Letting Nature Work in the Pacific Northwest:

A Manual for Protecting Ecosystem Services Under Existing Law

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I. Executive Summary

In the decades since most major environmental laws were passed, our knowledge about ecosystems and the goods and services they provide has increased dramatically. Environmental and natural resources laws, however, do not capture the vast importance of ecosystem services, from the migratory pollinators that sustain agriculture to the filtration and treatment services that clean our water. As ecologists learn more about the complex and dynamic interactions that produce these valuable services, decision-makers and advocates can adopt an ecosystem services approach that is environmentally protective and socially equitable to ensure lasting protection for these services.

An ecosystem services approach to environmental protection focuses policy and decision-making on restoring and maintaining the natural infrastructure and resources that the public values.

An ecosystem services approach to environmental protection focuses policy and decision-making on restoring and maintaining the natural infrastructure and resources that the public values. This approach combines scientific assessment tools to understand both our dependence and impacts on ecosystems and public participation to identify the most important services. The ecosystem services approach sets goals for environmental protection and helps direct policymakers and natural resource managers to identify and apply the legal, regulatory, and market-based tools to achieve these goals.

An ecosystem services approach integrates advances in ecology into the law. It also fosters creative thinking about how to restructure laws and regulatory programs to mimic the connectedness of ecosystem functions. The ecosystem services approach requires performance-based evaluations to measure success or failure of management decisions. It depends on public participation to prioritize those services that the public values most, thus ensuring long-term public support for and investment in achieving the identified goals.

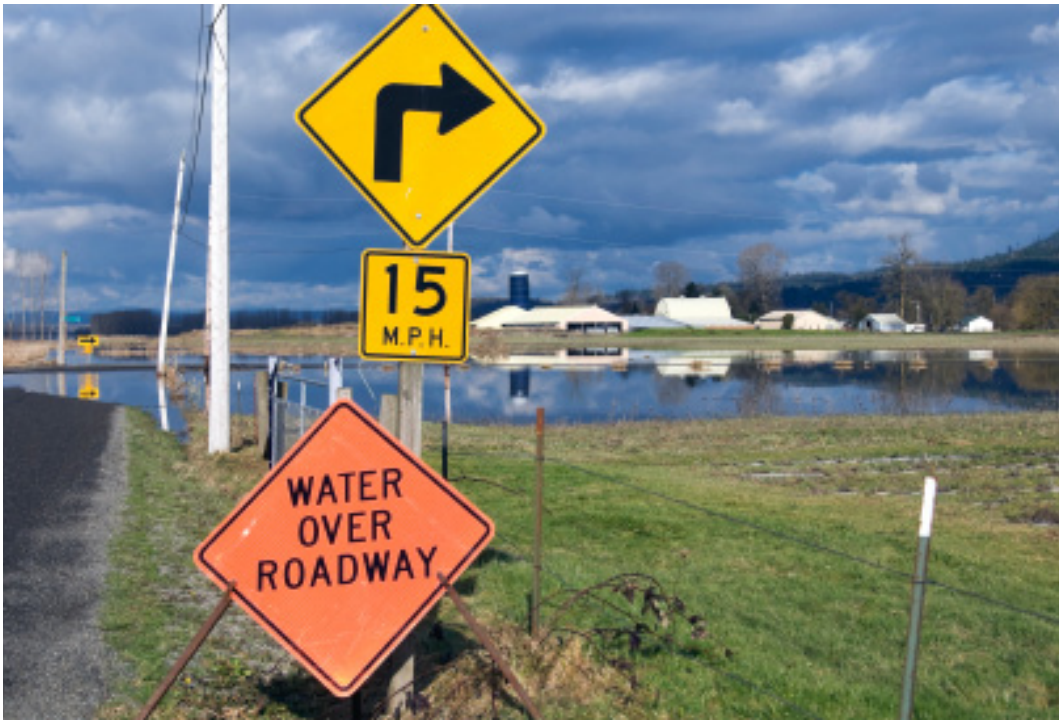
The ecosystem services approach requires four steps:

- **Identify the relevant ecosystems and the services they provide.** This information-gathering step is important for determining the health and status of an ecosystem and the services it provides.
- **Value the relevant services.** Value can be expressed in both monetary and non-monetary terms, and both are helpful in determining the value of an ecosystem service.
- **Prioritize the services most valuable to the public.** Public participation helps strengthen support for protecting ecosystem services and helps disparate interest groups find common ground by framing the goal as a continued provision of a certain service.
- **Identify mechanisms to protect the prioritized services.** Mechanisms to protect ecosystem services can be legal, regulatory, market-based, or a combination. Ultimately, selecting the appropriate mechanism should follow the principles discussed below.

Principles of the Ecosystem Services Approach

To determine the relative merits of a potential tool to protect ecosystem services, policymakers and advocates should consider certain principles that support environmental protection and social equity. Does the potential tool:

- Promote and support functioning, whole, and intact ecosystems that display ***ecological integrity***? Ecological integrity is determined by elements such as biodiversity, viable populations of native species, intrinsic disturbance regimes, and natural ecosystem boundaries.
- Consider principles of temporal, spatial, socio-economic, and cultural ***fairness***? The ecosystem services approach requires tradeoffs, and decision makers should identify who should bear the burdens and reap the benefits and burdens of these tradeoffs.
- Restore and strengthen ecosystem ***resilience***? Resilience is the ability of a social or ecological system to absorb disturbances or change and retain its basic structure and functionality. At the outset, removing existing stressors and building strong social networks will help both ecosystems and human communities adapt to future changes.
- Establish management actions that over time are ***sustainable***? Humans rely on ecosystems to continually provide services, but impacts from climate change will disrupt ecosystem functions and affect management actions to maintain ecosystem services.
- Maximize ***system synergies and positive spillover effects***? Ecosystem services are not generated in isolation but instead are the product of dynamic and connected processes within and among ecosystems. Tools that protect ecosystem services should explicitly recognize these connections and protect as many as possible.
- Err on the side of ***precaution***? Ecosystem complexity demands that ecosystem managers, policymakers, and regulators minimize disturbances while gathering information to resolve uncertainties or conduct additional experiments.
- Ensure that the selected tool is ***effective***? Here, resource managers should periodically evaluate the outcomes and achievements from applying this approach to ensure that the selected tools are meeting performance-based targets and providing the intended service and other benefits. Resource managers must also have the funding and authority to implement a chosen tool.
- Lead to increased ***efficiency***? Applying an ecosystem services approach requires new and creative ways of implementing the law and regulatory programs, and these new strategies should consider how a single action could fulfill multiple objectives under different laws and agencies.



Relying on ecosystem services to absorb and mitigate flood damage is a common-sense investment with multiple benefits for other resources and floodplain services we value.

To illustrate the ecosystem services approach, the second part of this manual focuses on multiple benefits of floodplain restoration on flood hazard mitigation and other floodplain services. Flood hazard mitigation is a combination of terrestrial and aquatic effects on the quantity, timing, location, and quality of water. This regulating service is provided by a variety of ecosystems and natural land features, such as upland forests, riparian areas, floodplains, wetlands, rivers, and lakes. Relying on ecosystem services to absorb and mitigate flood damage is a common-sense investment with multiple benefits for other resources we value.

In particular, floodplains provide a remarkable range of ecosystem services that are vital to the communities located in or near them. Floodplains are hydrologically connected to their adjacent waterbodies and have substantial benefits for their health and functions. Floodplain restoration generates many system synergies and efficiencies and promotes ecological integrity and long-term sustainability. Floodplains support myriad ecosystem services we care about, such as salmon and their habitat, recreation opportunities, and clean water. Floodplains also sit at the intersection of many overlapping federal, tribal, state, and local laws and regulatory programs.

The table below summarizes the suite of ecosystem services provided by floodplains and some of the tools discussed in this manual, focusing on an overarching strategy of restoring floodplain ecosystems to best protect flood hazard mitigation services and other floodplain services:

Floodplain Services	Provisioning Services	Food (fish, game, fruit), raw materials (timber, fuel, energy, fodder, fertilizer), genetic resources, medicinal resources, ornamental resources
	Regulating Services	**Flood hazard mitigation**, gas regulation, disturbance prevention, water regulation, water supply (filtering, retention, and storage), soil retention, soil formation, nutrient regulation, waste treatment, pollination, biological control
	Cultural Services	Aesthetic, recreation, cultural/artistic, spiritual and historical information; science and education
	Supporting Services	Climate regulation, refugia for flora and fauna, nursery function[1]
Specific Steps & Legal Tools	Improve water quality in the adjacent waterbody	Achieve ecological integrity under the Clean Water Act (CWA) with robust biological criteria List aquatic-based services as designated uses under the CWA Allow water pollutant permit holders to achieve water quality-based effluent limits with ecosystem services Link actions taken under the National Flood Insurance Program (NFIP) that produce water quality outcomes to the CWA
	Discourage new development in floodplains	Enact protective building, zoning, and setback restrictions based on public trust duties to protect ecosystem services as public uses and values Update minimum criteria in the NFIP
	Rebuild existing development according to specific criteria that restore or protect existing floodplains in their natural state	Update and enforce minimum criteria in the NFIP Enforce Endangered Species Act in floodplains
	Provide incentives to rely on green infrastructure or restoration of flood hazard services	Use the Community Rating System program of NFIP to structure incentives Adjust incentive distribution between grey and green infrastructure in NFIP

II. Introduction & Purpose of the Manual

We depend on the myriad functions and processes of the ecosystems we inhabit. Our dependence ranges from the food we eat and the air we breathe to the water we drink. Beyond these essential, everyday needs, ecosystems perform many of the functions and processes that enable life: regulating climate, cycling nutrients, and maintaining soils. These *ecosystem services* range from the global level (oceans that regulate the climate) to the very local level (coastal dunes that protect inland areas from storm surges) to providing valuable goods such as water and timber. We cannot live without these services.

The ecosystem services approach sets the priorities and goals for natural resource managers and helps identify the tools to achieve these goals. It integrates advances in ecology with the law and promotes a legal framework that reflects the connectedness of ecosystems.

This manual provides policymakers, advocates, and the public with an environmentally protective and socially equitable approach for protecting ecosystem services that is driven by existing laws and regulatory programs at the federal, state, tribal, and local government levels. This ecosystem services approach sets the priorities and goals for management decisions and directs policymakers and resource managers to identify and apply the tools to achieve these goals. This approach integrates advances in ecology into the law. It also fosters creative thinking about how to restructure laws and regulatory programs to mimic the connectedness of ecosystem functions. After all, many of the major federal environmental laws share common goals and values related to protecting the air, water, and lands that we most value.

This manual then applies the ecosystem services approach to explore ways to protect the valuable service of flood hazard mitigation. Floods are highly beneficial for the environment: they deposit sediment, provide temporary habitat and spawning grounds for fish, and distribute nutrients throughout a floodplain. Floods are also extremely costly for the people and infrastructure located in a floodplain. Modern flood management has relied on concrete dams and levies and modified waterways to divert floodwaters away from homes and businesses, ignoring the significant and free flood hazard mitigation services provided by rivers, floodplains, forests, and other ecosystems.

Restoring floodplains promises to protect not only flood hazard mitigation but also many other ecosystem services provided by floodplains. This manual focuses on three existing legal tools that advocates, policymakers and regulators, and state court judges should consider to protect flood hazard mitigation services by restoring floodplains:

- The water quality standards component of the Clean Water Act;
- The public trust doctrine; and
- The minimum criteria and the Community Rating System of the National Flood Insurance Program.

