Riverine Habitats
22. Floodplain Reconnection

DEFINITION

A *floodplain* is a low-lying area directly adjacent to a waterbody and partially or fully flooded during high-water events (Demek 1988). Generally located on the floor of a river valley, floodplains provide a natural inundation area that aids with water retention during high flows. The ecology of a floodplain primarily consists of herbaceous vegetation, with peat bogs, streams, lakes and small stands of forest interspersed. All floodplain habitats are reliant on ample water for their ecological processes (Krizek 2006). Across the United States, development has resulted in disconnections between floodplains and their adjacent waterbodies (primarily rivers). Engineered river channels, levees, berms, channel straightening, dam construction, and high levels of water withdrawal are all drivers of floodplain disconnection (Loos and Shader 2016). Floodplain reconnection, also referred to as *floodplain restoration*, can take a variety of forms including dam removal, levee removal or setback, the aggradation of mainstem channels, restoration of floodplain habitat, and culvert replacement or removal (Pess et al. 2005).

TECHNICAL APPROACH

The following strategies are used in floodplain reconnection projects to reverse anthropogenic alterations of a floodplain:

- **Dam removal:** Increasingly, dam removal has been used as a floodplain reconnection technique. Dams alter nutrient cycling, impact the deposition of sediment, reduce flood frequency, and limit the range of migratory aquatic species, all of which reduce floodplains' ecological health (Bednarek 2001). Dam removal techniques vary. Often, water is diverted before dam removal so that the dam can be deconstructed "in the dry." Alternatively, dams can be deconstructed "in the wet," where the dam is slowly lowered over an extended period to allow the riverine system time to adjust to the new water flows (American Rivers 2023). The impacts of dam removal are immense and affect the whole riverine system, not just floodplains (Bednarek 2001).
- **Levee removal or setback:** Levee setback projects allow rivers to migrate and create different floodplain channel types. Given the space constraints on floodplains in developed areas, levees can be set back instead of completely removed to protect nearby property from floods (Figure 1). Levee setback and removal is often paired with floodplain restoration habitat projects (descriptions follow), given that they create additional space for wildlife habitat (Pess et al. 2005).
- **Installing submersible check dams and logjams:** Submersible check dams and logjams are meant to reconnect relic channels or disconnected meanders back to the main river channel (Cowx and Welcomme 1998). *Logjams* are large piles of timber

Figure 22.1 Construction equipment traverses a new setback levee to remove material from the old levee along the Sacramento River

Photo courtesy US Army Corps of Engineers

that often accumulate in floodplains after being carried from upriver during floods. Gathering logs in a central location can help aggrade mainstem channels and create new habitat (Roni et al. 2019). Submersible check dams help facilitate the aggradation process as well as slow the velocity of the water (Pess et al. 2005).

- **Culvert replacement or removal:** Culverts and other stream passages limit connection within a floodplain. Flows of wood, sediments, nutrients, and fish become better distributed throughout the floodplain when culverts are removed or upgraded (Roni et al. 2002).
- **Construction of side and off channels:** Creating side channels allows for nearby ponds and wetlands in the floodplain to be connected to the primary river (Figure 2). These arteries can serve as vital breeding grounds for salmon (Pess et al. 2005).

Once the hydrological, geological, and chemical processes of the floodplain have been restored, habitat restoration is usually also performed to help jump-start natural processes. This usually involves planting native species. Micromanipulation of topography is also common to provide habitat for specific species, such as spawning grounds for salmon (Pess et al. 2005).

Figure 22.2 Constructed channel with reconnected floodplain at Black Forest Creek, CO

Photo courtesy USFWS Mountain-Prairie

OPERATIONS AND MAINTENANCE

Following floodplain reconnection, it is important to clear invasive vegetation and excessive understory vegetation in the restored floodplain. After heavy rains, logjams and submersible check dams should be inspected and repaired if needed. Side channels will need to be periodically redredged to maintain their connection to the main channel.

