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Montana/Dakotas Low-Tech, Process-Based Riverscape Restoration

Programmatic Environmental Assessment
DOI-BLM-MT-0000-2020-0006-EA

Montana/Dakotas State Office
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Low-Tech, Process-Based Riverscape Restoration

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Chapter 1.0 - Introduction

1.1 Summary of Proposed Project

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 is to 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 (EA) identifies the proposed restoration techniques, establishes the scope and sideboards for their future use, analyzes the potential environmental consequences of the typical projects, and compares those outcomes to a No Action Alternative. Due to the programmatic nature of the Proposed Action, the EA 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)

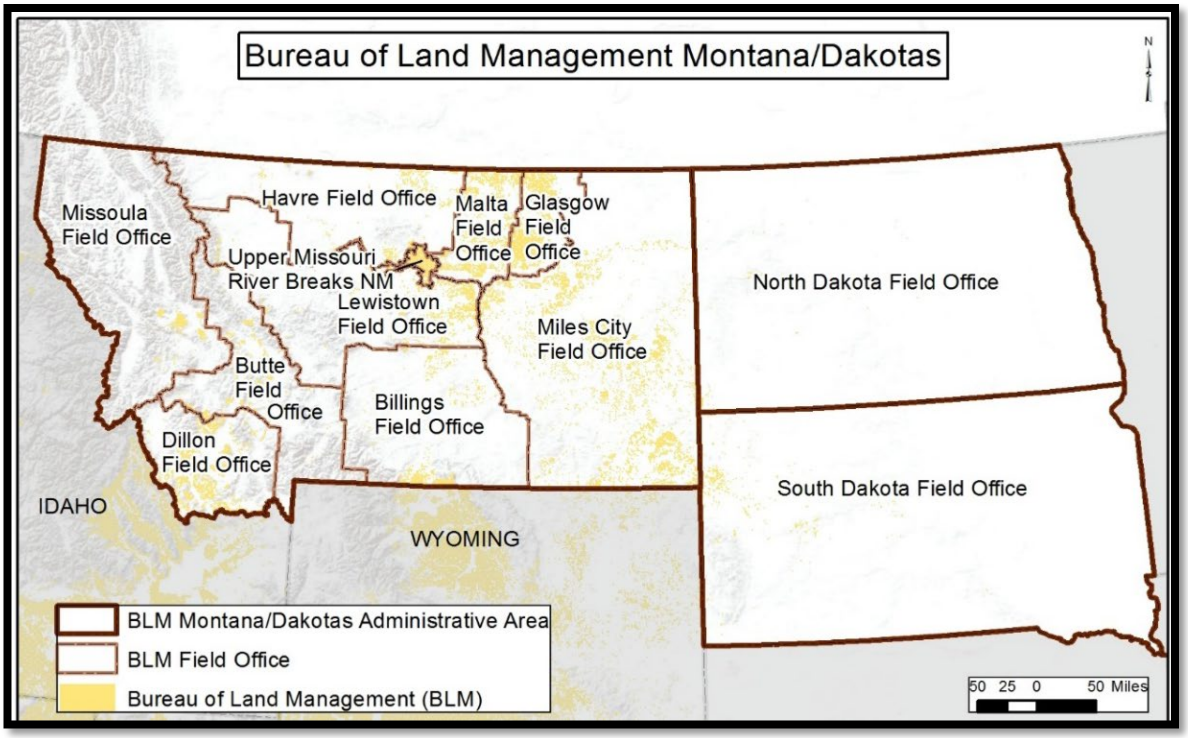

Figure 1: BLM Lands Administered by Montana/Dakotas Field Offices.

1.2 Purpose and Need

The purpose and need for action is to analyze simple, cost-effective (i.e., low-tech) restoration methods that would improve the health of riverscapes 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 mimic, promote, and sustain the processes that historically maintained 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.

1.3 Decision to be Made

The State Director must determine whether to approve use of the programmatic treatments identified in this EA and if so, which conditions of approval would apply. Though future projects would be able to tier to this programmatic EA in order to reduce duplication of NEPA analyses, all applicable permits and authorizations would be obtained from all pertinent regulatory agencies on a project-by-project basis.

1.4 Land Use Plan Conformance

The Proposed Action is consistent with all the field offices' Resource Management Plans (RMPs) within Montana/Dakotas. It was designed to help them achieve or exceed the *Fundamentals of Rangeland Health* and corresponding *Montana/Dakotas Standards for Rangeland Health and Guidelines for Livestock Grazing Management, 1997* (over time), which are statements of physical and biological condition or degree of function required for healthy sustainable rangelands. The BLM is required to ensure that the ecosystem functions and corresponding resource conditions are meeting or making significant progress towards the standards (43 CFR 4180.1). They also provide the basis for many of the goals, objectives, and management actions within our RMPs. The Proposed Action would be implemented to help field offices achieve the goals and objectives within their RMPs that depend on riverscape health.

Table 1: List of BLM field offices and associated RMPs

Field Offices	Name of RMP
Butte Field Office	Butte RMP, 2009
Dillon Field Office	Dillon RMP, 2006, as amended
Missoula Field Office	Missoula RMP, 2021
Malta Field Office	HiLine RMP, 2015
Glasgow Field Office	
Havre Field Office	
UMRB National Monument	Upper Missouri River Breaks NM RMP, 2009
Lewistown Field Office	Lewistown RMP, 2021
Billings Field Office	Billings Field Office RMP, 2015
Miles City Field Office	Miles City Field Office RMP, 2015, as amended
South Dakota Field Office	South Dakota RMP, 2015
North Dakota Field Office*	North Dakota RMP, 1988, as amended

1.5 Relationship to Statutes, Regulations, Other NEPA Documents

The following laws, regulations, policies, and programs are relevant to the Proposed Action:

- Laws and Statutes
  - National Environmental Policy Act of 1969 (NEPA)
  - Endangered Species Act of 1973
  - Migratory Bird Treaty Act of 1918
  - Federal Land Policy and Management Act of 1976 (FLPMA)
  - Clean Water Act of 1977
  - State of Montana Streamside Management Zone Law of July 1991
  - State of Montana Stream Protection Act (SPA 124 Permit)
  - Wild and Scenic Rivers Act
  - Fish and Wildlife Coordination Act
  - Rivers and Harbors Act of 1899
- Regulations and Manuals
  - Title 43 Code of Federal Regulation, Part 4100
  - Management of Wilderness Study Areas (manual 6330), 2012
  - Management of Designated Wilderness Areas (manual 6340), 2012
  - Water Rights Manual (manual 7200), 2013
  - Water Quality Manual (manual 7240), 2015
  - Aquatic Resource Management Manual (manual 6720), 1991
  - National Flood Insurance Program
- Other Plans and NEPA
  - Memorandum of Understanding and Conservation Agreement for Westslope Cutthroat Trout in Montana
  - 2010 Nonpoint source Memorandum of Understanding
  - 2016 Memorandum of Understanding between the U.S. Department of Interior, BLM, the U.S. Department of Agriculture, NRCS, and the U.S. Department of Agriculture, Forest Service to accomplish common goals related to conservation of the Greater Sage-Grouse and its habitat.
  - Montana Statewide Fisheries Management (2019 – 2027)
  - Montana State Water Plan (2015)

1.6 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? And how would vegetation within the valley bottoms be affected?
- Issue 2: How would implementation of the alternatives affect water quality and water quantity?
- Issue 3: How would implementation of the alternatives affect aquatic species depend on riverscapes to meet their lifecycle needs (including sensitive status, candidate, threatened, or endangered species)?
- Issue 4 – How would implementation of the alternatives affect the resources, objects, and values of national monuments, wilderness, wilderness study areas, and wild and scenic rivers?
- Issue 5: How would implementation of the alternatives affect aquatic terrestrial species that depend on riverscapes to meet their lifecycle needs?

1.7 Issues Identified but Eliminated from Further Analysis (If Applicable)

Issue: Livestock Grazing – Temporary project protection fences will reduce the amount of forage that is available to livestock within the immediate vicinity of a project. However, the impacts will be temporary, the amount of forage that will be unavailable to livestock during this period will be negligible (e.g., less than 1% of the forage within an allotment) and all fences will be designed to allow for livestock watering within the affected areas. This issue is therefore eliminated from further consideration.

Design Features: *Livestock Grazing* – project protection fences will be temporary, designed to maintain livestock watering within the affected areas, and utilize standard specifications for livestock and wildlife friendly fences on BLM administered lands.

