrial vertebrate species" in a state, to predicatively model the spatial distribution of vertebrate species habitat. The final geodatabase used in GAP Analysis is PAD-US, which depicts public and private conservation lands throughout the contiguous United States, AK, HI, and PR. PAD-US rates the level of land stewardship (1-4) for each parcel based on the status of biodiversity preservation and other natural, recreational, and cultural uses for the land. These three data layers are then subsequently overlain and evaluated to inform resource management goals and stewardship decision-making.

http://www.nbii.gov/portal/server.pt/community/gap_home/1482

USGS-NPS Vegetation Characterization Program (National Vegetation Classification System (NVCS)): The NVCS is currently a seven-level classification system for distinguishing vegetation types in imagery of the US. The top five levels, which are all grouped based on physiognomic traits, are recognized as a standard of the Federal Geographic Data Committee (FGDC), while the lower two levels are divided based upon floristic vegetation characteristics. The lower, floristic levels of the NVCS are being improved indefinitely, and already contain several thousand vegetation cover types. The primary GIS data associated with the NVCS is available through the USGS-NPS Vegetation Characterization Program, with the ultimate objective to "classify, describe, and map vegetation communities in more than 280 national park units across the

United States." The Vegetation Characterization Program will also expand coverage to the Ouray and Lacreek National Wildlife Refuges and the Gunnison Gorge National Conservation Area. This USGS-NPS initiative will be "both the first to provide national-scale descriptions of vegetation for a Federal agency and the first to create national vegetation standards for its data products."

http://biology.usgs.gov/npsveg/nvcs.html
http://biology.usgs.gov/npsveg/about.html

National Land Cover Dataset (NLCD): Although Landsat TM data was available beginning in 1984, NLCD 1992 provides the first comprehensive land-cover mapping data for the continental US. The target date for the initial Landsat imagery analyzed by NLCD was 1992, though data from other years was used when cloud cover or other factors precluded use of scenes acquired in 1992. NLCD segregates the nation into 21 distinct land cover classes, using the default 30-meter spatial resolution of Landsat TM sensors. NLCD 2001 followed NLCD 1992, and expanded the land-cover data to include imagery of AK, HI, and PR, along with two new distinct data layers: ratings of impervious surface and canopy density. Both features rank pixels on a scale of 0-100%. In addition, remote sensing analysis from 2001 only segregates Landsat imagery into 16 land-cover classes. A logical extension of NLCD 1992 and 2001 is the NLCD Change dataset, which analyzes land-cover change over the period 1992-2001; because of differences in classification algorithms, methodologies, and datasets used in 1992 and 2001, the raw versions of these two NLCD products are not directly comparable. The next iteration of the NLCD data series, NLCD 2006, is slated for release in September of 2010. NLCD 2006 utilizes change detection models to identify land-cover change between 2001 and 2006, incorporate these changes into the NLCD 2001 maps, and finally produce the 2006 land-cover maps. As with NLCD 2001, NLCD 2006 will include analysis of impervious surface.

http://www.mrlc.gov/index.php

National Wetland Condition Assessment: "The National Wetland Condition Assessment is a statistical survey of the quality of our Nation's wetlands. The Wetlands Assessment is designed to: determine regional and national ecological integrity of wetlands; promote collaboration across jurisdictional boundaries; build state and tribal capacity for monitoring and analyses; achieve a robust, statistically-valid set of wetland data; and develop baseline information to evaluate progress."

http://water.epa.gov/type/wetlands/assessment/survey/upload/2008_01_Wetland_Survey_Fact_Sheet.pdf

National Land Cover Pattern Database: Forest Area Density (7-ha scale): "This dataset is a grid map at 30 meter resolution. Each pixel value represents an index of forest area density for the surrounding 7.29 ha.(9 x 9 pixel) analysis window." Forest Fragmentation (7-ha scale): "This dataset is a grid maps at 30 meter Resolution. Each pixel value represents an index of forest fragmentation for the surrounding 7.29 ha.(9x9 pixel) analysis window." Landscape Pattern Types (590-ha scale): "This dataset is a grid map at 30 meter resolution. Each pixel value represents an index of landscape pattern type (LPT) for the surrounding 590.49 ha.(81x81 pixel) analysis window." "LPTs provide geographic strata for identifying differences in landscape characteristics (e.g., forest patch size, amount of edge). They are motivated by the prevailing tendency for land cover to be spatially autocorrelated."

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http://www.lsc.usgs.gov/gis/nlpd/asp/index.htm

Satellite imagery (Google): Satellite images & aerial photography for the world, patched together from various sources. Google also maintains a repository of past satellite images that can be compared with recent imagery.

http://maps.google.com/
http://earth.google.com/

Landsat Data Archive: "Landsat represents the world's longest continuously acquired collection of space-based land remote sensing data. The Landsat Project is a joint initiative of the U.S. Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA) designed to gather Earth resource data from space. Landsat satellites have been collecting images of the Earth's surface for more than thirty years. Landsat's Global Survey Mission is to repeatedly capture images of the Earth's land mass, coastal boundaries, and coral reefs, and to ensure that sufficient data are acquired to support the observation of changes on the Earth's land surface and surrounding environment." NOTE: The Landsat archive is not processed land-cover data as with NLCD; it contains raw satellite images that need processing to reveal specific land-uses.

http://landsat.usgs.gov/contactus.php
http://landsat.usgs.gov/
http://glovis.usgs.gov/

Coastal Change Analysis Program (C-CAP): "The Coastal Change Analysis Program (C-CAP) produces a nationally standardized database of land cover and land change information for the coastal regions of the U.S. C-CAP products provide inventories of coastal intertidal areas, wetlands, and adjacent uplands with the goal of monitoring these habitats by updating the land cover maps every five years. C-CAP products are developed using multiple dates of remotely sensed imagery and consist of raster-based land cover maps for each date of analysis, as well as a file that highlights what changes have occurred between these dates and where the changes were located. NOAA also produces high resolution C-CAP land cover products [(1- to 5-meter resolution; typical C-CAP is 30-m)], for select geographies. These products focus on bringing NOAA's national mapping framework to the local level, by providing complimentary data, at a more detailed resolution to compliment regional C-CAP land cover."

http://www.csc.noaa.gov/digitalcoast/data/ccapregional/index.html

National Aquatic Resource Surveys: See applicable rows below and throughout spreadsheet.

http://water.epa.gov/type/watersheds/monitoring/nationalsurveys.cfm

Wadeable Stream Assessment: "The Wadeable Streams Assessment (WSA) is a first-ever statistically-valid survey of the biological condition of small streams throughout the U.S. The WSA is designed like an opinion poll: that is, 1,392 sites were selected at random to represent the condition of all streams in regions that share similar ecological characteristics. Wadeable streams were chosen for study because they are a critical natural resource and because we have a well-established set of methods for monitoring them."

http://water.epa.gov/type/rsl/monitoring/streamsurvey/index.cfm

National Lakes Assessment: "The National Lakes Assessment (NLA) is a first-ever statistically-valid survey of the biological condition of lakes and reservoirs throughout the U.S. The U.S. Environmental Protection Agency (EPA) worked with states and tribes to conduct the assessment in 2007."

http://water.epa.gov/type/lakes/lakessurvey_index.cfm

National Rivers and Streams Assessment: "The National Rivers and Streams Assessment (NRSA) is a statistical survey of flowing waters of the U.S. This survey is designed to: assess the condition of the Nation's rivers and streams; help build state and tribal capacity for monitoring and assessment; promote collaboration across jurisdictional boundaries; establish a baseline to evaluate progress; and evaluate changes in condition since the 2004 Wadeable Streams Assessment" "All streams and rivers within the contiguous U.S. that have flowing water during the study index period are included in the NRSA. This includes wadeable and non-wadeable rivers and streams, run-of-the-river ponds and pools, and Great Rivers. Not included are the portions of tidal rivers up to the head of salt."

http://water.epa.gov/type/rsl/monitoring/riverssurvey/riverssurvey_index.cfm

National Resources Inventory (NRI): "The National Resources Inventory (NRI) is a statistical survey of natural resource conditions and trends on non-Federal land in the United States. Non-Federal land includes privately owned lands, tribal and trust lands, and lands controlled by state and local governments… The 2007 NRI provides nationally consistent data for the 25-year period 1982–2007." The NRI uses points for sampling, in place of farms or fields, to allow investigation of a number of factors and their relation to land-use change over time. NRI data sites are "not public information and are to be used only for official NRI data gathering activities or for such purposes approved by the Secretary." "The NRI provides not only overall estimates of changes in resource conditions but also the dynamics of those changes. For example, gross losses and gains in cropland can be examined, and it can be determined why cropland was lost (say to development), how much had been classified as prime farmland, and where these losses occurred." Beginning in 2004, NRCS established Remote Sensing Laboratories (RSLs) to integrate use of geospatial technology into the collection and processing of data for the NRI.

nri@wdc.usda.gov
http://www.nrcs.usda.gov/technical/NRI/
http://www.nrcs.usda.gov/technical/NRI/maps/aboutmaps/coverages.html

National Agricultural Statistical Service (NASS): "The National Agricultural Statistics Service provides timely, accurate, and useful statistics in service to U.S. agriculture." The majority of the data maintained by the NASS tracks the status and trends in commodity sales for various agricultural products; however, NASS also maintains geospatial data charting Vegetative Condition maps (NDVI-Normalized Difference Vegetation Index derived from AVHRR) and Cropland extent data.