Relying on the flood mitigation services provided by ecosystems to absorb and mitigate this damage is a common-sense investment with multiple benefits for other ecosystem services we value. Floodplains provide salmon and other fish habitat, recreation opportunities, nutrient cycling, and many other ecosystem services. This manual serves as the beginning of a much longer discussion of the ways to protect the services provided by healthy, intact ecosystems in the face of pressure from human impacts and climate change.

III. Ecosystems and Their Services

An ecosystem is a functional unit of nature, a community of living organisms that interacts with the nonliving components in the same environment.[2] The living organisms may include humans, other animals, plants, and microbes that cycle energy, nutrients, water, and organic material throughout the ecosystem. We receive many benefits from healthy, intact, and functioning ecosystems. These *ecosystem services* are the range of tangible and intangible products and functions that we value. In many cases these services are indispensible to sustaining human life.

A. Categories of Ecosystem Services

The United Nations' Millennium Ecosystem Assessment divides ecosystem services into four categories:

- ***Provisioning Services***. This category includes the tangible goods from nature, such as food, timber, petroleum and other fuel, genetic resources, natural medicines and pharmaceuticals, ornamental resources, and freshwater.
- ***Regulating Services***. This category consists of intangible services, processes, and conditions that sustain and improve human life. These services include air quality maintenance, climate regulation, water regulation, and erosion control by forests; water purification, waste treatment, and storm hazard protection by wetlands; and pollination by birds, bats, and bees.
- ***Cultural Services***. This category includes the spiritual, cultural, and religious benefits that we experience from tourism, outdoor recreation, or simply being in a natural environment. Cultural services support spiritual, religious, educational, and social values and diversity and sustain indigenous knowledge systems.
- ***Supporting Services***. This category underlies all ecosystem services that are fundamental for the production of provisioning, regulating, and cultural services. They overlap with regulating services but occur over a longer period of time. Supporting services may include soil formation, climate regulation, and erosion control.[3]

B. Valuing Ecosystem Services

With the exception of most provisioning services, ecosystem services are mostly unaccounted for in the market place, despite their clear economic benefits. They are not assigned monetary values and, until recently, have not been bought or sold, like traditional goods or services. Ecosystem services are difficult to package into salable units. Ecosystem services tend to be common-pool resources or public goods, which makes them difficult to privatize or to exclude others from using them. Ecosystem services are "ecologically, geographically, and economically much more complex than any other kind of commodity or service traded in the marketplace."[4]

Despite the difficulty of accounting for the value of ecosystem systems, such an accounting can be a valuable tool for recognizing their importance and protecting them. In 1997, ecological economist Dr. Robert Costanza and his colleagues published an estimated value of selected ecosystem services: between 16 to 54 trillion USD per year, with an estimated average of 33 trillion USD per year—and likely to be much higher if the value of all services were included.[5] This and more recent attempts to value ecosystem services are informative because they clarify the potential range of values of these services and translate the services into a commonly understood language.[6] Ecological economists may disagree on the exact value of ecosystem services or even how to calculate their value, but they agree on this: ecosystems provide valuable services that we cannot live without or easily substitute.

The Value of Numbers

Although numbers offer the promise of objectivity, the total monetary value of the services provided by a certain ecosystem is difficult to calculate with any accuracy. The final numbers tend to be highly uncertain, and they often include value judgments that may not be immediately obvious.

Knowing an estimated value of a particular ecosystem service can point policymakers and natural resources agencies in a certain direction but should not dictate a specific path or be used as the exclusive factor in a strict cost-benefit analysis. Calculated monetary values can help demonstrate the significance of a service in terms that governments and institutions understand, but they do not tell the entire story.

IV. The Ecosystem Services Approach

An ecosystem services approach to environmental protection focuses policy and decision-making on restoring and maintaining the natural infrastructure and resources that we value. This approach depends on scientific assessment tools to understand both our dependence and impacts on ecosystems, and it also depends on public participation to identify the most important services.[7] With this information, the ecosystem services approach sets goals for environmental protection and helps direct policymakers and natural resource managers to identify and apply the legal, regulatory, and market-based tools to achieve these goals.

An ecosystem services approach integrates advances in ecology with the law. It also fosters creative thinking about how to restructure laws and regulatory programs to mimic the connectedness of ecosystem functions. Ecologists have long studied the importance of healthy ecosystems, but law and policy have not kept apace. At the federal level, the pillars of environmental law—the Clean Water Act, the Clean Air Act, the Endangered Species

Act, among others—touch on protecting aspects of ecosystem services and emphasize the aesthetic, educational, ecological, recreational, and economic value of clean water, clean air, and certain species. More often than not, however, they propose single, media- or species-specific approaches.

The ecosystem services approach requires performance-based evaluations to measure success or failure of management decisions. What we ultimately care about is whether or not a management action maintains or restores an ecosystem service. Instead of measuring administrative outcomes, such as the number of permits issued or the number of impaired waters listed, an ecosystem services approach measures indicator endpoints, such as biological, chemical, and physical criteria that characterize a functional ecosystem. In wetlands restoration, for example, success is determined by whether a restored wetland provides the desired environmental and other benefits, rather than by counting the number of wetland acres that are recreated.

Public participation is essential to the ecosystem services approach because it helps prioritize the most valuable services and thus ensures long-term public support for achieving the identified goals. The average person may not know how excess nitrogen causes algal blooms and deadly pathogen outbreaks, but she is disappointed when a weekend fishing trip or day at the beach is canceled. The manager of a waterwater plant understands the difference between a multi-million dollar upgrade to her facility and a much less expensive program to pay landowners to protect upstream wetlands that filter and retain water. In such cases, relying on ecosystem services reduces costs and provides significant benefits.

A. Applying the Ecosystem Services Approach

The ecosystem services approach helps policymakers and the public identify those services that are the most important to protect and maintain. This framework is modeled on the process laid out by Professor James Salzman and his colleagues:[9]

- ***Identify the relevant ecosystems and the services they provide***. This information-gathering step is important for determining the health and status of the ecosystem and the services it provides. Is the ecosystem healthy or in decline? What are threats to the continued provision of services? Who benefits from the service? Is there a geographic or spatial difference between the service and the beneficiaries?

- ***Value the relevant services***. Value can be expressed in both monetary and non-monetary terms. Although monetary values are easily understood, they can also give a false sense of accuracy. Thus, it is important to recognize non-monetary values such as the diversity of bird species in a wetland or indirect measurements of value such as the cost of a technological substitute for the service. For example, a price-tag of $50 million for implementing a new wastewater treatment technology may point toward the free or relatively less expensive filtration and treatment services provided by wetlands and vegetated riparian areas.

- ***Prioritize the services most valuable to the public.*** This step requires public participation to determine the most valuable services. By framing the goal as continued provision of a certain service, disparate interest groups may be able to find common ground. For example, fisherfolk and environmental groups both seek a continued supply of indigenous fish, which represent a provisioning service for the former and a cultural service for the latter.

- ***Identify mechanisms to protect the prioritized services.*** Mechanisms to protect ecosystem services can be legal, regulatory, or market-based, and it is important to pick the appropriate tool for the specific situation. To date, much of the focus has been on market mechanisms such as water quality trading, prompted by legal drivers such as a Total Daily Maximum Load or other CWA permitting requirements. Although market-based tools may foster creative approaches for implementation, they may not be appropriate for all types of services (such as those that are essential to life or produce greater benefits in the aggregate). For example, a coastal dune system provides collective buffering services along the entire coastline, but those services may disappear or become less effective if the coastline were divided into marketable parcels, with some purchased to protect the services and others purchased for development. The principles below may help determine which combination of tools is appropriate.

Leverage Points and Intersections

When identifying mechanisms to protect ecosystem services, policymakers and environmental advocates should consider both *leverage points and intersections*. Leverage points refer to reasons why a landowner, company, or institution may be motivated to protect ecosystem services. Leverage points could range from public pressure and community goodwill to the threat of penalties and enforcement for failure to comply with legal mandates. The option to reduce costs is also an important leverage point for businesses.

Intersections refer to places where multiple regulatory programs or laws come together. For example, protecting floodplain services serves a variety of federal, state, tribal, and local interests. By taking action under one law or using funding from one agency, policymakers should consider what additional goals can be achieved under other laws.

B. Prerequisites for the Ecosystem Services Approach

The ecosystem services approach may already be familiar to natural resource managers and policymakers. This approach unifies an assortment of anthropocentric environmental goals

that environmental law in the United States has sought to protect for decades. The ecosystem services approach is a new lens through which to view environmental goals in the twenty-first century. A successful approach requires:

- ***Clear Goals.*** The ecosystem services approach requires clear, explicit, and specific goals with end-point indicators or metrics against which to measure success. Goals may be affected by the available funding, administrative resources or obstacles, and what tradeoffs will be made. It is important to understand both the goals and constraints at the outset of adopting an ecosystem services approach.

- ***Strong Science.*** Ecologists and scientists have made significant progress in understanding ecosystem functions and processes and the conditions required for healthy ecosystems. However, much more remains unknown about how ecosystem services interact and affect each other, how internal and external dynamics and interactions alter ecosystem services, and what features make an ecosystem resilient. Natural resource managers pursuing an ecosystem services approach should start by conducting basic survey of ecosystem services.

- ***Information and Data Collection***. The ecosystem services approach will take existing information and link it together in new ways, as well as generate significant amounts of information that can be used to achieve other management objectives as well. One important role is for scientists and other science-based groups to provide the important information in useful, consistent, and clear formats for policymakers and natural resource managers.

- ***Monitoring and Assessment***. The effectiveness of an ecosystem services approach relies on monitoring and assessment, the basic components of any management approach. Because protecting ecosystem services means ensuring that the ecosystems continue to provide those services, monitoring by natural resource managers is paramount.

- ***Intergovernmental and Interagency Cooperation***. An ecosystem services approach relies on functional ecosystems, which rarely correspond with political or administrative boundaries. Preserving flood hazard mitigation services from wetlands, forests, and coastal areas requires cooperation from a variety of federal agencies, as well as tribal, state, and local governments. Vertical cooperation among levels of government and horizontal cooperation—among agencies at the same level of government—are both necessary.

- ***Public Communication and Participation***. Because the ecosystem services approach identifies services that are most important to the public, restoring and protecting those services are goals that citizens are likely to support and understand. However, it remains important for scientists, policymakers, and community leaders to clearly link the health of ecosystems to public benefits. Experts should explicitly identify ecosystem services and the beneficiaries of those services to ensure public support for them. Communities that

are active in decision-making are more likely to participate and sustain the long-term effort required to protect ecosystem services.

C. Principles for the Ecosystem Services Approach

The ecosystem services approach described in this manual relies on principles that support environmentally protective and socially equitable outcomes. These principles include:

- ***Ecological Integrity.*** To both protect the environment and maintain ecosystem services, resource managers should prioritize services from functioning and resilient ecosystems. Ecological integrity means relying on a functioning ecosystem to provide services and promotes protection of the whole ecosystem, including elements such as biodiversity, viable populations of native species, and natural disturbance regimes, for example. It also means management that follows natural ecosystem boundaries, rather than political, administrative, or institutional boundaries.