Issue: Cultural Resources – The Proposed Action could temporarily disturb the ground surface and increase the influence of fluvial processes on the surrounding valley bottom, where cultural resources may be located. Compliance with Section 106 of the NHPA and/or with the Montana's State Protocol with the Montana State Historic Preservation Offices would minimize or avoid such impacts to the extent that the level of significance is below the threshold for analysis under NEPA. This issue is therefore eliminated from further consideration.

Design Features: Cultural Resources - Prior to initiation of a specific riverscape restoration project the field office shall comply with Section 106 of the National Historic Preservation Act (NHPA) and/or the terms specified by Montana's State Protocol Agreement between the Montana State Director and the Montana State Historic Preservation Office (SHPO). Compliance with Section 106 or with Montana's State Protocol may require a Class III Cultural Resource Inventory of the project area and consultation with consulting parties including tribes. If a survey is not required or no sites are located following a survey and there are no potential residual issues stemming from consultation with consulting parties including tribes the project may proceed as planned. However, if cultural resources are found that may be eligible for the National Register of Historic Places (NRHP) those resources must be considered in accordance with Section 106 of NHPA or the Montana State Protocol Agreement. Where there are eligible cultural resources that may be affected by the restoration project mitigation measures would have to be considered and implemented prior to project approval.

*Issue 3: BLM Terrestrial Special Status Species (SSS) and Big Gam*e – Throughout the Montana/Dakotas, there are 44 BLM SSS (terrestrial species), including 7 Federally Listed Species, 2 areas of designated critical habitat and 6 big game animals that utilize riverscapes to varying degrees to meet lifecycle needs. Refer to Appendix I for a Biological Evaluation Summary Table for a comprehensive list of species identified across the Montana / Dakotas BLM. The Montana Natural Heritage Program (https://mtnhp.org/), ND Game and Fish Department (https://gf.nd.gov/wildlife), and South Dakota Heritage Program (https://gfp.sd.gov/natural-heritage-program/) each provide additional information on BLM SSS and big game habitat associations and population status and biology. Riverscapes that have lost much of their structure and function become degraded to varying levels where their productivity can no longer or is very limited in supporting suitable habitat for terrestrial species. Although some areas may be marginally suitable for species where elements of habitat exist, continued occupancy and use is highly dependent on the seasonal persistence and resiliency of habitat. The BLM and other federal, state, and local fish/wildlife agencies strive to maintain viable populations of all native species, including the protection, maintenance, and restoration of native habitat where feasible.

Under current management, the BLM would maintain and or restore riverscape habitat on a case-by-case basis, however, it does not proactively address and adaptively manage the larger problem across ownership boundaries and watersheds. The continued degradation of riverscapes would result in the loss of native habitat, food production areas, water sources, cover and security for terrestrial wildlife and big game. Climate change is also exacerbating the impacts from drought and fire, insect disturbances and invasive encroachment across landscapes, cumulatively affecting natural resources, where the current conditions predominantly are not conducive to supporting the biological requirements of BLM SSS and big game. The Proposed Action will mimic, promote, and sustain natural riverscape processes that historically maintained the health of most alluvial stream segments in the project area, and proactive landscape-level restoration would build and support the process and function of resilient ecosystem which would increase habitat suitability and diversity for terrestrial wildlife and big game. Consequently, healthy, and proper functioning riverscapes will provide suitable habitat in the long-term for species associated with those systems. Although short-term impacts may arise from disturbance of individuals, stream bank alteration, vegetation loss (undesirable), soil disturbance and topographical alteration (trampling and compaction), or alteration of stream current; those impacts if any, are expected to be minor, localized and low risk, and only in areas already providing marginal habitat for species and not to any extent that is expected to result in permanent displacement and or unsuitable conditions in the short or long term.

Design Features: *BLM Terrestrial Special Status Species (SSS) and Big Gam*e - Refer to Appendix I.

On April 28, 2022, the BLM submitted a biological assessment to the USFWS for draft review to fulfil Section 7 obligations.

Chapter 2.0 - Alternatives

The National Environmental Policy Act (NEPA) requires analysis of a Proposed Action and other reasonable alternatives, including no action. The No Action Alternative provides a baseline for estimating environmental effects. Two alternatives, including the Proposed Action and the No Action, are considered in detail. The Proposed Action (Alternative B) was developed to meet the Purpose and Need.

2.1 Alternative 1 - No Action Alternative

Under this alternative, Montana/Dakotas field offices would not pursue the programmatic restoration actions proposed in this analysis. Instead, the BLM would continue to maintain or improve riparian-wetland conditions primarily through the application of BMPs, which minimize or avoid current impacts to riverscapes associated with land use authorizations (i.e., livestock grazing management, road construction/maintenance, forestry BMPs, etc.). There may be scattered, individual physical restoration projects authorized on a case-by-case basis. However, few physical restoration projects would be implemented. Due to other priorities and the absence of a programmatic approach, most field offices would restore short stream segments that are impacted by recent land use authorizations, when the actions can be analyzed in association with parallel efforts like watershed assessments and livestock grazing permit renewals. These are often completed on a ten-year, rotating cycle. Streams affected primarily by historic impacts would typically not be prioritized for restoration.

2.2 Alternative 2 - 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 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 mimic, promote, and sustain natural processes that produce the desired attributes and functions over time (i.e., help the water do the work). Table 1, below, explains the four different categories of actions, the associated goal and objectives, as well as the typical techniques. Each action is described in detail after Table 1.

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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 (e.g., beaver dams and wood accumulations); 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 2: 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 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 [5]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

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[5] Disclimax: A stable ecological community (distribution and abundance of plant species and age classes) that has replaced the normal climax plant community in a given area, often caused by human disturbances (i.e. fire suppression, livestock grazing, removal of structural elements from riverscapes, etc.) to the ecological processes that historically created and maintained the climax plant community.

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) and LTPBR Design Manual (Appendix D and E), Utah State University Restoration Consortium, 2019.* In many cases, local stream conditions, often at the sub-reach[6] 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[7] 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). During this process, the BLM would time and/or stage project implementation to minimize or avoid potential streamflow declines that could adversely impact downstream water users or ecosystems. Combinations of primary and secondary dams would also be installed to create a series of pools and elevation drops that mimic natural beaver dam complexes and correspondingly enable or enhance passage of native fish.

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

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

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

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.

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 F). 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.

Common maintenance activities for PALS include:

- Adding more wood to existing structures.
- Adding posts to existing structures.
- Building new structures where other structures have been washed downstream; and
- Adding wood either by hand or falling trees in treatment areas and allowing the system to rearrange the wood.

- Increasing density of mid-channel PALS at the downstream end of a project to act as Velcro for wood recruited from the project area.

Common maintenance activities for BDAs include:
- Adding more posts to reinforce a dam.
- Repairing minor breaches.
- Building out the BDA further onto the floodplain to increase the size of the pond by raising the crest elevation; and
- Adding more fill to 'seal' the dam and raise the water label or building new BDAs if previous BDAs aggraded or the channel has migrated.

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 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-wetland 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, valley bottoms have dried due to the removal of wood, beaver, and/or loss of process-space, and/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. Where restoration objectives cannot be attained without beaver re-establishment and natural dispersal is unlikely or insufficient, the Proposed Action may be implemented in tandem with partners and/or state wildlife agency efforts to facilitate beaver reintroduction to the restoration sites.

Most projects would be implemented with manual labor and associated tools (e.g., shovels, picks, pneumatic/hydraulic post pounders, etc.). However, where BLM's land use authorizations allow (e.g., areas outside of the National Landscape Conservation System and similar designations), 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, fish/wildlife, visual resources, national monuments, wilderness, and wilderness study areas. Implementation and effectiveness monitoring would be conducted for all projects to facilitate adaptive management (Appendix H) 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.