Tables: nass@nass.usda.gov

GIS data: hq_rdd_gib@nass.usda.gov
GIS data: http://www.nass.usda.gov/research/Cropland/SARS1a.htm; http://www.nass.usda.gov/research/avhrr/avhrrmnu.htm
Tabular data (QuickStats): http://www.nass.usda.gov/Data_and_Statistics/index.asp

Forest Inventory and Analysis National Program (FIA): "The Forest Inventory and Analysis (FIA) program is the Forest Service's national program for collecting and reporting information on status and trends in forested ecosystems across all land ownerships, public and private. This includes information on status and trends in area, location, growth, mortality, harvesting, composition, and structure of forests. FIA operates at a strategic scale; with one field sample location approximately every 6,000 acres, FIA data are statistically useful from the National scale down to areas of about 200,000 acres [(33 ground plots)]. [Recent modifications to the FIA program will incorporate] subsampling of an extended suite of ecosystem attributes such as soil, lichen communities, total vegetative profiles, crown conditions, and surveys for ozone damage through incorporation of the plot portion of the Forest Health Monitoring Program." Status and trends of in forested lands are generally reported at a broad scale that may be too coarse for site-specific mitigation project evaluation. FIA data may be useful to identify the quality of wildlife habitat. Monitoring data reported through FIA is available online with identifying information on the county and state of samples; however, FIA has a policy of not releasing the exact latitude/longitude coordinates of sample plots used for reports to protect landowner privacy and prevent interference with FIA study sites. Researchers interested in utilizing FIA data can submit data requests to FIA, who will return geospatial data that both protects site confidentiality and advances projects. FIA also distributes a nationwide, remotely sensed forest cover types layer (25 classes; available through National Atlas) and species basal area layer (raster).

http://www.fia.fs.fed.us/tools-data/default.asp

National Insect and Disease Risk Map: The National Insect and Disease Risk Map project (NIDRM) integrates 188 models designed to simulate interactions between individual tree species and varying mortality agents, along with interactions between these mortality agents and designated forest parameters (i.e. stand basal area, stand density index). The results of the disease-tree interactions projected in all 188 models were compiled to show a) "the likelihood (on a scale of 0 - 10) of an agent/host interaction resulting in mortality" and b) "the percent contribution to total basal area loss attributed to that model." The final risk map portrays areas with greater than or equal to 25% mortality as "at risk," while other areas are not at risk.

http://www.fs.fed.us/foresthealth/technology/nidrm.shtml

LANDFIRE: LANDFIRE (Landscape Fire and Resource Management Planning Tools Project) is a joint national project between USDA and DOI to comprehensively assess "vegetation, wildland fuel, and fire regimes across the United States." As part of its mission, LANDFIRE produces 30-meter resolution data products describing vegetation composition and structure. Relevant to wetlands mapping and establishing trends in wetlands habitat loss, LANDFIRE produces data layers depicting Environmental Site Potential ("the vegetation that could be supported at a given site based on the biophysical environment"), biophysical settings ("the vegetation that may have been dominant on the landscape prior to Euro-American settlement"-incorporates current scientific knowledge of ecological processes), and existing vegetation type. A number of data layers measuring forest fire regime and behavior exist as well (see "Data Layers," also, more detailed descriptions of each layer are provided on the LANDFIRE data products webpage (see http://www.landfire.gov/products_national.php).

helpdesk@landfire.gov
http://www.landfire.gov/
Also linked to NatureServe: http://www.natureserve.org/explorer/servlet/NatureServe?menuselect=none&distributionLogicOp=OR&searchCategory=distributionSearch&loadTemplate=nameSearchEcol.wmt&refineTarget=locationSearchEcol.wmt&sourceTemplate=locationSearchEcol.wmt&referringPage=locationSearchEcol.wmt&post_processes=PostDistrib&jump_to=

Fire Regime Condition Class (FRCC): The FRCC is a three-tiered index describing the departure of a region from its natural fire regime, with a ratings of low (1), moderate (2), and high (3). An area's natural fire regime status is determined by analyzing its projected historical fire potential as determined by "vegetation characteristics, fuel composition; fire frequency, severity and pattern." LANDFIRE (see above) distributes nationwide FRCC-indexed datasets based on comparisons of models of historical vegetative composition and current vegetation. The various agencies involved in managing the FRCC also distributes a mapping tool for use in ArcMap that determines vegetation departure from reference conditions.

helpdesk@niftt.gov
http://coastalmanagement.noaa.gov/mystate/welcome.html

TNC Ecological Drainage Units (EDU) map: "Ecological Drainage Units (EDUs) group watersheds that share a common zoogeographic history, physiographic and climatic characteristics, and therefore likely have a distinct set of freshwater assemblages and habitats. EDUs are hypothesized to account for the variability within fish zoogeographic sub-regions due to finer-scale drainage basin boundaries and physiography. EDUs are delineated as groups of 8-digit US Geological Survey Hydrologic Unit watersheds. EDUS were qualitatively defined by the TNC Freshwater Initiative using primarily USFS Fish Zoogeographic Subregions, USFS Ecoregions and Subsections, and major drainage divisions."

dsmetana@tnc.org

EDDMaps (Invasive Species Monitoring/Early Detection): "EDDMapS documents the presence of invasive species. A simple, interactive Web interface engages participants to submit their observations or view results through interactive queries into the EDDMapS database. Users simply enter information from their observations into the standardized on-line data form, which allows specific information about the infestation and images to be added. Data entered is immediately loaded to the Website, allowing real time tracking of species. Being able to see the current data of a species as it moves into a new area helps to facilitate Early Detection and Rapid Response programs (EDRR). EDRR programs help stop or control an invasive species before it becomes an unmanageable problem. All data is reviewed by state verifiers to ensure all data is accurate. The data is made freely available to scientists, researchers, land managers, land owners, educators, conservationists, ecologists, farmers, foresters, state and national parks."

http://coastalmanagement.noaa.gov/mystate/welcome.html

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Table 4: Datasets documenting current trends in habitat loss or conversion

Dataset	Specifics of interest	Spatial?	Category	Format	Scope	Currentness
National Wetlands Inventory (NWI)	Wetlands status and trends, especially Wetlands Losses in the US: 1780s to 1980s	spatial and non-spatial	biological	Map viewer, web map service, for download (NWI: GIS format, Google Earth; Status & Trends: document)	NWI covers 82 percent of the conterminous U.S., 31 percent of Alaska and 100 percent of Hawaii. National by state, national by AOI, national by USGS quadrangle	State file downloads last updated 1/22/2010; individual state file dates vary
GAP Analysis	Protected Areas Database of the US (PAD-US), GAP National Land Cover Data, GAP Species Distribution Models	spatial	abiotic and biological	Map viewer, for download (GIS format), web map service	GAP National Land Cover Data: National by region, national by state; PAD-US: National, national by region, national by Landscape Conservation Cooperative (LCC), national by state; Species Models: Variable scope	PAD-US: 5/2010; GAP National Land Cover Data: 2/2010; Species Models: Variable
USGS-NPS Vegetation Characterization Program (National Vegetation Classification System (NVCS))	Seven-level classification system for distinguishing vegetation types in US imagery; NPS Vegetation map data	spatial and non-spatial	biological	For download (GIS data)	National Parks throughout US: National by park, national by state, national by theme	Varies by National Park
National Land Cover Dataset (NLCD)	NLCD 1992, NLCD 2001, NLCD Change 92-01, and NLCD 2006 (when available); particularly info on impervious surface	spatial	abiotic and biological	Map viewer, for download (GIS format)	NLCD 1992: National by state, national by scene (only contiguous US); NLCD 2001: National by scene, national by zone (includes AK, HI, PR) NLCD Change 92-01: National by scene, national by zone (contiguous US) NLCD 2006: Should be same as NLCD 2001 (national by scene, zone)	NLCD 1992 released in 2000 (data acquired ca. 1992), NLCD 2001 released in 2007 (acquired ca. 2001), NLCD Change (2009), NLCD 2006 (should be 2010)

National Wetland Condition Assessment	Field sampling in 2011; final report data to be released 2013 Will provide a "baseline assessment of condition for some wetland types" across the Nation.	spatial and non-spatial	biological and abiotic	Not available until 2013	National (continental US); will use sampling sites from FWS Status & Trends reports; for static map of sampling sites, see http://water.epa.gov/type/wetlands/assessment/survey/upload/2008_01_Wetland_Survey_Fact_Sheet.pdf	2013 (final report scheduled)
National Land Cover Pattern Database	Forest Area Density, Forest Fragmentation, Landscape pattern types	spatial	abiotic and biological	For download (GIS format)	PA, MD, DE, VA, WV: by state or county	2000
Satellite imagery (Google)	Satellite imagery at various time steps	spatial	other	web map, web map service	Global	Updated frequently; varies by location
Landsat Data Archive	Raw landsat imagery	spatial	abiotic and biological	map viewer, for download (GIS format)	National by scene (Global coverage)	2010
Coastal Change Analysis Program (C-CAP)	Coastal land use data, coastal land use change data (Originally said: "Specifically info on impervious surfaces"--C-CAP appears to have no specific impervious surface data as in NLCD 2001; though there are two developed land use classes which are assigned based on % impervious surface. ISAT tool may be helpful here; see tab on "ArcGIS Extensions").	spatial	abiotic and biological	map viewer, for download (GIS format, Google Earth)	"Coastal intertidal areas, wetlands, and adjacent uplands of the contiguous U.S., Puerto Rico, the U.S. Virgin Islands, Hawaii, and the Pacific Islands territories" (see coverage here: http://csc-s-maps-q.csc.noaa.gov/CCAPAtlas/viewer.html). National availability by user-defined AOI, or by state.	Most recent iteration-2005/6.
National Aquatic Resource Surveys	Includes National Coastal Assessment, National Coastal Condition Report, National Lakes Assessment, National Rivers and Streams Assessment, National Wetland Condition Assessment, Wadeable Stream Assessment (see these assessments in rows below/other rows in document). Data is available for NCA, NCCR III, WSA.	spatial and non-spatial	biological and abiotic	See applicable rows below and throughout spreadsheet.	See applicable rows below and throughout spreadsheet.	See applicable rows below and throughout spreadsheet.

