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Integrating Watershed Restoration in Wildfire Management

Opportunities, Approaches, and Examples

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Front cover and final photo: Sheep Creek wetlands were restored using timber from riparian thinning from local active management work with multiple partners. Grande Ronde Ranger District, Wallowa-Whitman National Forest, OR. Courtesy photo by Levi Old, Trout Unlimited.

Executive Summary

Wet fuel break creation increases wildfire resilience.

It may sound simple, but **water doesn't burn**. Techniques for river and stream restoration, known as process-based restoration (PBR), store more water on the land, which can increase fire resilience and bolster fuel treatments. PBR applied in stream corridors, meadows, and valley bottoms can quickly and cost-effectively increase surface water and groundwater by utilizing non-merchantable timber and slash to raise water tables and increase soil moisture. Integration of watershed restoration during fire and fuels planning can strengthen suppression-control features such as Potential Operational Delineation (POD) boundaries while increasing ecological benefits (fig. 1). Intact wetland complexes and streams connected to their floodplains can better withstand wildfires, provide refuge from fire for fish, wildlife, and plants, then capture ash and sediment following wildfire.

U.S. Department of Agriculture (USDA), Forest Service partners are funding and implementing appropriate PBR techniques designed for specific landscapes. Case studies have demonstrated successful integrated outcomes.

When river and stream restoration is fully integrated with fuels reduction treatments and active management, low-value wood and slash are directly utilized, reducing some need for piling and burning or wood hauling. Techniques such as beaver dam analogs, large wood addition, and valley-bottom restoration can be combined with active management practices to achieve multiple goals. The wet fuel breaks created may potentially serve as control lines in prescribed burning operations.

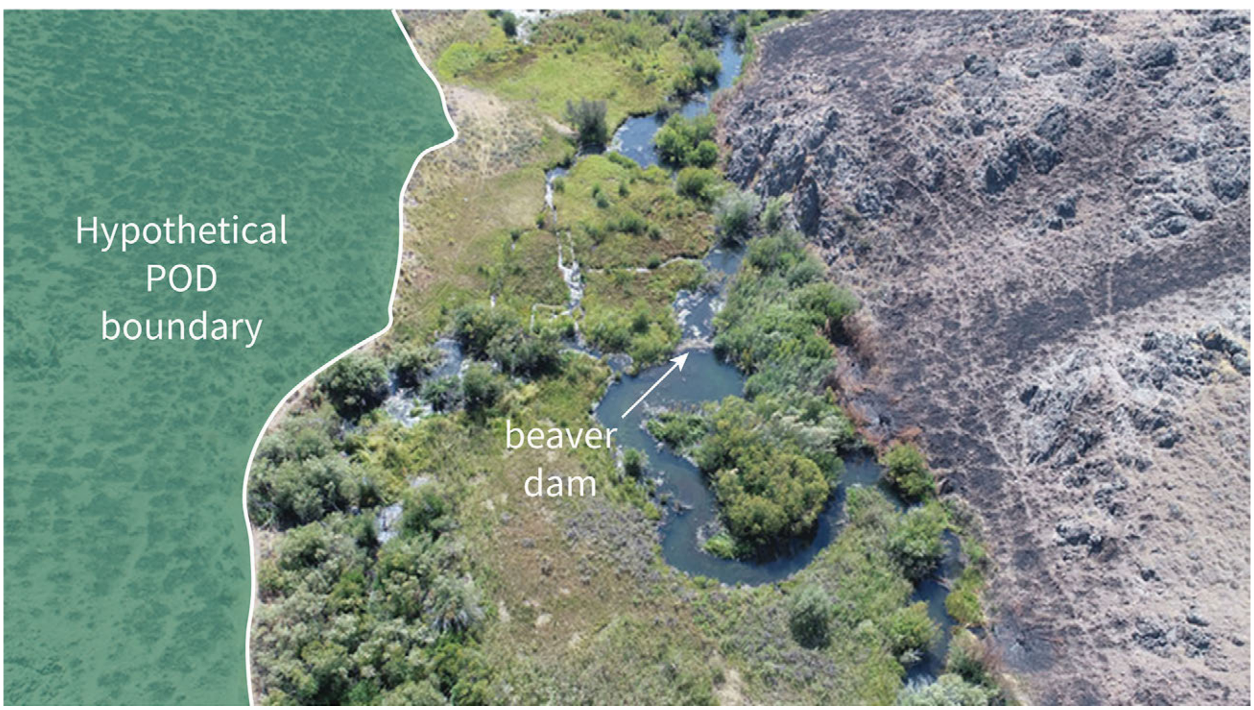


Figure 1—Hypothetical coupling of a Potential Operational Delineation (POD) and fuels treatment boundary alongside a connected beaver-created wetland may provide enough surface water and soil moisture to influence fire behavior and spread. In this example, the enhanced wetland stream valley, combined with the western POD treatment, might inhibit the east-to-west spread of the fire. Courtesy image by J. Wheaton, Utah State University—Creative Commons Attribution 4.0 License.

Why Watershed Restoration?

Watersheds are defined by streams and rivers and include the hillslopes from which water drains through valleys and into streams or wetlands that are home to a wide variety of fish and wildlife species. In national forests and grasslands, many meadows, stream and river systems, and valleys have been highly altered. The low-lying and often flat areas associated with surface waters have undergone significant use and modification over time (Skidmore and Wheaton 2022). For example, beavers, once prevalent across North America, were eradicated from many areas by trappers and those seeking to convert wetlands to pasture (Wohl 2021). Streams were straightened and ditched to accommodate roads, infrastructure, and mining development. Streamside vegetation was heavily grazed by livestock, and Tribal stewardship and fire management were halted (Catton 2016, Knight et al. 2022). These legacy impacts, in combination with ongoing uses, result in many streams that are incised and straightened, with steep banks and deeper water channels (Brown et al. 2018, Mason et al. 2025), and meadows and other former wetlands that are now filled with flammable vegetation (Pope and Cummings 2023) (fig. 2a). These changes reduce the natural ability for valleys and riparian areas to store water and sediment, support wetland vegetation (Shahverdian et al. 2019a, Cummings et al. 2023), and withstand drought and fire (Fairfax and Whittle 2020).

This report is intended for fuels planners, watershed scientists, fisheries biologists, line officers, and partners interested in integrating watershed restoration to restore natural processes in valley bottoms and along streams and river systems that achieve wildfire management and other multiple-use objectives (fig. 2b).

