**Principles of Wetland Restoration**

To help build on the lessons of restoration projects and promote effective restoration, the Office of Wetlands, Oceans and Watersheds assembled the following list of principles that have been critical to the success of a wide range of aquatic resource restoration projects. These principles apply to different stages in the life of a restoration project - from early planning to post-implementation monitoring - and are offered here for use by a wide variety of people and organizations, ranging from Federal, State, Tribal and local agencies to outdoor recreation or conservation groups, corporations, landowners and citizens' groups.

These principles focus on scientific and technical issues, but as in all environmental management activities, the importance of community perspectives and values should not be overlooked. The presence or absence of public support for a restoration project can be the difference between positive results and failure. Coordination with the people and organizations that may be affected by the project can help build the support needed to get the project moving and ensure long-term protection of the restored area. In addition, partnership with stakeholders can also add useful resources, ranging from money and technical expertise to volunteer help with implementation and monitoring.

**Restoration Guiding Principles**

On this page:

* [Preserve and protect aquatic resources](https://www.epa.gov/wetlands/principles-wetland-restoration#preserveandprotectaquaticresources)
* [Restore ecological integrity](https://www.epa.gov/wetlands/principles-wetland-restoration#restoreecologicalintegrity)
* [Restore natural structure](https://www.epa.gov/wetlands/principles-wetland-restoration#restorenaturalstructer)
* [Restore natural function](https://www.epa.gov/wetlands/principles-wetland-restoration#restorenaturalfunction)
* [Work within the watershed/landscape context](https://www.epa.gov/wetlands/principles-wetland-restoration#workwithinwatershed)
* [Understand the potential of the watershed](https://www.epa.gov/wetlands/principles-wetland-restoration#understandthenaturalpotential)
* [Address ongoing causes of degradation](https://www.epa.gov/wetlands/principles-wetland-restoration#addressongoingcauses)
* [Develop clear, achievable and measurable goals](https://www.epa.gov/wetlands/principles-wetland-restoration#developclearachievablegoals)
* [Focus on feasibility](https://www.epa.gov/wetlands/principles-wetland-restoration#focusonfeasibility)
* [Use reference sites](https://www.epa.gov/wetlands/principles-wetland-restoration#useareferencesite)
* [Anticipate future changes](https://www.epa.gov/wetlands/principles-wetland-restoration#aniticipatefuturechanges)
* [Involve a multi-disciplinary team](https://www.epa.gov/wetlands/principles-wetland-restoration#involvetheskillsandinsights)
* [Design for self-sustainability](https://www.epa.gov/wetlands/principles-wetland-restoration#designforselfsustainability)
* [Use passive restoration, when appropriate](https://www.epa.gov/wetlands/principles-wetland-restoration#usepassiverestoration)
* [Restore native species, avoid non-native species](https://www.epa.gov/wetlands/principles-wetland-restoration#restorenativespeciesandavoidnon)
* [Use natural fixes and bioengineering](https://www.epa.gov/wetlands/principles-wetland-restoration#usenaturalfixeswherepossible)
* [Monitor and adapt where changes are necessary](https://www.epa.gov/wetlands/principles-wetland-restoration#monitorandadaptwherechangesarenecesaary)

**Preserve and protect aquatic resources.** Existing, relatively intact ecosystems are the keystone for conserving biodiversity, and provide the biota and other natural materials needed for the recovery of impaired systems. Thus, restoration does not replace the need to protect aquatic resources in the first place. Rather, restoration is a complementary activity that, when combined with protection and preservation, can help achieve overall improvements in a greater percentage of the Nation's waters. Even with waterbodies for which restoration is planned, the first objective should be to prevent further degradation.

**Restore ecological integrity.** Restoration should re-establish insofar as possible the ecological integrity of degraded aquatic ecosystems. Ecological integrity refers to the condition of an ecosystem -- particularly the structure, composition and natural processes of its biotic communities and physical environment.

* An ecosystem with integrity is a resilient and self-sustaining natural system able to accommodate stress and change. Its key ecosystem processes, such as nutrient cycles, succession, water levels and flow patterns, and the dynamics of sediment erosion and deposition, are functioning properly within the natural range of variability.
* Biologically, its plant and animal communities are good examples of the native communities and diversity found in the region.
* Structurally, physical features such as the dimensions of its stream channels are dynamically stable.