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Wadeable Stream Assessment	Bank geometry and substrate measurements, benthic macroinvertebrate 300 counts, benthic macroinvertebrate 300 metrics, canopy cover measured by densitometer, channel constraint data, field chemistry (conductivity, DO, temp.), in-channel fish cover ratings, large woody debris counts, legacy tree data, legacy tree metrics, mesotransect substrate data, short list of best physical habitat metrics (subset of phabmet), physical habitat metrics, rapid habitat assessment, rapid habitat assessment metrics, visual riparian estimates, post-sampling site info and survey design, stream velocity, Thalweg data, stream verification, water chemistry, watershed metrics	spatial and non-spatial	biological and abiotic	For download (tabular format with lat/lon; document)	National (continental US)	2004-05 (data collected)
National Lakes Assessment	Lake basin landuse metrics, lake buffer landuse metrics, lake chemical condition estimates, lake water quality data, lake diatom IBI condition estimate, lake diatom IBI data, lake diatom inference model, lake sediment diatom count data/sample information, lake physical habitat condition estimates/index values/metrics, lake profile data, lake visual assessment data, lake phytoplankton soft algae count data, lake phytoplankton diatom count data, lake phytoplankton sample information, lake zooplankton count data, lake plankton observed over expected model values, lake mean DO values, lake mean DO condition estimate,s lake secchi disk data, lake trophic condition estimate, lake recreational condition estimates.	spatial and non-spatial	biological and abiotic	For download (tabular format with lat/lon; document)	National (continental US)	2007 (data collected)

National Rivers and Streams Assessment	Field sampling in summers 2008-09; final report to be released 2011. Similar data to WSA (see above). Sampling will "include water chemistry, nutrients, chlorophyll-a, sediment enzymes, enterococci, fish tissue, physical habitat characteristics, and biological assessments including sampling of phytoplankton, periphyton, benthic macroinvertebrates, and fish community."	spatial and non-spatial	biological and abiotic	Not available until 2011	National (continental US); for static map of sampling sites, see: http://water.epa.gov/type/watersheds/monitoring/upload/2008_05_20_riverssurvey pdfrivers_survey_factsheet_mar18.pdf	2011 (final report scheduled)
National Resources Inventory (NRI)	Survey results regarding wetlands coverage, urbanization, farmland, general land cover	spatial (data available is aggregated by larger geographic units, but no discrete coverage), non-spatial	abiotic and biological	For download (GIS format, tabular)	upload/2008_05_20	Most GIS products and tables available online are from 1997 NRI; most recent NRI (only provides large-scale summary data) was in 2007
National Agricultural Statistical Service (NASS)	Vegetation Condition maps, Cropland extent	spatial and non-spatial	biological	For download (GIS format, tabular)	_riverssurvey	GIS data (2009); Tabular data mostly from 2009, see http://www.nass.usda.gov/Data_and_Statistics/County_Data_Files/Release_Schedule/index.asp
Forest Inventory and Analysis National Program (FIA)	Forest status and trends, forest types, soils data	spatial, non-spatial	biological	Map viewer, for download (tabular, limited GIS data), available by request (GIS data)	pdfrivers_survey	Inventory date varies by layer type/location, FIA conducts annual surveys; Forest Types layer: derived from 1991 imagery, released 2002; species basal area layer
National Insect and Disease Risk Map	Composite Insect and Disease Risk Map, projected basal area loss	spatial	biological	For download (GIS format)	_factsheet	Risk map (2006); Insect and Disease Detection Survey Data (2005-08, depending on layer)

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LANDFIRE	Vegetation-related products: Environmental Site Potential, Biophysical Settings, Existing Vegetation Type, Existing Vegetation Height, Existing Vegetation Cover, Vegetation Dynamics Model Fire-regime products: FRCC, FRCC Departure Index, Fire Regime Groups, Mean Fire Return Interval, Percent low-severity fire, Percent mixed-severity fire, Percent replacement-severity fire, succession classes. Fire behavior data products: Anderson (1982) Fire Behavior Fuel Models, Scott and Burgan (2005) Fire Behavior Fuel Models, Canadian Forest Fire Danger Rating System, Forest Canopy Bulk Density, Forest Canopy Base Height, Forest Canopy Height, Forest Canopy Cover, Elevation, Aspect, Slope	spatial	biological & abiotic	Map viewer, for download (GIS format)	_mar18.pdf	Noted layers: 2006
Fire Regime Condition Class (FRCC)	FRCC-indexed raster datasets (available via LANDFIRE), FRCC Mapping Tool	spatial	biological & abiotic	Map viewer, for download (GIS format)	National by user-defined AOI (LANDFIRE FRCC data).	LANDFIRE FRCC data: 2007; FRCC Mapping Tool-new version will be available 9/2010.
TNC Ecological Drainage Units (EDU) map	EDUs	spatial	abiotic	request by email	National; excludes parts of AK, CA, FL, MT, and some other minor areas	2005 (from EDU metadata online)
EDDMaps (Invasive Species Monitoring/Early Detection)	Invasive species sightings	spatial	biological	For download (tabular, .kml)	Southeast US, Alaska	Allows real-time tracking of invasive species locations (user sightings are immediately loaded online)

Immediate and long-term aquatic resource needs within watersheds that can be met through compensatory mitigation projects:

Coastal zone management plans/programs (CZMPs): Pursuant to the Coastal Zone Management Act (CZMA) of 1972, the National Coastal Zone Management Program establishes voluntary partnerships between state and federal agencies involved in coastal resource management. Thirty-four states maintain approved coastal management programs. Some state CZM programs have additionally developed Coastal Zone Management Plans to guide administration of coastal resources.

http://coastalmanagement.noaa.gov/mystate/welcome.html

USGS database of invasive species: USGS Nonindigenous Aquatic Species database; National Institute for Invasive Species Science (NIISS)- housed at USGS: "[NAS] has been established as a central repository for accurate and spatially referenced biogeographic accounts of nonindigenous aquatic species. The program provides scientific reports, online/realtime queries, spatial data sets, regional contact lists, and general information." "The National Institute of Invasive Species Science is a consortium of government and non-government organizations formed to develop cooperative approaches for invasive species science that meet the urgent needs of land managers and the public." NIISS coordinates user uploading of invasive species locations to the Global Organism Detection and Monitoring System, and eventually use of the Invasive Species Forecasting System (ISFS), a "web-based decision support environment that combines field data with satellite and other environmental data to generate landscape- and regional-scale predictive maps of invasive species distributions and potential habitat."

http://nas.er.usgs.gov//default.aspx
http://www.niiss.org/cwis438/websites/niiss/Home.php?WebSiteID=1

IMAP (Invasive Species Mapping Project): "[IMAP has] created high-resolution maps of the distribution and abundance of Chinese/European privet (Ligustrum sinense/vulagare), kudzu (Pueraria montana), and cogongrass (Imperata cylindrica) across the Southeast United States. Using these maps, Southeast weed managers will be able to determine hot spots of invasion, coordinate management across the region, and attract funding to eradicate or contain these species and mitigate the impacts in areas of widespread infestation."

http://invasive.princeton.edu/index.php

State nonpoint source management plans (CWA 319 plans): "Under Clean Water Act Section 319(h), EPA awards grants for implementation of state NPS management programs." EPA tracks these grants in its GRTS (Grants Reporting and Tracking System). "State grant recipients are required to report annually in GRTS their progress in meeting milestones, including reductions of NPS pollutant loadings and on improvements to water quality achieved by implementing NPS pollution control practices. GRTS pulls grant information from EPA's centralized grants and financial databases and allows grant recipients to enter detailed information on the individual projects or activities funded under each grant." The GRTS database includes geospatial data indexed via NHD to track the location of 319(h) projects. State NPS management plans are generally stored on the website of a state's water quality agency along with any associated GIS data.

U.S. EPA Assessment and Watershed Protection Division
http://www.epa.gov/owow_keep/NPS/where.html
EPA tracking of 319 projects via GRTS:
http://iaspub.epa.gov/pls/grts/f?p=110:199:744779551199161

Table 5: Datasets documenting immediate and long-term aquatic resource needs within watersheds that can be met through compensatory mitigation projects

Dataset	Specifics of interest	Spatial?	Category	Format	Scope	Currentness
Coastal zone management plans/programs (CZMPs)	Coastal Zone Management Plans, or similar planning efforts conducted by a Coastal Zone Management Program (state-level)	spatial and non-spatial	planning	Varies by state. GIS data, if available, is on state agency site.	National by state; only applicable for states/territories with coastal/Great Lakes shoreline	Varies by state
USGS database of invasive species: USGS Nonindigenous Aquatic Species database; National Institute for Invasive Species Science (NIISS)- housed at USGS	USGS Nonindigenous Aquatic Species (NAS) database includes invasive species sitings/references with lat/lon data. NIISS database also includes detailed listing of spatial datasets compiled from various sources.	spatial and non-spatial	biological	NAS: Map viewer; NIISS: Map viewer, for download (GIS format, tabular)	NAS: National; will also display introduced range maps by HUC-8, state. Can also query database by state, HUC-2, HUC-4, HUC-6, HUC-8	NAS and NIISS: Updated as new sitings/studies are submitted
IMAP (Invasive Species Mapping Project)	Princeton IMAP coverage of Southeast US for Chinese/European Privet, kudzu, and cogongrass	Spatial	biological	For download (GIS format, tabular, Google Earth)	Southeast US	2008
State nonpoint source management plans (CWA 319 plans)	319-funded NPS projects	spatial and non-spatial	abiotic and biological	Map viewer, for download (tabular), web map service	National (GRTS sites), national by state (319/NPS management plans)	Updated annually

Inventories of historic and existing aquatic resources

Essential Fish Habitat (EFH): "NOAA Fisheries works with the regional fishery management councils to identify the essential habitat for every life stage of each federally managed species using the best available scientific information. Essential fish habitat has been described for approximately 1,000 managed species to date. NOAA and the councils also identified more than 100 "habitat areas of particular concern" or HAPCs. These are considered high priority areas for conservation, management, or research because they are rare, sensitive, stressed by development, or important to ecosystem function."