With disruptions and changes to natural processes in low-lying areas and across the broader landscape, watersheds are now drier and more prone to high-severity wildfire and erosion, making them less productive for fish and wildlife, grazing, and other cultural uses (Poff et al. 1997, Fairfax et al. 2024). In some lowland areas of watersheds, water tables have fallen, contributing to the disappearance of wetlands and turning valleys and meadows into dry corridors stocked with hazardous fuels. Instead of resisting and slowing the spread of fire as these wet ribbons of streams and wetlands historically did (Pugh et al. 2022) (fig. 3), they now have the potential to carry fire up and down valleys, contributing to fire spread from hillslope to hillslope (Pettit and Naiman 2007).

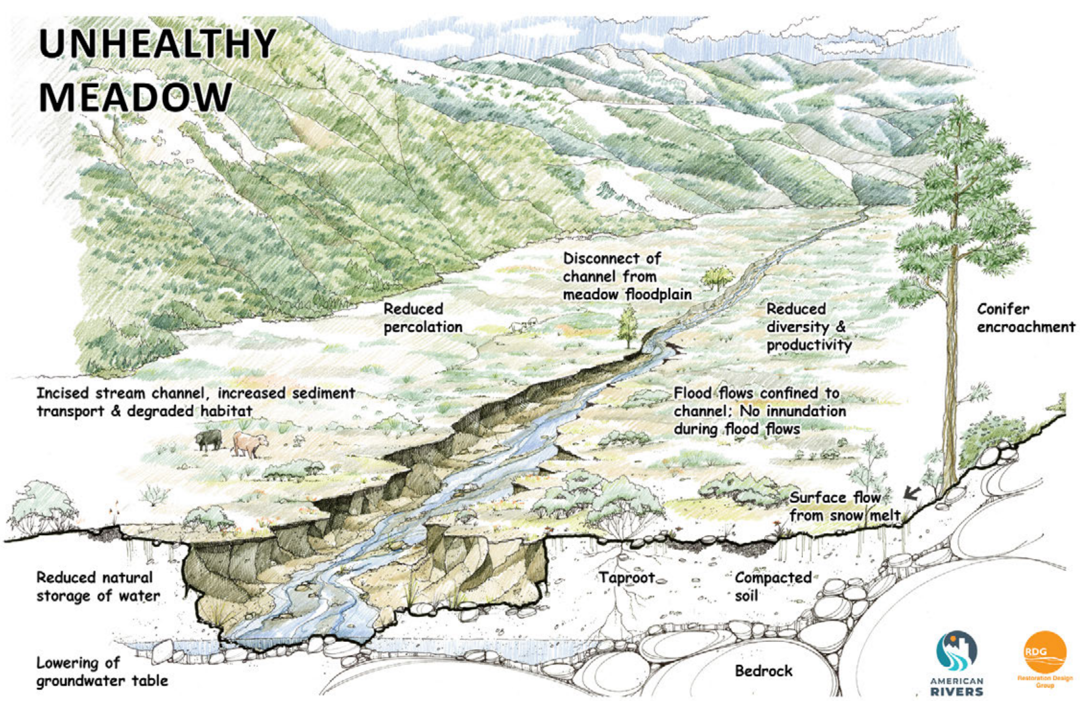


Figure 2a—A typical dried-out meadow where the stream has been straightened and has downcut deep into the valley floor. Now the water moves more quickly downstream, and the water features themselves are narrow and reduced. This type of valley is prime for invasive grasses, flammable shrubs, and conifer establishment that provide fuel for hotter, faster fires. Courtesy image by American Rivers.

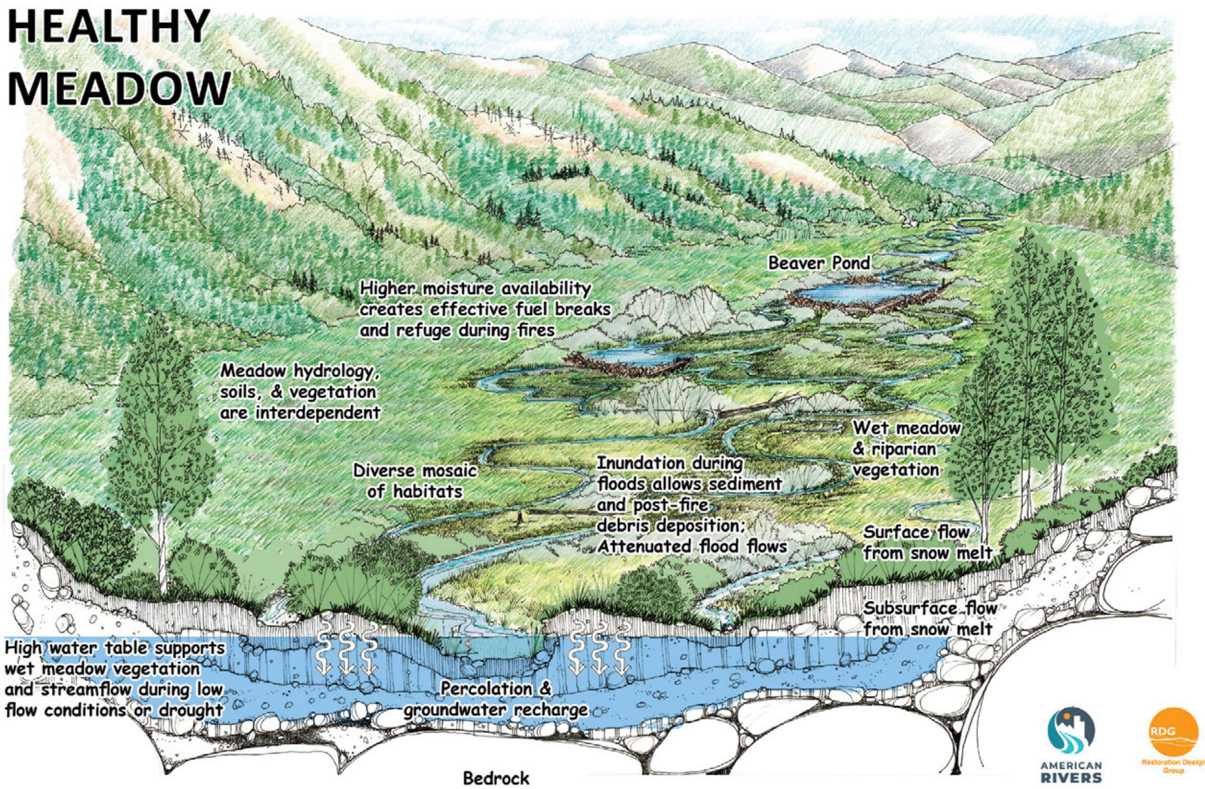


Figure 2b—A healthy wet meadow and valley. The stream is typically less straight and more complex, and wetlands, beaver ponds, side channels, and water features are more numerous. With a much higher water table and groundwater filtering slowly downstream and laterally across the valley, wetland vegetation like willows, sedges, aspen, and other less flammable vegetation covers the stream sides and valley floor. Courtesy image by American Rivers, developed with the support of Colorado Water Conservation Board grant number CWP AG HB21-1260.

