DRAFT – PROPOSED ACTION

MONTANA/DAKOTAS LOW-TECH, PROCESS-BASED RIVERSCAPE RESTORATION

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U.S. Department of the Interior

Bureau of Land Management

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Proposed Action and Background

The Bureau of Land Management Montana/Dakotas State Office (BLM) is proposing to utilize a suite of relatively simple, cost effective restoration methods (commonly referred to as "low-tech, process-based restoration") to improve the condition of riverscapes[1]on BLM managed lands in Montana, North Dakota, and South Dakota. While previous land health assessments indicate that current management is typically maintaining or improving conditions, resource issues associated with historic management practices persist throughout the region, and opportunities to restore these systems are routinely identified. The Proposed Action would restore riverscapes, thereby helping the BLM to achieve related goals and objectives that depend on healthy riparian-wetland and aquatic habitat, such as: water quantity, water quality, habitat for terrestrial and aquatic species, recreation, wildland fire mitigation, floodwater retention, and drought resilience. It prioritizes low gradient, wadable streams that require floodplains and riparian vegetation to function properly but lack the amount and type of structural elements[2] needed to maintain their health and/or ensure acceptable progress toward the achievement of land health standards and associated resource management plan (RMP) objectives.

BLM field managers would prioritize project locations and corresponding restoration actions as resources and workloads allow. Actions are divided into four categories, each of which would be used to address separate, but inter-related issues. They include:

- **Addition of structural elements** (i.e., artificial beaver dams and wood accumulations) to "kickstart" hydraulic, hydrologic, and geomorphic processes that historically maintained the health of these systems.
- **Vegetation management** actions that would allow riverscapes to grow and consume the woody material necessary for the restored processes to become self-sustaining.
- **Headcut control** techniques to prevent erosional features from migrating into and degrading otherwise healthy riparian-wetland habitat.
- **Beaver mitigation** actions to mitigate potential flooding or undesirable tree removal associated with beaver dam building activity.

This programmatic environmental assessment (PEA) identifies the proposed restoration techniques, establishes the scope and sideboards for their future use, analyzes the potential environmental consequences of the typical projects programmatically, and compares those outcomes to a No Action Alternative. Due to the programmatic nature of the Proposed Action, the PEA does not include site specific projects.

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[1] Riverscape

noun

1. Streams and riverine landscapes, or "riverscapes" are composed of connected floodplain and channel habitats that together make up the valley bottom. See Chapter 1
2. A term used to indicate a holistic perspective of the broad scale patterns and processes associated with fluvial systems. From: (Ward, 1998)
3. Defined spatially by the extents of a drainage network and laterally by the valley bottom margins.