Regional contacts: http://www.habitat.noaa.gov/protection/efh/regionalcontacts.html
http://www.habitat.noaa.gov/protection/efh/habitatmapper.html

Estuarine Living Marine Resources database: NOAA's Estuarine Living Marine Resources (ELMR) project, which ran from 1985-2000, developed a "consistent data base on the presence, distribution, relative abundance, and life history characteristics of ecologically and economically important fishes and invertebrates in the nation's estuaries… The nationwide data base was completed in 1994, and includes data for 153 species found in 122 estuaries and coastal embayments in five regions." The ELMR database is organized into five regions and reports the monthly relative abundance for the life stages of each species by estuary and salinity zone (five categories).

http://ccma.nos.noaa.gov/ecosystems/estuaries/elmr.html

National Benthic Inventory (NBI): "The NBI consists of a dynamic quantitative database on benthic species distributions and a corresponding taxonomic voucher collection of preserved benthic specimens obtained from studies conducted by NOAA and partnering institutions in estuarine and other coastal areas around the country. The quantitative database provides information on benthic species abundances by species and location."

http://www.nbi.noaa.gov/default.aspx

Table 6: Datasets documenting inventories of historic and existing aquatic resources

Dataset	Specifics of interest	Spatial?	Category	Format	Scope	Currentness
Essential Fish Habitat (EFH)	EFH, Habitat areas of particular concern (HAPC)	spatial	biological	Map viewer, for download (GIS data, tabular)	National by Fisheries Council	Varies by Council/Species/EFH/HAPC
Estuarine Living Marine Resources database	Relative abundance of important species of estuarine fishes and invertebrates	spatial and non-spatial	biological	Online database tool (tabular), for download (GIS format)	National (in estuaries) by region, estuary, species, life stage, salinity zone	2000
National Benthic Inventory (NBI)	Benthic species abundance	spatial	biological	For download (tabular, with location data)	National by taxa or by study	12-Sep-07

Other information sources that could be used to identify locations for suitable compensatory mitigation projects in the watershed

WRP sites: "In support of the Wetlands Reserve Program (WRP), State Conservationists and the National Cartography and Geospatial Center (NCGC) in Fort Worth, Texas have worked to develop a digital geospatial data layer for all wetlands easements: the Wetlands Reserve Program (WRP), the Emergency Wetland Reserve Program (EWRP), and the Emergency Watershed Protection Program-Flood Plain (EWP-FP). Each state digitizes all easement boundaries and forwards the data to the NCGC who compile and serve the dataset online."

http://www.ncgc.nrcs.usda.gov/programs/wetlands-reserve.html
http://proceedings.esri.com/library/userconf/proc02/pap0869/p0869.htm
http://ncgcws.ftw.nrcs.usda.gov/easements/imagery/

Ducks Unlimited data: DU: Distributes shapefiles of Habitat Project Deliveries as tracked through "CONSERV - DU's Oracle based Habitat Project tracking system. CONSERV is designed for DU conservation staff to assist tracking, reporting, and administration of conservation projects." DU also maintains shapefiles of focus areas, which areas prioritized by the DU Board for obtaining land or conservation easements, flyway regions, which categorize US counties by migratory flyway, and international conservation planning regions, which "identify and prioritize ecological regions which serve as guidance to regional planning and implementation of habitat protection, enhancement and restoration." ICPs are adapted versions of Bird Conservation Regions developed by the NABCI (see below).

http://www.ducks.org/Conservation/GIS/3404/GISSpatialDataDownload.html

Statewide inventories of historic properties: "Several state historic preservation offices offer information on National Register listed properties in their state through their websites. The depth of information available varies from state to state, but ranges from basic locational information to searchable databases with downloadable narrative descriptions and photos."

See state office website
http://www.nps.gov/nr/shpoinventories.htm

Historic American Landscape Survey: "The Historic American Landscapes Survey (HALS) mission is to record historic landscapes in the United States and its territories through measured drawings and interpretive drawings, written histories, and large-format black and white photographs and color photographs." Point data available for some HALS features; may not be very specific, though. Some of the places in the inventory were destroyed a long time ago and so their spatial data may be very general, e.g. the city of the feature. CRGIS call-estimated that only 20-30% of HABS/HAER/HALS sites had locational data.

NPS_HALS@nps.gov.
http://www.nps.gov/history/hdp/hals/index.htm

Historic American Engineering Record: "The Historic American Engineering Record (HAER) was established in 1969 by the National Park Service, the American Society of Civil Engineers and the Library of Congress to document historic sites and structures related to engineering and industry." Point data available for some HAER features; may not be very specific, though. Some of the places in the inventory were destroyed a long time ago and so their spatial data may be very general, e.g. the city of the feature. CRGIS call-estimated that only 20-30% of HABS/HAER/HALS sites had locational data.

NPS_HAER@nps.gov.
http://www.nps.gov/history/hdp/haer/index.htm

Historic American Building Survey: "The Historic American Buildings Survey (HABS) is the nation's first federal preservation program, begun in 1933 to document America's architectural heritage… As a national survey, the HABS collection is intended to represent 'a complete resume of the builder's art.' " (record drawings, history, and photographs) Point data available for some HABS features; may not be very specific, though. Some of the places in the inventory were destroyed a long time ago and so their spatial data may be very general, e.g. the city of the feature. CRGIS call-estimated that only 20-30% of HABS/HAER/HALS sites had locational data.

NPS_HABS@nps.gov
http://www.nps.gov/history/hdp/habs/index.htm

National Register of Historic Places (since 1966): "The National Register Information System (NRIS) is a database of over 84,000 historic buildings, districts, sites, structures and objects listed on, removed from, or pending listing in the National Register." While many of the historic sites listed in the National Register havee been digitized and are available online, this is an ongoing process. More detailed data may be available from State Historic Preservation Offices (SHPOs); see: http://www.nps.gov/nr/shpoinventories.htm.

http://www.nps.gov/nr/research/index.htm

Traditional cultural properties: "One kind of cultural significance a property may possess, and that may make it eligible for inclusion in the Register, is traditional cultural significance."

Watershed Notebook (EPA Watershed Approach Handbook): "Th[e EPA watershed handbook] is intended to help communities, watershed organizations, and state, local, tribal and federal environmental agencies develop and implement watershed plans to meet water quality standards and protect water resources. It was designed to help any organization undertaking a watershed planning effort, and it should be particularly useful to persons working with impaired or threatened waters. EPA intends for this handbook to supplement existing watershed planning guides that have already been developed by agencies, universities, and other nonprofit organizations. The handbook is generally more specific than other guides with respect to guidance on quantifying existing pollutant loads, developing estimates of the load reductions required to meet water quality standards, developing effective management measures, and tracking progress once the plan is implemented."

watershedhandbook@epa.gov
http://water.epa.gov/polwaste/nps/handbook_index.cfm

Appendix B: Data Sources for Applying a Watershed Approach

Table 7: Datasets documenting other information sources that could be used to identify locations for suitable compensatory mitigation projects in the watershed

Dataset	Specifics of interest	Spatial?	Category	Format	Scope	Currentness
WRP sites	National Wetlands Easement Database (includes WRP sites)	spatial	planning	By request: Map service, download* (appears that geospatial data is only available for agency use)	National or national by state	Updated monthly
Ducks Unlimited data	DU Habitat Projects locations, Focus Areas, Flyways, International Conservation Planning Regions	spatial	planning	For download (shapefile, .kml)	National, including AK and HI	Habitat project deliveries: 2008 International Conservation Planning Regions: 2005 Focus Areas: 2008 Flyways: 2005
Statewide inventories of historic properties	Boundaries/locations of significant historic properites	spatial and non-spatial	other	Varies by state	National by state (41 state offices referenced on NPS website)	Varies by state
Historic American Landscape Survey	Location of HALS-designated historic landscape sites	Spatial	other	Available by request	National	"Very current"
Historic American Engineering Record	Location of HAER-designated historic engineering sites	Spatial	other	Available by request	National	"Very current"
Historic American Building Survey	Location of HABS-designated historic buildings	Spatial	other	Available by request	National	"Very current"
National register of historic places (since 1966)	National Register of Historic Places	spatial and non-spatial	other	For download (tabular, GIS format)	National by region (US divided into 5 regions)	"Currently digitizing records"
Traditional cultural properties	Subset of National Register of Historic Places dataset					
Watershed Notebook (EPA Watershed Approach Handbook)	Chapters on: Gathering Existing Data and Creating an Inventory, Identifying Data Gaps and Collecting Additional Data if Needed, and Analyzing Data to Characterize the Watershed & Pollutant Sources (in addition to a number of other chapters on watershed planning); also Appendix A has resources for watershed planning	Non-spatial	planning	For download (document)	N/A	Mar-08

Site conditions that favor or hinder the success of compensatory mitigation projects