FACTORS INFLUENCING SITE SUITABILITY

- ✓ **Slope of terrain less than 6%:** Floodplains need to be flat to adequately hold excess water. High gradients along the river will channel more runoff into the river instead of reducing the peak water flow (Rosgen 1994).
- ✓ **Near-natural river flow**: A floodplain must be adjacent to a river with near-natural flow conditions to receive periodic inundations of water. Inland waterbodies independent of riverine systems are generally classified as wetlands (see strategy summary).

- ✓ **Close to gravel pits or other anthropogenic water retention infrastructure:** Gravel pits have been identified as critical habitat for many riparian species, especially amphibians. This allows for increased habitat connectivity for these species (Rhode et al. 2006)
- ✓ **Ample space between infrastructure and the river:** Roads, industrial parks, and housing complexes are often located close to rivers. Attempting to restore a floodplain in developed areas increases flood risk for the community. Structures should be moved as part of a managed retreat strategy or floodplain restoration should be sited elsewhere.
- ✓ **Within 10 km of an established floodplain:** An already functioning floodplain near a restoration site facilitates the colonization of the restored site by local flora and fauna. It is preferable if the established floodplain is upstream of the restored site, given that many organisms use the river flow to aid their movement (Rhode et al. 2005).
- ✓ **High levels of nutrient pollution due to nearby agricultural runoff:** Like riparian buffers, floodplains can block nutrient pollution from entering a river. Floodplains often replace farmland formerly sited too close to the river, which discharged excess fertilizer into the river when the fields were inundated (Ribarova et al. 2008).
- ✗ **Significant riverbed erosion:** Riverbed erosion is an indicator that sediment transport is being blocked. A lack of sediment will hinder the creation of natural floodplain components such as sandbars and transient islands (Rhode et al. 2006).
- ✗ **Close to a dam that will not be removed as part of the project:** Dams function as sediment retention basins, blocking sediment from moving downstream. Dams also limit water flow to downstream floodplains and permanently flood upstream areas, disrupting the natural inundation cycles that make floodplains successful.
- ✗ **In a densely populated urban area:** Floodplains need significant space, and this space is often not available in densely developed urban areas.

TOOLS, TRAINING, AND RESOURCES FOR PLANNING AND IMPLEMENTATION

Name and Link	Resource Type	Year	Authors/ Authoring Organization	Geography	Description	Resource Includes: Design/Construction Guidance?	Site Selection?	Monitoring Guidance?	Example Projects?
Floodplain Restoration Resources	Website	2023	American Rivers	National	Website with links to more than 20 resources relating to floodplain reconnection. These include handbooks on floodplain reconnection, using nature to mitigate flood damage, and floodplain planning strategies.	✓	✓	—	✓
Central Valley Flood Protection Plan	Guidebook	2022	California Department of Water Resources	California	Document that lays out steps planners have taken to manage floodplains in California's Central Valley. This resource includes case studies on levee setback, flood management equity, and incorporating climate change into floodplain planning.	✓	—	✓	—
Project Management Resources	Website	2023	Floodplains by Design	Written with an emphasis on Washington state but most of the information is more broadly applicable	Website with links to resources about floodplain management collaboration, permitting through the US Army Corps of Engineers (USACE), and managing contractors. The site also provides resources tailored toward tribal projects, communication, and monitoring mechanisms.	✓	—	✓	—
State of Vermont Flood Ready—Use Natural Flood Protection	Website	2013	State of Vermont	Designed for Vermont but most of the information is more broadly applicable	Overview webpage outlining the new paradigm of nature-based floodplain management. This resource links to case studies, technical guides, and videos pertaining to floodplain reconnection.	✓	—	—	✓