synonym: riverine landscape

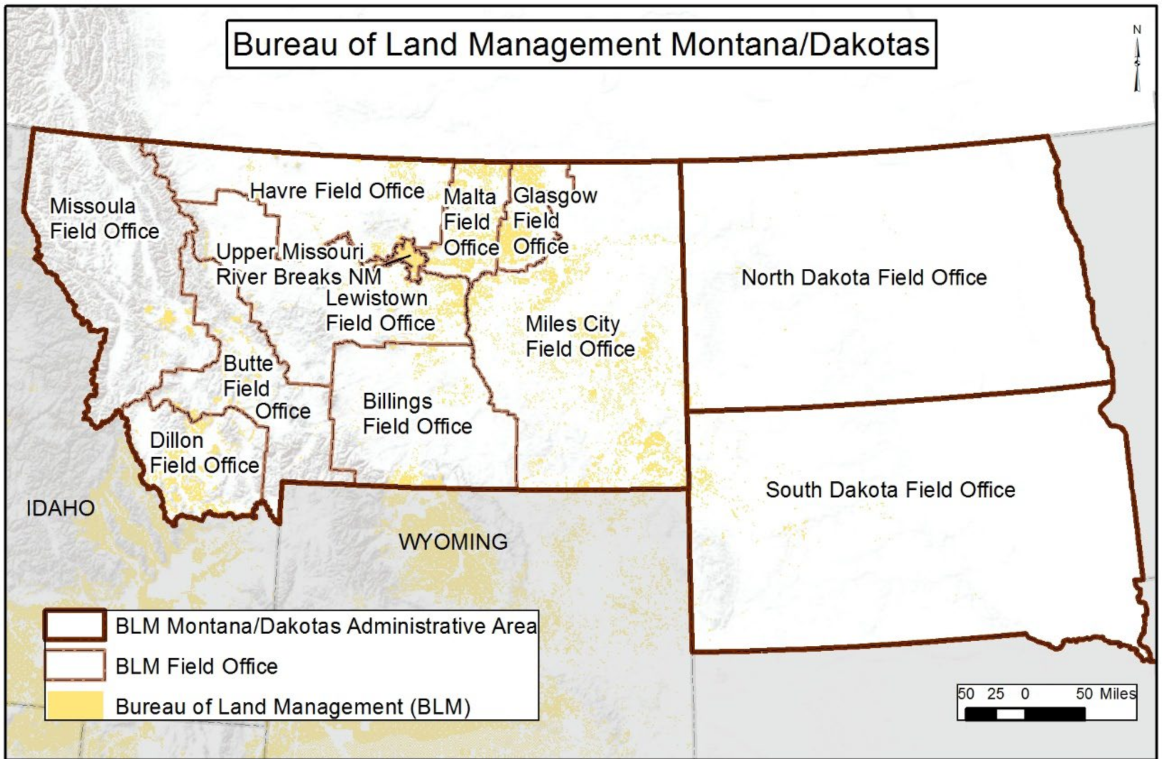
[2] Structural elements

noun

1. Discrete objects that directly influence hydraulics (e.g., wood, boulders, beaver dams, bedrock, vegetation).

From: Wheaton et al. (2015a)

Figure 1: BLM Lands Administered by Montana/Dakotas Field Offices.



Purpose and Need

The purpose and need for action is to improve the health of as many miles of riverscape as possible or necessary to achieve the corresponding goals and objectives for:

- water quality
- water availability
- riparian-wetland health
- habitat for aquatic and terrestrial species
- recreation, fishing, and hunting opportunities
- floodwater retention
- ecosystem resilience to drought and flood
- wildland fire management

Given the scope of degradation from historical practices, land managers need restoration techniques that are sufficiently simple, cost-efficient, low risk, and effective to be scaled up to the scope of the issues. This includes the use of techniques that restore the biophysical processes that historically sustained the attributes and resource values of these areas. These projects would help the bureau to meet or exceed the associated goals and objectives in our resource management plans (RMPs), the Montana/Dakotas Standards and Guidelines for Rangeland Health, as well as the following Fundamentals of Rangeland Health (43 CFR 4180.1):

a) Watersheds are in, or are making significant progress toward, properly functioning physical condition, including their upland, riparian-wetland, and aquatic components; soil and plant conditions support infiltration, soil moisture storage, and the release of water that are in balance with climate and landform and maintain or improve water quality, water quantity, and timing and duration of flow.

b) Ecological processes, including the hydrologic cycle, nutrient cycle, and energy flow, are maintained, or there is significant progress toward their attainment, in order to support healthy biotic populations and communities.

c) Water quality complies with State water quality standards and achieves, or is making significant progress toward achieving, established BLM management objectives such as meeting wildlife needs.

d) Habitats are, or are making significant progress toward being, restored or maintained for Federal threatened and endangered species, Federal proposed or candidate threatened and endangered species, and other special status species.

Potential Resource Issues Identified for Analysis

The following resource issues have been identified for analysis.

- Issue 1: How would implementation of the alternatives impact riverscape processes and attributes?
- Issue 2: How would implementation of the alternatives affect aquatic and terrestrial wildlife that depend on riverscapes to meet their lifecycle needs (including sensitive status, candidate, threatened, or endangered species)?
- Issue 3: How would implementation of the alternatives affect water quality and water quantity?
- Issue 4: How would implementation of the alternatives affect vegetation within the valley bottoms?

Details of Proposed Action

The BLM would utilize a suite of relatively simple, cost effective techniques to restore riverscapes that have been adversely impacted by current and/or historical (i.e., removal of beaver dams and woody debris) practices in Montana, North Dakota, and South Dakota (Table 1). These techniques were selected because they: (i) address some of the most common issues (consequences of structural starvation[3]) affecting riverscape health on BLM administered lands, (ii) minimize or avoid potential adverse impacts from restoration on other resources within the historical valley bottoms[4], (iii) are sufficiently effective and cost-efficient to be applied at the scale of the underlying issues, and (iv) often need to be implemented together to achieve project-level objectives. Unlike many traditional restoration practices that physically reconstruct the form and function of the system, the restoration techniques included in the Proposed Action would be used to initiate, maintain, and promote natural processes that produce the desired attributes and functions over time (i.e., help the water do the work).

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[3] Structural starvation
noun
Refers to the loss or decline of biophysical functions and corresponding attributes to any riverscape or system that has a deficiency of structural elements; due to direct removal and/or disruption of processes that maintain structural inputs into the riverscape.