Hydric soils survey, Soil Survey Geographic Database (SSURGO): Hydric soils lists are produced from information contained in soil survey databases based on particular soil properties that are documented to potentially indicate their presence. The hydric soils list also requires proof of anaerobic conditions, either through soil survey data or through "best professional judgment;" this analysis results in a list of map units that are likely to contain soils meeting the hydric definition. "SSURGO is the most detailed level of soil mapping done by the Natural Resources Conservation Service (NRCS). SSURGO is linked to a Map Unit Interpretations Record (MUIR) attribute data base. The attribute data base gives the proportionate extent of the component soils and their properties for each map unit. The SSURGO map units consist of 1 to 3 components each. The Map Unit Interpretations Record data base includes over 25 physical and chemical soil properties."

http://soils.usda.gov/use/hydric/
http://soils.usda.gov/survey/geography/ssurgo/

US General Soils Map (STATSGO2): "The U.S. General Soil Map consists of general soil association units. It consists of a broad-based inventory of soils and non-soil areas that occur in a repeatable pattern on the landscape and that can be cartographically shown at the scale mapped. The dataset was created by generalizing more detailed soil survey maps. Where more detailed soil survey maps were not available, data on geology, topography, vegetation, and climate were assembled, together with Land Remote Sensing Satellite (LANDSAT) images. Soils of like areas were studied, and the probable classification and extent of the soils were determined. This dataset consists of geo-referenced vector and tabular digital data. The map data were collected in 1- by 2-degree topographic quadrangle units and merged into a seamless national dataset. It is distributed in state/territory and national extents. The soil map units are linked to attributes in the tabular data, which give the proportionate extent of the component soils and their properties. The tabular data contain estimated data on the physical and chemical soil properties, soil interpretations, and static and dynamic metadata. Most tabular data exist in the database as a range of soil properties, depicting the range for the geographic extent of the map unit. In addition to low and high values for most data, a representative value is also included for these soil properties."

http://soils.usda.gov/survey/geography/statsgo/

Protected Areas Database of the United States (PAD-US), Conservation Biology Institute: "In early May, 2010, the PAD-US Partnership suspended its operations due to funding constraints." Restricted funding for the PAD-US collaborative effort resulted in USGS and CBI each publishing one dataset covering protected public and private lands across the US. The CBI version of PAD-US "uses a standardized spatial geometry and documents standard attributes on land ownership, management designations and conservation status" to essentially map the same objectives as the GAP Analysis PAD-US product. Non-sensitive conservation easement data as compiled in the National Conservation Easement Database will be distributed via PAD-US; however, NCED is a distinct database from PAD-US that will also privately maintain sensitive easement information.

http://www.protectedlands.net/
http://www.conservationeasement.us/index.html

Appendix B: Data Sources for Applying a Watershed Approach

Critical habitat designations under ESA for terrestrial species (FWS): "The ESA requires the Federal government to designate "critical habitat" for any species it lists... Critical habitat is defined as: 1. Specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to conservation, and those features may require special management considerations or protection; and 2. Specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation." FWS designates critical habitat for endangered/threatened terrestrial species and maintains geospatial data depicting the extent of critical habitat areas. Note: not all critical habitat data is available through the FWS critical habitat portal. In this instance, the portal directs users to contact the lead FWS Region for that species.

http://ecos.fws.gov/ecos/helpdesk.do
http://criticalhabitat.fws.gov/

Critical habitat designations under ESA for marine species (NMFS): "The ESA requires the Federal government to designate "critical habitat" for any species it lists... Critical habitat is defined as: 1. Specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to conservation, and those features may require special management considerations or protection; and 2. Specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation." NMFS designates critical habitat for endangered/threatened marine species and maintains geospatial data depicting the extent of critical habitat areas (though they note that Fed. Reg. notices are the definitive source for critical habitat designations).

Office of Protected Resources (F/PR)
National Marine Fisheries Service
PR.Webmaster@noaa.gov
GIS data:
http://www.nmfs.noaa.gov/gis/data/critical.htm
Federal Register notices of critical habitat:
http://www.nmfs.noaa.gov/pr/species/criticalhabitat.htm

National landscape condition map: See LANDFIRE dataset comparing current vegetative condition to environmental site potential.

National Estuarine Restoration Inventory (NERI): "The National Estuaries Restoration Inventory (NERI) has been created to track estuary habitat restoration projects across the nation. The purpose of the inventory is to provide information on restoration projects in order to improve restoration methods, as well as to track acreage restored toward the million-acre goal of the Estuary Restoration Act."

neri@noaa.gov
https://neri.noaa.gov/neri/index.htm

USGS Fisheries: Aquatic and Endangered Resources Program (FAER): "[FAER] focuses on the study of fishes, fisheries, fish diseases and parasites, aquatic organisms and their water based and water-dependent habitats. Endangered species and those that are imperiled receive special research interest. The program's research on the diversity, natural history, health, and habitat requirements of fish and other aquatic organisms is carried out to support the management, conservation, and restoration of our Nation's aquatic resources." FAER maintains geospatial data on bathymetry for the Upper Mississippi River System, aquatic contaminants and their effects on fish in particular western states, fisheries mark/recapture tracking data, nonindigenous aquatic species (NAS), nonindigenous fish distribution, paddlefish movement, and effects of sediment contaminants on surrogate species. FAER also houses the detailed geospatial databases created by the Upper Midwest Environmental Sciences Center (UMESC). In addition, FAER distributes an acute toxicity database which summarizes aquatic acute toxicity tests (non-spatial).

http://biology.usgs.gov/faer/data.html

<u>CBRA (Coastal Barrier Resources Act) CBRS (Coastal Barrier Resources System)</u>: "The Coastal Barrier Resources Act (CBRA) of 1982 established the John H. Chafee Coastal Barrier Resources System (CBRS), comprised of undeveloped coastal barriers along the Atlantic, Gulf, and Great Lakes coasts. The law encourages the conservation of hurricane prone, biologically rich coastal barriers by restricting Federal expenditures that encourage development, such as Federal flood insurance through the National Flood Insurance Program… The Fish and Wildlife Service maintains the repository for CBRA maps enacted by Congress that depict the CBRS. The Service also advises Federal agencies, landowners, and Congress regarding whether properties are in or out of the CBRS, and what kind of Federal expenditures are allowed in the CBRS." In 2009, FWS held public comment on the CBRS Digital Mapping Pilot Project, which released draft maps for 70 CBRS units, "describe[d] the results of the pilot project," and presented a "framework for modernizing the remainder of the CBRS maps." The CBRS pilot project covers around 10% of the CBRS program, and has pilot sites located in DE, NC, SC, FL, and LA.

U.S. Fish and Wildlife Service; Division of Habitat and Resource Conservation
http://www.fws.gov/habitatconservation/coastal_barrier.html

<u>Marine Protected Areas (MPA) Inventory</u>: "The Marine Protected Areas Inventory (MPA Inventory) is a comprehensive geospatial database designed to catalog and classify marine protected areas within US waters. The Inventory contains information on over 1,600 sites and is the only such comprehensive dataset in the nation. The database has various applications for marine management and conservation, but its primary purpose is to maintain baseline information on MPAs to the assist in the development of the National System of MPAs, as defined in Executive Order 13158."

http://mpa.gov/
http://mpa.gov/dataanalysis/mpainventory/mpaviewer/mpaviewer.swf

<u>National Assessment of Coastal vulnerability to Sea-Level Rise</u>: "This project, within the USGS Coastal and Marine Geology Program's National Assessment, seeks to objectively determine the relative risks due to future sea-level rise for the U.S. Atlantic, Pacific, and Gulf of Mexico coasts. Through the use of a coastal vulnerability index, or CVI, the relative risk that physical changes will occur as sea-level rises is quantified based on the following criteria: tidal range, wave height, coastal slope, shoreline change, geomorphology, and historical rate of relative sea-level rise."

Appendix B: Data Sources for Applying a Watershed Approach

Data inputs for these criteria, along with the resultant CVI ranking for coastal locations across the US, are included in the geospatial dataset distributed by USGS.

http://woodshole.er.usgs.gov/project-pages/cvi/

<u>Sea Level Affecting Marshes Model</u>: "The Sea Level Affecting Marshes Model (SLAMM)-View is a web browser-based application that displays map pairs of the same area, each at different sea levels. SLAMM also looks at sediment and organic matter accumulation on the marshes as well as erosion from tides and storms that can overtake coastal barrier beaches. In addition, SLAMM depicts how these relationships will remain coupled as sea levels rise. The SLAMM also predicts changes in coastal wetlands and shorelines. These simulations are based on the best available science and technology. Users can select different scenarios by combining time, in 25-year intervals, at different severities, e.g., 0.5 meters to 1 meter increase in sea level. For most [SLAMM] studies, an output file is produced for each of 5 different dates in a time-series (i.e., Base Year, 2025, 2050, 2075, and 2100) for each different scenario of sea level rise (e.g., IPCC A1B Mean, IPCC A1B Max, and 1m)."

http://www.fws.gov/slamm/
http://www.slammview.org/

Table 8: Datasets documenting site conditions that favor or hinder the success of compensatory mitigation projects

Dataset	Specifics of interest	Spatial?	Category	Format	Scope	Currentness
Hydric soils survey, Soil Survey Geographic Database (SSURGO)	Hydric soils survey data by map unit (from Map Unit Interpretations Record database). SSURGO database also by map unit; includes detailed soil statistics, i.e. "water capacity, soil reaction, salinity, flooding, water table, and bedrock; building site development and engineering uses; cropland, woodland, rangeland, pastureland, and wildlife; and recreational development."	spatial and non-spatial	abiotic	For download (tabular, GIS format through NRCS geospatial gateway)	Tabular data (hydric soils): National, national by state. SSURGO: National, national by state, national by county	Hydric Soils lists by state: 2/2010 SSURGO: 2003-04 (may differ in some areas; this range is for national dataset)
US General Soils Map (STATSGO2)	Physical/chemical soil properties, soil interpretations	spatial	abiotic	For download (GIS format, tabular), by request	National by state, county, or user-defined AOI	2006
Protected Areas Database of the United States (PAD-US): Conservation Biology Institute	CBI version of PAD-US database, includes non-sensitive information from National Conservation Easement Database	spatial	other	For download (GIS format)	National, national by region, national by state	May-10