- ***Fairness***. Because implementing an ecosystem services approach requires tradeoffs, policymakers should be guided by principles of fairness. Fairness has many dimensions: temporal, spatial, socio-economic, and cultural. For example, ensuring that flood mitigation exists for future generations may require constraints on developing in floodplains for current property owners. Similarly, the pollination services provided by migratory bats may benefit agriculture in Texas but require habitat protection in Mexico. Policymakers should identify how fairness considerations affect the choice of who should bear the cost of necessary tradeoffs. For example, should the public (through public funds) pay a landowner not to deforest his land, or should the private party absorb the economic loss of not being able to sell timber in order to protect the broader public good? Existing statutes can provide guidance about how to allocate benefits and burdens. For example, the CWA places the burden on polluters of avoiding pollution and cleaning up their discharges.

- ***Resilience***. An environmentally protective ecosystem services approach should increase ecosystem resilience. Resilience is the ability of a social or ecological system to absorb disturbances or change and retain its basic structure and functionality. Resilient ecosystems are more likely to adapt to stress and change without disrupting their basic functions. Similarly, resilient communities are more likely to adapt to changes or fluctuations in ecosystem services. With an ecosystem services approach, removing existing stressors at the outset is helpful to increasing resilience.

- ***Sustainability***. Policymakers should ensure management actions under an ecosystem services approach are sustainable, produce lasting outcomes, and consider the impact of climate change. A long-term perspective is intrinsic to the ecosystem services approach because its goal is to maintain these services. Assigning adequate monetary values to services and folding those costs into a decision that affects ecosystem services can also help sustain services over time. Climate change will disrupt ecosystem functions

and affect management actions to maintain ecosystem services. Policymakers should anticipate these impacts in designing management.

- ***System Synergies and Positive Spillover Effects***. An environmentally protective ecosystem services approach should prioritize actions that benefit multiple ecosystem components or services. This approach explicitly recognizes the interdependence and connections among different ecosystems that function to provide a service. It also recognizes that services are not provided in isolation and themselves are connected to other services. For example, wetlands filter water and also cycle nutrients, provide habitat and feeding grounds for birds that birdwatchers depend on, and absorb flood waters. Restoring wetlands to maintain flood mitigation capacity will generate positive spillover effects that support other ecosystem services and environmental goals.

- ***Precaution.*** In the face of uncertainty and incomplete information, policymakers should err on the side of preservation, conservation, and adaptive management. The burden of proof should shift to those proposing actions that harm an ecosystem. As ecologist Frank Egler commented, "Ecosystems are not only more complex than we think, but more complex than we can think."[10] This complexity demands that ecosystem managers, policymakers, and regulators minimize disturbances while studying how to act.[11]

- ***Effectiveness***. We should adopt the ecosystem services approach when and where it promises to strengthen the capacity of ecosystems to provide services and where resources are dedicated and adequate to sustain the approach. As part of the monitoring and assessment processes that are critical parts of the ecosystem services approach, resource managers should periodically evaluate the outcomes and achievements from applying this approach. Are ecosystems functioning as anticipated to produce the valued services? Are we dedicating resources and efforts to maximize the production of these services—for example, can we preserve continuous forest rather than unconnected smaller squares of forest? Based on the information obtained, resource managers can make appropriate adjustments in management strategies.

- ***Efficiency***. Adopting the ecosystem services approach should lead to increased efficiency by removing administrative hurdles and fostering creative approaches. By identifying points of intersection or common goals among different regulatory programs, a single action could fulfill multiple objectives.

Adopting an ecosystem services approach to protecting the environment and protecting the services that we care about offers significant advantages in aligning science and the law and in shifting to performance rather than administratively identified outcomes. This approach depends on information-gathering and public participation, as well as creative approaches within the existing legal framework. The remaining sections apply this approach to protecting flood hazard mitigation services and other ecosystem services by restoring the health and vitality of floodplains and their adjacent waterbodies.

Connections Between Adaptive Management and the Ecosystem Services Approach

In many instances, protecting ecosystem services will require the continuous and deliberate learning process that adaptive management generates. Using an ecosystem services approach, policymakers can identify which services need protection and set management goals accordingly, while the iterative, deliberate learning process of adaptive management can help guide decision-making to achieve those goals in the face of scientific uncertainty.

Detailed definitions of adaptive management abound, but there is general agreement that it embraces these elements: (1) *explicitly stated goals* and *measurable indicators* of progress toward those goals; (2) an *iterative approach* to decision-making, providing the opportunity to adjust decisions in light of subsequent learning; (3) *systematic monitoring* of outcomes and impacts; (4) *feedback loops* so that monitoring and assessment produce *continuous and systematic learning* that in turn is incorporated into subsequent rounds of decision-making; (5) explicit *acknowledgement and characterization of risks and uncertainties*, identification of key uncertainties for management purposes; and (6) an overarching goal to *reduce uncertainty over time*.

Adaptive management can help address two challenges common to protecting ecosystem services: incomplete understanding and changing systems. Ecosystems are highly complex, and their internal dynamics and relationships within a given ecosystem are poorly understood. Gaps in baseline data for basic ecosystem services are common. The dramatic impacts of climate change introduce even more uncertainty about how ecosystems will adapt to and function in a warming world. Together, these circumstances call for provisional management decisions and the structured learning adaptive management can provide. Adaptive management is especially appropriate when uncertainties make management choices difficult and when this focused learning process is likely to reduce those uncertainties.

Nevertheless, adaptive management is not appropriate for every situation. When misused, it can provide an excuse to delay politically uncomfortable decisions and to inhibit effective public oversight. It requires more human and financial resources than conventional management, and it imposes unfamiliar demands on management institutions. For example, adaptive management may require trading the anticipated best outcome in the short-term for long-term learning and improvement.

For more information, please see *Making Good Use of Adaptive Management*, CPR White Paper No. 1104.

V. The Ecosystem Services Approach in Action: Protecting Flood Hazard Mitigation Services

One of the most important ecosystem services in the Pacific Northwest is flood hazard mitigation or water damage mitigation. Unfortunately, management schemes have historically overlooked these services, particularly in the vital role of functioning ecosystems in reducing flood-related damages. The remainder of this manual applies the ecosystem services approach to flood hazard mitigation, identifying legal tools that contribute to specific aspects of the service. The following sections also promote a broader strategy of floodplain restoration to protect the suite of ecosystem services provided by floodplains. Relying on ecosystem services to absorb and mitigate flood damage is a common-sense investment with multiple benefits for other resources we value.

Flooding is a natural process that governs floodplains, contributing to their health, functionality, and resilience. Periodic flooding replenishes nutrients, shapes the landscape and habitat, and is vital to the health of riparian corridors, wetlands, and other natural areas. Flooding increases soil fertility, revitalizes habitat for spawning fish and other aquatic species, and deposits sediment to build riverbanks and shorelines.

However, flooding also tops the annual list of costliest natural disasters in the United States. For example, in 2007 a severe storm dropped 20 inches of rain in 48 hours in Lewis County, Washington, causing an estimated 166 million USD in private and public damages.[12] Significant development within flood-prone areas has occurred throughout Washington and Oregon, and existing urban centers are expected to expand further into high-risk areas. Modern water and flood management has been development-centered, relying on dams, levies, and other structures to contain floodwaters. These structures tend to fail or require costly maintenance, all the while creating a false sense of security that allows communities to keep building in flood-prone areas.

A. Flood Hazard Mitigation and Floodplain Restoration

Flood hazard mitigation is a combination of terrestrial and aquatic effects on the quantity, timing, location, and quality of water. For example, trees, grasses, other vegetation, and healthy soils with organic matter absorb significant storm events that otherwise can prove damaging.[13] Tree canopies and other riparian vegetation deflect and absorb precipitation, decreasing the speed of water flow during peak flows caused by sudden, intense precipitation. Their roots stabilize soils and form channels so the water can rapidly infiltrate the ground, altering the location of water (from surface to ground) and reducing the quantity discharged into waterbodies. Vegetation, microbes, and soils also improve water quality by filtering and trapping contaminants, stabilizing erosion-prone riverbanks and shorelines, and transforming nutrients and contaminants through biochemical processes.[14]

Flood hazard mitigation is a regulating service provided by a variety of ecosystems and natural land features, such as upland forests, riparian areas, floodplains, wetlands, rivers, and lakes. In particular, floodplains provide a remarkable range of ecosystem services that are vital to the communities located in or near them. These low, flat areas are adjacent to rivers, lakes, and oceans. Floodplains are hydrologically connected to their adjacent waterbodies and have substantial benefits for their health and functions. The potential value of floodplain services is immense: A 2010 study by Earth Economics estimated the value of selected ecosystem services in the Chehalis River Basin in Washington to be 1.3 to 11.6 billion USD per year.[15]

In the Pacific Northwest and around the country, floodplains provide a remarkable range of ecosystem services that are important to us. These services include:

Provisioning Services	**Food (fish, game, fruit), raw materials (timber, fuel, energy, fodder, fertilizer), genetic resources, medicinal resources, ornamental resources**
Regulating Services	**Gas regulation, disturbance prevention, water regulation, water supply (filtering, retention, and storage), soil retention, soil formation, nutrient regulation, waste treatment, pollination, biological control**
Cultural Services	**Aesthetic, recreation, cultural/artistic, spiritual and historical information; science and education**
Supporting Services	**Climate regulation, refugia for flora and fauna, nursery function[16]**

B. Floodplains: A Point of Intersection

Restoring floodplains to protect flood hazard mitigation services meets many of the principles that embody an ecosystem services approach. For example, restoring floodplains promotes ecological integrity and enhances salmon restoration by promoting natural flood dynamics. Functional floodplains have greater resilience, ensuring long-term sustainability of flood hazard mitigation services.

Floodplain restoration also generates many system synergies and efficiencies. For example, floodplains provide critical habitat and spawning grounds for many of the fish species iconic to Pacific Northwest. Conversely, the National Marine Fisheries Services (NMFS) determined that development in floodplains, facilitated by the availability of flood insurance through the National Flood Insurance Program (NFIP), is likely to harm species of salmon and trout and the orcas that live in Puget Sound. Building in Puget Sound floodplains not only diminishes the natural flood hazard mitigation services, but it also displaces salmonid habitat. The negative impacts are amplified: development attracts more development, leading to increased pollution, stormwater runoff, and vegetation removal that degrade the waters of Puget Sound. Restoring floodplains serves two crucial purposes: protecting flood hazard mitigation services and protecting salmon habitat, services that affect many in the Pacific Northwest.

Floodplains also sit at the intersection of many overlapping federal, tribal, state, and local laws and regulatory programs. For example, protecting floodplains is consistent with regional applications of important federal laws such as the CWA, the NFIP, and the Endangered Species Act, among others. Protecting access to salmon, water, and other natural resources is also a goal of tribes across the Pacific Northwest. State and local environmental laws, building codes, and zoning ordinances all affect floodplains. Focusing on floodplain restoration and protecting floodplain services may be the most efficient way to meet the multiple objectives of these laws.

With the ecosystem services approach in mind, the remainder of this manual examines legal tools in the CWA, the public trust doctrine, and the NFIP that address specific dimensions of flood hazard mitigation and more broadly apply to floodplain restoration.