Types of watershed restoration

The Forest Service and its partners have the expertise to restore and rewet degraded stream systems, meadows, and valley floors, using a variety of watershed restoration techniques. Generally, process-based restoration (PBR) techniques attempt to restore important natural functions that have been altered (fig. 4a), including the flow and storage of groundwater, the movement and storage of sediment, and the shape and maintenance of water features like streams, ponds, and wetlands. The Forest Service and its partners are increasingly focusing watershed restoration in valleys, meadows, and stream and river corridors, or riverscapes, where many natural processes have been disrupted. The disruption of these watershed processes has important implications for fire behavior, hazardous fuels and vegetation flammability, and successful fire suppression. Strategic watershed restoration can increase the effectiveness of management strategies for both wildfire and prescribed burning in these areas by restoring natural processes that promote soil moisture, expand water features, and encourage growth of less flammable vegetation.

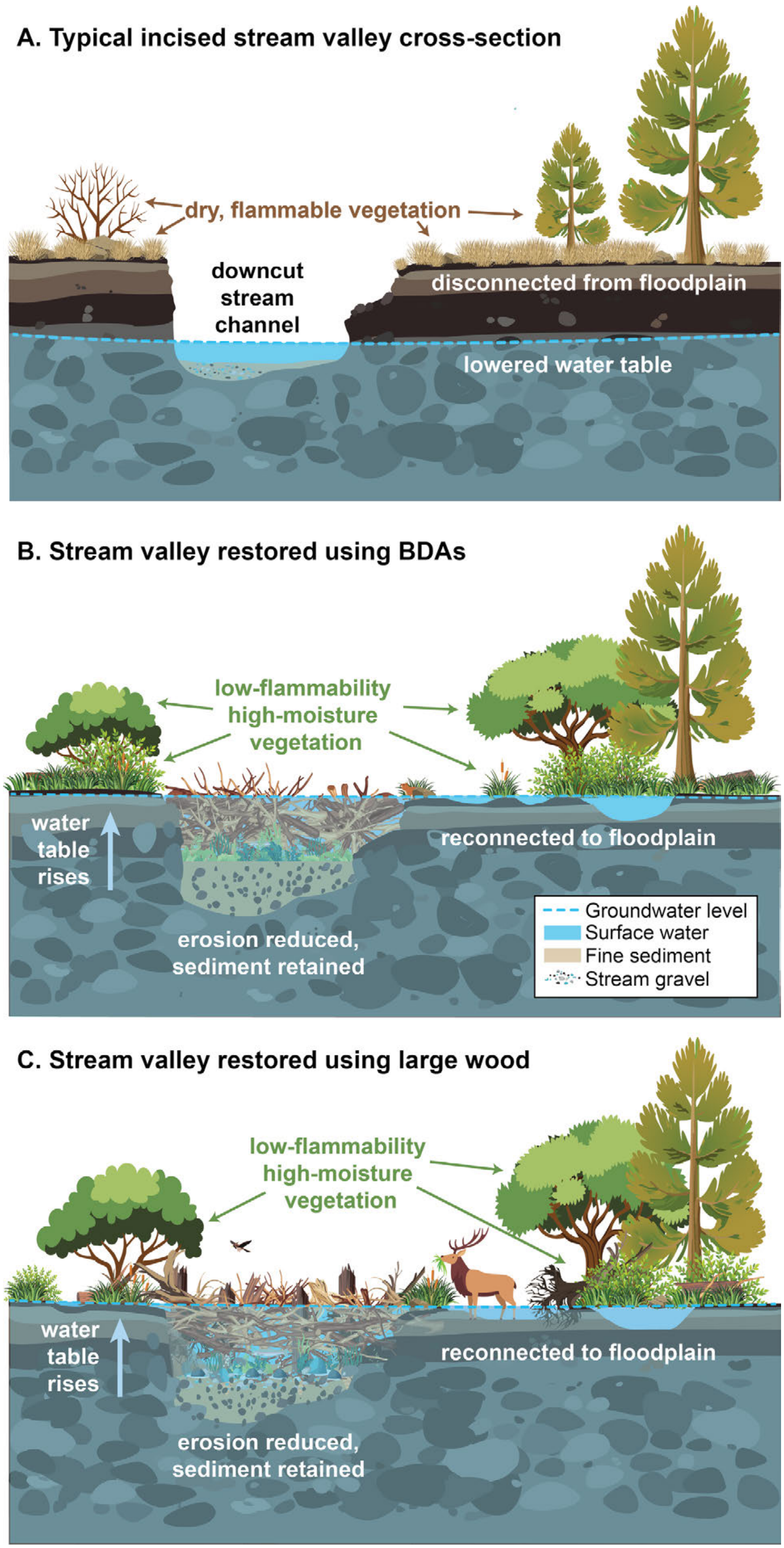
Coordinating and integrating active management of forested hillslopes with restoration of adjacent lowland valleys has the potential to enhance wildfire resilience at a watershed scale. Forest Service units, States, other Federal agencies, Tribes, and partners have been using a variety of stream and floodplain restoration methods, many of which are cost-effective and relatively simple to implement, to restore multiple benefits to the landscape and the public. (More details on these techniques, where they are most appropriate, and how to integrate them into hazardous fuels management and post-fire recovery planning will be shared later).

Watershed restoration techniques can include:

- **Beaver mimicry:** Building beaver dam analogs (BDAs) (fig. 4b) and post-assisted log structures (PALS) (Shahverdian et al. 2019a) with small-diameter wood, brush, and local materials to restore wetlands, rewater riparian zones, and encourage beaver to colonize the area (also known as low-tech process-based restoration).
- **Beaver reintroduction:** Translocating beavers into the watershed so they can naturally create and maintain wetlands and water features along streazms and across floodplains and valleys for no additional cost.
- **Meadow restoration:** Reestablishing wet meadows by raising water tables, storing sediment, and removing conifers and other trees.
- **Stream connectivity:** Upgrading culverts and relocating roads to restore the processes that create and maintain wet meadows, wetlands, and wet valleys.
- **Large wood restoration:** Building wood jams and log structures along stream corridors (fig. 4c) using hazardous fuels materials, a cost-effective way to raise water tables, capture sediment, and expand stream channels and wetlands.
- **Valley-bottom reset:** Using cut and fill with heavy equipment to fill downcut channels with sediment and large quantities of wood from hazardous fuels and forest thinning treatments, rewetting entire floodplains and valleys and expanding fuel breaks (also known as high-tech process-based restoration).