Critical habitat designations under ESA for terrestrial species (FWS)	Critical habitat areas for threatened/endagered terrestrial spp.	spatial and non-spatial	biological	For download (shapefile), web map, web map service	Varies by spp; website has critical habitat for marine species across nation.	Varies by species
Critical habitat designations under ESA for marine species (NMFS)	Critical habitat areas for threatened/endagered marine spp.	spatial and non-spatial	biological	For download (GIS format)	Varies by spp; website has critical habitat for marine species across nation.	1979-2009 (some proposed critical habitat areas from 2010)
National landscape condition map	See LANDFIRE dataset comparing current vegetative condition to environmental site potential.	spatial	biological			
National Estuarine Restoration Inventory (NERI)	NERI estuary restoration projects	spatial	abiotic	Map viewer, for download (tabular, GIS format)	National	2006
USGS Fisheries: Aquatic and Endangered Resources Program (FAER)	Acute toxicity database, Upper Mississippi River bathymetry data, Biological Environmental Status & Trends (BEST), Historical Fisheries Mark/Recapture and Telemetry Database, Nonindigenous Aquatic Species Database, Nonindigenous Fish Distribution Information, Paddlefish Movement Data, Sediment Effects Concentration Database, UMESC data library (Upper Mississippi Environmental Sciences Center), UMESC Fish Database	spatial and non-spatial	abiotic and biological	Acute toxicity: for download; Upper MS River bathymetry: for download; Historical Fisheries Mark/ Recapture and Telemetry Database: for download; NAS: for download; Paddlefish movement: static maps (images), for download. Sediment Concentrations: for download. UMESC data library: web maps, for download. UMESC fish database: searchable online database.	Acute toxicity: N/A. Upper MS bathymetry: Upper MS River System. BEST: Most of nation by river basin (see http://www.cerc.usgs.gov/data/best/search/). Historical Fisheries Mark/Recapture: Upper MS. NAS: see above (USGS Invasive Spp. Database). Paddlefish Movement: Upper MS. Sediment Effects Concentration Database: Clark Fork River/Milltown Reservoir system in MT, the Great Lakes, the Upper MS River, the Trinity River in TX, Mobile Bay in AL and Galveston Bay in TX.	Acute toxicity database: Based on 1986 study, updated as needed. Upper MS River bathymetry data: 1992-2001. BEST: 1995-2004. Historical Fisheries Mark/ Recapture: 1995 (dataset contains date of fish capture). NAS: Updated as new studies/sitings reported. Nonindigenous Fish Distribution Info: see NAS. Paddlefish Movement Data: 1995-96. Sediment Effects: 1996. UMESC data library: varies by dataset. UMESC fish database: 2009.

CBRA (Coastal Barrier Resources Act) CBRS (Coastal Barrier Resources System)	CBRS boundaries	spatial	other	For download (GIS format, pdf)	CBRS Boundaries: national (only applicable to AL, FL, ME, MI, NJ, NC, RI, Virgin Isl., CT, GA, MD, MN, NY, OH, SC, VA, DE, LA, MA, MS, PR, TX, WI). Proposed boundaries: national by state	CBRS boundaries: 1990-2008 Proposed boundaries: 2009
Marine Protected Areas (MPA) Inventory	Inventory of MPAs managed at federal/ state/local/other government level	spatial	other	Map Viewer, For download (tabular, GIS format)	National	"The MPA Center is continually updating and verifying the Inventory data"
National Assessment of Coastal vulnerability to Sea-Level Rise	Data on geomorphology, relative rate of sea-level rise, coastal slope, mean wave height, tidal range and erosion and accretion rates, as well as their ranked values (1 - 5) and the calculated coastal vulnerability index (CVI).	spatial and non-spatial	abiotic	For download (document, GIS format)	National by region (US divided into Gulf, Pacific, Atlantic)	Atlantic: 1999; Pacific and Gulf: 2000
Sea Level Affecting Marshes Model	Coupled sea level rise-marsh models for various IPCC emissions scenarios	spatial	abiotic	Map viewer	Delaware Bay, coastal South Carolina, coastal Georgia, Puget Sound and Chesapeake Bay	GA/SC: 2008; Chesapeake: 2008; Puget Sound: 2007

The presence and needs of sensitive species/Information on rare, endangered and threatened species and critical habitat

State wildlife action plans: "[I]n 2001 Congress developed new conservation funding legislation, the Wildlife Conservation and Restoration Program and the State Wildlife Grants Program. These programs were designed to assist states by providing annual allocations for the development and implementation of programs to benefit wildlife and their habitats. The funding was intended to supplement, not duplicate, existing fish and wildlife programs, and to target species in greatest need of conservation, species indicative of the diversity and health of the states' wildlife, and species with low and declining populations, as deemed appropriate by the states' fish and wildlife agencies." The federal legislation mandated eight criteria that must be included in a state wildlife action plan; the five relevant to geospatial data/other data acquistion and analysis are noted in the "Specifics of interest" field. The datasets used or created for a WAP are variable at the state level; many states include GAP data, land-cover data, etc. to analyze/delineate habitat for species designated as "species in greatest need."

Varies by state; see: http://www.wildlifeactionplans.org/pdfs/implementation_contacts.pdf
http://www.wildlifeactionplans.org/about/index.html

Conservation Action Plans: The Nature Conservancy's conservation projects, where TNC are doing work on the ground within a strategic planning framework.

http://conpro.tnc.org/

Ecoregional Assessments – portfolios for terrestrial assessments: The Nature Conservancy's priorities for where TNC should focus our conservation efforts to have the biggest impact.

http://maps.tnc.org/

Natural heritage databases: "NatureServe Explorer [is] an authoritative source for information on more than 70,000 plants, animals, and ecosystems of the United States and Canada. Explorer includes particularly in-depth coverage for rare and endangered species. NatureServe Explorer is a product of NatureServe and its natural heritage member programs." The database includes "scientific and common names, conservation status, distribution maps, images for thousands of species, life histories, conservation needs, and more." NatureServe Explorer will link users to available geospatial data on species distribution when available. In addition, state natural heritage programs maintain databases and commonly have geospatial data available charting condition and occurrence of rare species, threatened species, and natural communities.

NatureServe Explorer: explorer@natureserve.org.
Varies by state; see state natural heritage program websites (http://www.natureserve.org/visitLocal/).
Links to natural heritage programs by state:
http://www.natureserve.org/visitLocal/
NatureServe Explorer; national product of natural heritage data:
http://www.natureserve.org/explorer/ (no geospatial)

Appendix B: Data Sources for Applying a Watershed Approach

NatureServe Data:
http://www.natureserve.org/getData/index.jsp

NatureServe national coverage at HUC-10/HUC-8 of freshwater fish, snails, mussels: "NatureServe has compiled detailed data on the current and historic distributions of the native freshwater fishes of the United States, excluding Alaska and Hawaii. Presented here are lists of the native fish species of each small watershed [HUC-8]…These data derive in part from precise location data (element occurrences) compiled by state natural heritage programs for 307 vulnerable or imperiled U.S. fish species. The natural heritage-derived locational data were supplemented with information from the scientific literature and from species experts to compile the most complete distributional information possible for these species at the level of USGS 8-digit cataloging unit."Custom data requests can also be submitted for freshwater fish, mussel, and snail occurrence at the HUC-10 level. NatureServe will compile dataset based on precise species location data they collect from state Natural Heritage partner programs. Depending on state, HUC-10 level data may be deemed "sensitive"; this may incur more cost for data acquisition.

http://www.natureserve.org/getData/dataSets/watershedHucs/index.jsp
http://www.natureserve.org/getData/fishMaps.jsp

Candidate Notice of Review: The Candidate Notice of Review (CNOR), released by FWS, is a "yearly appraisal of the current status of plants and animals that are considered candidates for protection under the ESA…Candidate species are plants and animals for which the Service has enough information on their status and threats to propose them as threatened or endangered, but developing a proposed listing rule is precluded by higher priority listing actions… Candidate species do not receive protection under the ESA, although the Service works to conserve them. The annual review and identification of candidate species provides resource managers advance notice of species in need of conservation, allowing them to address threats and work to preclude the need to list the species." The annual list of candidate species is released by FWS in a Federal Register notice and maps of the geographic distribution of candidate species are available online.

http://www.fws.gov/endangered/what-we-do/cnor.html

Statewide assessments of forest resources: The 2008 Farm Bill mandates that states complete statewide assessments of forest resources in order to continue receiving USFS funding. Although the statewide assessments and their constituent information are generally mandated nationally, the geospatial components of individual statewide forestry assessments vary between states. USGS is working on a State and Private Forestry Redesign Project Layer with nationwide coverage, but this layer is a product of other national indices (i.e. NIDRM, LANDFIRE, ESA critical habitat, etc.; see "Specifics of interest" for list of layers). Also, while geospatial analysis is a centerpiece of many states' assessments, the processed GIS data does not appear to be available for download in many cases. Static maps are commonly included in the statewide reports. See below for broad description of statewide forestry assessments and required information: At a minimum, state forest resource assessments will: a) Describe forest conditions on all ownerships in the state; b) Identify forest related benefits and services; c) Highlight issues and trends of concern as well as opportunities for positive action; d) Delineate high priority forest landscapes to be addressed; e) Outline broad strategies for addressing the national themes along with critical issues and landscapes identified through the assessment. State forest resource assessments will be geospatially based and make use of the best existing data. States are encouraged to identify critical information gaps as part of their assessment process so that this information can be acquired as opportunities arise."