Restoration strives for the greatest progress toward ecological integrity achievable within the current limits of the watershed, by using designs that favor the natural processes and communities that have sustained native ecosystems through time.

**Restore natural structure.** Many aquatic resources in need of restoration have problems that originated with alteration of channel form or other physical characteristics, which in turn may have led to habitat degradation, changes in flow regimes and siltation. Stream channelization, ditching in wetlands, disconnection from adjacent ecosystems and shoreline modifications are examples of structural alterations that may need to be addressed in a restoration project. In such cases, restoring the original site physical attributes is essential to the success of other aspects of the project, such as improving water quality and bringing back native biota.

**Restore natural function.** Structure and function are closely linked in river corridors, lakes, wetlands, estuaries and other aquatic resources. Reestablishing the appropriate natural structure can bring back beneficial functions. For example, restoring the bottom elevation in a wetland can be critical for reestablishing the hydrological regime, natural disturbance cycles and nutrient fluxes. In order to maximize the benefits of the restoration project, it is essential to identify what functions should be present and make missing or impaired functions priorities in the restoration. Verifying whether desired functions have been re-established can be a good way to determine whether the restoration project has succeeded.

**Work within the watershed and broader landscape context.** Restoration requires a design based on the entire watershed, not just the part of the waterbody that may be the most degraded site. Activities throughout the watershed can have adverse effects on the aquatic resource that is being restored. A localized restoration project may not be able to change what goes on in the whole watershed, but it can be designed to better accommodate watershed effects. New and future urban development may, for example, increase runoff volumes, stream downcutting and bank erosion, and pollutant loading. By considering the watershed context in this case, restoration planners may be able to design a project for the desired benefits of restoration, while also withstanding or even helping to remediate the effects of adjacent land uses on runoff and nonpoint pollution.

**Understand the natural potential of the watershed.** Establishing restoration goals for a waterbody requires knowledge of the historical range of conditions that existed on the site prior to degradation and what future conditions might be. This information can then be used in determining appropriate goals for the restoration project. In some cases, the extent and magnitude of changes in the watershed may constrain the ecological potential of the site. Accordingly, restoration planning should take into account any irreversible changes in the watershed that may affect the system being restored, and focus on restoring its remaining natural potential.

**Address ongoing causes of degradation.** Restoration efforts are likely to fail if the sources of degradation persist. Therefore, it is essential to identify the causes of degradation and eliminate or remediate ongoing stresses wherever possible. While degradation can be caused by one direct impact, such as the filling of a wetland, much degradation is caused by the cumulative effect of numerous, indirect impacts, such as changes in surface flow caused by gradual increases in the amount of impervious surfaces in the watershed. In identifying the sources of degradation, it is important to look at upstream and up-slope activities as well as at direct impacts on the immediate project site. In some situations, it may also be necessary to consider downstream modifications such as dams and channelization.

**Develop clear, achievable and measurable goals.** Restoration may not succeed without good goals. Goals direct implementation and provide the standards for measuring success. Simple conceptual models are a useful starting point to define the problems, identify the type of solutions needed and develop a strategy and goals. Restoration teams should evaluate different alternatives to assess which can best accomplish project goals. The chosen goals should be achievable ecologically, given the natural potential of the area, and socioeconomically, given the available resources and the extent of community support for the project. Also, all parties affected by the restoration should understand each project goal clearly to avoid subsequent misunderstandings.

**Focus on feasibility.** Particularly in the planning stage, it is critical to focus on whether the proposed restoration activity is feasible, taking into account scientific, financial, social and other considerations. Remember that solid community support for a project is needed to ensure its long-term viability. Ecological feasibility is also critical. For example, a wetlands restoration project is not likely to succeed if the hydrological regime that existed prior to degradation cannot be reestablished.

**Use a reference site.** Reference sites are areas that are comparable in structure and function to the proposed restoration site before it was degraded. As such, reference sites may be used as models for restoration projects, as well as a yardstick for measuring the progress of the project. While it is possible to use historic information on sites that have been altered or destroyed, historic conditions may be unknown and it may be most useful to identify an existing, relatively healthy, similar site as a guide for your project. Remember, however, that each restoration project will present a unique set of circumstances, and no two aquatic systems are truly identical. Therefore, it is important to tailor your project to the given situation and account for any differences between the reference site and the area being restored.