Name and Link	Resource Type	Year	Authors/ Authoring Organization	Geography	Description	Resource Includes: Design/Construction Guidance?	Site Selection?	Monitoring Guidance?	Example Projects?
Association of State Floodplain Managers Flood Resource Library	Website	2023	Association of State Floodplain Managers (ASFPM)	National	This library contains a diverse array of resources pertaining to floodplain management, including technical reports and government documents. The library also holds the research of the Flood Science Center, a branch of the ASFPM.	✓	—	✓	✓
Inter-Fluve Floodplain Reconnection Atlas	Website	2020	Inter-Fluve	National	Collection of case studies containing past floodplain reconnection projects, including habitat restoration and side channel creation. At the bottom of the page, Inter-Fluve also has information for related nature-based solutions (NBS) such as dam removal, large log design, and off channel habitat restoration.	—	—	—	✓
Connecting Rivers to Floodplains	Guidebook	2016	American Rivers	National	This guidebook describes how to perform a floodplain reconnection project in four easy-to-follow steps. This resource also provides characteristics of a functional floodplain to provide a standard for successful projects.	✓	—	—	—

GRAY INFRASTRUCTURE ALTERNATIVES

Floodplain reconnection can be an alternative to several gray infrastructure approaches designed to address riverine flooding: dam construction and levee/dike systems. The ability of a floodplain reconnection project to replace or supplement one of these gray infrastructure types depends strongly on the project's location and whether it is designed to create the necessary outcomes. Certain environmental conditions may require gray infrastructure rather than floodplain reconnection. See the gray infrastructure alternative tables in Section 1 for a comparison of floodplain reconnection to these alternatives.

LIKELY BENEFITS AND OUTCOMES

Climate Threat Reduction

Primary objectives for each strategy are highlighted.

- **Reduced flooding:** Floodplain reconnection can reduce the peak velocity of water by establishing alternative routes for the water to flow (side channels, ponds, meanders, and so on), reducing the load on the main channel of the river (FEMA 2015). Floodplain reconnection frequently entails levee setbacks or removals, giving floodwaters a greater area to disperse over and reducing the flow of water entering individual communities (NRC Solutions 2023).
- **Drought mitigation:** Floodplains facilitate groundwater recharge by providing greater surface area to percolate for floodwater to percolate into belowground aquifers. Reconnected floodplains are highly effective at retaining water during flash floods (American Rivers 2023). Instead of the water being washed downriver, the water recharges aquifers, helping store water for future droughts (FEMA 2015).
- **Heat mitigation:** Temperatures within a floodplain can vary significantly, with exposed sediments considerably hotter than aquatic or forested habitats (Tonolla et al. 2010). Floodplain reconnection enhances and expands both the vegetation cover and water flow within a floodplain. Therefore, reconnected floodplains help reduce both water and surface temperatures during heatwaves (ASFPM 2023).
- **Reduced wildfire risk:** Because floodplain reconnection increases the diversity of habitats across a floodplain, it creates greater heterogeneity in burn severity during a fire, also called *pyrodiversity* (Jones and Tingley 2021). As a result, floodplains are better able to serve as a fire break and reduce the chance of a large wildfire jumping across the river. Increased pyrodiversity also enhances biodiversity as the floodplain recovers from the wildfire, creating new ecological niches (Pugh et al. 2022).
- **Carbon storage and sequestration:** Reconnected floodplains have been shown to sequester greater amounts of CO_2 than degraded ones (Craft et al. 2018).

Social and Economic

- **Reduced erosion:** Healthy floodplains help reduce erosion during extreme floods. Floodplains are natural regulators of sedimentation, helping redistribute excess sediment throughout a river system (Ahilan et al. 2016).

- **Property and infrastructure protection:** By restoring the natural floodplain, reconnection reduces the height of floodwaters. As a result, floods are less likely to penetrate nearby levees and infiltrate local communities (NRC Solutions 2023).
- **Agriculture and timber yields**: Reconnected floodplains protect nearby agricultural areas from floods, provided that the agricultural areas are far enough away from the river. Additionally, floodplains improve water quality, pollinator habitat, and aquifer recharge rates, all of which increase agricultural yields (TNC 2018).
- **Mental health and well-being:** Floodplains can serve as public green space, which helps improve residents' mental health.
- **Recreational opportunities:** Floodplain reconnection makes an area more suitable for a plethora of recreational activities, including kayaking, birdwatching, and fishing.
- **Jobs:** Workers will need to be hired to perform the restoration activity, boosting the local economy.
- **Increased property values:** Floodplain reconnection has been shown to increase nearby property values, potentially because of reduced flood threats to the property (Gourevitch et al. 2020).
- **Cultural values:** Floodplain reconnection can increase local knowledge of the ecosystem and provide aesthetic values that increase sense of place.
- **Resilient fisheries:** Reconnected floodplains provide ideal spawning grounds for migratory fish species like salmon, aiding both inland and coastal fisheries (Pess et al. 2006). Floodplain reconnection also can entail dam removal, which improves passage for migratory fish species.