http://svinetfc4.fs.fed.us/clearinghouse/state_private/nationaldata.html

Environmental Conservation Online System (ECOS): "The Environmental Conservation Online System (ECOS) is a gateway web site that provides access to data systems in the Endangered Species and Fisheries and Habitat Conservation program areas, as well as other FWS and Government data sources. ECOS provides a central point of access to assist FWS personnel in managing data and information as well as provide general public access to information from numerous FWS databases. ECOS also provides a mapping tool, the ECOS Mapper, that provides a way to visualize the information provided by ECOS." See "specifics of interest" cell for a list of the datasets available through ECOS. Of particular interest is IPaC, "which will be a tool for action agencies, their applicants, and other project proponents to use during the initial phases of project development and assessment. The system, currently under development by the U.S. Fish and Wildlife Service (FWS), will allow for more effective integration of listed resource conservation needs and the eventual streamlining of Endangered Species Act Section 7(a)(2) consultation. The first phase of this system will allow project proponents to obtain species lists, species ecological information, bibliographic references, recommended conservation measures for incorporation into project designs, and Service contact information via the internet. It will also notify Service offices of upcoming project activities allowing for better workload planning."

http://ecos.fws.gov/ecos/helpdesk.do
http://ecos.fws.gov/ecos/indexPublic.doc

North American Bird Conservation Initiative (NABCI): "The U.S. North American Bird Conservation Initiative (NABCI) Committee is a forum of government agencies, private organizations, and bird initiatives helping partners across the continent meet their common bird conservation objectives. The Committee's strategy is to foster coordination and collaboration on key issues of concern, including coordinated bird monitoring, conservation design, private land conservation, international conservation, and institutional support in state and federal agencies for integrated bird conservation." Primary products of the NABCI process are national and international bird conservation initiatives, which create conservation plans to chart "species status assessments, population goals, habitat conservation threats, issues and objectives, and monitoring needs." Additionally, these bird initiatives create regional bird conservation plans for landbirds, shorebirds, waterbirds, and waterfowl at varying scales. Conservation plans designed for all birds are also available for some Joint Ventures (JVs). "[JVs] are self-directed, regional partnerships of public and private organizations and individuals, which were originally established to carry out the North American Waterfowl Management Plan. [JVs] have now accepted the challenge of carrying out multiple bird conservation plans using an integrated approach." Available spatial data from NABCI appears to be limited to bird conservation regions/PIF physiographic areas/JV areas, etc. To supplement this data, some JVs distribute region-specific GIS data, such as vector conservation datasets, satellite imagery, high-res DOQs, etc.

Appendix B: Data Sources for Applying a Watershed Approach

http://www.nabci-us.org/map.html
(links to all plan types by Bird Conservation Region-BCR)

Important Bird Areas (IBA) Program (Audubon): "Important Bird Areas, or IBAs, are sites that provide essential habitat for one or more species of bird. IBAs include sites for breeding, wintering, and/or migrating birds… IBAs may include public or private lands, or both, and they may be protected or unprotected. To qualify as an IBA, sites must satisfy at least one of the following criteria. The site must support: 1) Species of conservation concern (e.g. threatened and endangered species) 2) Restricted-ranges species (species vulnerable because they are not widely distributed) 3) Species that are vulnerable because their populations are concentrated in one general habitat type or biome 4) Species, or groups of similar species (such as waterfowl or shorebirds), that are vulnerable because they occur at high densities due to their congregatory behavior. Identification of a site as an IBA indicates its unique importance for birds. Nonetheless, some IBAs are of greater significance than others. A site may be important at the global, continental, or state level [(see web map)]. The use of a hierarchical classification system further helps to establish priorities for conservation efforts." Audubon has a web map of all IBAs throughout the US (point data) and also maintains a searchable online database of IBAs. The online IBA search tool contains static maps of the spatial extent of an IBA (polygon) along with detailed site-specific information on IBA status, priority, location, site description, ornithological significance, species data and criteria, ownership, habitat, land use, and conservation issues.

For regional contacts, see: http://www.audubon.org/bird/iba/state_coords.html
http://web4.audubon.org/bird/iba/index.html

Information, Planning, and Consultation system: See ECOS

Waterfowl management plans/ Joint Ventures: See NABCI

Recovery Online Activity Reporting System (ROAR) (Note: this is also part of ECOS): Online database of recovery plans for endangered/threatened species across the US.

https://ecos.fws.gov/ecos/helpdesk.do?version=ROAR-2_1_23
https://ecos.fws.gov/roar/pub/ConfigureRecActionReport.do?path=ROAR%20Custom%20Queries.Public%20Actions%20AdHoc

Table 9: Datasets documenting the presence and needs of sensitive species/Information on rare, endangered and threatened species and critical habitat						
Dataset	Specifics of interest	Spatial?	Category	Format	Scope	Currentness
State wildlife action plans	Varies by state; national standards mandate wildlife action plans include, among other criteria, "1) Information on the distribution and abundance of species of wildlife 2) Descriptions of locations and relative condition of key habitats and community types essential to conservation of species identified in (1); 3) Descriptions of issues that may adversely affect species identified in (1) or their habitats, and priority research and survey efforts needed to identify factors which may assist in restoration and improved conservation of these species and habitats; 4) Descriptions of conservation actions determined to be necessary to conserve the identified species and habitats and priorities for implementing such actions; 5) Proposed strategies for monitoring species identified in (1) and their habitats, for monitoring the effectiveness of the conservation actions proposed in (4), and for adapting these conservation actions to respond appropriately to new information or changing conditions"	spatial & non-spatial	planning	For download (document and/or GIS format; varies by state)	National by state	Legislation required states to develop a Wildlife Action Plan by October 2005; plans must include "descriptions of procedures to review the Plan at intervals not to exceed ten years"
Conservation Action Plans	TNC conservation project locations, tabular data on conservation strategies	spatial	planning	map service / web map / complete download	Global	ongoing updates (weekly)
Ecoregional Assessments – portfolios for terrestrial assessments	Marine Ecoregional Assessments, Terrestrial Ecoregional Assessments	spatial	planning	map service / web map / complete download	Both layers are global	ongoing updates (roughly monthly)

Appendix B: Data Sources for Applying a Watershed Approach

Natural heritage databases	NatureServe Explorer, state-level natural heritage data on rare/threatened species and communities	spatial	biological	Natural Heritage data varies by state; NatureServe Explorer (when available, for download; otherwise, searchable online database)	National (NatureServe Explorer), national by state (state-level natural heritage programs)	Variable nationally/by species dataset
NatureServe national coverage at HUC-10/HUC-8 of freshwater fish, snails, mussels	Watershed maps of freshwater fish, mussels, and snails	spatial	biological	Available by request (HUC-10 level) For download (GIS format) (HUC-8 level; includes all native freshwater fish, G1-G3 mussels) For download (GIS format) (HUC-6 level), all mussel species	National by HUC-10, data gaps may/may not preclude coverage for PA, NJ, DE; AK is sparse National by HUC-8 (freshwater fish and G1-G3 mussels) National by HUC-6 (all mussels)	Current; updated continuously as data is sent in
Candidate Notice of Review	Candidate species for ESA listing; species distributions	spatial and non-spatial	biological	Web map, for download (document)	National	Nov. 2009 (latest Fed. Reg. notice)
Statewide assessments of forest resources	National dataset compiled by USFS (State and Private Redesign Assessment Data): Critical Habitat, Development Risk, Wildland Fire Potential, Forest Fragmentation, Insect and Disease Risk, Woody Biomass, Woodland-Urban Interface (WUI). Statewide assessment layers vary, see individual state reports for what may/may not be available. Examples include: fragmentation, fragmentation prevention potential, roadless forest patches, projected development patterns, erosion potential, targeted slope percentages for forestry, buffered wetlands (woody/non-woody), forest biodiversity potential, etc.	spatial and non-spatial	biotic, planning	National, USFS compiled dataset: For download (GIS format); State-specific forest assessments: primarily appear by request only	National, national by state	Farm Bill (2008) requires states to complete assessments by 6/18/2010 to continue receiving USFS funds. "Assessments should be reviewed for needed updates on at least a five year cycle."

Environmental Conservation Online System (ECOS)	Links to HCPs, Safe Harbor agreements, Candidate Conservation agreements, FWS critical habitat portal, Fish Passage decision support system, listed species reports, refuge contaminant assessments (see BEST above), FWS Information, Planning, and Conservation System (IPaC)	spatial and non-spatial	biological	HCPs, Safe Harbor agreements, Candidate conservation agreements: Searchable on-line database. FWS critical habitat portal: web map, for download (GIS format). Fish passage decision support system: web map Listed species reports: web map, searchable online database BEST: documents available for download by refuge IPaC: web map interface	HCPs, Safe Harbor agreements, Candidate conservation agreements: National, national by region. FWS critical habitat data: National, but not all species available (if not, contact FWS region). Fish passage decision support system: National Species reports: National; can access nationally by state, nationally by (lead) region BEST: National by region/National Wildlife Refuge IPaC: National	Varies by dataset/within datasets (i.e. not all HCPs are same date)
North American Bird Conservation Initiative (NABCI)	Landbird conservation plans, shorebird plans, waterbird plans, waterfowl plans	Spatial and non-spatial	biological	For download (document)	Landbird conservation plans: National by state (in west), Partners in Flight (PIF) physiographic area (rest of US) Shorebird plans: National by shorebird planning regions Waterbird plans: National by waterbird conservation planning regions Waterfowl plans: National by Joint Venture area (regional public-private partnerships; see dataset summary)	Varies by region/plan

Appendix B: Data Sources for Applying a Watershed Approach

Important Bird Areas (IBA) Program (Audubon)	Audubon-designated IBAs across the US; segregated by site significance (state-level, continental, global)	spatial and non-spatial	biological	Web map, searchable on-line database	National	7/29/2010
Information, Planning, and Consultation system	See ECOS					
Waterfowl management plans/ Joint Ventures	See NABCI		planning			
Recovery Online Activity Reporting System (ROAR) Note: this is also part of ECOS	Endangered/threatened species recovery plans	Non-spatial	biological	For download: tabular	National, national by lead region	Varies by recovery plan. Database provides estimated initiation/ completion date of individual plans.