Floodplain Restoration for Johnson Creek in Portland

The city of Portland has taken successful actions to protect floodplain services, maintain natural flood dynamics, and minimize property damages to homes and businesses along the Johnson Creek. In 2001, the city's Bureau of Environmental Sciences released the Johnson Creek Restoration plan to use natural floodplain features to reduce damages, improve water quality, and restore habitat for fish and wildlife. Portland has acquired more than 260 acres of vulnerable land and has moved dozens of homes out of flood zones. It has also constructed the Brookside Wetland that stores up to 20 million gallons of flood water and provides other ecosystem services: habitat for fish and wildlife, opportunities for recreation, and water filtration. Portland has also supported the use of green infrastructure such as rain gardens, green roofs, and replanting trees to mitigate stormwater in urban areas and has completed the Schweitzer Restoration Project, which provides 74 acre feet of flood storage to the Johnson Creek floodplain.[17]

The success of these restoration actions was marked by a non-event: in January 2012, a serious storm event caused the creek to rise to a high of 13.2 feet, and the surrounding streets *did not* flood. The city's watershed manager attributed this success to removing fill from the lowlands adjacent to the creek and reconnecting the creek to its floodplain.[18]

VI. Flood Hazard Mitigation and the Clean Water Act

The CWA has the capacity, if implemented thoughtfully and creatively, to become an effective legal tool for protecting flood hazard mitigation services and other ecosystem services from floodplains. The connected, hydrological relationship between a waterbody and its surrounding floodplain is crucial in protecting the habitat of aquatic and semi-aquatic species.[19] Regulating services from floodplains such as water filtering, retention, and storage, nutrient regulation, and waste treatment clearly support the goals of the CWA, so the question is how can the CWA promote these services to achieve its goals. The answer may lie in the role of ecological integrity in the Act and how a renewed focus on water quality standards (WQS) can protect floodplain services. Ecological integrity is the combination of, chemical, physical, and biological integrity, which the CWA explicitly seeks to restore. If the one of the key principles of the ecosystem services approach is to rely on healthy, functioning ecosystems to provide the most effective and low-maintenance services, then protecting ecological integrity in waterbodies and their connected floodplains and aquatic systems is critical.

EPA and state environmental agencies should take two steps to make better use of WQS to protect aquatic ecosystem services. First, flood hazard mitigation should be identified as a designated use in a state's water quality standards program. Waterbodies such as rivers and lakes absorb floodwaters and serve as storage reservoirs, and the riparian areas near them are important in regulating the timing and location of floodwaters. Second, EPA should encourage and states should adopt robust and stringent biological criteria, or biocriteria, that support this service. These criteria describe the qualities that must be present to support a functioning waterbody, which in turn supports floodplain services. Biocriteria serve as end-point, performance-based metrics that determine the success of management actions. These steps will help protect flood hazard mitigation services, generate positive spillover effects for floodplain health and other services, and help achieve the long-sought goal of ecological integrity in the CWA.

A. Ecological Integrity and Ecosystem Services

Using the CWA to protect aquatic ecosystem services requires a renewed emphasis on achieving ecological integrity and WQS and adopting biocriteria that measure the health of an aquatic ecosystem. Viewed through an ecosystem services lens, the Act focuses on water as a provisioning service for drinking, agricultural use, and industrial use, but the structure of the Act also provides protection for regulating, cultural, and supporting services from aquatic ecosystems as well.

Congress intended the CWA to stand on three pillars of integrity: chemical, physical, and biological. An ecosystem displays ecological integrity when it functions successfully, is resilient, and able to withstand stress. The ecosystem should display and contain the full range of chemical, physical, and biological parameters of a healthy system. For example, biological integrity means that the ecosystem contains both a full range of ecosystem elements (such as genes, species, and assemblages of species) and a full range of ecosystem processes (such as species mutations, biotic interactions, nutrient and energy dynamics, and metapopulation dynamics).[20] Biological integrity is affected by multiple chemical and physical variables, such as the flow and sources of energy, nutrients, and water and habitat structure. Aquatic species respond to all stressors in the water with which the CWA is concerned: reduced oxygen, excess nutrients, toxic chemicals, increased temperature, excess sediment loadings, and habitat degradation.

For much of the history of the Act, chemical integrity has been the priority of the U.S. Environmental Protection Agency (EPA) and state and tribal environmental agencies.[21] The Act has dramatically reduced pollution in waterbodies across the United States, yet many remain contaminated from both point and nonpoint sources. Toxics and heavy metals, excess nutrients, and physical alterations of rivers and other aquatic landscapes harm these ecosystems, along with their resilience and capacity to provide the services that we depend on and value. When considering ecosystem services, however, biological integrity is particularly important. Unlike one-time measurements of chemical concentrations in the water column, more broadly focused measurements and assessments of the biological characteristics of an aquatic ecosystem reveal the cumulative effects of these multiple stressors.

Achieving ecological integrity under the CWA leads to functioning, resilient ecosystems that generate valuable services.

B. Water Quality Standards in the Clean Water Act

The CWA's water quality standards can be used to achieve ecological integrity and thus to protect the ecosystem services provided by aquatic ecosystems. WQS and water-quality based effluent limits promote integrity because they are tailored to the quality of specific waterbodies into which discharges are occurring. The WQS provide a secondary layer of protection for waterbodies, in addition to the statute's technology-based effluent limitations.[22] The CWA requires states to adopt and implement WQS because the cumulative effect of all discharges into that waterbody may still produce unacceptable water quality, even if all the point sources that discharge into a particular waterbody comply with applicable technology-based effluent limitations.

WQS consist of *designated uses*, *water quality criteria* that support the designated uses (which specify, either in numeric or narrative terms, the maximum levels of pollution for the waterbody concerned), and an *anti-degradation policy* to ensure that all designated uses and existing water quality is maintained. The CWA identifies the purposes of setting WQS as protecting the public health or welfare, enhancing the quality of water, and serving the overall purposes of the CWA.[23] To set these standards, regulators must consider uses of and services provided by the waterbody, including:

- Public water supplies, for drinking water and for food processing;
- Protection and propagation of fish and wildlife, including aquatic flora, waterfowl, shorebirds, and water-dependent wildlife;
- Recreational uses, depending on the type of human contact with the water;
- Agricultural, industrial, and other uses; and
- Navigation, to protect ships and to maintain water quality so as not to impede navigation.[24]

A *designated use* communicates to the public what the water is used for and sets the restoration and conservation goals for regulators and natural resource managers. A state must designate uses for its waterbodies, which at a minimum requires conditions "wherever attainable" that protect and allow propagation of fish, shellfish, and wildlife and that allow recreation in and on the water.[25] The designated use cannot include waste assimilation or transport. "Other uses" can include uses such as coral reef preservation, groundwater recharge, and aquifer protection, indicating room to include ecosystem services.[26]

To begin implementing the CWA as a tool to protect aquatic ecosystems, policymakers and environmental advocates should ask:

- Do the existing designated uses cover *all* existing uses, including all relevant ecosystem services, provided by a given waterbody?
- If the designated uses include all ecosystem services, do the existing water quality criteria adequately protect and maintain them?
- Are there gaps that lead the existing water quality criteria to inadequately protect designated uses? Is adequate scientific information available? Are there gaps in the data? Other gaps?
- What new criteria need to be developed to protect designated uses?

Answering these questions will lead to a better understanding of the groundwork that already exists and how to use the CWA. For example, if the existing designated uses do not include all the ecosystem services that should be protected, the first step is to amend the list of designated uses. If the list of uses is adequate, the focus shifts to information gathering and criteria design.

C. Flood Hazard Mitigation as a Designated Use

The designated use component of water quality standards is pragmatic and anthropocentric, similar to ecosystem services. The uses listed in the CWA already include provisioning and cultural services that we seek to protect, even though the Act predates the study of ecosystem services. The Act mandates the identification and protection of *all* existing uses, making it a potential mechanism for protecting ecosystem services. EPA regulations define "existing uses" to include "those uses actually attained in the waterbody on or after November 28, 1975, whether or not they are included in the water quality standards."[27]

New knowledge from the field of ecology and ecological economics reveals many more uses than those identified in 1972 when the modern CWA was passed, such as the role of rivers, lakes, and other waterbodies in mitigating flood hazards and the role of surrounding floodplains in maintaining water quality. Under the CWA, a state is required to conduct a triennial review of designated uses and update them as additional information becomes available. This periodic update forces regulators to better align the science of ecosystem services and the law. The designated uses listed in the CWA are not intended to be exclusive, and states are free to add additional uses based on evolving scientific understanding and other factors. Thus, a state has room to include ecosystem services as designated uses and is potentially obliged to, if the use counts as an existing use.

D. The Role of Biological Criteria in Ecological Integrity

Biological criteria, or biocriteria, are important to restoring biological integrity and healthy aquatic ecosystems that provide valuable services. If one advantage of the ecosystem services approach is that it measures success by performance rather than process, then achieving biocriteria is a clear performance metric. These criteria describe the qualities that must be present to support a desired condition in a waterbody, and they are based on the reference condition of a biologically intact aquatic system in both structure and function. Biocriteria are different from other types of criteria because they account for the health and function of the entire waterbody. For example, chemical or nutrient criteria address contaminants that enter the water or the concentration of these contaminants, whereas biocriteria address the composition of species that the aquatic ecosystem supports. Ecologists consider biocriteria and biodata to be a better predictor of environmental impact than chemical or toxicological data.[28]

On a basic informational level, biocriteria provide a measure of the health and function of an aquatic ecosystem, help regulators to set restoration goals,[29] and can serve as a benchmark for progress in achieving those restoration goals. A waterbody may meet all the chemical and physical parameters that apply and still not be healthy, and biocriteria allow regulators to more specifically characterize the outstanding impairment and causes. Biocriteria allow progress to be measured in environmental results and outcomes and not simply administrative accomplishments such as the total number of permits issued.

As a more detailed, nuanced, and precise measure of aquatic ecosystem health, developing and applying biocriteria will likely lead to more accurate identification of which waterbodies are impaired and for what reasons. These impairment findings trigger legal consequences under the CWA, namely the development of a Total Maximum Daily Load (TMDL) for the waterbody. In turn, this leads to the development and application of National Pollutant Discharge Elimination System (NPDES) permit limits for point sources and an obligation for nonpoint sources to meet the TMDL. Point sources should be able to meet additional water quality based effluent limitations by restoring ecosystem services that address the limitations and help achieve biocriteria.

Developing specific biocriteria depends on strong science. Biocriteria are anchored to a reference condition, typically a condition that is minimally impacted by human activities.[30] The ideal reference condition should represent "aspects of naturalness such as an aquatic ecosystem that is balanced, adaptive, and reflects the natural evolutionary processes."[31] Determining this condition requires no small amount of scientific studies, data culled from selected or similar sites, historical data, models, and best professional judgment. Regulators should partner with ecologists to determine what are the key criteria to restoring and protecting ecosystem health and biological integrity and consider factors other than reducing single-parameter pollutants. Achieving biocriteria and meeting this specific performance metric could include actions such as restoring stream substrate, reintroducing of woody debris, or reintroducing key species.[32]

EPA has a national policy that encourages states to adopt more comprehensive biocriteria, and Ohio has had numeric biocriteria since 1990.[34] The criteria are based on measurable characteristics of fish and macroinvertebrate communities, such as species richness, taxonomic groupings, functional guilds, environmental tolerances, and the condition of organisms. For example, the Warmwater Habitat in Ohio is described as:

> Waters capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater aquatic organisms having a species composition, diversity, and functional organization *comparable to the twenty-fifth percentile of the identified reference sites* within each of the following ecoregions…[35]

In Ohio, failing to meet biocriteria can trigger additional limits on pollutant discharge permits.[36] Ohio regulations specify that if a waterbody meets chemical and other criteria but does not meet biological criteria (and thus does not attain its designated use), the Ohio Environmental Protection Agency must determine why the designated use is not being attained. The Ohio EPA can reassign the designated use if it is not attainable. If the designated use is attainable, however, Ohio EPA must implement additional pollutant controls to attain the use. These additional controls are triggered by the failure to meet biological criteria.[37]

Both Washington and Oregon have an expansive list of designated uses for aquatic life that protect salmonid habitat for spawning and rearing. Washington's aquatic life use standard requires "all indigenous fish and nonfish aquatic species to be protected."[38] Oregon has general biocriteria that states, "Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the residential biological communities."[39] Aquatic ecosystem services are generally covered as designated or beneficial uses. However, neither state includes flood hazard mitigation as a designated use.