Figure 3—Aerial view of the Bootleg Fire on the Fremont-Winema National Forest, 2021. This natural beaver dam complex resisted fire and served as refuge and provided ash/sediment retention for post-fire recovery, which benefits downstream water users. Courtesy photo by Charles Erdman/Trout Unlimited.

Figure 4—Diagram of a cross-section of a degraded stream, before and after employing two different methods of process-based restoration. Panel (A) shows a typically incised or downcut stream with lowered groundwater table, dry floodplain, and highly flammable vegetation with little fire resistance. In (B), the same stream is restored using a beaver dam analog (BDA) installation, resulting in higher groundwater table, wet floodplain and soils, and low-flammability vegetation. In (C), the same incised stream channel is restored by means of large wood addition, resulting in higher groundwater table, wet floodplain and soils, and low-flammability vegetation within the entire stream zone. Forest Service images by Peggy Wilson.



Watershed restoration, and more specifically process-based restoration (PBR), is intended to recover the self-supporting processes and connections that historically maintained these areas. In freshwater systems, restoration often targets recovering pathways of water and sediment movement, which then enables aquatic systems to support native plant, animal, and fish species.

Restoring natural processes in meadows, streams, and across valley floors can result in higher groundwater tables, slower stream velocities, and retention of sediment, contributing to complex and dynamic habitats for fish and wildlife, and enhancing watershed-scale resilience to wildfire. These approaches specifically benefit the agency and local communities in numerous ways.

Fire and fuels benefits:

- Restore wetter valleys and stream zones with less flammable vegetation to create increased fire resistance during wildfire and prescribed burning (fig. 5).
- Expand potential operational delineations (PODs) and safety zones for fire-management planning and wildfire suppression.
- Make productive use of waste wood and slash generated from active management, reducing the need for piling and burning.
- Increase riparian vegetation and surface water that can serve as green/wet lines during prescribed burning, and are likely to expand burn windows, by making these areas resistant to fire spread for longer time periods.
- Reduce post-fire flood damage from sediment that can be captured on floodplains and meadows as opposed to being transported downstream, which is particularly important for drinking water sources.
- Achieve "acres treated to reduce wildfire risk" for target accomplishment.

Figure 5—Beaver dam analogs (BDAs) constructed on Soda Creek, Dillon Ranger District, White River National Forest, funded through the Colorado Western Slope In-Lieu Fee Program. Courtesy photo by National Forest Foundation.

Ecological benefits:

- Store surface water and groundwater so that it is released more slowly and thereby decreases drought and flooding impacts on agriculture, streams, and people.
- Restore habitat for salmon, elk, sage grouse, and many other valuable fish and wildlife, including ESA-listed threatened and endangered and State-listed species.
- Maintain refuge for fish, wildlife, and plants during fires (figs. 3 and 6).
- Protect soil health and carbon storage from high-intensity wildfires.

Figure 6—Camp Creek Reach 1 valley bottom restoration the winter following large wood additions and valley bottom restoration that used wood derived from a large vegetation management project where commercial, non-commercial, fuels, and forest health treatments were completed. Malheur National Forest, OR in 2024. Forest Service photo.

Community benefits:

- Provide opportunities for Tribal co-stewardship, food and fiber sources for Indigenous and local communities, and community co-stewardship.
- Provide opportunities for Tribal youth, Job Corps, other community work crews, and volunteers to gain experience and find local jobs (fig. 7).
- Improve important habitat for the public to hunt and fish and increase opportunities for recreational wildlife viewing.
- Provide good-paying local jobs for contractors in the watershed restoration and hazardous fuels management economies.
- Add to community wildfire risk reduction work, linking treatment areas across drainages and along stream networks and valleys.
- Ensure water security: Mitigate costly fire impacts on municipal drinking water sources, especially suspended sediment and ash that affect water quality and storage, even for communities that may be many miles downstream of the burn area (City of Greeley 2025).

Figure 7—Forest Service and Wyoming Conservation Corps work on Tincup Creek on the Caribou-Targhee National Forest, ID, where the placement of large spreads water and sediment across the floodplain and improves fish habitat, reconnects the channel and floodplain to groundwater, and improves local wildfire resistance. Undersized culverts were also replaced to restore natural flows of water and sediment within the valley. Courtesy photo by Trout Unlimited.

How Watershed Restoration Can Benefit Fire Outcomes

Fire is an important natural process that can also be used as a tool for many purposes. Fuel on the landscape may drive fire behavior, so land managers and fire experts attempt to track and manipulate fuel loads to assess fire risk, control fire behavior, and restore ecosystems. Thus, understanding the relationships between fire, vegetation dynamics, fuel loads, and the presence of wetlands and water is critical to the successful management and promotion of "good fire" as well as the restoration and maintenance of many healthy ecosystems.

Wet fuel break creation

A fuel break is a barrier to slow or stop the spread of wildfire. Fuel breaks can be created using fire-resistant vegetation or non-flammable materials, or by exposing bare ground to prevent the spread of fire. Process-based restoration (fig. 8) increases surface water, soil moisture, and green vegetation, creating a wet fuel break that may withstand wildfires and serve as a control line for prescribed burning.

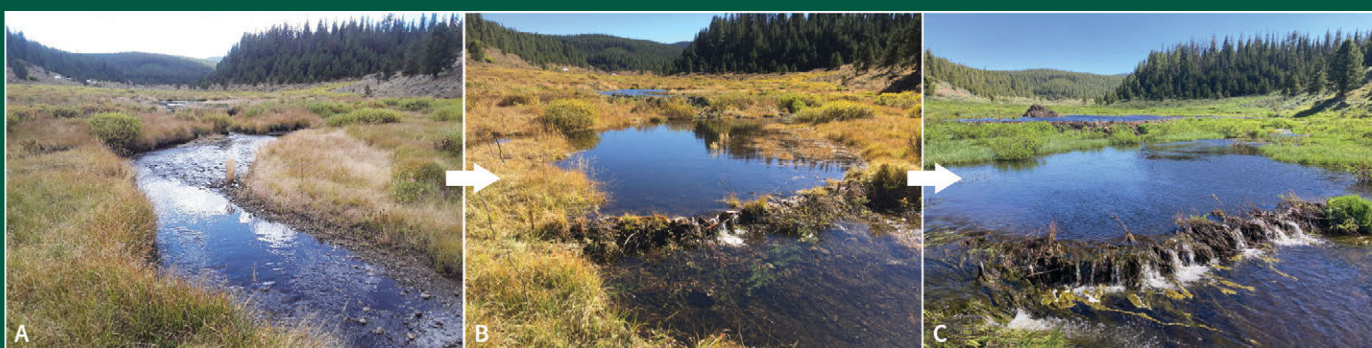


Figure 8—Process-based restoration (PBR) application increases surface water, potentially creating wet fuel breaks that increase wildfire resilience. Before restoration of Trail Creek (A), the stream has dry vegetation and a disconnected floodplain. Beaver dam analogs (BDAs) were then installed (B), after which beavers reestablished at the site and built upon the BDAs (C), actively maintaining the wetted floodplain. Grand Mesa, Uncompahgre, and Gunnison National Forests, CO in 2022. Courtesy photo by Mark Beardsley, EcoMetrics.