U.S. Geological Survey topographic and hydrologic maps

Watershed Boundary Dataset (WBD): The Watershed Boundary Dataset (WBD) depicts HUC watersheds ranging in spatial scale from the 2-digit level (water resource region; average area 177,560 sq. mi.) to the 12-digit level (subwatershed; average area 40 sq. mi.). HUCs are delineated based on hydrologic and topographic features; for more detail on federal guidelines for HUC delineation see ftp://ftp-fc.sc.egov.usda.gov/NCGC/products/watershed/hu-standards.pdf. http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/

National Cartography & Geospatial Center
datahelp@ftw.usda.gov; call 1-800-672-5559
http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/

Orthophoto/ orthoimagery theme of the National Map: The orthoimagery used in The National Map include High Resolution Orthoimagery, Landsat 7 Mosaics, and seamless Digital Orthophoto Quarter Quadrangles/Digital Orthophoto Quadrangles (DOQQs/DOQs). To support Homeland Security and Emergency Response functions, USGS is acquiring high-resolution (generally about 1/3 meter/1 ft. resolution) orthoimagery of select urban and coastal areas. Landsat "provide[s] multispectral orthoimagery at a resolution of 30 meters, with a revisit cycle of as few as 8 days (using Landsat 5 and Landsat 7). As the Landsat scenes are acquired and loaded into a "seamless database," they will provide a full-coverage orthoimagery layer for the entire United States." Finally, DOQQs are also being integrated into The National Map with the ultimate objective of achieving seamless coverage of the US. DOQQs are the original source data for DOQs, which are a seamless version of DOQQs. DOQs are "a computer-generated image of an aerial photograph in which the image displacement caused by terrain relief and camera tilt has been removed" and provide imagery at 1-meter spatial resolution.

http://gisdata.usgs.net/website/Orthoimagery/feedback.php
http://gisdata.usgs.net/website/Orthoimagery/index.php

National Elevation Dataset (NED): The orthoimagery used in The National Map include High Resolution Orthoimagery, Landsat 7 Mosaics, and seamless Digital Orthophoto Quarter Quadrangles/Digital Orthophoto Quadrangles (DOQQs/DOQs). To support Homeland Security and Emergency Response functions, USGS is acquiring high-resolution (generally about 1/3 meter/1 ft. resolution) orthoimagery of select urban and coastal areas. Landsat "provide[s] multispectral orthoimagery at a resolution of 30 meters, with a revisit cycle of as few as 8 days (using Landsat 5 and Landsat 7). As the Landsat scenes are acquired and loaded into a "seamless database," they will provide a full-coverage orthoimagery layer for the entire United States." Finally, DOQQs are also being integrated into The National Map with the ultimate objective of achieving seamless coverage of the US. DOQQs are the original source data for DOQs, which are a seamless version of DOQQs. DOQs are "a computer-generated image of an aerial photograph in which the image displacement caused by terrain relief and camera tilt has been removed" and provide imagery at 1-meter spatial resolution.

custserv@usgs.gov
http://ned.usgs.gov/

New US topography (US Topo): US Topo is the next generation of digital topographic maps from the U.S. Geological Survey. While US Topo maps are arranged in the traditional 7.5 minute quadrangle format familiar to USGS topo map users, they are distributed in a GeoPDF format, allowing users to turn layers on and off, zoom in and out, and print customized maps. US Topo maps include key layers of geospatial data from The National Map: "orthoimagery, roads, geographic names, contours, and hydrographic features." US Topos are not designed as a GIS product, but rather as a medium scale-tool for non-GIS users in need of maps. The data layers presented in US Topos are of lower resolution than their original input datasets due to data processing for the target audience.

USGS National Geospatial Program (NGP)
http://nationalmap.gov/ustopo/index.html

National Hydrographic Dataset (NHD): See above.

NHDPlus: "The EPA Office of Water, assisted by the US Geological Survey, has supported the development of NHDPlus to enhance the EPA WATERS application. NHDPlus is an integrated suite of application-ready geospatial data sets that incorporate many of the best features of the National Hydrography Dataset (NHD), the National Elevation Dataset (NED), the National Land Cover Dataset (NLCD), and the Watershed Boundary Dataset (WBD). First released in 2006, the NHDPlus consists of nine components: greatly improved 1:100K National Hydrography Dataset (NHD); a set of value added attributes to enhance stream network navigation, analysis and display; an elevation-based catchment for each flowline in the stream network; catchment characteristics; headwater node areas; cumulative drainage area characteristics; flow direction, flow accumulation and elevation grids; flowline min/max elevations and slopes; flow volume & velocity estimates for each flowline in the stream network."

info@Horizon-Systems.com
http://www.horizon-systems.com/nhdplus/contact.php

Coastal Assessments Framework (CAF) – estuaries: "The Coastal Assessment Framework (CAF) is a digital spatial framework developed using geographic information system (GIS) technology, which allows resource managers and analysts to organize and present information on the nation's coastal and marine resources." While the CAF drainage areas provide coverage for the entire contiguous United States, 150 Estuarine (and sub-estuarine) Drainage Areas (EDAs) comprise a subdivision of the CAF dataset. Additionally, various socioeconomic data, including Census trends, Census data, demographic/income projections to 2040, income and earnings trends, employment trends, and coastal economy data are all available by CAF drainage area.

http://coastalgeospatial.noaa.gov/back_gis.html#caf
http://marineeconomics.noaa.gov/socioeconomics/download/download2.html#c

FEMA watershed approach (flood insurance studies): Especially the geospatial database, Digital Flood Insurance Rate Map, and the national flood hazard information layer.

Digital Raster Graphics (DRG): "A Digital Raster Graphic (DRG) is a scanned image of a USGS standard series topographic map, including all map collar information. The image inside the map neatline is georeferenced to the surface of the earth and fit to the Universal Transverse Mercator (UTM) projection. The horizontal positional accuracy and datum of the DRG matches the accuracy and datum of the source map. The map is scanned at a minimum resolution of 250 dots per inch."

Earth Science Information Center
mcmcesic@usgs.gov
http://topomaps.usgs.gov/drg/

Table 10: Datasets documented by U.S. Geological Survey topographic and hydrologic maps

Dataset	Specifics of interest	Spatial?	Category	Format	Scope	Currentness
Watershed Boundary Dataset (WBD)	HUC watershed delineations to 12-digit level	spatial	abiotic	For download (GIS format)	National; national by state, county, or other area	8/31/2010
Orthophoto/ ortho-imagery theme of the National Map	High Resolution Orthoimagery, Landsat 7 Mosiacs, and seamless Digital Orthophoto Quarter Quadrangles (DOQQ)	spatial	other	Web map, web map service, for download (GIS format)	High-res ortho-imagery (1/3-1 ft. resolution): Nationally in select urban areas. Landsat 7: contiguous US DOQQs: contiguous US	High-res ortho-imagery: varies by state/area, 2000-09. Landsat 5/7 mosaic: revisit cycle less than every 8 days DOQQs: varies by image
National Elevation Dataset (NED)	National raster dataset of elevation values (see dataset summary for details on resolution).	spatial	abiotic	Web map, for download (GIS format)	National	updated on a two-month cycle
New US topography (US Topo)	New series of digital USGS topo maps	spatial	abiotic	For download (GeoPDF; can also be imported into ArcGIS but see caveats here: http://nationalmap.gov/ustopo/Import_US_Topo_Instructions.pdf)	National where completed; see status here: http://nationalmap.gov/ustopo/about.html#status	Digital Map--Beta Versions released in 2009; other areas of contiguous US are slated for completion in 2010/11; AK/HI/PR slated for completion in 2012 or beyond
National Hydrographic Dataset (NHD)	See above	spatial	abiotic			
NHDPlus	Greatly improved 1:100K National Hydrography Dataset (NHD); a set of value added attributes to enhance stream network navigation, analysis and display; an elevation-based catchment for each flowline in the stream network; catchment characteristics; headwater node areas; cumulative drainage area characteristics; flow direction, flow accumulation and elevation grids; flowline min/max elevations and slopes; flow volume & velocity estimates for each flowline in the stream network.	spatial	abiotic	For download (GIS format: GRID, shapefile, xls, dbf; varies by data layer)	National	2006
Coastal Assessments Framework (CAF) – estuaries	Coastal (estuarine) watershed delineations, Spatial Trends in Coastal Socioeconomics data by watershed (demographic data, personal income/employment data, marine recreation data)	spatial	abiotic	For download (GIS format)	National coverage of CAF drainage basins; estuarine watersheds available nationally where present	Geospatial data: 2004 Socioeconomic data varies by factor; most recent is 2008
FEMA watershed approach (flood insurance studies)	Especially the geospatial database, Digital Flood Insurance Rate Map, and the national flood hazard information layer					
Digital Raster Graphics (DRG)	Scanned images of USGS standard series topographic map	spatial	other	For download (GIS format via Earth Explorer/ USGS Seamless; GeoTIFF; web map service (TerraServer); web map)	National	Original DRGs produced 1995-98; about 1,000 new/ replacement DRGs per year have been produced since 1998.

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