[4] Valley bottom
noun
Low-lying area in a valley containing the stream channel and contemporary floodplain. The valley bottom represents the current maximum possible extent of channel movement and riparian areas.
Area comprised by the active channel and contemporary floodplain. From: Wheaton et al. (2015b)

Table 1: Summary of the goal, objectives, actions, and techniques associated with the Proposed Action.

Goal	Objective	Action	Techniques
Riverscapes - restore or sustain fluvial processes that historically maintained the health of low gradient, wadeable streams	Restore the composition and distribution of structural elements that historically altered local hydraulics to produce diverse and complex physical habitat, as well as healthy, resilient, and self-sustaining riverscapes.	**Beaver Dam Analog (BDA)**	• Postless BDA • Post-Assisted BDA • Post-Line Wicker Weave
		Post Assisted Log Structure (PALS)	• Bank-Attached PALS • Mid-Channel PALS • Channel-Spanning PALS
	Maintain the health of riparian-wetland systems that are at risk of incision from headcut advancement. Note: Used where we lack control over the root causes for incision OR where the processes have since been restored, but the geomorphic instability persists	**Headcut Control**	• Zuni Bowl • Rock Run Down
	Restore or maintain the composition and distribution of woody vegetation necessary to sustain the processes of wood accumulation and beaver dam building activity.	**Vegetation Management**	• Project Protection Fencing • Native Shrub/Tree Plantings • Targeted Removal of Disclimax Conifer & Invasive Plants
	Mitigate flooding impacts or damage from undesirable harvest of trees, while allowing the beaver to remain in place.	**Beaver Mitigation Strategies**	• Breach Dam • Install Fish Friendly Pond Leveler to Control Stage • Install Culvert Barrier to Prevent Culvert Clogging • Install Fencing Around Important Trees • Use Abrasive Paint to Protect Important Trees

Action 1 - Beaver Dam Analogs and Post Assisted Log Structures

Beaver dam analogues (BDAs) and post-assisted log structures (PALS) are artificial structures that mimic the functions of their natural counterparts. They are permeable, temporary, and typically built by hand using natural materials to "kick start" processes that historically maintained the health and ecosystem services of many low gradient, wadable streams within the region. The BLM would install PALS to mimic and promote the processes of wood accumulation and BDAs to mimic the effects of beaver dams.

These structures would be installed in complexes (typically 2-15 structures) to mitigate a range of specific impairments associated with the systematic removal of vegetation, beaver dams, and/or the supply of woody debris, as well as anthropogenic impacts to the supply of water and sediment. For example, the BLM would install these structures to reconnect streams with their floodplains, capture sediment, reduce stream power, enhance the storage of water in the streambed/banks, and raise water tables that have declined due to channel incision. They would also be used to accelerate stream evolution processes and the development of structurally forced habitat features that historically formed around the interaction of water and in-channel features like woody debris and beaver dams. Like the physical characteristics of natural beaver dams and wood accumulations, the BLM would adapt the design of BDAs and PALS to influence specific hydraulic, hydrologic and geomorphic processes.

For an overview of the typical design and application of the PALS and BDA subtypes associated with the Proposed Action, refer to the *Low-Tech Process-Based Restoration of Riverscapes* *Pocket Field Guide* *(pages 27 – 48), Utah State University Restoration Consortium, 2019.* In many cases, local stream conditions, often at the sub-reach[5] scale (10_1 -10_2 m) will lend themselves to a particular structure type. The BLM would select Individual structures to perform specific functions at the sub-reach scale but design them to work synergistically with other structures in the complex to achieve reach[6] and project-scale objectives.

Since these techniques mimic natural beaver dams and wood accumulations, they would typically be used where these features historically existed, such as partially confined or unconfined valley settings. These settings are characterized by medium to low hillslope connectivity and the potential for medium to high floodplain development. They would generally not be used in highly confined or high gradient streams. Similarly, they would not typically be used in rivers with annual peak flows that exceed the capacity of the typical beaver dam to persist or where human development limits our ability to give the stream enough space to adjust to the treatment (i.e., where potential threats to infrastructure would be high and not easily avoidable). Prior to implementing a project, the BLM would evaluate the risk and potential for conflict (LTPBR Design Manual, pages 36 - 38).

Although it may be possible to achieve project goals with one treatment, the BLM would implement multiple successive treatments within a single restoration complex when the desired geomorphic adjustments exceed the hydraulic influence of the original structures. When designing each project, the BLM would estimate the number of treatments by evaluating the likely hydraulic zone of influence for each treatment, relative to the width of the available valley bottom. For example, some projects may require three or four high flow events to shift the channel laterally and rework the valley bottom topography or inset floodplain. After each geomorphic shift, the BLM would add structures and/or woody debris to correspondingly expand the hydraulic zone of influence. This iterative process would continue until the project objectives are met or the BLM modifies the objectives in response to new information.