Ecological

- **Improved water quality:** Reconnected floodplains can absorb greater quantities of sediment, nutrient pollution, and toxins thanks to the ability of native vegetation to filter water. As a result, healthier floodplains can reduce hypoxic zones and algae blooms downstream and help to prevent bioaccumulation and biomagnification of toxins in seafood (Grift 2001; Craft et al. 2018; TNC 2018).
- **Enhanced biodiversity:** Floodplain reconnection has been shown to increase the number of microhabitats interwoven within a floodplain, increasing overall biodiversity (Mount 2011).
- **Supports wildlife:** Floodplains slow down water flows, creating conditions for higher primary productivity among zooplankton. This increase of biomass at lower trophic levels supports higher native fish populations (Mount 2011).
- **Increased habitat connectivity:** Floodplain reconnection provides lateral connectivity from the main channel of the river to various ecological niches throughout the floodplain via the creation of side channels (Opperman et al. 2010).

BARRIERS AND SOLUTIONS FOR PRACTITIONERS

Common Barriers

- Several barriers are common across many of the NBS strategies; these are described in more detail in Section 1 of the Roadmap. Additional notes about the barriers specific to floodplain reconnection are included here.
- **Expense:** While the costs of floodplain reconnection projects can be low compared to flood damage expenses, the upfront costs of reconnection are still high (Gourevitch et al. 2020). This is especially true when large infrastructure adjustments are involved. For example, a levee setback project in West Sacramento, CA, carried a price tag of $20 million per mile (NRC Solutions 2023).
- Capacity
- **Public opinion:** While floodplain buyouts compensate residents for their property at market value, this does not account for the costs of relocating and adjusting to a new community. Community members are usually unwilling to move out of an area to make way for floodplain reconnection (Lipuma 2021).
- **Conflict with other land uses:** Agricultural or urban areas are frequently sited in floodplains, meaning that certain structures and fields may have to be removed for reconnection (Brouwer and van Ek, 2004). This is usually done through floodplain buyouts, which can be expensive and are voluntary, so a project may not be feasible to complete if property owners are not willing to sell (Lipuma 2021). Floodplain reconnection may also reduce the navigability and straightness of a waterbody for use as a shipping corridor.
- **Regulation**
- **Lack of effectiveness data**

Community

- **Legal:** River flow may not be able to be altered because of water rights or other legal issues (Loos and Shader 2016).
- **Safety:** Levee setbacks or dam removals may not be possible because of engineering difficulties or flood safety concerns (Loos and Shader 2016).

Ecological

- **Habitat disruption:** Riverbed incision, where the riverbed drops a few meters because of dam removal, may disrupt sensitive habitat (Loos and Shader 2016, Maaß and Schüttrumpf 2019).
- **Nutrient pollution:** Fertilizer runoff from nearby agricultural fields may overwhelm the ability of the floodplain to filter nutrient pollution and cause ecosystem collapse.
- **Invasive species:** Floodplains are prone to being overrun by invasive species. Invasive species have been shown to limit the ability of floodplains to attenuate floodwaters. However, native species can better compete with invasives as the floodplain is more frequently inundated (Hutchinson et al. 2020).