Biocriteria are most useful in assessing the ambient condition of a waterbody, whereas chemical criteria can be used to assess the condition and to derive enforceable limits.[40] Monitoring may indicate that a stream is impaired, but the causes vary: habitat loss, water flow reductions, channelization, or loss of floodplain habitat. More sophisticated biocriteria may lead to more accurate identification of impaired waters, but *how* to restore those waters—particularly those impacted by nonpoint sources—is still a challenge. The CWA authorizes and encourages, but does not require, states to control those sources of impairment. States have flexibility under sections 208 and 319 of the CWA to act to control pollutants from these sources, but most choose not to act.[41] The Ohio regulations, discussed above, are one example of how to implement biocriteria.[42]

E. Ecological Integrity and Floodplain Functions

Rivers, lakes, and other waterbodies protected by the CWA provide flood hazard mitigation services by absorbing and retaining water and channeling it away from human development. Waterbodies and nearby riparian areas filter contaminants in floodwaters and slow the speed of floodwaters. Healthy, intact waterbodies best provide these services, and the CWA offers tools to achieve ecological integrity in these waterbodies. The advantage of using the CWA to protect ecosystem services is simple: it already exists and is flexible enough to accommodate an ecosystem services approach, even if it has not widely been administered using that approach to date.

Across the United States, water and natural resources managers are confronting the dilemma of implementing and achieving water quality standards. As they move forward, they should adopt an ecosystem services approach during triennial water quality standards reviews. In addition to the listed uses, states are required to identify all existing uses as designated uses. New science and new information suggests that the current designated uses are incomplete, failing to account for the many ecosystem services that have been identified since 1972. More importantly, states should adopt more robust biocriteria. The ecosystem services approach identified in this manual prioritizes protection of ecological integrity and the reliance on healthy, functioning ecosystem to generate the services we value. Robust biocriteria, particularly those that apply to higher levels of aquatic use, necessarily set restoration goals at reference conditions that promote ecosystem health and functions.

VII. Flood Hazard Mitigation and the Public Trust Doctrine

Incorporating the benefits and values of ecosystems as a protected use of public trust resources establishes a legally recognized value for land in an unaltered state, aligns science and law more closely and accurately, and creates a duty for states—as trustees of public resources—to protect ecosystem services such as flood hazard mitigation. As law professors J.B. Ruhl and James Salzman note that by protecting ecosystem services as specific trust uses:

> [N]atural capital and ecosystem services would stand on equal footing with other economically valuable doctrine-protected uses. Indeed, when those other uses are not present, ecosystem service values may provide the state its exclusive means to defend its protection of trust resources and may afford citizens their sole means of challenging the state when it fails to do so.[43]

By itself, the doctrine alone is not always a sufficient legal mechanism for protecting ecosystem services. But it can be helpful ally. Professor Robert Verchick notes that "the magic of the public trust doctrine is its ability to bind onto more modern rules with epoxy-like strength in order to stabilize a controversial position."[44] This section will discuss the public trust doctrine and its utilitarian purpose and then explore how courts in other states have used the doctrine to protect ecosystem services. This section will also discuss how the doctrine could work in Washington and Oregon.

The public trust doctrine acts as a shield and a sword. As a shield, a state can use it as a defense against takings litigation arising from a regulation that prevents development on trust resources or that harms trust resources. As a sword, the doctrine establishes an affirmative duty for a state to protect ecosystem services provided by trust resources. Navigable waters and submerged lands are key to water retention, water purification, soil and shoreline stabilization, and flood hazard mitigation. The doctrine can encourage state policymakers and regulators to pursue environmental goals, and citizens can challenge state actions that violate the duty to protect trust uses.

A. The Potential of the Public Trust Doctrine

The public trust doctrine stems from the unique status of certain resources—the ocean, large bodies of water, shorelines, submerged lands, and the air—that are immensely important to individuals and to society as a whole. This importance transcends private ownership and largely places ownership in the public domain. After all, we may not all be able to afford beachfront property, but that doesn't mean we shouldn't be able to enjoy the beach. The doctrine is part of the body of court-created common law that evolves and grows as social values and mores change. This flexibility and ability to modernize is one of the great advantages of the public trust doctrine, however slowly and deliberately the changes may

occur. Similar to any legal trust, the traditional public trust doctrine consists of three primary components:

Component	Public Trust Doctrine Context
Trust Principal or Resources	Navigable waters and the submerged lands beneath them
Trustee	The State, which manages the trust principal for specific uses and values related to navigation, fishing, and water-based commerce
Trust Beneficiaries	Present and future generations

The doctrine charges the state to ensure that trust resources are used for public purposes and held available for use by the general public and to ensure that public trust resources may not be privatized.

The doctrine has long captured the imagination of environmentalists, who see in its flexibility the potential of protecting a wider range of public resources than simply the traditional, water-related ones. The expansion of the doctrine involves either expanding the list of *uses* of trust resources or expanding the list of trust resources beyond navigable waters and submerged lands. The enthusiasm from conservation interests comes from the latter expansion, but across the country state courts have generally not expanded the doctrine to include ecological preservation or active conservation by extending the doctrine beyond traditional resources.[45]

Instead expanding the list of trust resources, a more palatable expansion may involve the *uses* of trust resources.[46] The public trust doctrine is fundamentally utilitarian: water-related natural resources are protected chiefly because of their importance to society in navigation, fishing, and commercial activities. This proposed expansion stays within the confines of the doctrine's utilitarian nature by incorporating ecosystem services into the types of uses protected by the doctrine. The ecosystem services approach shares this utilitarian perspective by focusing on how certain services benefit the public, and thus it fits neatly into the public trust doctrine. The key is to reframe the manner in which ecological resources fit within the corpus of the public trust.[47]

B. A Defense in Takings Litigation

The public trust doctrine can play a role in defending state action against takings challenges and give states more legal room to enact zoning or building restrictions or other regulations that would protect flood hazard mitigation services. The U.S. Supreme Court has established two types of takings: physical takings, where the government physically occupies private property, and regulatory takings, where the government imposes a regulation that interferes with private property rights. Regulatory takings are further divided into *categorical* takings and *non-categorical* takings.

Categorical Takings. A state may enact a regulation that prevents a property owner from developing all or a portion of his property. As the U.S. Supreme Court recognized, a categorical taking occurs when a government regulation deprives a property owner of "all economically beneficial use of land."[47] These takings occur under "extraordinary circumstances" and are rare, occurring only where there is a permanent deprivation of *all* beneficial use.[48] The state's defense against a taking, however, is that the government is not required to pay just compensation where the regulation duplicates "restrictions that background principles of the State's law of property and nuisance place on existing property ownership."[49] In other words, the property was already limited by these *background principles* at the time the challenged regulation was adopted. Applying those principles or the regulation would lead to the same restrictions on property ownership.

The magic of the public trust doctrine is its ability to bind onto more modern rules with epoxy-like strength in order to stabilize a controversial position.

In explaining this exception to its categorical takings rule, the Court acknowledged that the law evolves, such that "changed circumstances or *new knowledge* may make what was previously permissible no longer so."[50] The growing body of scientific information about the ecosystem services provided by traditional trust resources is precisely the type of new knowledge that fits into this takings defense.[51]

The ecosystem services approach has two roles in the litigation of categorical takings: First, including ecosystem services among the uses of public trust resources refutes the argument that a prohibition on development deprives the property owner of all economically beneficial use of land. Until relatively recently, ecosystem services on undeveloped land have not been well accounted for, but the growing body of science demonstrates for example how crucial soil stabilization and coastal dune buffering are for inland infrastructure and buildings and hazard mitigation. These services, and the landowner's opportunity for recreation and other aesthetic uses, do not render land completely valueless in its natural state.[52]

Second, the public trust doctrine is arguably among the background principles that land use restrictions duplicate. The doctrine has deep roots in the U.S. legal system and predates the establishment of many states. As a background principle and in the absence of a government regulation, the doctrine would preclude certain actions that harm public trust resources.[53] Restrictions on harming trust resources predate an owner's acquisition of property, meaning that the owner never had a right to engage in those uses in the first place.

Penn Central takings. The vast majority of takings are analyzed under a three-prong inquiry arising from the U.S. Supreme Court's decision in Penn Central Transportation Co. v. City of New York.[55] When a regulatory restriction challenged as a taking does not deprive the property's owner of *all* economically beneficial use, courts assessing whether a compensable taking has occurred consider (1) the economic impact of the regulation; (2) the interference with the reasonable investment-backed expectations of the property owner; and (3) the character of the government action.

Knowledge about ecosystem services can influence all three prongs and help a state defend against takings claims. Both the economic impact and the investment-backed expectations

can be diminished by a public trust doctrine that includes ecosystem services among its uses. Courts have found that undeveloped land has value, reflecting in part evolving knowledge about wetlands and other aquatic resources.[56] Similar to the "background principles" defense against categorical takings, a regulation and the public trust doctrine may both result in the same restrictions on development. The third prong is murkier: traditionally, courts assess whether and to what extent the regulation approximates a physical invasion of property. If the regulation does not approximate a physical invasion, this prong works in favor of the state. A government action that serves to prevent harm (such as a zoning ordinance that prohibits development in flood-prone areas, leaving floodplains intact) would also be less likely to trigger takings liability than an action that is designed to derive a public benefit.

C. A Duty to Act

Including ecosystem services among the uses for which trust resources are protected also establishes a duty for the state to protect those uses. As the trustee, the state must act to prevent harm to ecosystem services if they are considered "uses" of the trust resources. For example, if a state action harms the storage capacity of a river by rechanneling it from its natural course and thus reducing its ability to mitigate flood waters, a citizens group could bring a suit against the state for violating this duty.[57]

D. The Public Trust Doctrine in Courts

Courts around the country have begun to recognize ecosystem services as among the uses protected by the public trust doctrine. Courts frequently note the advances in ecology that illustrated the values of ecosystems related to trust resources. These illustrate the potential for the public trust doctrine to serve as both a shield and a sword and indicate judicial recognition of the importance of ecosystem services in riparian and coastal areas.