[5] Sub-Reach
noun
A length of stream (10 – 100 m) within a reach that is characterized by unique hydraulic, hydrologic and/or geomorphic attributes.

[6] Reach (segment)
noun
Section of stream having relatively uniform physical attributes, such as slope, sinuosity, bedforms, and dominant bed material.

Type and Source of Materials for BDAs and PALS

- As with natural beaver dams and wood accumulations, the BLM would use a diversity of ingredients. Natural Materials that would plausibly be found in or near the treatment area and can be sustainably sourced on-site or located elsewhere would be prioritized for use. This could include wood removed as part of conifer or fuels reduction projects, as well as from other watersheds where the source materials are more abundant and/or accessible. However, if building structures to support beaver and desirable woody species (i.e., those that can be used by beaver as a food source and building material) are in short supply, the BLM would use less desirable species (e.g., conifers), more abundant species, and/or cuttings from locations where such concerns do not exist (i.e., artificial or abandoned reservoirs, nearby riverscapes where cuttings can be sustainably sourced, upland forests, etc.). Where posts are used to provide temporary stability by pinning structure material in place, only untreated posts would be installed. Typical ingredients include:

PAL Ingredients

- **Branches, limbs, small logs, brushy fill:** generally, < 6-15' long and 6-16" diameter (i.e., can be carried by 1-3 people and constructed by crew of 2-4)
- **Untreated wooden posts:** 6 - 8' long and 2-4" diameter; can sometimes be built on site with small diameter trees and/or branches but may not be practical for building hundreds of structures. Consequently, pre-cut posts may also be purchased and installed.

BDA Ingredients

- **Woody fill material:** branches, limbs, small logs, brushy fill
- **Finer fill material (organic)**: e.g., turf mats, roots, leaves, conifer needles, grass, etc.
- **Finer fill material (inorganic)**: e.g., fine bed sediment, silt, clay, soil, gravel
- Optional if available onsite: key pieces: logs, cobbles, or small boulders
- Optional: untreated wooden posts if post-assisted

Adaptive Management (BDAs and PALs)

- The BLM would utilize an iterative, adaptive management approach to maintain alignment between the actions and corresponding project objectives (LTPBR Design Manual, pages 27 – 28 and Appendix G). Although it may be possible to achieve project goals with one treatment, multiple treatments would be required for other projects. For example, riverscape restoration projects would incrementally improve form and function by accelerating stream evolution during successive floods. Depending on the hydraulic zone of influence of a treatment (defined in Chapter 5: Shahverdian et al., 2019b), relative to the valley bottom width, it might take several high flow events to shift the channel laterally and rework the floodplain topography. After each shift, the BLM may add structural elements to expand the lateral zone of influence in accordance with project objectives. With the collection and analysis of assessment data and a re-examination of the original problem, the BLM would update the elements of the adaptive management framework to reflect further understanding of the treatment response and behavior of the riparian-wetland system. The BLM would continue using this information to guide project decisions until the objectives are met.

Action 2 - Headcut Control

Headcuts are highly mobile erosional features characterized by dramatic slope breaks (like a small waterfall) with the potential to migrate upstream during successive flow events. Where present, they diminish stream-floodplain connections and impair riverscape health. They are often symptoms of an imbalance between the driving and resisting forces that historically supported the maintenance of a dynamically stable dimension, pattern, and profile within the riverscape. The BLM would stabilize headcuts with hand-built structures to halt the formation of larger, more destructive and difficult to repair erosional features, while maintaining the health of riverscape segments located up-gradient.

However, unlike other techniques associated with the Proposed Action, which target the root cause of the issues and would be applied at the scale that is required to restore the biophysical processes responsible for riverscape health, headcut control techniques would be applied at the scale of the symptoms and used to sustain the processes of healthy stream segments located above the erosional features.

These methods would be used to compliment processes-based restoration and typically reserved for locations where: (a) the BLM lacks sufficient control of the watershed processes that are causing the vertical instability (i.e., limited ownership within a large watershed), but the resource values at risk from incision warrant the cost of mitigation; or (b) the issues that originally caused the erosional feature(s) to develop have been addressed. Of these locations, the BLM would typically reserve the use of headcut control techniques to ensure the success of other restoration efforts located upstream, to protect stream segments that contain high resource values (i.e., habitat for sensitive status, candidate, threatened, or endangered species), and/or where the headcuts are still small and easily stabilized. Although the BLM would typically utilize Zuni Bowls and Rock Run Downs (described below) to control headcuts, numerous similar methods exist. The selected techniques would vary according to site-specific attributes, such as headcut size, substrate characteristics, availability of natural building materials, and flow regime. The method that best aligns with the physical attributes and objectives of the project would be selected. However, all would would be constructed with natural materials and have the purpose of stopping the advancement of a headcut by stepping the water down into the channel to minimize the erosive power.