Table 3: Comparison of Alternatives

	Indicator	Alternative 1 - Proposed Action	Alternative 2 -No Action
	Principle 1 - Streams need space.		
	Proportion of Active Valley Bottom	Increase - The Proposed Action will increase or maintain the distribution of structural elements and riparian vegetation. These flow obstructions will disrupt longitudinal connectivity (from upstream to downstream) and increase lateral and vertical connectivity between the stream, streambed, and floodplain aquifer. These impacts will increase the proportion of the valley bottom that is active, which will: (i) increase the ecosystem services that riverscapes provide and (ii) make riverscapes more resistant and resilient to future disturbances.	Maintain or Decrease: Historic impacts to riverscapes have caused structural starvation and channel incision in many streams. These impacts have reduced the proportion of active valley bottom by confining most of the water, sediment, and organic matter to the channel, rather than distributing it across the floodplain, where it can recharge aquifers and dissipate energy associated with high flows. Without application of the Proposed Action to restore stream-floodplain connectivity and riparian vegetation, large valley bottom areas will not be influenced by the fluvial processes that historically maintained riparian-wetland and aquatic attributes in those areas. As a result, impacted streams will provide fewer resource values and be less resistant/resilient to disturbances.
	Principle 2 - Structure forces complexity and builds resilience		
Structure Indicators	Jam Density (LWD jams / km)	Increase: The Proposed Action will mimic, promote, and sustain the processes of dam building activity and wood accumulations. These structural elements will force changes in flow patterns that produce physically diverse habitats, high water tables, and frequent stream-floodplain interactions. These processes will accelerate and sustain the recovery of structurally starved riverscapes. As recovery occurs, the capacity and density of beaver dams and debris accumulations will correspondingly increase.	Maintain or Decrease: Historic impacts have caused structural starvation and channel incision. This degradation has further reduced the capacity of impacted riverscapes to grow riparian vegetation and sustain beaver dam building activity or wood accumulations. Without application of the Proposed Action to mimic, promote, and sustain these ecological processes, habitats will remain spatially limited and over-simplified; water and sediment will be confined to the channel rather than spread across the floodplain; floodplain aquifer levels will not be restored; and the spatial extent of the riparian zone will remain diminished.
	Jam Capacity (LWD jams / km)		
	Beaver Dam Density (beaver dams / km)		
	Beaver Dam Capacity (beaver dams / km)		
Complexity Indicators	Length of Active Primary Channels	Increase: Increasing the distribution of structural elements via application of the Proposed Action will create hydraulic diversity. Hydraulic diversity will help streams build more geomorphically complex riverscape attributes by influencing erosional and depositional processes. Increased geomorphic complexity will correspondingly increase the residence time and length of hydrologic flow paths, as well as riparian plant communities. Together, these attributes will provide unique habitat niches for native flora and fauna	Maintain or Decrease: The distribution of structural elements would not be increased to restore hydraulic diversity to oversimplified, structurally starved riverscapes. Without more hydraulic diversity, degraded streams will erode, disconnect from, or not re-develop the complex array of geomorphic features that historically existed. As a result, residence time, length of hydrologic flow paths, and riparian plant communities will remain far below the reaches' potential. Impacted streams will therefore provide fewer and less diverse habitat niches for native flora and fauna, making it more difficult for species to meet their lifecyle needs, particularly when amplified by climate change.
	Length of Active Secondary Channels		
	Diffluence Density (# / km)		
	Confluence Density (# / km)		
	Floodplain Channel Head Density (# / km)		
	Pool Desnity (# / km)		

	Indicator	Alternative 1 - Proposed Action	Alternative 2 -No Action
	Mid Channel Bar Density (# / km)	throughout their lifecycles and variable climatic conditions.	
	Riffle Density (# / km)		
Resilience Indicators	VB Mesic Resources (% of years mesic)	Increase: The Proposed Action will restore physical diversity and the residence time of water. Physically diverse habitats are more resilient to disturbances than simplified, homogeneous habitats. They provide geomorphic features and hydrologic conditions that sustain a correspondingly diverse array of water loving plants and store enough water in the valley bottom to sustain plant productivity for longer periods.	Maintain or Decrease: Without application of the Proposed Action to increase hydraulic diversity and geomorphic complexity, simplified and homogeneous habitats will persist in structurally starved streams. As a result, they will not contain the geomorphic features and hydrologic conditions needed to sustain the diverse array of water loving plants and associated ecological processes across the valley bottom.
	VB Mesic Resource Resilience (0 to 1)		
	Complexity Resilience (0 to 1)		
	Riparian Vegetation Area (% of VB)	Increase: The Proposed Action will restore stream-floodplain connectivity and aquifer recharge. These processes are conducive to riparian vegetation growth across most of the active valley bottom area. This vegetation increases the supply of woody material for wood accumulations and beaver dam building activity. It also stabilizes soil, improves water quality and habitat values, and minimizes or avoids damaging impacts to riverscapes and ecosystems from floods, drought, and other resource uses.	Maintain or Decrease: Without application of the Proposed Action to restore flow obstructions, hydraulic diversity, geomorphic complexity, and the residence time of hydrologic flow paths; stream-floodplain connectivity and aquifer recharge will remain diminished. As a result, large parts of the valley bottom will remain inactive and no longer support the historic distribution and abundance of riparian vegetation. Without sufficient types and amounts of vegetation to support beaver dam building activity and wood accumulations, recovery rates will be correspondingly limited. Similarly, impacted streams may cause water quality impairments, support fewer habitat values, and be less resistant and resilient to floods, drought, and other resource uses.
	Principle 4 - Inefficient conveyance of water is healthy		
	% Inundated @ Baseflow	Increase: The Proposed Action will increase the distribution of structural elements and riparian vegetation. These impacts will obstruct the flow of water and force degraded streams to inundate their floodplains more frequently, over larger areas, and in more diverse ways. Although the same amount of water will flow out of the reach as occurred before restoration, the water will be spread over a much larger proportion of the valley bottom, more frequently. This will increase hydrologic inefficiency.	Maintain or Decrease: Without application of the Proposed Action to obstruct flow and increase the vertical and lateral connectivity between the stream and floodplain, water will be confined to homogeneous, oversimplified stream channels. Since impacted streams will transport water and sediment rapidly through the reach, the frequency and extent of valley bottom inundation will be far less than historically occurred.
	% Inundated @ Typical Flood		
Inundation	Free-Flowing		

	Indicator	Alternative 1 - Proposed Action	Alternative 2 -No Action
	Backwater / Ponded	Increase: Healthy riverscapes spread water throughout the valley bottom, where it flows in channels, gets backed-up/pooled, and flows back and forth among pools and channels. The Proposed Action will increase the type and extent of valley bottom inundation by reducing hydrologic efficiency.	Maintain or Decrease: Unhealthy riverscapes contain most of their water in a single channel, which rapidly transports the water from upstream to downstream. Due to this hydrologic efficiency, nearly all the water is free flowing. Without application of the Proposed Action to restore hydraulic diversity and stream-floodplain interactions, impacted riverscapes will continue to rapidly transport water out of the reach, rather than spread it across the floodplain where it historically sustained ecological processes.
	Overflow		
	Geomorphic Condition		
Percent RS Length in Cluer & Throne Stages	Stage 0 - Anastamsoing	Increase: Streams degrade and recover through a reliable sequence of changes, which are commonly called "stages in stream evolution." Stages 0 and 8 represent the best conditions that a stream can achieve. In general, the closer a stream is to Stages 0 and 8, the healthier they are and the more ecosystem services they can provide. The Proposed Action will mimic, promote, and sustain processes that naturally transition streams that have been impacted by historical uses to stages in the stream evolution sequence that are healthier.	Maintain or Decrease: Streams that have been impacted by historical uses and transitioned to less healthy stages in the stream evolution sequence must undergo a series of vertical and lateral adjustments to regain their historic functions. If the activities that caused degradation are corrected, streams will recover naturally through erosional and depositional processes. However, this can take decades to centuries (or longer). Meanwhile, the resource values and ecosystem services will remain impaired or fully unsupported.
	Stage 1 - Single Thread		
	Stage 2 to 3 - Incised		
	Stage 4 - Degradation & Widening		
	Stage 5 - Aggradation & Widening		
	Stage 6 - Quasi-Eqilibirum		
	Stage 7 - Laterally Active		
	Stage 8 – Anastamosing		
	Management & Project Specific Indicators		
	Day of Year Flows Dry Up	Increase: The Proposed Action will increase physical habitat complexity and hydrologic inefficiency. These impacts will increase transient water storage, create more diverse habitat niches, and often increase the miles of stream (by activating secondary channels). They therefore can flow longer and support more types and amounts of fish.	Maintain or Decrease: Without the Proposed Action to restore physical habitat complexity and hydrologic inefficiency, riverscapes that have been impacted by structural starvation will continue to provide over-simplified, homogeneous habitats and diminished transient water storage. They will therefore flow for shorter periods and support fewer types and amounts of fish.
	Fish Density (fish / 100 m)		

3 Affected Environment and Environmental Consequences

3.0 General Setting

Riverscapes:

The BLM administers approximately 8.4 million acres of surface estate in Montana/Dakotas, of which 96% is in Montana, 3% in South Dakota, and < 1% in North Dakota. These landscapes are topographically and ecologically complex and extend across the Northern Great Plains, Northern Glaciated Plains, and Middle Rockies Ecoregions. The associated riverscapes are similarly diverse and reflect these environmental gradients. Land ownership is scattered and often intermingled with other public and privately administered resources. Most of the surface water and riparian-wetland features they support have been mapped (Table 4).