**Anticipate future changes.** The environment and our communities are both dynamic. Although it is impossible to plan for the future precisely, many foreseeable ecological and societal changes can and should be factored into restoration design. For example, in repairing a stream channel, it is important to take into account potential changes in runoff resulting from projected increases in upstream impervious surface area due to development. In addition to potential impacts from changes in watershed land use, natural changes such as plant community succession can also influence restoration. For instance, long-term, post-project monitoring should take successional processes such as forest regrowth in a stream corridor into account when evaluating the outcome of the restoration project.

**Involve the skills and insights of a multi-disciplinary team.** Restoration can be a complex undertaking that integrates a wide range of disciplines including ecology, aquatic biology, hydrology and hydraulics, geomorphology, engineering, planning, communications and social science. It is important that, to the extent that resources allow, the planning and implementation of a restoration project involve people with experience in the disciplines needed for the particular project. Universities, government agencies and private organizations may be able to provide useful information and expertise to help ensure that restoration projects are based on well-balanced and thorough plans. With more complex restoration projects, effective leadership will also be needed to bring the various disciplines, viewpoints and styles together as a functional team.

**Design for self-sustainability**. Perhaps the best way to ensure the long-term viability of a restored area is to minimize the need for continuous maintenance of the site, such as supplying artificial sources of water, vegetation management, or frequent repairing of damage done by high water events. High maintenance approaches not only add costs to the restoration project, but also make its long-term success dependent upon human and financial resources that may not always be available. In addition to limiting the need for maintenance, designing for self-sustainability also involves favoring ecological integrity, as an ecosystem in good condition is more likely to have the ability to adapt to changes.

**Use passive restoration, when appropriate.** Before actively altering a restoration site, determine whether passive restoration (i.e., simply reducing or eliminating the sources of degradation and allowing recovery time) will be enough to allow the site to naturally regenerate. For some rivers and streams, passive restoration can re-establish stable channels and floodplains, regrow riparian vegetation and improve in-stream habitats without a specific restoration project. With wetlands that have been drained or otherwise had their natural hydrology altered, restoring the original hydrological regime may be enough to let time reestablish the native plant community, with its associated habitat value. It is important to note that, while passive restoration relies on natural processes, it is still necessary to analyze the site's recovery needs and determine whether time and natural processes can meet them.

**Restore native species and avoid non-native species.** American natural areas are experiencing significant problems with invasive, non-native (exotic) species, to the great detriment of our native ecosystems and the benefits we've long enjoyed from them. Many invasive species outcompete natives because they are expert colonizers of disturbed areas and lack natural controls. The temporary disturbance present during restoration projects invites colonization by invasive species which, once established, can undermine restoration efforts and lead to further spread of these harmful species. Invasive, non-native species should not be used in a restoration project, and special attention should be given to avoiding the unintentional introduction of such species at the restoration site when the site is most vulnerable to invasion. In some cases, removal of non-native species may be the primary goal of the restoration project.

**Use natural fixes and bioengineering techniques, where possible.** Bioengineering is a method of construction combining live plants with dead plants or inorganic materials, to produce living, functioning systems to prevent erosion, control sediment and other pollutants and provide habitat. Bioengineering techniques can often be successful for erosion control and bank stabilization, flood mitigation and even water treatment. Specific projects can range from the creation of wetland systems for the treatment of storm water, to the restoration of vegetation on river banks to enhance natural decontamination of runoff before it enters the river.

**Monitor and adapt where changes are necessary.** Every combination of watershed characteristics, sources of stress, and restoration techniques is unique and, therefore, restoration efforts may not proceed exactly as planned. Adapting a project to at least some change or new information should be considered normal. Monitoring before and during the project is crucial for finding out whether goals are being achieved. If they are not, "mid-course" adjustments in the project should be undertaken. Post-project monitoring will help determine whether additional actions or adjustments are needed and can provide useful information for future restoration efforts. This process of monitoring and adjustment is known as adaptive management. Monitoring plans should be feasible in terms of costs and technology, and should always provide information relevant to meeting the project goals.

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