Zuni Bowl - The Zuni bowl is a rock-lined, step fall with plunge pools used to dissipate the energy of falling water and stabilize a headcut. These structures stabilize the progression of a headcut by both stepping down the water in a way that minimizes the erosive and scour potential of falling water, and by protecting and maintaining moisture to sustain vegetation at the pour-over. The BLM would install Zuni Bowls to treat in-channel headcuts. For further information, including construction details for the typical installation, see *Range Technical Note No. 40, U.S. Department of Agriculture, Colorado Natural Resource Conservation Service, May 2018; pages 11-12*.

Key Design Features:

- Top rocks of the headcut pour-over would match the existing elevation so that water freely flows over the structure. Trim the headcut back to reduce slope angle and expose live roots.
- When building the back wall up the face of the headcut, the BLM would offset the layers of rock for stability and lean them back to form a sloping wall around the headcut (to retain soil moisture and dissipate energy of the falling water).
- Armor the plunge pool with tightly-placed rock of sufficient size to avoid scouring.
- Construct a one rock dam (ORD) or BDA downstream of the Zuni bowl to create another pool. Place the upstream edge of the ORD or BDA four to six times the height of the headcut, away from the bottom of the Zuni bowl.

Rock Run Down - The BLM would install rock rundown structures to stabilize low energy headcuts, often in small catchments and off-channel return sites. This would typically involve laying back the headcut by shaping it to a stable angle (~3:1 slope), and then armoring the slope with rock. For further information, including construction details for the typical installation, see *Range Technical Note No. 40, U.S. Department of Agriculture, Colorado Natural Resource Conservation Service, May 2018; page 13 and Appendix B*.

Key Design Features:

- Emplace rocks at the pour-over lip are at the same elevation of the headcut, so that water flows freely over it. Trim the headcut back until live plant material and roots are exposed.
- The center of the rundown should be the lowest elevation, so water runs down the middle and not around the structure.
- Install rocks tightly to reduce gaps between rocks.

Action 3 - Vegetation Management

Vegetation management actions would be implemented where necessary to achieve restoration objectives, such as those associated with Restoration Principal 10 (self-sustaining systems are the solution). Although BDAs and PALS would be used to mimic and promote the processes of wood accumulation and beaver dam activity, vegetation management actions would be implemented where necessary to ensure that sufficient vegetation re-occupies the historic riparian zone and expands across the newly created niches, so that they can eventually sustain those processes without further structural additions (i.e., riverscape is healthy enough to grow its own food). Consequently, the BLM would: (1) install small fences around the riparian zone where woody browse by livestock, beaver, and/or other wildlife is likely to prevent sufficient regrowth of woody plant communities; (2) plant trees/shrubs where suitable niches exist, but historical impacts have depleted the sources for recovery; and (3) reduce the composition of disclimax and/or invasive plants that are outcompeting the native species needed to sustain riverscape recovery.

Project Protection Fences - In some stream reaches, woody species use by livestock, beaver, and/or other wildlife (i.e., deer, elk, moose) could exceed the capacity of the riparian plant communities to sustain adequate quantities for recovery and maintenance of the riverscape. Although the BLM would implement adaptive riparian grazing management practices when necessary to sustain the yield and productivity of these plant communities, the requisite changes may be impractical, insufficient, or outside the control of management (i.e. wildlife browse). In these locations, the BLM would install project protection fences to allow for the expansion and recovery of the amount and type of woody plant communities necessary to achieve self-sustaining restoration objectives. In such circumstances, the BLM would ensure that alternative water sources or access points exist to sustain authorized uses.

All project protection fences would be wildlife friendly, limited to the spatial extent necessary to achieve restoration objectives, and implemented where other alternatives to mitigate woody browse are likely to be ineffective or impractical. Field offices would generally follow BLM's Fencing Design Manual (H-1741, Appendix A). However, as noted in the handbook, it does not describe all fence designs found to be satisfactory in certain situations. Consequently, in accordance with that manual, BLM managers would select alternative designs when a site-specific review indicates that design adaptations are needed to better meet the project goals and objectives. This would include application of the designs described in *A Landowner's Guide to Wildlife Friendly Fences* (Montana Fish, Wildlife and Parks, 2012; Appendix B).