Table 4: *Surface Water and Riparian Wetland Features Administered by Montana/Dakotas Field Offices*

Field Office Name	BLM Surface (ac)	Intermittent & Ephemeral Streams (mi)	Perennial Streams (mi)	Springs (count)	Waterbodies (acres)	Riparian-Wetland Area (ac)	% BLM Surface Mapped as Riparian
BILLINGS	430730	1915	50	26	1192	3409	1%
BUTTE	320046	1141	154	34	1891	4618	1%
DILLON	908040	2941	363	123	6023	16878	2%
GLASGOW	1017260	6815	70	44	4696	19551	2%
HAVRE	412487	1967	12	6	12016	27358	7%
LEWISTOWN	635916	3257	95	24	3858	7178	1%
MALTA	1031430	5096	48	44	9987	38051	4%
MILES CITY	2757030	17892	89	171	10196	27639	1%
MISSOULA	162448	371	119	9	181	2887	2%
NORTH DAKOTA	57877.5	549	23	1	620	1493	3%
SOUTH DAKOTA	278582	1581	63	2	1550	5392	2%
UPPER MISSOURI RIVER BREAKS NM	353233	1910	25	5	179	3611	1%
MONTANA/DAKOTAS TOTAL	8365080	45435	1109	489	52389	158063	2%

This includes approximately 45,400 miles of intermittent/ephemeral stream and 1,100 miles of perennial stream (National Hydrography Dataset, Version 3.1) on BLM administered lands. The associated corridors are characterized by a diverse array of landscape elements, including surface waters (a gradient of lotic and lentic waterbodies), alluvial aquifers, riparian systems, and geomorphic features (bars and islands, ridges and swales, levees and terraces, fans and deltas, fringing floodplains, wood debris deposits and channel networks) that together comprise the "riverscape" (Ward et. al, 2002). These connected floodplain and channel habitats make up the valley bottom, which represents the area that could plausibly flood in the contemporary flow regime (Fryirs et al., 2015). Within these valley bottoms, current fluvial processes (erosion, transport, deposition) create and maintain riverscape attributes and are the predominant agents of landscape evolution. *The valley bottom therefore represents the maximum area that can be influenced by any riverscape restoration project and is a conservative spatial domain for evaluating direct, indirect, cumulative, and reasonably foreseeable impacts to water resources, riparian-wetland areas, vegetation, and aquatic habitat from the Proposed Action.*

Valley bottom areas were recently modelled within the Montana/Dakotas BLM via tools embedded in Utah State University's Beaver Restoration Assessment Tool ((BRAT) http://brat.riverscapes.xyz/)). They are estimated to span approximately 1.3 million acres of BLM administered surface estate and contain approximately 140,000 acres of diverse riparian-wetland and aquatic habitat (Montana State Library, Appendix E, Figures 19 -21). This represents approximately 92% of all BLM administered riparian-wetland and aquatic areas, illustrating the importance of riverscape health to regional riparian-wetland and aquatic ecosystem management. In general, the capacity of these riverscapes to provide abundant resource values and ecosystem services increases proportionally with the extent of the riparian-wetland and aquatic zone, geomorphic complexity, and hydroperiod (e.g., extent and duration of wet conditions within the valley bottom). As described in Sections 3.1.1 and 3.2.1, these attributes have declined across the project area.

Although flow permanence is described above (Table 4) via discrete classes (based largely on observations from the mid-20th Century), it varies through space and time (due to differences in weather/climate, riverscape conditions, and physiographic controls), occurs along a continuum, and can change when riverscape health improves or declines. Streams at the dry end of the spectrum typically do not receive or store water long enough within the valley bottom to support riparian-wetland plant communities. They are ephemeral because of physiographic and climatological limitations (i.e. small water supply) and/or because they have degraded (i.e. they function more like ditches than sponges). Conversely, intermittent and perennial streams can inundate and/or saturate portions of the valley bottom long enough to support riparian-wetland plants. These streams are typically fed by larger and/or wetter contributing areas, springs and/or groundwater. They are particularly common in the BLM's Western District but are present in all BLM field offices. However, as described in Section 3.2.1, perennial streams were historically more common, and many streams currently classified as intermittent and ephemeral were much wetter. This is especially true of broad, unconfined valley bottoms (focal areas for the Proposed Action), where flow obstructions like woody debris and beaver dams were more abundant; forcing streams to regularly inundate the surrounding valley bottoms, sort sediments into complex multi-threaded channel configurations, recharge groundwater to maintain high water tables, and sustain correspondingly extensive riparian-wetland zones.

Throughout the project area, flow obstructions historically associated with beaver, wood, and riparian vegetation have declined (before the BLM was even formed); streams have incised and converted to simpler, straighter, single-threaded channel configurations that inundate their floodplains less frequently; floodplain aquifer elevations have declined and large portions of the surrounding valley bottom have dried, causing riparian-wetland areas to contract and the duration of flow to decline. As described in the subsequent sections, these impacts continue to adversely affect the health, productivity, and resilience of BLM administered riverscapes and recovery through natural processes could take centuries to millennia (Pollock et. al, 2014; Cluer and Thorn, 2013; Beechie et. al, 2007) without intervention, even where BLM's land uses do not contribute to the existing impairments.

Climate has played and continues to play a large role in the riverscape conditions. The regions' climate is warming, which will increasingly influence regional snowpack, streamflow dynamics, and groundwater resources, while increasing wildfires and extreme climate events, ranging from flood to drought. These impacts will have far-reaching consequences for water resources, riverscapes, vegetation, and the flora/fauna that depend on the attributes of these resources. They will also amplify the impacts of riverscape degradation. Since degraded riverscapes support fewer ecosystem functions (Appendix E, Figure 26) and are less resistant and resilient to disturbance than those which are physically and ecologically complex (Sections 3.1.1, 3.2.1, and 3.3.1), they will be impacted more by climate change, more likely to unravel during extreme events, and do less to buffer the associated impacts on ecosystems and economies. Additional information and details on climate and the implications for riverscape processes, attributes, and water resources can be found in Appendix G.

3.1 Resource Issue 1: How would implementation of the alternatives impact riverscape processes and attributes? And how would vegetation in the valley bottoms be affected.

3.1.1 Affected Environment – Riverscape Processes and Attributes (including vegetation)

Floodplain Inundation, Flow Permanence, and Historical Changes:

Riverscape processes and attributes have been impacted by a wide array of human activities that continue to affect their health and associated capacity to support large, diverse, and productive riparian-wetland and aquatic areas. In healthy riverscapes, the valley bottom is comprised of active channel(s) and/or active floodplain, which regularly floods (even during periods of low flow). They tend to temporarily retain water, sediment, and nutrients through more diverse flow paths, often forced by structural elements, which maintain physical, chemical, and biological processes that create many of the attributes and ecosystem services. They also typically support complex mosaics of riparian-wetland and/or aquatic habitat across all or most of the valley bottom (Photo 1) and sustain associated ecosystem functions over time, even during flood and drought events (i.e. they are resistant and resilient to extreme events). Few riverscapes in the project are currently functioning at this level.

Photo 1: *Healthy Riverscape: Extensive beaver dams and woody riparian vegetation retain water and sediment, which creates and maintains riparian-wetland and aquatic habitat throughout the entire valley bottom. Riverscapes in this condition act like a natural sponge, soaking up water to dampen floods, where it can later be released downstream. Such a system exhibits frequent and extensive surface water inundation throughout most/all the year, including during periods of low flow or even drought.*

Where riverscape health has declined (common throughout the project area), some portion of the valley bottom width has become disconnected from the stream, as opposed to being regularly engaged by active fluvial processes (e.g. flooding, erosion, deposition). In some places, these "inaccessed" areas were made inaccessible by the historic construction of anthropogenic levees, roads, railroads, realigned channels, and incompatible land uses. More commonly on remote BLM administered lands, structural starvation (lack of beaver dams and large wood), excessive grazing by livestock and wildlife, and the resulting channel incision has led to disconnected, entrenched channels, which contain most floods without engaging floodplains. These altered riverscapes often contain simplified channels that rapidly transport water and sediment through the system, causing a decline in the extent, frequency, and duration of floodplain inundation, as well as their capacity to buffer the effects of flood and drought. Where this has occurred, the riparian-wetland and aquatic zones have correspondingly contracted, and plants adapted to drier conditions have infilled those areas (Photo 2).