EXAMPLE PROJECTS

Name and Link	Location	Leading Organizations	Techniques Used	Size	Cost, $	Duration	Project Description	Climate Threats Targeted	Lessons Learned or Adaptive Management
Salamander Parcel Floodplain Reconnection	Douglass County, OR	**US Fish and Wildlife Service (USFWS),** the Confederated Tribes of the Siletz Indians	Dike removal, channel reconstruction	41 acres, 8 stream miles	200,000	Not provided	Old roads and dikes were removed to allow water to reach the floodplain. Channels were reconstructed to allow fish to access the floodplain as well.	Inland flooding	Indigenous Knowledges from the Confederated Tribes of the Siletz Indians was used to help restore fisheries.
Pocomoke River Floodplain Restoration Project	Southeastern Maryland	**USFWS**, Maryland Department of Natural Resources, US Department of Agriculture, The Nature Conservancy (TNC), **US Geological Survey**	Levee breach at selected locations	3,000 acres, 9 river miles	1 million	3 years	Contractors breached a levee in more than 100 spots to allow water to reach the adjacent floodplain.	No	Conservation easements were negotiated on many of the parcels in the floodplain to avoid costly floodplain buyouts.
Green River Reconnection Project	Ouray National Wildlife Refuge, UT	**USFWS, Bureau of Reclamation**	Levee breach at selected locations	800 acres	234,800	3 months	To connect wetlands to the main channels of the Green River, a levee was breached at several locations to let floodwaters come through.	Drought	Hydrodynamic modelling was used to help create an effective restoration plan.
Steigerwald Reconnection Project	Steigerwald National Wildlife Refuge, WA	**USFWS,** National Oceanic and Atmospheric Administration, Bonneville Power Administration	Side channel creation, infrastructure relocation, levee setback	965 acres	32 million	3 years	Contractors installed large wood habitat structures, treated invasive species, reforested an alluvial fan, removed current levees and built levee setbacks.	Inland flooding	The project eliminated the need for pumps to protect a nearby industrial park and wastewater treatment plant.

Name and Link	Location	Leading Organizations	Techniques Used	Size	Cost, $	Duration	Project Description	Climate Threats Targeted	Lessons Learned or Adaptive Management
Redwood Creek Restoration Project	Golden Gate National Recreation Area, CA	**National Park Service (NPS)**	Levee removal, infrastructure relocation, bridge renovation, invasive species management, revegetation	42 acres, 1,700 linear feet of stream	1.76 million	2 years	Workers removed a levee and artificial fill from the floodplain to restore the natural hydrology. Because the area is popular with visitors, a parking lot and trails had to be reconfigured. Hillsides were also revegetated to prevent erosion.	Inland flooding	Side channels and ponds were built to serve as spawning grounds for coho salmon.
Elwha Floodplain Restoration Project	Olympic National Park, WA	**NPS,** Lower Elwha Klallam Tribe, **Bureau of Reclamation**	Dam removal, logjam construction, culvert correction	715 acres, 70 river miles	324.7 million	4 years	This project is the largest dam removal project in history, allowing floods to reach the Elwha River's floodplain after more than 100 years of damming. Two dams were removed and the floodplain was enhanced with new culverts and logjams.	Inland flooding	The project greatly impacted sedimentation throughout the river, restoring the delta of the Elwha River.
Mollicy Farms Floodplain Restoration Project	Upper Ouachita National Wildlife Refuge, LA	**USFWS,** TNC	Levee removal and revegetation	16,000 acres, 17 river miles	4.5 million	1 year	A levee was breached to reconnect a historic floodplain to the Ouachita River. The forest in the floodplain was also replanted.	Inland flooding	While the project was still in the planning phase, the levee was naturally breached by historic floods. Managers adapted their plan to widen already existing breaches and create new ones.

Name and Link	Location	Leading Organizations	Techniques Used	Size	Cost, $	Duration	Project Description	Climate Threats Targeted	Lessons Learned or Adaptive Management
Sacramento-to-Kern Rivers Floodplain Reconnection Project	Sacramento National Wildlife Refuge, CA	**USFWS,** USACE, TNC, **Reclamation**	Levee removal, floodplain buyouts, and habitat restoration	1,400 acres	1.37 million	Not provided	Managers purchased orchards that had been built in the floodplain protected by a levee. They removed the levee, restored native vegetation, and built a levee setback.	Inland flooding	The project was initiated after fixing the levee was deemed too expensive.

Bolding indicates DOI affiliates.

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