Where beaver historically occupied a stream and future dam building activity is desired, fences would typically extend at least 300 feet from the centerline of the stream, as this represents the distance that most beaver will travel when foraging for dam building material. However, the exact locations would depend on site specific objectives, characteristics of the landscape, and other practical considerations (i.e., access, topographic controls, existing fences/boundaries). Once sufficient woody vegetation exists to sustain the processes of wood accumulation and/or beaver dam activity, while also supporting utilization by wildlife and livestock, the BLM would re-evaluate the need for fencing and remove those that no longer align with the bureau's goals and objectives for that area.

Shrub & Tree Plantings - In some stream reaches, current and historical impacts have reduced or eliminated the types and amounts of woody riparian plant communities necessary for maintenance and recovery. If suitable niches currently exist for those species (i.e., in response to physical restoration within the stream channel), but their abundance and distribution have been so depleted that recovery where and when they are needed (i.e., to achieve restoration objectives) is unlikely, the BLM would plant them, using sustainable sources. This could include cuttings, bare root, or potted plants. Only native species that historically occupied the riverscape and are important to the processes of wood accumulation and/or dam building activity would be transplanted. To increase survival rates, planted trees and shrubs would typically be protected from browse by wildlife and livestock. Typical methods would include the use protective tubing, scents, or fencing. All materials would be removed once the objectives are met or the plants are sufficiently mature to no longer require further protection from browse.

Removal of Disclimax & Invasive Woody Plants - As described in Chapter 3, many riverscapes contain invasive and disclimax species that compete with native riparian trees/shrubs and correspondingly reduce their composition and abundance within the riverscape. These changes are especially pronounced where the natural fire regime has been severely altered due to fire suppression or invasive trees/shrubs have been able to replace their natural counterparts (i.e. where growing conditions have changed due to altered riverscape processes). Where this has occurred, the sources of woody material for beaver dam activity and wood accumulations have declined.

The BLM would stimulate the growth and expansion of native riparian trees and shrubs in these areas by reducing the composition of non-native and/or disclimax species. Depending on site-specific objectives, dead or inert woody material from vegetation treatments would be used to construct structures (BDAs and PALS), placed loosely within the streams to augment the supply of woody debris, left in-place (i.e. to support riverscape processes during flood events), or removed for disposal.

Action 4 - Beaver Mitigation Strategies

To mitigate flooding impacts or damage from undesirable tree removal by beaver dam building activity, the BLM would coordinate directly with state wildlife agencies and follow an adaptive management strategy. This would include the use of "Beaver Mitigation Strategies" (Table 8) where such techniques are suitable and necessary to mitigate potential flooding impacts or damage from undesirable harvest of trees, while allowing them to remain in place for ecological purposes. These options are summarized succinctly in *Tippie (2010)* in a non-technical manner*, The Beaver Restoration Guidebook (2017, pages 117 – 125)*, as well as Mike Callahan's Beaver Solutions website (http://www.beaversolutions.com/). Below we summarize each of the proposed beaver mitigation actions that BLM would utilize where site specific reviews indicate that they are viable or even likely to be more successful than lethal removal (note: BLM does not authorize the removal of beaver, which is the jurisdiction of state agencies).

Breach Dam - When a dam is no longer actively maintained by beaver, but still poses flooding problems, the BLM may partially breach (i.e., notching) the dam. The BLM would not breach dams where beaver are still actively maintaining the dams, as they can repair a breach in a matter of hours.

Install Fish-Friendly Pond Leveler to Control Stage
- In situations where beaver are active and causing flooding problems, fish-friendly pond levelers would be used to control pond stage heights and flooding, while allowing beaver to continue to build their dams and fish to pass through the structure. These installations would be checked regularly during spring runoff and/or periods of intense rainfall and maintained accordingly. The potential for each project to adversely affect fish passage would be evaluated prior to installation and reviewed in coordination with the associated state wildlife agency. BMPs to allow sufficient passage would be incorporated into every project. This would include the placement of the leveler pipe in a pool, with the outlet close to the face of the dam, as well as two-slot fishways (Snohomish Pond Leveler). This technique would not be used where adverse impacts to aquatic species would be expected and not easily mitigated. See https://www.beaversolutions.com/get-beaver-control-products/fish-passage-at-beaver-dams/ for more information.

Install Culvert Barrier to Prevent Culvert Clogging
- In situations where beaver are clogging culverts, which are already sized appropriately, culvert barriers would be installed as a deterrent. However, they would only be used when the threat of clogging has major consequences and/or in response to actual clogging. See https://www.beaversolutions.com/get-beaver-control-products/culvert-protective-fences/ for more information.