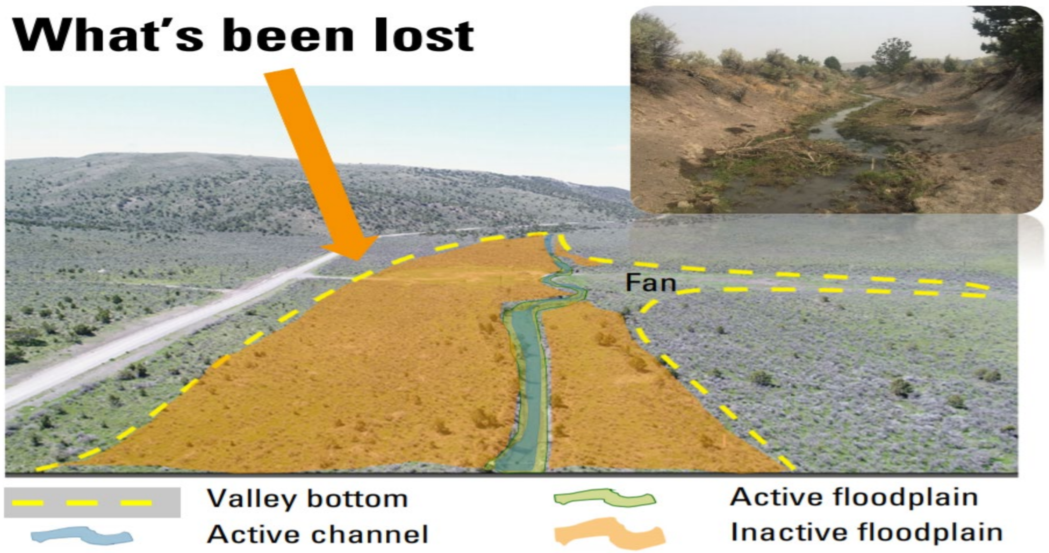

Photo 2: *Unhealthy Riverscape: Without structural elements to capture, spread, and store water/sediment throughout the valley bottom, this oversimplified channel functions like a ditch. The natural "sponge" has dried, so most of the riparian-wetland and aquatic habitat within the historic valley bottom has been replaced by upland plant communities. This degraded stream can no longer buffer floods, retain water at/near the floodplain surface, and may lack the natural water storage it needs to flow year-round, particularly during periods of drought.*

Role of Beaver Dams, Woody Debris, and Historic/Ongoing Impacts on Riverscape Health:

Beaver dams and woody vegetation increase vertical and lateral connectivity between the stream, floodplain, and shallow subsurface aquifers, while increasing the duration of streamflow. These keystone processes are critical to sustaining and/or improving the health of most riverscapes in the project area. However, starting in the late 1700's and early 1800's, there was a rapid expansion of activities that caused a reduction in wood accumulations, riparian vegetation (especially woody plants), and beaver. These include beaver trapping to supply the fur trade, mining, railroad construction, agricultural development (crop, pasture, and rangelands), logging, channel modification, roads, invasive species, livestock grazing, and consequences of climate change (Rienman et al., 2015). This led to an unprecedented scope, scale, and rate of structural starvation, which continues to affect the health and productivity of riverscapes throughout the project area.

Beaver historically altered low-gradient, small stream ecosystems by constructing millions of dams made primarily of wood. Almost every riverscape that had trees or shrubs growing along streams also once had beaver dams and correspondingly more extensive riparian-wetland and aquatic zones, which sustained self-perpetuating supplies of vegetation for dam building activity and wood accumulations. The influence beaver had on these riverscapes prior to European arrival is difficult to overstate. Beaver dams influenced stream complexity by altering patterns of erosion and deposition, resulting in increased physical heterogeneity; increasing lateral connectivity by promoting overbank flows, which are critical for creating and maintaining floodplain habitats and promoting groundwater recharge (Westbrook et al., 2006); and increasing access to water resources for riparian vegetation. Although beaver populations are generally increasing and conservation-oriented resource management practices help to maintain or improve riverscape conditions (especially vegetation), their historic near-extirpation and ongoing policies that favor lethal removal of nuisance beaver (Siemer et al., 2013) has had a significant impact on riverscape health (Goldfarb, 2018; Polvi and Wohl, 2013). These impacts are still observed across the landscape today. In fact, many if not most riverscapes look and function very differently than they did for millennia, prior to European arrival.

Along both wadeable streams and large rivers, large woody debris (LWD) promotes healthy riverscapes by influencing hydraulic conditions, which lead to a structurally-forced pathway to more complex habitat (Abbe and Montgomery, 2003; Montgomery et al., 2003; Wheaton et al., 2019b). Hydraulic and geomorphic diversity creates niches for aquatic biota and conditions to meet the needs of individual organisms throughout a variety of life-stages (Lonzarich and Quinn, 1995; Zalewski et al., 2003). Large woody debris also increases channel-floodplain connectivity and channel planform and lateral mobility by increasing roughness and forcing multi-threaded channels (Gurnell et al., 2002). Like early observations of beaver dams, early accounts describe abundant large woody debris in nearly all forested regions of the continental United States (Kramer and Wohl, 2014; Wohl, 2014), including riverscapes throughout the project area. However, these keystone processes have significantly declined across the planning area, causing previously wet and productive riparian-wetland and aquatic areas to dry and contract.

Current vs. Historic Beaver Dam Capacity, Human Development, and Restoration Potential:

Beaver dams, not beaver themselves; provide the impacts that maintain or improve riverscape health. The Beaver Restoration Assessment Tool (BRAT) was therefore developed (Macfarlane, et al., 2017) to estimate beaver dam capacity, not beaver habitat. Dam building activity varies dramatically according to flow regime and availability of dam building materials. While beaver can survive in wide range of conditions, where they build dams is more limited. Thus, BRAT's backbone is a capacity model developed to assess the upper limits of riverscapes to support beaver dam-building. BRAT (http://www.umt.edu/spatial-analysis-lab/projects/current-work/montana-brat/default.php) was run for the project area and results (Appendix E, Figures 1-18) provide insight to existing and historic beaver dam building capacity, infrastructure/human development, and potential restoration opportunities.

According to the model, there are 2,100 miles of BLM administered stream that can support occasional dam building activity (2-8 dams/mile), 1,350 miles that can support frequent dam building activity (8-24 dams/mile), and 460 miles that can support pervasive dam building activity (24-64 dams/mile). The model also estimates dam building capacity for pre-settlement conditions and therefore, can provide insight to historical changes. Although there is more uncertainty associated with these estimates due to the need for additional assumptions regarding historical riverscape attributes, results indicate that dam building capacity has declined throughout the project area by an average of 9 dams/km. Furthermore, the length of stream for which large dam complexes (greater than 5 dams) could be supported have declined by 57% (from 776 to 332 miles), 24% (from 674 to 514 miles) for medium dam complexes (3-5 dams) but increased by 52% (from 2,850 to 3,500 miles) for small and single dam complexes. Similarly, the miles of stream that could sustain pervasive dam building activity have declined by 53% (from 990 to 460 miles), most of which are now only capable of supporting occasional or rare dam building activity.

Human land and water use activities within the valley bottoms occur throughout the project area, which can impact riverscape health, but also be impacted by beaver dam building activity (creating human-beaver conflict). These changes typically involve roads, culverts, fences, dams, water diversions, drainage ditches, and other infrastructure designed to utilize land and water resources more effectively for multiple use management objectives (i.e., livestock grazing, forestry, recreation access, etc.). In many locations, this infrastructure was emplaced after impacts such as the removal of beaver and/or woody debris diminished stream-floodplain interactions, causing them to dry. As a result, restoration (natural or human induced) of the processes that sustained the pre-disturbance conditions could impact fluvial processes such as flooding, erosion, deposition, or even undesirable tree removal by beaver. To account for these factors, BRAT includes a management model that highlights potential impacts of beaver dam building activity on human activities or infrastructure (Appendix E) and rates the risks accordingly. It accounts for the distance of roads, road crossings, railroads, canals, points of diversion, average land use intensity, and infrastructure from streams and is designed to over-predict the potential risk (to error on the side of caution). Streams for which the risk is low or negligible are considered candidate reaches for restoration, while those that are rated considerable or major risks are not. Risk to infrastructure is classified as negligible along 3,780 miles of stream (86%) and minor along 389 miles of stream (9%). Risk along the remaining 220 miles of stream is classified as considerable (167 miles, 4%) and major (50 miles, 1%). As described in the Proposed Action, techniques that mimic and promote beaver dam building activity would not be used along these high risk reaches if field observations validate the findings or potential impacts could not be easily mitigated. However, they would be considered where the risk is negligible or minor.