Process-based restoration contributes to wildfire hazard risk reduction goals and benefits fire suppression:

Research has shown that intact wetland complexes and streams connected to their floodplains with healthy wetlands and more fire-resistant vegetation can persist during wildfires (Pettit and Naiman 2007, Fairfax et al. 2024). These zones can serve as fire refugia, including refugia for wildlife and seed sources (fig. 3), thus providing risk reduction for these values and wet fuel breaks that can alter fire behavior and capture ash and sediment post-fire.

When process-based restoration (PBR) techniques are applied in valleys, meadows, and stream zones to raise groundwater tables, saturate soils, and expand wetlands and standing water, the creation of wet fuel breaks adjacent to potential operational delineations (POD) boundaries can be more durable and robust. When applied to prescribed burning treatments, the change in vegetation type and presence of surface water allows for a wet control line. In both cases, fire behavior is modified to reduce risk in the surrounding areas.

PODs:

Potential operational delineations (PODs) are fire management and planning units defined by potential control features that can be leveraged for fire containment during a wildfire or prescribed fire. Typical POD boundaries are a combination of roads, rivers, major ridges, barren areas, waterbodies, major fuel changes, or other locations that facilitate control. By creating wet fuel breaks through watershed restoration, PODs can be expanded and hardened.

Use of non-merchantable, low-value, and waste wood as the foundation for watershed restoration projects can:

- Cost-effectively utilize wood locally from active management projects (fig. 9).
- Reduce prescribed burning smoke impacts by putting wood in the stream, meadow, and valley floor to increase soil moisture, groundwater levels, and surface water.
- Reduce transportation costs of hazardous fuel materials.
- Contribute to acres treated for hazardous fuels reduction targets (which can be accounted for in the Forest Service Activity Tracking System [FACTS] database) through expansion of wetlands and wetted valleys across valley bottoms and stream corridors (fig. 8).

Figure 9—The Fish Creek Wildfire Mitigation project on the Arapaho and Roosevelt National Forests provided wood for the South Fork Cache La Poudre restoration project led by the Coalition for the Poudre River Watershed following the Cameron Peak fire in Colorado. Benefits include productive use of timber and slash as well as reduced costs to transport timber to distant mills or purchase wood material. Courtesy photo by Larimer Conservation District.

Watershed restoration may target vegetation composition along rivers and streams. For example, as rivers and streams become incised and valley bottoms dry out, conifers tend to encroach on meadows and stream corridors, where they become highly flammable vegetation. Conifer thinning may encourage growth of riparian vegetation and can often be part of restoration plans, not just to create a patchwork of less flammable vegetation to modify fire behavior and support a diversity of wildlife habitat types, but also to serve as local source material (fig. 9) for installing process-based restoration techniques to rewet valleys, meadows, and stream corridors (fig. 10).

Wood and slash from fuels treatments can be strategically placed in low-gradient stream channels and floodplains so that water is slowed and stored in the valley bottom. Using whole trees and slash material generated from forest health vegetation treatments in some types of floodplain restoration may raise the water table, expand riparian vegetation, and ultimately create wet fuel breaks. Watershed restoration can thereby reduce the need for fire-suppression activities in adjacent upland vegetation and during prescribed fire treatments when restored valley floors serve as wet control lines that the fire can naturally burn down to, rather than building a man-made fuel break (fig. 10). The coupling of watershed tactics and POD boundaries strengthens the overall effectiveness of the POD and reduces costs associated with maintaining PODs over time.

Figure 10—Floodplain restoration project on the South Fork McKenzie River, Willamette National Forest, OR, 5 years post wildfire in June 2025. The expansive wetted area reduced fire intensity, provided refuge for wildlife during the fire and supported faster ecological recovery. Courtesy photo by Kate Meyer.

Process-based restoration can be used post fire and in disaster recovery

- Increased water retention and sediment/ash capture through low-tech methods can easily be integrated into Burned Area Rehabilitation (BAR) plans.
- Use of unburned, low-value wood can reduce future fire risk while helping promote wetland expansion and natural wetland revegetation.
- Salvage wood can be used productively to build PBR structures.

Beaver wetlands, constructed beaver dams, and other low-tech restoration approaches can help capture sediment, enhancing watershed processes and benefitting downstream communities after fire (Dunn et al. 2024, Shahverdian et al. 2018). When applied after a disaster, these process-based restoration techniques help reduce sediment and ash transport downstream that can benefit water quality and water supplies. By utilizing salvage wood onsite, these cost-effective watershed tactics can be integrated into the BAR program and reduce the need for additional stabilization measures and thereby lower overall treatment costs. Research has shown that applying watershed restoration practices after fires occur improves water quality, and when applied in municipal watersheds, drinking water treatment costs are significantly reduced (Fairfax and Whittle 2020, Fairfax et al. 2024).

Integrating Watershed Restoration to Support Fire-Suppression Efforts

Considerations for strategic inclusion of water features into fuels treatments and potential operational delineations

Potential operational delineation (POD) boundaries provide a logical basis for integrating natural features with fuel treatments and wetland restoration. Restoring wetlands, valleys, and forest health at strategic locations can strengthen and improve POD boundaries (fig. 11).