Install Fencing Around Sensitive Trees
- Heavy gauge wire mesh (6 x 6 inches or smaller gaps and 6 gauge or thicker wire) would be emplaced around the bottom 3-4 feet of the trunks of important trees (species, age classes, or relative distributions of trees necessary to sustain multiple use objectives) to deter beaver from removing them. This method would be used where necessary to balance the ecological benefits of beaver dam building activity with the utility of the trees to other stakeholders (i.e., recreation, wildlife, etc.) or to mitigate threats to human life or property if felled. For example, the BLM would protect trees from beaver activity where, if felled, they could cause damage to infrastructure, block roads and trails, or threaten the safety of visitors at recreation sites and campgrounds. When fencing, the BLM would allow sufficient space between the wire mesh and tree to prevent girdling and related adverse impacts to the trees. All protective fencing would be checked for effectiveness annually and potentially removed and/or replaced every three to five years to account for new growth. Consequently, this method would only be used where annual inspections are feasible, such as near campgrounds and other areas that are frequently visited by BLM personnel. See http://www.beaversolutions.com/tree_protection.asp for more information.

Apply Paint Mixed with Sand to Protect Sensitive Trees
- Exterior latex paint that resembles the color of the tree bark would be mixed with sand (~5 oz sand per quart of paint) and applied three to four feet from the bottom of the trunk (or at least 2 feet above the typical snow depth) of sensitive trees. Due to the limited effectiveness of this technique for saplings, it would typically be applied only to middle age class and mature trees. This method would most commonly be used where the BLM lacks sufficient access to inspect mesh wire wraps annually and the risk of tree felling to life and property is negligible. See https://www.beaversolutions.com/beaver-facts-education/tree-protection-from-beaver-chewing/ for more information.

Guiding Principles for Project Implementation

Ten guiding principles would be incorporated into the design and implementation of all projects (*Utah State University, 2019*). They are broken into: (1) riverscape principles and (2) restoration principles, both of which are described below:

Riverscapes Principles – would inform planning and design through an understanding of what constitutes healthy, functioning riverscapes and therefore what are appropriate targets and analogues to aim for. They include:

1. **Streams need space**. Healthy streams are dynamic, regularly shifting position within their valley bottom, reworking and interacting with their floodplain. Allowing streams to adjust within their valley bottom is essential for maintaining functioning riverscapes.

2. **Structure forces complexity and builds resilience.** Structural elements, such as beaver dams and large woody debris, force changes in flow patterns that produce physically diverse habitats. Physically diverse habitats are more resilient to disturbances than simplified, homogeneous habitats**.**

3. ***The importance of structure varies.*** The relative importance and abundance of structural elements varies based on reach type, valley setting, flow regime and watershed context. Recognizing what type of stream you are dealing with (i.e., what other streams it is similar to) helps develop realistic expectations about what that stream should or could look (form) and behave (process) like.

4. ***Inefficient conveyance of water is often healthy.*** Hydrologic inefficiency is the hallmark of a healthy system. More diverse residence times for water can attenuate potentially damaging floods, fill up valley bottom sponges, and slowly release that water later elevating baseflow and producing critical ecosystem services.

Restoration Principles – Restoration Principles' relate to our specific restoration actions and give us clues as to how to develop designs to promote processes that lead to recovery and resilience. These principles are rooted in the notion that we are not designing and building the solution, but rather we are simply initiating and promoting natural processes with structural additions as efficiently as possible to maximize the miles of riverscape we can improve. The low-tech Restoration Principles elaborated below and illustrated in Figure 1 help place our restoration actions in the right context to maximize our effectiveness in promoting better riverscape health.

5. **It's okay to be messy**. When structure is added back to streams, it is meant to mimic and promote the processes of wood accumulation and beaver dam activity. Structures are fed to the system like a meal and should resemble natural structures (log jams, beaver dams, fallen trees) in naturally 'messy' systems. Structures do not have to be perfectly built to yield desirable outcomes. Focus less on the form and more on the processes the structures will promote.

6. **There is strength in numbers.** A large number of smaller structures working in concert with each other can achieve much more than a few isolated, over-built, highly-secured structures. Using a lot of smaller structures provides redundancy and reduces the importance of any one structure. It generally takes many structures, designed in a complex (see Chapter 5: Shahverdian et al., 2019c), to promote the processes of wood accumulation and beaver dam activity that lead to the desired outcomes.

7. **Use natural building materials**. Natural materials should be used because structures are simply intended to initiate process recovery and go away over time. Locally sourced materials are preferable because they simplify logistics and keep costs down.

8. **Let the system do the work.** Giving the riverscape and/or beaver the tools (structure) to promote natural processes to heal itself with stream power and ecosystem engineering, as opposed to diesel power, promotes efficiency that allows restoration to scale to the scope of degradation.