- *Avenal v. State*. In this case, the Louisiana state supreme court denied a takings claim in part because the state was obligated to protect the coastal wetland ecosystem as part of its public trust duty. A group of oyster fishermen claimed that, by operating a coastal restoration project that changed the salinity of the oyster beds they leased, the state took their property rights. State and federal environmental agencies designed the Caernarvon project to abate saltwater intrusion into underground aquifers and marine tidal invasion, to promote restoration of Louisiana's coastal wetlands, and to enhance fisheries and wildlife along the coast. In clear language supporting the state's actions, the Louisiana Supreme Court said:

  "We find that the implementation of the Caernarvon coastal diversion project fits precisely within the public trust doctrine. The public resource at issue is our very coastline, the loss of which is occurring at an alarming rate. The risks involved are not just environmental, but involve the health, safety, and welfare of our people, as coastal

erosion removes an important barrier between large populations and ever-threatening hurricanes and storms. Left unchecked, it will result in the loss of the very land on which Louisianans reside and work, not to mention the loss of businesses that rely on the coastal region as a transportation infrastructure vital to the region's industry and commerce. The State simply cannot allow coastal erosion to continue; the redistribution of existing productive oyster beds to other areas must be tolerated under the public trust doctrine in furtherance of this goal."[58]

- *Just v. Marinette County*. In 1972, the Wisconsin Supreme Court wrestled with the distinction between regulations that create a public benefit and those that prevent a public harm. In upholding a zoning ordinance that prohibited infill of wetlands along a lake against a taking claim, the court said:

  "The state of Wisconsin under the trust doctrine has a duty to eradicate the present pollution and to prevent further pollution in its navigable waters…. What makes this case different from most [takings] cases is the interrelationship of the wetlands, the swamps and the natural environment of shorelands to the purity of the water and to such natural resources as navigation, fishing, and scenic beauty. *Swamps and wetlands were once considered wasteland, undesirable, and not picturesque. But as the people became more sophisticated, an appreciation was acquired that swamps and wetlands serve a vital role in nature, are part of the balance of nature and are essential to the purity of the water in our lakes and streams. Swamps and wetlands are a necessary part of the ecological creation and now even to the uninitiated possess their own beauty in nature."* [59]

These cases demonstrate that courts in some states recognize the valuable ecosystem services already provided by traditional public trust resources and are willing to reject takings claims against land use controls adopted to protect trust resources.

E. The Public Trust Doctrine in Washington and Oregon

Washington. In Washington, the public trust doctrine has been a part of state common law since statehood. State courts have expanded the traditional uses to include those related to navigation and use of public waters, such as boating, swimming, water skiing, and others. State courts have also expanded trust resources to include protection of shellfish that are part of the submerged lands that the state owns.[60] In the *Geoduck Harvest Association* case, the court suggested that the public trust doctrine protects functioning services (shellfish and their habitat, embedded in the soil), not exclusively the water and submerged lands. The Washington Supreme Court ruled in favor of regulations on geoduck harvesting because they facilitated sustainable harvesting and natural regeneration of the shellfish, suggesting that ecological integrity is part of the trust package. Here, the public trust doctrine served to protect both a provisioning service (the harvest of geoducks) and the public's right to recreation on public trust resources.[61]

The state doctrine seems open to including ecosystem services values among the uses protected by the public trust. The Washington State Supreme Court has recognized the ability of science to identify public needs and has not yet defined the total scope of the doctrine.[62]

Oregon. The public trust doctrine in Oregon is also part of state common law and in state statutes but is not explicitly stated in the state constitution. Oregon statutes provide that all water in the state "belongs to the public for public uses,"[63] and these uses include recreation, conservation, maintenance, and enhancement of aquatic and fish life, wildlife, fish and wildlife habitat, and any other ecological values, pollution abatement, and navigation.[64] Law professor Michael Blumm argues that Oregon's public trust doctrine provides comprehensive protection of public rights to use water, wildlife, ocean beaches, and associated uplands. As a result, the state has authority to protect and allocate these resources, a duty to preserve them for present and future generations, and the ability to seek damages for private misuse.[65]

F. The Doctrine in Action

The public trust doctrine is a legal tool to protect ecosystems, yet it cannot be relied on to achieve complete protection. In the absence of statutory regimes that recognize the value of natural capital and ecosystem services, however, the doctrine has a few basic advantages: it already exists and does not have to overcome legislative hurdles, and its utilitarian nature is well suited to match the utilitarian nature of ecosystem services.

The question remains, however: what gaps need to be filled in order to "activate" the doctrine? An ongoing dialogue should help answer questions such as:

- ***New Knowledge***. What are the ecosystem services provided by traditional trust resources? Who derives the benefits? What components of the ecosystem are necessary to sustain these services?
- ***Economic Value***. What are the economic benefits and value of land in its undeveloped state? To the landowner? Is a proxy calculation available?
- ***Public Awareness***. Has knowledge of the protective ecosystem services provided by trust resources reached the public such that property owners are aware and on notice of these benefits?
- ***Judicial Precedent***. What case law supports the expansion of trust uses?

By recognizing the ecosystem services provided by water-related public trust resources, courts can ensure that this common law doctrine continues to evolve with new knowledge. The storage capacity of a waterbody plays a significant role in flood hazard mitigation, and maintaining this capacity would become a state duty under the trust doctrine with ripple effects for the health of both the aquatic ecosystem and the neighboring floodplain.

VIII. Flood Hazard Mitigation and the National Flood Insurance Program

Incorporating an ecosystem services approach in the National Flood Insurance Program (NFIP) provides a potential framework for floodplain protection and therefore the preservation of flood hazard mitigation services. To promote efficiency, the Federal Emergency Management Agency (FEMA) could take actions under NFIP that link to water quality improvements under the Clean Water Act or fall under a state's public trust doctrine duties. This section looks at the role of the NFIP in protecting flood hazard mitigation services and overall floodplain protection and restoration.

The NFIP was established in 1968 to provide flood insurance, to diminish future flood loss through public mitigation, and to reduce overall federal expenditures for flood disaster assistance and control.[66] The majority of flood-prone communities participate, constituting more than 20,000 communities across the nation, U.S. territories, and tribes.[67] Roughly 5.6 million insurance policies are in force, including more than 85,000 policies in Washington and Oregon.[68]

A. Environmental Mandates for FEMA

The NFIP is neither viewed nor administered as an environmental program, even though it has extensive environmental impacts. A 2006 FEMA-commissioned study on the environmental impact of the NFIP concluded that NFIP both promotes safer and better planned urban development than in its absence. However, the program "removes barriers to development by reducing economic risk through building standards and making flood insurance available," particularly in coastal and riparian floodplains in rapidly developing areas, and "does not significantly… encourage the preservation of floodplains' natural and beneficial values."[69] The consequences of this failure to restrict floodplain development are clear: more deadly and devastating floods; harm to endangered and threatened species that live in the floodplain; and deteriorating water quality in waterbodies across the Pacific Northwest.

FEMA is subject to a few environmental mandates: its implementation of the NFIP is subject to the National Environmental Policy Act (NEPA) and the 1977 Executive Order on Floodplain Management. Under NEPA, FEMA must conduct an environmental impact analysis for any activity that significantly affects the quality of the human environment. It must also implement NFIP to "attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences."[70]

The Executive Order specifically addresses floodplain management; its purpose is to "avoid to the extent possible the long and short term adverse impacts associated with the occupancy and modifications of floodplain development wherever there is a practicable alternative." The Order also requires federal agencies to take actions to "minimize the impact of floods on human safety, health and welfare" and to "restore and preserve the *natural and beneficial*

values served by floodplains." FEMA last conducted comprehensive reviews of the NFIP under these environmental mandates in 1976 and 1980, respectively, but the agency is in the process of conducting a new review.[71]

Intersections: The National Flood Insurance Program and the Endangered Species Act

More recently, litigation in Washington forced FEMA to seek a section 7 consultation under the Endangered Species Act. Section 7 mandates all federal agencies to ensure that any action they authorize, fund, or conduct "does not jeopardize the continued existence of an endangered or threatened species or designated or proposed critical habitat."[72] If an agency concludes that, through an informal consultation, that its action is likely to adversely affect protected species, the agency must then submit a request for a formal consultation from the U.S. Fish and Wildlife Service (USFWS) or, for actions affecting marine species, the NMFS. If the formal consultation results in a jeopardy finding, the USFWS or the NMFS must provide reasonable and prudent alternatives.

In its final Biological Opinion to FEMA, NMFS concluded that FEMA's implementation of NFIP is "likely to jeopardize the continued existence of Puget Sound Chinook salmon, Puget Sound Steelhead, Hood Canal summer-run chum salmon, and Southern Resident killer whales." NFMS also concluded that development is "likely to adversely modify" critical habitat for all species except the steelhead. The BiOp proposed several alternatives on how to implement NFIP consistent with the needs of salmon, which parallel the protection of floodplain ecosystems.[73] These far-reaching alternatives are discussed below.

B. Discouraging Floodplain Development: General Reforms

NFIP has long been the target of criticism from a variety of groups across the political spectrum because of problems with long-term solvency, as well as other operational issues.[74] Discussing these problems goes beyond the scope of this manual, but many of the proposed reforms to NFIP would improve flood hazard mitigation services and ultimately benefit floodplains. These reforms would help discourage development in floodplains and promote restoration and conservation of floodplains in their natural state. Such reforms include:

- ***Update flood risk maps***. One of NFIP's most essential functions is to generate floodplain maps that designate zones of flood risk. These designations are based on computer models that estimate hydrologic and hydraulic conditions, and communities participating in NFIP use these maps to guide development and building codes. Many of these maps are decades old, and the models do not account for new information

about the potential impacts of climate change on flooding location and severity. The models also do not account for the dynamic interactions between hydrological, geomorphological, and climatological processes that shape floodplain ecosystems.[75] FEMA's Map Modernization program is tackling some of these challenges, but the agency should accelerate the completion and ensure that climate change models are incorporated.

- ***Increase public awareness about the risks of flooding***. Property owners in floodplains routinely underestimate or are unaware of their risk from flooding. The 2006 NFIP study also found a mismatch in public perception about the importance of flood insurance and behavior in purchasing insurance. More than half of homeowners living in a serious flood hazard area (SFHA) and more than a third of homeowners living outside an SFHA considered flood insurance important but did not own NFIP Policies.[76] Greater awareness of flood hazards may prompt some property owners to reconsider their development plans and may dissuade potential property owners from purchasing land in flood-prone areas.

- ***Ensure insurance rates are actuarially sound and fair***. The widespread availability of inexpensive, subsidized flood insurance allows many homeowners to build on flood-prone land. More actuarially sound rates would help NFIP's long-term viability and also help dissuade development in and purchase of flood-prone property. Adjusted rates should consider principles of socioeconomic fairness, particularly for those whose primary assets are property in flood-prone areas.

These reforms serve a dual purpose: to strengthen and improve NFIP overall and to discourage development in floodplains, which would in turn protect the floodplains in their natural state and preserve important ecosystem services. However, NFIP can also protect flood hazard mitigation services and other floodplain services directly by preserving floodplains in their natural state and directing development away from floodplains.

C. Protecting Floodplain Services: Specific Reforms

Although NFIP is not traditionally viewed as an environmental program, it has clear environmental impacts. FEMA has the authority to incorporate the explicit protection of floodplain services. Indeed, many of the existing criteria and programs are meant to protect these services indirectly but lack meaningful enforcement.

1. *Minimum Criteria*

All communities that participate in NFIP are required to adopt the minimum criteria identified by FEMA. These criteria are a significant leverage point for incorporating floodplain services into NFIP, and FEMA should include protecting these services in the minimum criteria. Communities in flood-prone areas have a strong incentive to participate

in NFIP: it ensures the availability of flood insurance, and having flood insurance opens the way to obtaining federal disaster assistance for flood damage and to federal financing or federally secured financing for commercial or residential properties in floodplains.