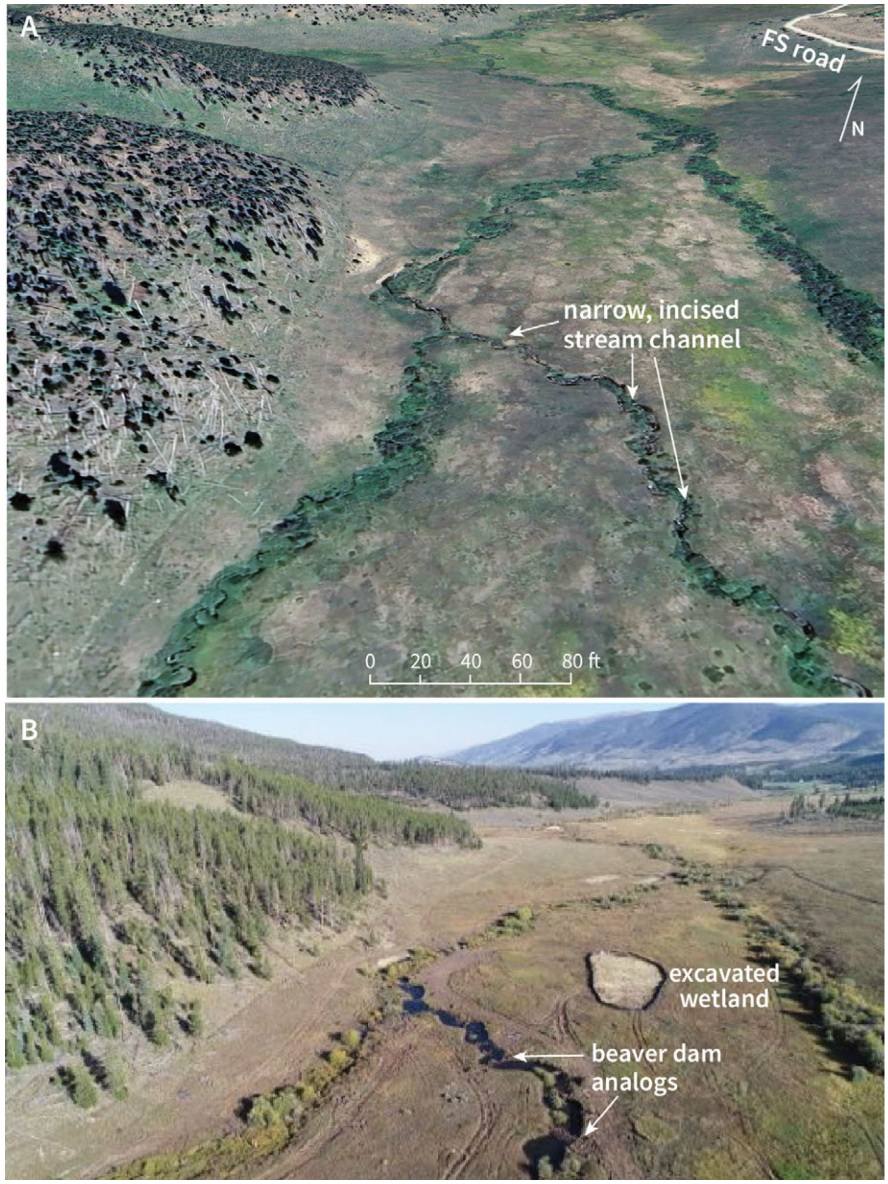


Figure 11—Soda Creek on the White River National Forest, CO before (A) and in 2024 (B), 1 month after the installation of 150 beaver dam analogs and an excavated wetland that hardened an existing POD boundary along the forest road. This project reconnected the floodplain to the water table and restored 42 acres of historic wetlands in the valley. This project involved the National Forest Foundation and the Coca-Cola Foundation through the Wetland In-Lieu Fee Program. Courtesy photos by (A) Google Earth and (B) Adde Sharpe, National Forest Foundation.

Planning options for potential operational delineations that incorporate watershed restoration can:

- Use analytical tools to stratify landscapes based on hydrology, watershed function, suppression difficulty, likelihood of control, operational hazard, fire transmission, and fire impacts.
- Identify opportunities to raise the water table, increase wet meadows and valleys, and protect water sources that align with treatments for wildfire risk reduction. Both are more successful when coordinated and implemented across boundaries to use the best features, such as roads, wetland corridors, and water features, regardless of jurisdiction, and build a shared understanding of realistic opportunities for prescribed fire implementation and controlling large wildfires.

Potential operational delineation boundaries and process-based restoration

Considering the pre-settlement conditions and the current demands on a given watershed will help identify where restoration or enhancement using PBR would assist in fireshed function. The PODs framework is about much more than containment along potential control lines. PODs can help delineate where changes are likely to occur in fire intensity and severity, and in consequences for ecosystems.

PBR can complement the extensive networks of fuel breaks, fuels treatments, and POD boundaries. Water features often disrupt or change fire behavior. Efforts to improve, expand, and enhance these features at a landscape scale can reduce the suppression difficulty index, reduce large-scale, uncharacteristic fire effects, and reduce large-scale, post-fire disruptions. The intent of including PBR is to interrupt landscape fire behavior, and to provide strategic advantages for suppression efforts and prescribed fire opportunities.

Restoring floodplains, reducing conifer encroachment, and encouraging growth of riparian species can help to connect fuel breaks, fuels treatments, and other features critical to suppression efforts, while also enhancing post-fire recovery and ecosystem resilience. PBR that expands beyond administrative boundaries, incorporate traditional ecological knowledge, and align with the larger landscape is more likely to provide for the most effective returns (Pope and Cummings 2023).

Practitioner Tips

- Include a full interdisciplinary team when performing a wildfire risk assessment of a given landscape to identify the most effective placement and prioritization of PODs.
- Include watershed restoration needs identified through proper field assessments that address the sources of degradation in environmental analyses. Use the Watershed Condition Framework to help guide restoration actions.
- Use low-cost, low-tech PBR techniques such as conifer release in meadows, beaver dam analogs, large wood additions, and planned burns to improve POD effectiveness.
- Identify in fire management response plans the key watershed features that can be used as control points during wildfire events (fig. 12).

Figure 12—Water doesn't burn. A natural beaver complex survives the Cameron Peak fire in 2020 on the Arapaho and Roosevelt National Forests, CO. Courtesy photo by Emily Fairfax, University of Minnesota.

Watershed Restoration Tactics: From Low-Tech to High-Tech Applications

A variety of methods used in watershed restoration can align with hazardous fuels and wildfire programs. Using free geospatial models, like the Beaver Restoration Assessment Tool (BRAT) and the Riparian Condition Assessment Tool (RCAT), specific stream locations adjacent to PODs or hazardous fuels treatment units can be evaluated for watershed restoration tactics that can bolster fuels treatments. Field validation of geospatial tools and site-specific assessments that identify the source of problems are needed to lay the foundation for properly addressing long-term restoration objectives.