9. **Defer decision making to the system**. Wherever possible, let the system make critical design decisions by simply providing the tools and space it needs to adjust. Deferring decision making to the system downplays the significance of uncertainty due to limited knowledge. For example, choosing a floodplain elevation to grade to based on limited hydrology information can be a complex and uncertain endeavor, but deferring to the hydrology of that system to build its own floodplain grade reduces the importance of uncertainty due to limited knowledge.

10. **Self-sustaining systems are the solution.** Low-tech restoration actions in and of themselves are not the solution. Rather they are just intended to initiate processes and nudge the system towards the ultimate goal of building a resilient, self-sustaining riverscape.

Integration and Application of Restoration Actions – A Strategic Framework

Field offices would prioritize project locations and include riparian-wetland areas that are unlikely to make acceptable progress towards the achievement of land health standards or RMP objectives through natural processes, alone. Individual projects would be aligned with management goals seeking ecological outcomes, cost-effectiveness, and self-sustaining solutions in areas with minimal risk to infrastructure (Riverscape Principal 1). This would typically involve low gradient, wadable streams that require floodplains and riparian vegetation to function properly because they can adjust laterally, respond relatively quickly to the treatments, and often support high resource values (Riverscape Principles 2 - 4).

Unless otherwise noted (i.e., headcut control), projects would be designed around the central premise that to restore/maintain functions, we first need to restore/maintain the physical and ecological processes that historically created and maintained the attributes and resource values of the site. Consequently, to the extent practicable, projects would be implemented in accordance with the following principles of process-based restoration:

- Target root causes of habitat and ecosystem change
- Tailor restoration actions to local potential
- Match the scale of restoration to the scale of the problem
- Be explicit about expected outcomes.

Decisions regarding technique selection would generally be based on the physical parameters of the site, restoration goals, constraints imposed by adjacent land uses, as well as pragmatic considerations on how best to allocate limited project resources. Consequently, the BLM would utilize the technique or combination of techniques that most appropriately invokes the processes that match the restoration objectives for the stream. Where current management of an existing land use authorization is contributing to the impairment of riparian-wetland processes (i.e., livestock grazing impacts to the source of woody material, road design/maintenance, etc.), corrective actions would be enacted in combination with the Proposed Action to ensure the benefits of restoration are self-sustaining. However, such adjustments must recognize valid existing rights and be within the terms and conditions of the BLM's associated authorizations, or separate analysis would first be required.

Projects would be implemented over a subset of an entire drainage network and represent the intersection of priorities and practical opportunities (e.g., partnerships, willing landowners adjacent to public land, etc.). Projects would tend to be organized around these discrete locations, a collaboration of project organizers and stakeholders, and tied to a specific set of conservation and/or restoration actions. They would also be implemented on a reach-by-reach basis to ensure that the selected treatments account for the unique, site-specific characteristics. Although the site-specific project objectives would vary according to the desired outcomes, site potential, and current conditions; the target for most projects would include a state in which the processes of wood accumulation and/or beaver dam activity are self-sustaining.

Most projects would be intended to initially mimic and promote natural fluvial processes by adding the structural elements that historically supported ecological functions and riverscape health (Restoration Principles 5 – 9). However, to ensure that those processes become self-sustaining (Restoration Principal 10), the BLM would also implement vegetation management actions where necessary to promote the growth of the requisite types and amounts of woody material. Similarly, where potential flooding or undesirable tree removal associated with beaver dam activity becomes an issue, the BLM would consult with the relevant state wildlife agencies and other stakeholders to identify the most appropriate solution. Where non-lethal methods are determined to be viable and the persistence of beaver in the system aligns with the ecological objectives for that stream segment, Beaver Mitigation Strategies would be implemented (Restoration Principal 10). Headcut control strategies would be used to compliment processes-based restoration.

Most projects would be implemented with manual labor and associated tools (i.e. shovels, picks, pneumatic/hydraulic post pounders, etc.). However, limited use of heavy equipment may be authorized on a project-specific basis to increase efficiency and productivity (i.e., to transport materials or drive posts at difficult locations) or where such equipment is the only practicable alternative. Field offices would follow all requisite BMPs associated with the specific details of an individual project, including those for weed prevention, the protection of sensitive soils, water quality, and fish/wildlife.

Implementation and effectiveness monitoring would be conducted for all projects to facilitate adaptive management and ensure progress towards the project goals and objectives, as well as those of the field offices' resource management plans. This could include the installation of environmental monitoring equipment such as such as piezometers, thermistors, soil moisture sensors and stream gauges, as well as the establishment of monitoring transects (permanent or temporary) and biological sampling. All equipment would be removed once sufficient data has been collected to answer the management question, which could be short and/or long-term.