The model further subdivides low risk reaches by the likelihood and speed at which successful recovery could be achieved. 1,487 miles of stream (34%) are classified as Easiest/Low Hanging Fruit. These are reaches where mimicking or promoting beaver dam building activity can offer quick results with little risk of conflict based on high existing dam capacity, low departure from historic capacity, and low risk. 520 miles of stream (12%) are classified as Straight Forward/Quick Return. These reaches are where short-term riparian vegetation restoration can quickly increase capacity with little risk of conflict based on some existing dam capacity, low departure from historic, and low intensity land use. 380 miles of stream (9%) are classified as Strategic/Long-Term Investment. These are reaches where long-term riparian vegetation re-establishment is the only option based on low existing dam capacity, high historic dam capacity, and low intensity land use. 2,000 miles of stream (45%) are classified as "NA" because they would present a moderate/high risk to infrastructure, lack existing capacity (because of vegetation, slope, or streamflow constraints), or exhibit high land use intensity.

Stream Evolution: Recovery via Natural Processes take Centuries to Millenia

Human impacts (described above) since the late 1700's and early 1800's have caused a series of changes to riverscape processes and attributes that affect their health, as well as their ability to health themselves. Most of these impacted systems are still responding, even where current management is appropriate. The processes and attributes that change as they degrade and subsequently recover are often similar and predictable (Cluer and Thorne, 2013 Schumm et al., 1984; Simon and Hupp, 1986; Doyle and Shields, 2000; Simon and Darby, 2002; Beechie et al., 2008; Hawley et al., 2011). Although streams are dynamic and always changing; hydraulic, hydrologic, geomorphic (including stream pattern, dimension, and profile), and vegetative attributes of healthy riverscapes are typically maintained at the reach-scale, over time. However, where the dynamic equilibrium between vegetation, hydrology, hydraulics, and geomorphology has been severely disrupted by current or historic management practices (i.e.. by the removal of wood, beaver, water, and/or riparian vegetation), ecological processes that historically maintained site attributes have correspondingly broken-down, causing instabilities (i.e. headcuts) to develop that propagate throughout the system (i.e. channel incision). The resulting morphological adjustments have been so severe in many areas that the systems no longer look or function like they did historically. This is commonly described as a stage change in the stream evolution sequence[8] and is depicted conceptually in Appendix E, *Figures 25* and *26*.

Stages involving channelization, dredging or incision that concentrate flows within the channel accentuate flood peaks and have damaged or washed out physical and habitat features and diminished floodplain interactions. These conditions are common where current or historic management activities have led to structural starvation (e.g. insufficient riparian vegetation, woody debris and/or beaver dams to maintain the complex channel configurations, high water tables, and extensive riparian-wetland and aquatic zones that historically existed). Relative to their potential condition, streams in these degraded stages are unable to support many of their historic ecosystem services (Appendix E, Figure 26). Conversely, the attenuating effects of floodplain and multi-channel morphologies that commonly existed prior to the widespread removal of beaver and wood sustained hydrogeomorphic complexity and ecological benefits. These riverscape processes and attributes support the ecosystem functions and resource values that help the BLM to achieve its multiple use management objectives and regulatory mandates. These conditions are also created and maintained by the processes of beaver dam building activity, wood accumulations, and the growth of riparian vegetation.

Although most riverscapes in the project area are currently supported by single-thread channels with episodic stream-floodplain interactions, multi-channel configurations with more frequent and extensive floodplain inundation better represent the pre-disturbance condition of most alluvial streams. Before these human-altered riverscapes can recover through natural processes, the streams must undergo a series of vertical adjustments involving degradation and aggradation of the bed and subsequent lateral adjustments involving retreat and advance of the banks (Little et al., 1981; Thorne et al., 1981). The need for such adjustments to occur are especially well documented in streams for which the processes of wood accumulation and/or beaver dam building activity are important drivers of function, but historical practices have diminished or eliminated the distribution and abundance of wood and beaver dams throughout the valley bottom.

This is largely because the removal structural elements from these systems has increased longitudinal connectivity (i.e. movement of water & sediment downstream) and reduced lateral and vertical connectivity (movement of water, nutrients and sediment between channel(s)) between the stream and the floodplain components of the riverscape. These altered processes are a concern to the BLM because lateral connectivity: (i) promotes the exchange of nutrients between channels and their floodplains, (ii) provides groundwater recharge and access to water resources for riparian areas, (iii) creates physical heterogeneity on the floodplain, (iv) creates areas of flow refuge during high flow events, and (v) creates important habitats for fish to meet life history requirements (Pollock et al., 2003). Specific consequences of structural starvation are routinely documented and include: headcut formation and associated channel incision; decreased physical complexity and simplification of instream habitat; decreased channel-floodplain connectivity; decreased floodwater capture; increased peak flows and reduced baseflows; decreased groundwater tables and water storage; decreased resistance and resilience to flood and drought; and the conversion of multithreaded channels to single threaded channels (Wohl, 2013; Cluer and Thorne, 2013) that rapidly transport water and sediment out of the system.

These changes have altered riverscapes in the planning area in two distinct ways. First, the absence or decline of beaver dam building activity and wood accumulations has impaired riverscape health. Second, the absence or decline of structural elements has negatively impacted the streams' ability to heal themselves by impacting the processes that are required to create and maintain ecologically

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[8] A stream evolution model/sequence depicts how channels/streams evolve from highly intact stages with diverse geomorphic, hydraulic, riparian, and ecological characteristics to more degraded and low diversity stages; then back to the original/near original stage through a series of physical and ecological adjustments. See Cluer and Thorne, 2014.

functional riverscapes. Although most will recover naturally in the absence of further anthropogenic disturbance via erosional and depositional processes associated with successive flow events, it may take centuries to millennia (Pollock et. al, 2014; Cluer and Thorn, 2013; Beechie et. al, 2007) without intervention, especially where the supply of the requisite "building blocks" (i.e. wood, sediment, water, etc.) has been highly altered and channel incision has occurred. Meanwhile, the riverscapes' functions that support associated resource values will remain diminished or wholly unsupported.

Data on the stage of stream evolution are not routinely collected. However, riparian-wetland areas have been mapped by the Montana Natural Heritage Program (http://mtnhp.org/nwi/) and valley bottom boundaries have been modeled via tools embedded in the Beaver Restoration Assessment Tool (https://umontana.maps.arcgis.com/apps/webappviewer). Through these datasets, it is estimated that riparian-wetland and aquatic areas currently comprise approximately 11% of BLM administered valley bottom area. Furthermore, less than 1% of the mapped riparian-wetland areas contain beaver dams, even where BRAT indicates capacity for dam building activity exists. Although the accuracy and precision of these data have not been quantitatively evaluated, these results, when combined with related qualitative observations, indicate that few streams are functioning at their potential. Instead, many have been impacted by the historic removal of beaver, large wood, and other land use practices that that have converted complex, multi-thread channels that historically supported riparian-wetland and aquatic habitat across the entire valley bottom to simplified, single-thread channels that currently occupy only a small fraction of the valley bottom. As a result, the spatial extent of riparian-wetland and aquatic areas have declined throughout the project area and most riverscapes are now adjusting at various rates between Stage 1 (sinuous, single thread channel) and Stage 8 (complex, multi-thread channels) in the stream evolution sequence. Each of the stream stages and corresponding changes to physical and vegetative attributes are estimated and summarized in *Cluer and Thorne, 2013, Table II: Physical and Vegetative Attributes for Each Stage in the Stream Evolution Model and conceptually illustrated in Appendix E, Figures 25 and 26*.

Field Assessments:

The BLM routinely evaluates the health of riparian-wetland areas against the Montana/Dakotas Standards and Guidelines for Rangeland Health via Proper Functioning Condition (PFC) Assessments (TR1737-15, 2015). Through this process, streams are categorized as either Properly Functioning Condition (PFC), Functioning-at-Risk (Trend Improving, Static/Non-Apparent, or Declining), or Non-Functioning. The minimum acceptable management goal for a stream is at least proper functioning condition (PFC) because any rating below PFC indicates a condition that is not sustainable. The BLM must ensure that riparian-wetland areas are at or making significant progress towards PFC. However, field offices may also need to improve conditions beyond the minimum regulatory threshold (between PFC and Potential Natural Condition (PNC)) to attain related objectives in our resource management plans.