Specific Applications and Tools

Low-tech approaches encourage natural processes, such as emulating beaver dams and translocating or encouraging colonization by beaver to expand and maintain wetlands, open water, and PODS.

- Low-tech process-based restoration of riverscapes - Design Manual
- Zeedyk structures
- Beaver Restoration Toolbox
- Beaver Restoration Guidebook
- Beavers in New Mexico: Coexistence and Relocation

Low-tech approaches use manual labor, limited equipment, and local materials. Hand crews strategically place locally sourced slash and waste wood into meadows, streams, and floodplains to meet restoration goals (Maestas et al. 2018). The slash and wood may be secured using posts driven into the stream bed with a gas-powered post pounder or mini excavator. These structures are called post-assisted log structures (PALS). An alternate method involves sawyers with chainsaws directionally felling trees into the stream channel or floodplain. Riparian plantings and livestock fencing are other important low-tech strategies to promote the establishment of and enhance streamside vegetation (Wheaton et al. 2019, Shahverdian et al. 2019b, Cummings et al. 2023, Dittbrenner et al. 2022).

Low-tech methods also include beaver mimicry opportunities such as building beaver dam analogs (BDAs), which often use post-assisted structures that are then woven with willow cuttings and slash material to mimic a natural beaver dam (Davee et al. 2019). Ideally, BDA structures are installed adjacent to watersheds with existing beaver populations, so that the riparian habitat and food sources are expanded, encouraging beaver migration. Ultimately, this approach seeks to encourage nearby beavers to build upon the man-made structures to further expand and maintain the wetland complex. By creating beaver habitat using BDAs, there is also an opportunity to translocate beavers from other locations where pond building may conflict with infrastructure needs. Translocating “nuisance” beavers to a more natural setting allows them to thrive and build wetland complexes that will serve as wet fuel breaks—a win for both beavers and humans.

Increasing wetted areas through low-tech methods is cost effective and often employs volunteers and youth corps to build the instream structures (fig. 13). Fire and fuels seasonal crews are also uniquely suited to support low-tech structure construction with their chain saw skills and by stockpiling woody material, making it a highly cost-effective way to achieve objectives. By applying these methods adjacent to PODs, boundaries can be widened and strengthened by connecting PODs to open-water sources.

Figure 13—Trout Unlimited's Northeast Oregon Hand Crew Initiative builds beaver dam analogs on the Sheep Creek Stewardship Project, a 5-mile-long meadow restoration project in the Upper Grande Ronde River on the Wallowa Whitman National Forest, OR. This partnership between Trout Unlimited, the Forest Service, and the Bureau of Land Management uses wood sourced from a local forest-thinning project for wildfire resilience. Courtesy photo by Levi Old, Trout Unlimited.

Medium-tech approaches address infrastructure and add large wood materials with heavy equipment or hand tools to restore water flows, increase complexity of streams, rivers, and floodplains, and rewet stream and river corridors.

- Managing for Large Wood and Beavers in Stream Corridors (Wohl et al. 2019)
- Working with Wood in Rivers in the Western United States (Ockelford et al. 2024)

The presence of wood and downed trees within a stream corridor and floodplain has long been recognized as serving an important role for these areas physically and ecologically and restoring large wood materials is increasingly used to reconnect to water tables (fig. 4c). Medium-tech approaches use a mix of heavy equipment and manual labor to achieve restoration objectives. Heavy equipment can be used to place large wood in streams and on valley floors to increase habitat complexity and rewet floodplain corridors (Wohl et al. 2016, Wohl 2017, Yochum and Reynolds 2020, Lininger et al. 2021, Nislow et al. 2024).

Medium-tech approaches are best for fixing problem infrastructure, like replacing culverts, and dealing with legacy impacts, such as stream straightening or ditching, that have altered hydrology, created drier sites, degraded former wetlands, streams, rivers, and floodplains, and promoted expansion of hazardous fuels. With an extensive road system and legacy of undersized culverts that disrupt the flow of streams and groundwater, many meadows and valleys across the National Forest System now contain drier meadows with downcut, straightened streams (fig. 2a).

These approaches often include reshaping banks, adding large wood and rock to promote the stream's interaction with the floodplain, increase sediment deposition, and reconnect to groundwater (fig. 14). "Plug and pond" is another technique that addresses historic ditching and channelization of streams and gives the stream access to its floodplain (Nash et al. 2019).

Figure 14—Large wood stream and floodplain habitat restoration on Panther Creek in the Salmon-Challis National Forest, ID, implemented in 2018 by Shoshone-Bannock Tribes, along with culvert replacements elsewhere in the watershed. Forest Service photo.

High-tech approaches, including stage 0 floodplain and valley-bottom reset methods, use large volumes of wood and remove legacy structures such as levees or dikes to expand wetlands and stream and river channels to return water to entire valley bottoms. "Stage 0 restoration," also known as "Stage Zero," is a river restoration approach that aims to reestablish natural processes in a valley by maximizing connectivity between the river and floodplain. It focuses on restoring the river to a condition where it can dynamically interact with its floodplain, allowing for natural sediment deposition and channel changes (Cluer and Thorne 2014, Powers et al. 2019, Flitcroft et al. 2022, Scott 2024).

Although valley-bottom reset projects (fig. 15) require heavy machinery and large volumes of local wood sources, they typically cost from $3,000 to $15,000 per acre, making them significantly less expensive than traditional stream and river-channel restoration projects.

Figure 15—Hauling wood and moving sediment along the McKenzie River floodplain valley-bottom reset project at Finn Rock reach, Willamette National Forest, OR in 2022. Courtesy photo by McKenzie River Trust/Steve Smith Photography.

Solving Complex Watershed Problems: Why Innovative High-Tech Methods Are Needed

Historically, some of the best, most species-rich fish and wildlife habitat within watersheds could be found in low-gradient, wet valley bottoms. During wildland fires, these hydrated valleys may burn at different severities than the surrounding forest. For example, Kobziar and McBride (2006) found that riparian areas in the Plumas National Forest, CA, burned at lower severity, acting as potential fire breaks and refuges for wildlife. However, high-severity riparian burns compromise the ability of riparian areas to function as fire breaks or refuges (Pettit and Naiman 2007). During early homesteading, moist and flat valley bottoms were attractive for homes and cultivation. Ditches, berms, and roadbeds constructed to accommodate settlement often led to deeply downcut single-thread channels disconnected from the rest of the valley. The historic water table dropped, leading to a conversion from wet to dry vegetation that burns more rapidly and intensely during fires.