The National Flood Insurance Act requires FEMA to develop comprehensive criteria "from time to time" that encourages state and local action to prevent flood damage.[77] The purpose of the criteria is to constrict development of land that is exposed to flood damage; guide development of proposed construction away from flood hazard areas; reduce damage caused by floods; and otherwise improve the long-range land management and use of floodprone areas.[78] To participate in NFIP, communities must adopt land use regulations and other regulations that are at least as restrictive as the federal criteria.

FEMA is prohibited from issuing insurance to property owners if these criteria are not in place. If a participating community fails to maintain or implement the minimum criteria, FEMA has the authority to put the community on probation or suspend the community from participating in NFIP. The agency has the authority to revise the criteria as it acquires experience from NFIP and as new information becomes available.[79]

The existing criteria consider the environment and the mitigation capacity of floodplains in a limited way. Depending on the amount of federally designated flood land, a community must "assure that the flood carrying capacity within the altered or relocated portion of any watercourse is maintained."[80] Another criterion requires communities to "prohibit man-made alteration of sand dunes and mangrove strands… which would increase potential flood damage." For the most part, however, the criteria relate to building requirements and elevation standards.[81]

To incorporate a more environmental perspective into NFIP, FEMA should adopt criteria that explicitly protect natural floodplain functions. For example, NMFS's biological opinion recommends that the agency prohibit development in certain areas or require a community to demonstrate that the proposed development does not affect water quality, water quantity, flood volumes, flood velocities, spawning substrate, or floodplain refugia for listed species.[82] NMFS also recommends prohibiting development in the 100-year floodplain or preventing loss of floodplain storage.[83]

2. The Community Rating System

The Community Rating System (CRS) is a voluntary program that provides discounted rates for communities that enact additional measures to protect floodplains. A community can receive points for taking actions in four categories: public information activities, mapping and regulatory activities, flood damage reduction activities, and flood preparedness activities. For example, a community could acquire floodplains and restore them to their natural state or protect their functions, or it could adopt stricter regulatory standards that prohibit fill in floodplains to protect the storage capacity of a floodplain.

Less than 6 percent of NFIP communities participate in CRS, but this translates into nearly two-thirds of all NFIP policyholders. The CRS contains ten classes, depending on the activities that a community undertakes. Seventy percent of all participating CRS communities are in the two lowest classes.[84]

The impact of the CRS program is unknown because FEMA does not have the data to make this assessment. The 2006 NFIP study interviewed floodplain administrators of 18 communities, and only a quarter perceived the NFIP to be moderately or very successful in preserving open space and water quality. The study indicated that NFIP activities intended to protect beneficial floodplain values "have only been moderately successful in many rapidly growing NFIP coastal communities," in part because local political and economic interests prioritize development over environmental protection.[85]

In the CRS program, FEMA should prioritize the protection of floodplain services by:

- ***Measuring the impact of CRS activities that are credited for floodplain conservation***. If a community receives points for acquiring and restoring floodplains, it should demonstrate that the acquired property contributes to flood mitigation and is maintained. Communities should report the impact of these activities to a central FEMA database that could serve as a reference for other communities interested in implementing similar activities.

- ***Encouraging more communities to participate in CRS and to participate in higher classes of CRS***. The CRS consists of 10 classes, with Level 10 receiving no discounted insurance premiums and Level 1 receiving a 45 percent discount for the most stringent and protective regulations and activities. The 2006 study found that the CRS program is generally not a priority for many communities because of limited staff with divided responsibilities and competing priorities, the lack of institutional knowledge and coordination, and limited access to flood insurance claims to assess floodplain management challenges.[86] Many communities focus on public information activities, which while important do not include on-the-ground efforts to restore floodplain functions or acquire land.

- ***Award bonus points for priority activities***. For certain activities that explicitly protect floodplain services, FEMA should award bonus points. FEMA should develop a list of priority activities that retain or restore natural floodplain features, improve water retention capacity, slow the flow of water, or prohibit development in critical hazard areas.

- ***Incorporate proven, effective CRS practices into the NFIP minimum criteria***. Communities that participate in CRS should be laboratories for experimenting with the most effective techniques that preserve floodplain function. As these techniques or activities are established and become successful, FEMA should upgrade its minimum criteria to include them.

Community Rating System: King County

King County, Washington, is rated as a Class 2 in the CRS and has undertaken activities in all four categories. Notably, it has acquired 40 repetitive loss properties through buyouts and prohibited new development in these areas and requires compensatory storage for fill placed in the floodplain.

3. *Monitoring and Enforcement*

At the most basic level, FEMA should ensure that existing criteria and CRS activities are monitored and implemented as required by law. The agency should take meaningful enforcement actions against communities that fail to comply. The 2006 NFIP study concluded that the nationwide compliance rate ranges between 70 and 85 percent and also found that some communities were upgraded in CRS class despite being non-compliant.[87] FEMA uses a cooperative enforcement approach that combines voluntary approaches with sanctions, but this approach assumes that most communities are willing to abide by the program's standards. The approach consists of three components:

- ***Compliance Promotion***. FEMA encourages compliance with NFIP requirements by providing technical assistance, education, training, and financial incentives. The majority of resources are directed toward this component.
- ***Monitoring Compliance***. FEMA monitors a community through periodic contacts and program evaluations. FEMA's goal is to contact each participating community once every five years, but the 2006 Review found that no more than 10 percent of communities receive a monitoring contact, and only half of those communities are comprehensively evaluated.[88]
- ***Enforcement***. As a last resort, FEMA may sanction a community that fails to comply with NFIP requirements. The agency is authorized to put a community on probation or even suspend a community until it comes into compliance.

Because many of the NFIP criteria and CRS actions support floodplain services, FEMA could better achieve both its mission and floodplain services protection by simply enforcing these elements. There is a widespread perception that FEMA is highly unlikely to formally enforce against a non-compliant community. In the history of NFIP, FEMA has imposed probation 49 times and has suspended 10 programs.[89] Even though sanctions are rarely used, they are effective, having achieved compliance 85 percent of the time.[90] FEMA should:

- Provide compliance assistance, monitoring, and enforcement that address not only building code and zoning compliance but also requirements meant to protect and conserve floodplains and floodplain services;

- Increase Community Assistance Visits to inspect and monitor communities' implementation of the NFIP criteria;
- Ensure that CRS communities are complying with the activities for which they receive credit; and
- More readily impose probation and suspension actions for communities that fail to resolve compliance problems or demonstrate willful recalcitrance.

Basic monitoring and enforcement of existing requirements would strengthen NFIP's effectiveness as a tool to protect flood hazard mitigation services and to help restore floodplains and their functions and services. Enforcement of other federal and state laws, such as the Endangered Species Act, could also play a significant role.

4. Quantifying Floodplain Values and Effectiveness

Accounting for the natural and beneficial values of floodplains is useful in guiding floodplain management decisions, determining the adequacy of existing criteria, providing greater detail to flood maps, and identifying the most important areas within a floodplain for flood mitigation. The science and ability to quantify floodplain values has increased dramatically since the passage of Executive Order 11988, which directs federal agencies to "restore and preserve the natural and beneficial values served by floodplains" when conducting their activities. FEMA should ensure that this new information is incorporated into NFIP, which generally has not included these values in analyzing and modeling floodplain properties or in assessing the socioeconomic benefits and costs of different floodplain uses.[91]

FEMA could also use data on floodplain effectiveness to support changes to existing incentives that promote hard-armoring with levies and other structures and disfavor soft, green infrastructure approaches. NFIP encourages hard-armoring by exempting communities from flood insurance requirements if they are behind a 100-year levee, but no exemption exists for communities that prefer green infrastructure approaches. These communities must still purchase flood insurance. Funding for hard-armoring tends to come from the federal or state government, but local governments and individual property owners tend to pay for green infrastructure approaches. Data that show the long-term benefits of soft approaches, such as restoring floodplains, should change the incentives for these different approaches.

D. Connecting the Dots

Floodplains sit at the intersection of many laws and regulatory programs and provide many of the ecosystem services we depend on. Restoring floodplains to protect flood hazard mitigation services and other floodplain services will generate many positive effects that serve the goals of the Clean Water Act and the Endangered Species Act, among others. The connectedness of ecosystem services to one another should be mirrored in the law, and the ecosystem services approach provides a way to connect these dots.

IX. Future Directions and Final Thoughts

The ecosystem services approach raises new questions and establishes new paths for policymaking. It requires re-imagining the existing toolbox to find links and intersections with laws and regulatory programs outside of traditional environmental law. Future research could answer these additional questions:

- How can publicly funded programs run by the U.S. Department of Agriculture, such as commodity crop payments, the Conservation Reserve Enhancement Program, and crop insurance, be structured or refocused to protect ecosystem services?
- How do federal, tribal, state, and local governments' budgets and accounting practices affect projects to protect ecosystem services?
- How can impacts to ecosystem services be accounted for in the National Environmental Policy Act or its state equivalents?

The historical and traditional ways of interpreting laws need updating, and frequently basic implementation and enforcement of existing laws is lacking. Protecting ecosystem services frames environmental goals in language with which we are intimately familiar and clarifies what is truly important. It gives the public new impetus to push for stronger implementation and enforcement of existing laws and for more efficient use of dwindling public funds. It gives policymakers and regulators more clarity about what environmental restoration projects should be prioritized and more public support for those projects. It gives courts the opportunity to push the common law along toward recognizing the new scientific knowledge and developments about the importance of ecosystem services. This manual marks the beginning of a long-term discussion that refocuses attention on environmental protection to benefit our everyday lives.

X. Acknowledgements

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The views and recommendations in this manual do not represent any individual's view or that of his or her institution.

XI. Endnotes

1 Paul Swedeen and James Pittman, *An Ecological Economic Assessment of King County's Flood Hazard Management Plan* (August 10, 2007).

2 Rashid Hassan et al., eds., *Ecosystems and Human Well-Being: Current State and Trends, Volume 1* (Island Press 2005) at 27.

3 *Id.* at 29.

4 J.B. Ruhl et al., *The Law and Policy of Ecosystem Services* (Island Press 2007) at 9.

5 Robert Costanza et al., *The Value of the World's Ecosystem Services and Natural Capital*, 387 Nature 253, 259 (May 15, 1997). Constanza and his colleagues calculated the value of 17 selected ecosystem services. The authors noted that many categories of ecosystem services were not included and emphasized that the $33 trillion value "must be considered an underestimate." *Id.* at 258.

6 *Id.* at 257.

7 Conservation Learning Exchange, "Ecosystem Services: Can Ecosystem Services Work for Your Conservation Project?"

8 The purpose of the Clean Water Act is "to restore and maintain the chemical, physical, and biological integrity" of the nation's waters. 42 U.S.C. § 1251. Similarly, the purpose of the Clean Air Act is more anthropocentric, its goal "to protect and enhance the quality of the Nation's air resources" for public health and welfare. 42 U.S.C. § 7401(b). In the preamble of the Endangered Species Act, Congress recognized that species of fish, wildlife, and plants are "of esthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people." 16 U.S.C. § 1531(a)(3).

9 James Salzman et al., *Protecting Ecosystem Services: Science, Economics, and Law*, 20 Stan. Envt'l L.J. 309, 327-28 (2001).