When they function properly, they dissipate energy from high waterflow, thereby reducing erosion and improving water quality; capture sediment and aid floodplain development; improve floodwater retention and ground-water recharge; develop root masses and plant communities that bind sediment and sustain complex hydraulics and maintain channel characteristics associated with the potential of the stream (TR 1737-15, 2015). If a riverscape is functioning properly, then processes are typically in place to create and maintain values associated with the potential of the reach, such as quality habitat and clean water. If, on the other hand, the system is not functioning properly, it is likely that these values will be impaired (Harman et al. 2012; Shields et al. 2010). As of 2018 (last year PFC data were summarized for national reporting), the BLM had assessed 4,191 miles of stream within the project area. Of those, 75% were rated either PFC or FAR with an improving trend (Chart 1).

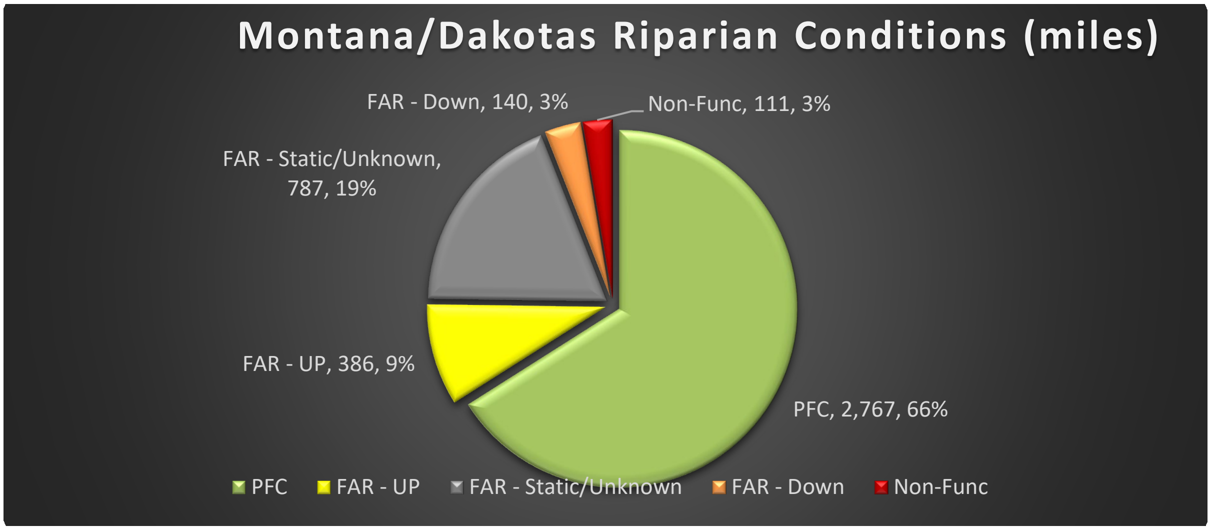

Chart 1: *Riparian assessment ratings for BLM administered streams in Montana, North Dakota, and South Dakota through 2018.*

Although the accuracy and precision of these qualitative assessments is typically too coarse to estimate trend at the reach-scale, results from a broad comparison of riparian conditions between 2001 and 2018 (first and last year's that PFC data was summarized for national reporting) indicate that regionally, conditions have likely improved (Chart 2).

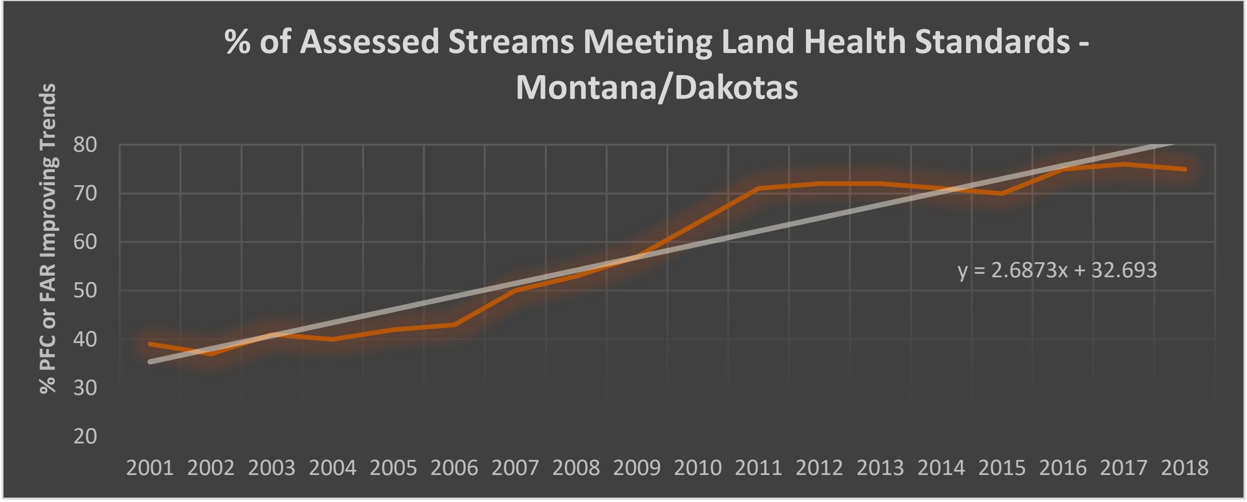

***Chart 2**: Riparian PFC Status and Trends – Statewide*

In fact, assuming that the assessed riparian reaches are representative of the population (i.e. all streams have been equally likely to be assessed, irrespective of condition) and that systematic bias of the assessment crews has been absent or negligible (i.e. no systematic bias towards positive or negative ratings), it's reasonable to conclude that riparian conditions at all of our field offices are better than they were in 2001.

However: (a) some streams have crossed a functional threshold and are unlikely to satisfactorily improve via passive management strategies, alone (i.e., riparian grazing management) and (b) attaining PFC does not necessarily mean that physical, chemical, and biological processes are unaffected, or that the desired ecosystem services are fully supported. For example, sediment, thermal, or nutrient regimes could remain impaired; the riparian-wetland extent may only represent a small fraction of historical conditions;

resistance/resilience to drought and flood may be limited, or a species of management concern could be better supported under a different state of channel evolution or vegetation succession. In such situations, further improvements may be necessary to achieve specific ecosystem objectives but require physical restoration of the processes that historically maintained those attributes.

Vegetation (including invasive and disclimax species) within the Valley Bottom[9]

The BLM administers approximately 1.3 million acres of valley bottom, which contain approximately 140,000 acres of riparian-wetland and aquatic habitat, distributed in complex mosaics throughout the region. These plants increase drag and surface roughness, resist erosion, and create obstructions to flow both within active channels and across the valley floor (e.g., Collins et al., 2012; Aberle and Järvelä, 2013). In so doing, they slow surficial flows, augment overbank flows, and promote the influent stream conditions that help to hydrate valley bottoms.

Many of the valley bottom areas that lack riparian-wetland and aquatic habitat currently only support species adapted to drier conditions (i.e., upland and facultative vegetation). This is often because the riverscapes are structurally starved and therefore, lack sufficient lateral and vertical hydrologic connectivity between the stream channel(s), floodplain, and floodplain aquifer. However, many of these areas were historically wetter, under greater influence of fluvial processes (erosion, deposition, inundation, etc.) and supported riparian-wetland plants that contributed more to the health of the overall system than the facultative and upland plants that currently occupy these zones. Consequences of these altered plant communities on the health of the overall riverscape are further exacerbated where: (i) disclimax plant communities and invasive species, (ii) grazing by wildlife and livestock, and (iii) human development have further reduced the type and amounts of deciduous woody vegetation grown and/or incorporated to the system.

Feedback Loop Between Physical Processes and Vegetation Attributes: Factors such as the kind, proportion, and amount (cover or density) of vegetation directly influences a riverscape's ability to sustain physical processes and associated ecosystem functions. Similarly, vegetation attributes and the structural elements that they supply to the system directly influence the hydraulic, hydrologic, and geomorphic processes and attributes that sustain plant community dynamics and associated ecosystem services. As a result, changes to any of the physical or vegetation attributes can initiate a cascading sequence of feedback loops that alter the health of the entire system. Throughout the project area: (a) altered physical processes and attributes have correspondingly impacted vegetation attributes, and (b) altered vegetation attributes have correspondingly impacted riverscapes' ability to sustain physical processes and attributes that maintain or improve riverscape health.