In situations where channels are deeply incised and leveed, low-tech restoration techniques such as beaver dam analogs or methods that add wood to channels are likely to be ineffective at recovering a wetted valley bottom. In these situations, innovative Forest Service professionals have developed and are using high-tech process-based restoration techniques to reverse negative effects and rehydrate whole valley bottoms (fig. 16). Designs for whole valley floors are developed using high-resolution LiDAR imagery combined with field-based reconnaissance. Restoration practitioners then use heavy equipment to scrape up legacy features such as levees or dikes in these altered valley bottoms, repurposing this material to directly fill downcut channels. The work includes careful planning for water diversion and rescue of aquatic organisms during construction. Large wood, often taken from upland fuels reduction and wildlife habitat treatment areas, is then spread throughout the valley bottom to create slow-moving water and allow for the establishment of wetlands. Similar to historic conditions, valleys restored in this manner may stay wetter through the dry summer (Munyon and Flitcroft 2025), increasing the possibility for resilience to fires and floods, protecting native species, and reducing downstream property damage (fig. 17).

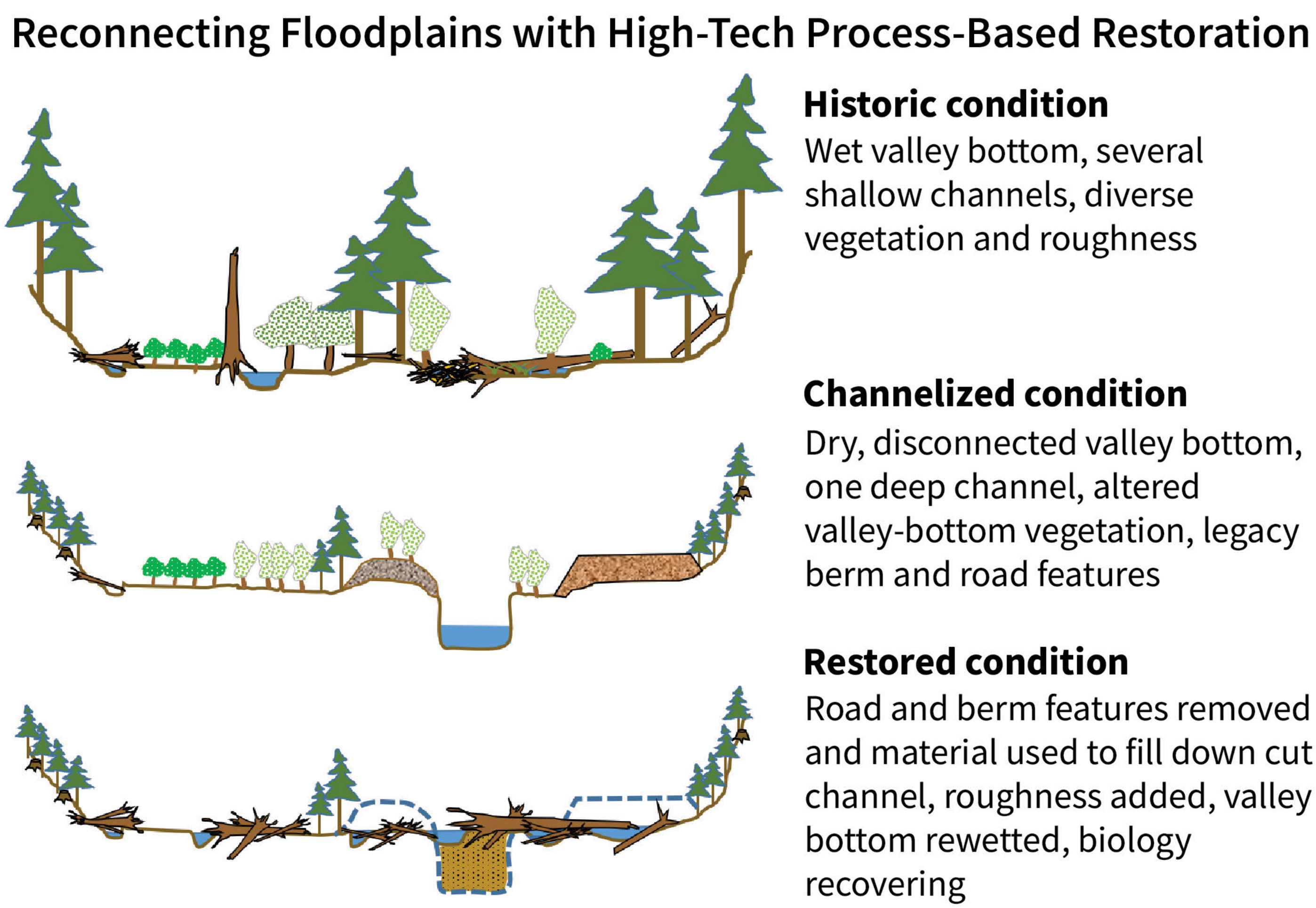


Figure 16—A cross section of a stream and floodplain shows a stream in its historic condition (top); its degraded, channelized condition (middle); and in its restored condition (bottom) after using a high-tech valley-bottom restoration technique as described. Courtesy image by Johan Hogervorst and Kate Meyer, Revive-Riverscapes, Inc.

Whychus Creek, Deschutes Land Trust Whychus Canyon Preserve

Figure 17—An example of high-tech process-based restoration at the Whychus Canyon Preserve near Sisters, OR, led by the Deschutes Land Trust and partners, including the Forest Service. Pre-restoration (A) shows the typical results of a channelized valley with water flowing in a deep ditch on the opposite side of the valley and introduced pasture grasses covering the valley proper. As-built condition after ditches have been filled with material generated from the valley regrade (B), wood has been spread throughout the valley and water has been turned onto the reconstructed surface. The same site is pictured 3 years (C) and 5 years (D) after restoration, where the water table is near the surface, wetland shrubs and plants are beginning to recover, and the residence time of water flowing through the valley has greatly increased. This valley now contains high-value habitat for native species, is resilient to severe storms, and can serve as defensible space during fires that occur in this high desert community. Courtesy image from Flitcroft et al. 2022.

Highlighted Research for More Information

- Expanding wet meadows support fuel breaks for increasing wildfire resistance (Pope and Cummings 2023).
- Floodplain re-wetting may reduce wildfire intensity and enhance biodiversity (Pugh et al. 2022).
- Restored floodplains enhance fish habitat and riparian vegetation and improve water quality (Flitcroft et al. 2022).
- Beaver wetland complexes provide refugia during wildland fires (Fairfax and Whittle 2020).
- POD boundaries benefit from collaboration (Weaving Spatial Strategy into Collaborative Engagement).
- Beavers contribute to wildfire resilience (Forest Service webpage on Firefighting Beavers).

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