10 Reed Noss, *Some Principles of Conservation Biology, as They Apply to Environmental Law*, 69 Chicago-Kent L. Rev. 893, 898 (1993-94). Noss notes that this quote probably originated from a 1927 statement by evolutionary biologist J.B.S. Haldane, who said, "My suspicion is that the universe is not only queerer than we suppose, but queerer than we *can* suppose." *Id.* at 898.

11 *Id.*

12 David Batker et al., *Flood Protection and Ecosystem Services in the Chehalis River Basin*, Earth Economics (May 2010) at 8.

[13] Kate A. Brauman et al., *The Nature and Value of Ecosystem Services: An Overview Highlighting Hydrologic Services*, 32 Ann. Rev. Envtl. Resources 67, 76 (2007).

[14] *Id.* at 77.

[15] The study notes that this estimate is likely undervalued because the study focused on only a handful of ecosystem services. Batker, *supra* note 12, at 14. These services included some of the most important to flood-damage mitigation, such as water flow regulation, soil erosion control, and disturbance regulation. *Id.* at 34.

[16] Sweeden and Pittman, *surpa* note 1.

[17] Shana Udvardy, "Portland, Oregon's Flood Protection Success Story: Reducing Flood Risk and Restoring Floodplains Along Johnson Creek" (March 15, 2012), *available at* http://www.americanrivers.org/newsroom/blog/sudvardy-20120315-portland-oregons-flood-protection-success-story.html (last visited March 18, 2013).

[18] David F. Ashton, *Flooding Disaster Averted Along Johnson Creek*, East PDX News, *available at* http://eastpdxnews.com/general-news-features/flooding-disaster-averted-along-johnson-creek-2/ (last visited March 18, 2013).

[19] Chris O. Yoder, *Policy Issues and Management Applications of Biological Criteria* in Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making 332 (W.S. Davis and T. Simon, eds., 1995).

[20] Chris O. Yoder, *Framework and Implementation Recommendations for Tiered Aquatic Life Uses: Minnesota River and Streams*, Midwest Biodiversity Institute Technical Report MBI/2012-4-4 (July 1, 2012) at 6.

[21] Robert W. Adler, *The Two Lost Books in the Water Quality Trilogy: The Elusive Objectives of Physical and Biological Integrity*, 33 Envtl. L. 29, 32 (2003).

[22] These limitations are the end-of-pipe controls required for classes of industrial and municipal point sources that are adopted by EPA and then incorporated into CWA discharge permits by state or federal permit-writers. With some exceptions, the limitations are uniform across the country within each class or category of discharger and require the same level of effluent treatment for point sources within a specific industry, regardless of where the point source is located and regardless of the quality of the local receiving water.

[23] 33 U.S.C. § 1313(c)(2)(A).

[24] 33 U.S.C. § 1313(c)(2)(A).

[25] 33 U.S.C. § 1251(a)(1).

[26] U.S. EPA, "Other Uses" in *Water Quality Standards Handbook: Second Edition* (September 15, 1993).

[27] 40 C.F.R. § 131.3(e).

[28] Thomas P. Simon, *The Uses of Biological Criteria as a Tool for Water Resource Management*, 3 Envt'l Science & Pol'y S43, S47 (2000).

[29] *Id.*

[30] Michael T. Barbour et al., *Measuring the Attainment of Biological Integrity in the USA: A Critical Element of Ecological Integrity*, 422/423 Hydrobiologia 453, 456 (2000).

[31] *Id.*

[32] Robert W. Adler, *Resilience, Restoration, and Sustainability: Revisiting the Fundamental Principles of the Clean Water Act*, 32 Wash. U.J.L. & Pol'y 139, 156 (2010).

[33] Simon, *supra* note 28, at S46-S47.

[34] U.S. EPA, Office of Water, *Biological Criteria: National Program Guidance for Surface Waters*, EPA-440/5-90-004 (April 1990).

[35] Ohio Admin. Code § 3745-1-07(B)(1)(a).

[36] Ohio Admin. Code § 3745-1-07.

[37] *See* City of Salem v. Korleski, 934 N.E.2d 360 (Ohio App. 2010) (upholding the additional regulatory controls in a discharge permit based on evidence showing that biocriteria were not being met).

[38] Washington Admin. Code §§ 173-201A-200 & -210.

[39] Oregon Admin. Regs. § 340-41-027. http://www.deq.state.or.us/wq/tmdls/docs/willamettebasin/tualatin/tmdlappxh.pdf.

[40] Yoder, *Policy Issues*, *supra* note 19, at 336.

[41] Section 208 requires each state governor to develop area-wide waste treatment management plans for areas with "substantial water quality control problems. These plans are required to identify processes that improve water quality in these areas. 33 U.S.C. § 1288. Section 319 requires each state governor to develop nonpoint source management programs, including a report that identifies sources that contribute to water quality standards violations and best management practices that help reduce water pollution from nonpoint sources. 33 U.S.C. § 1329.

[42] In Salem v. Koreleski, 934 N.E. 2d 360 (Ohio App. 2010), an Ohio Appellate court upheld additional pollutant controls based on the state's biological criteria. Those controls were single-pollutant based (in this case, phosphorus). It remains to be seen whether controls derived from biocriteria could include measures such as stream-bank restoration or other broader actions.

[43] J.B. Ruhl and James Salzman, *Ecosystem Services and the Public Trust Doctrine: Working Change from Within*, 15 Southeastern Envtl. L.J. 223, 238 (2006).

[44] Robert R.M. Verchick, Facing Catastrophe: Environmental Action for a Post-Katrina World 99 (Harvard Univ. Press 2010).

[45] Ruhl and Salzman, *supra* note 43, at 228. Some state courts have recognized wildlife as a trust resource.

[46] *See* Ruhl and Salzman, *supra* note 43.

[47] *Id.* at 230.

[48] Lucas v. South Carolina Coastal Council, 505 U.S. 1003, 1015 (1992).

[49] Tahoe-Sierra Pres. Council, 535 U.S. 302, 324 (2002).

[50] *Lucas*, 505 U.S. at 1030.

[51] Lucas, 505 U.S. at 1031.

[52] Ruhl and Salzman, *supra* note 43, at 236.

[53] Buechel v. State Dept. of Ecology, 884 P.2d 910, 918 (Wash. 1994). Other state court cases that have found land in its natural state to have economic value include Hall v. Bd. of Envtl. Prot., 528 A.2d 453 (Me. 1987) (holding that denial of a sand dune permit required to build residential structures on coastal property did not render the coastal property valueless and thus did not effect a compensable taking where landowner still had seasonal recreational use of property and where adjacent property had sold for substantial sums); Turnpike Realty Co. v. Dedham, 284 N.E. 2d 891 (Mass. 1972) (finding that the flood plain zoning that restricted development did not deprive landowner of all beneficial uses where zoning ordinance specifically permitted a variety of ecological, agricultural, and recreational uses); Turner v. Del Norte, 24 Cal. App. 3d 311 (Cal. Ct. App. 1972) (concluding that a flood plain zoning ordinance that limited use of appellants' property to parks, recreation, and agriculture did not effect an unlawful taking because appellants still had numerous ways to benefit economically from their property).

[54] In Tennessee, the doctrine was recognized as a background principle in a case where the federal Office of Surface Mining denied a mining permit to Rith Energy. The company failed to provide an adequate plan for disposing of the mining waste. The federal court denied the taking claim, relying on Tennessee's public trust doctrine and water quality statute. Rith Energy, Inc. v. U.S., 247 F.3d 1355 (2001).

[55] 438 U.S. 104 (1978)

[56] Christine A. Klein, *The New Nuisance: An Antidote to Wetland Loss, Sprawl, and Global Warming*, 48 Boston C.L. Rev. 1155, 1208 (2007).

[57] *See* Center for Biological Diversity v. FPL Group, 83 Cal. Rptr. 3d 588 (2008) (in dicta recognizing that wildlife and birds are protected by the public trust doctrine because the are "natural resources of inestimable value to the community as a whole"); National Audubon Soc. v. Sup. Ct., 658 P.2d 709 (1983) (finding that "the public trust is more than an affirmation of state power to use public property for public purposes. It is an affirmation of the duty of the state to protect the people's common heritage of streams, lakes, marshlands, and tidelands....").

[58] Avenal v. State, 886 So. 2d 1085, 1101-2 (La. 2004).

[59] Wa. St. Geoduck Harvest Ass'n v. Dept. of Natural Resources, 101 P.3d 891 (Wa. 2004).

[60] Just v. Marinette County, 201 N.W. 2d 761 (Wis. 1972).

[61] *Geoduck Harvest Ass'n*, 101 P.3d at 897.

[62] Orion Corp. v. State, 747 P.2d 1062, 1073 (1987). Daniel Jack Chasan, *A Trust for All the People: Rethinking the Management of Washington's State Forests*, 24 Seattle Univ. L.R. 1 (2000).

[63] Oregon Rev. Stt. §§ 537.010 & 537.525.

[64] Oregon Admin. Rules §§ 340-041-0101 et seq.

[65] *See* Michael C. Blumm and Erika A. Doot, *Oregon's Public Trust Doctrine: Public Rights in Waters, Wildlife, and Resources*, 42 Envt'l L. 375, 413 (2012).

[66] 42 U.S.C. § 4001.

[67] Jacquelyn Monday et al., *An Evaluation of Compliance with the National Flood Insurance Program Part A: Achieving Community Compliance* (October 2006) at 5.

[68] According to data from the Federal Emergency Management Administration, as of September 30, 2011, there were 50,660 policies in force in Washington and 34,589 policies in force in Oregon. NFIP, "Total Number of Policies in Force" (September 30, 2011).

[69] Walter A. Rosenbaum & Gary Boulware, *The Developmental and Environmental Impact of the National Flood Insurance Program: A Summary Research Report* (October 2005) at 3, 66; National Marine Fisheries Service, U.S. Dep't of Commerce, *Endangered Species Act—Section 7 Consultation Final Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation: Implementation of the National Flood Insurance Program in the State of Washington* (September 22, 2008) [*hereinafter* Biop].

[70] Executive Order 11988 on Floodplain Management, 42 Fed. Reg. 26951 (May 24, 1977).

[71] FEMA, *Notice of Intent to Prepare and Environmental Impact Statement*, 77 Fed. Reg. 28,891 (May 16, 2012).

[72] 16 U.S.C. § 1536(a)(2).

[73] *Biop*, *supra* note 69.

[74] U.S. Gov't Accountability Office, *Action Needed to Improve Administration of the National Flood Insurance Program*, GAO-11-297 (June 9, 2011).

[75] Biop, *supra* note 69, at 5.

[76] Rosenbaum, *supra* note 69, at 41.

[77] 42 USC § 4102(c).

[78] 42 USC § 4102(c).

[79] 44 C.F.R. § 60.7.

[80] 44 C.F.R. § 60.3(b)(7).

[81] 44 C.F.R. § 60.3(e)(7).

[82] Biop, *supra* note 69, at 154.

[83] *Id.* at 154.

[84] Rosenbaum, *supra* note 69, at 52.

[85] *Id.* at 70.

[86] *Id.* at 52.

[87] Monday, *supra* note 67, at 32.

[88] *Id.* at xi.

[89] *Id.* at 106.

[90] *Id.*

[91] Rosenbaum, *supra* note 69, at 22.

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