Effects of physical processes on vegetative attributes: There is strongly positive feedback between hydrologic connectivity, geomorphic complexity, and vegetation attributes. This is because vegetation type and density also influence the amount and spatial distribution of obstructions within the active channel(s) and floodplain associated with the presence of vegetation, large wood (e.g., Wohl et al., 2017b), and beaver dams (Pollock et al., 2017). These obstructions increase subsurface hydrologic connectivity and hyporheic exchange flows (e.g., Sawyer and Cardenas, 2012; Wang et al., 2018; Doughty et al., 2020), as well as surface hydrologic connectivity by promoting lateral channel migration (e.g., Eaton and Hassan, 2013), formation of multi-threaded channels (John and Klein, 2004; Collins et al., 2012; Polvi and Wohl, 2013), and enhanced overbank flows (Brummer et al., 2006; Westbrook et al., 2006). These processes directly influence the elevation of the floodplain water table, which affects the types, densities, and vitality of vegetation.

A wide variety of current and historic land uses have affected physical riverscape processes and attributes

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[9] This section expands on the discussion of vegetation in Section 3.1.1

(as described in Sections 3.0 and 3.1.1 (above)), which have correspondingly impacted vegetation attributes within the systems. Many of these changes relate to a transition from complex, multi-thread channels to simplified, single-thread channels that interact less frequently and/or extensively with their floodplains. These impacts have diminished hydrologic connectivity and correspondingly lowered the elevation of floodplain water tables. Consequences of these changes on vegetation include a decline in the distribution and abundance of riparian-wetland plant communities, and a corresponding increase in the species adapted to degraded conditions (especially non-native and upland plants). Some Special Status Plant Species have seen a decline in population vigor and decline in suitable habitat to maintain populations. Appendix F Table 9 shows the SSS Plants that could occur within project areas.

Effects of vegetation attributes on physical attributes: Riparian plants stabilize soil, capture and retain sediment, cycle nutrients, and facilitate the development of complex geomorphic features. They also supply material for beaver dam building activity and wood accumulations, which are critical for sustaining the hydraulic, hydrologic, and geomorphic attributes that create high water tables and extensive, topographically complex riparian-wetland and aquatic zones. As a rule-of-thumb, native riparian-wetland and aquatic plant communities (e.g. aspen, willow, cottonwood, red osier dogwood, alder) historically found in the region's valley bottom are better adapted to the physical attributes historically associated with these areas. Therefore, these species are typically better equipped to sustain biophysical functions that create and maintain healthy riverscapes and associated habitat for native species. This is especially true for riverscapes that require beaver dam building activity to maintain their health, as many upland, disclimax, and non-native species are either not preferred or unsuitable for forage and dam building. Other limitations on the number, extent, or strength of beaver dams include size constraints of the deciduous woody trees/shrubs (larger trees/shrubs resist blow-out more than smaller trees/shrubs), as well as density, distribution, and vigor of preferred species (dam density and size are positively correlated with physical processes that create healthy riverscapes). The capacity of vegetation to sustain dam building activity is estimated to have declined in most ecoregions (Appendix E, Figures 1-9).

Disclimax Plant Communities and Invasive Species: Throughout the project area, invasive species and disclimax plant communities are present. These plants and plant communities often represent an anthropogenic disturbance that correspondingly reduces the extent and distribution of their native/historic counterparts. Where present and abundant, some disclimax plants and invasive species can adversely impact the riverscapes' ability to sustain or restore the biophysical processes, which maintain or improve riverscape health and associated habitat values. The BLM and nearby land managers routinely implement treatments to remove or reduce the spread of disclimax plant communities and invasive species. However, given the extent of the problem, changing climate, and degree to which riverscape processes that historically controlled native plant distributions have been altered, associated impacts to riverscape health are likely to continue or increase into the foreseeable future.

Disclimax Plants: Conifer encroachment into the current or historic riparian-wetland zone is widespread, especially in Western Montana (Photos 1a-b and 2a-b).

Photos 1a and 1b: Mill Creek Gulch, Conifer Expansion – 1979 vs. 2015. These repeat photos illustrate the extent to which conifer expansion is occurring across the landscape.

Photos 2a-b: Centennial Valley, MT, 2015. – Abandoned beaver dams, conifer encroachment, and loss of wetland hydrology. (2a) Left - Historically, this channel held water for most of the year and supported the growth of deciduous trees/shrubs that beaver used to construct dams and retain water on the landscape. However, beaver no longer occupy the reach, the channel is now ephemeral, conifer have replaced many the historic deciduous plants, and the water/vegetation needed to restore the system is no longer present. (2b) Right- Conifer encroachment, loss of beaver, and excessive grazing by livestock and/or wildlife have caused this historic wetland to dry and contract. Restoration of this site would require land managers to address each of these factors.

These impacts are often attributed to fire suppression, climate change, riverscape degradation, and/or excessive ungulate browse of the competing native deciduous species. Where this occurs, there is typically a corresponding decline of the riparian-wetland vegetation that historically sustained riverscape health and recovery processes (i.e., beaver dam building activity and/or wood accumulations). Furthermore, due to conifer's ability to consume large quantities of water and alter wind redistribution of snow (by blocking wind that historically caused snow drift formation and prolonged snow-melt), encroachment has further impaired riverscape health and associated resource values in many areas, directly through impacts to the hydrologic cycle.

Invasive Plants: Invasive plants are common throughout many BLM administered riverscapes. Like disclimax plant communities, they can displace the native species that historically sustained the health and attributes of these systems. Relative to healthy riverscapes, where the conditions in which native plant communities evolved are maintained, invasive trees/shrubs are often better equipped to compete in degraded or anthropogenically modified systems. Throughout the project area, the BLM routinely implements projects to remove invasive species. Although many of these projects reduce the density, distribution, and spread of invasive plants, they are expected to persist throughout the project area. Where they have displaced the native species that historically supplied material for beaver dam building activity and wood accumulations, natural and/or human accelerated riverscape recovery rates may be slowed, altered, or even halted.

Some of the most prevalent issues are associated with salt cedar and Russian olive trees along mid-to-low elevation perennial streams. They spread rapidly along riverbanks, replace cottonwood, aspen, willow, and other native species, and use large volumes of water during the warm summer months. As a result, they reduce the supply of native woody plants for beaver dam building activity and wood accumulations, increase soil erosion, and decrease wildlife habitat and recreational opportunities.

Grazing by Wildlife and Livestock:

Grazing by livestock and wildlife is nearly ubiquitous in the project area. These uses can alter the amount, structure, and community composition of vegetation within riparian areas through consumption, selection, and trampling. Where excessive (e.g. due to livestock and/or where prey-predator imbalances exist), these alterations to vegetation remove important drivers of stream morphology, from channel-forming large wood to bank-stabilizing roots, while the compaction and shear of their hooves alter the physical form of floodplains and reduce riparian habitat quality for wildlife and aquatic species. Such impacts are often associated with decreased habitat quality for aquatic taxa in the form of decreased streambank stability, higher concentrations of fine sediments, decreased riparian vegetation, and altered food webs. Where grazing pressure is high enough to reduce the vigor, extent, and distribution of woody plants, the riverscapes' capacity to sustain woody debris accumulations or beaver dam building activity often correspondingly declines. Cumulatively, these grazing impacts can impair riverscape health, as well as recovery potential.

To minimize or avoid these adverse impacts, BLM managers increasingly use conservation-oriented livestock grazing strategies that mitigate impacts to vegetation, biodiversity, and hydrology within the stream corridor. These strategies attempt to balance grazing periods with opportunities for plant growth by adjusting grazing season, duration, and intensity, and often include a combination of tools and techniques designed to improve livestock distribution and reduce use of riparian areas. However, the legacy effects of livestock and wildlife grazing can persist long after the issues have been corrected and many impacted riverscapes will remain especially sensitive to further use during the stream evolution process. This is particularly true where the supply of native woody plant communities is already diminished by the combined effects of channel incision, invasive species, the formation of disclimax plant communities, and/or other factors.

3.1.2 Environmental Effects - No Action Alternative

The BLM would not apply the Proposed Action to mimic, promote, and sustain the processes that historically maintained the attributes and resource values of riverscapes in Montana, North Dakota, and South Dakota. Instead, the BLM would continue to maintain or improve riparian-wetland conditions primarily through the application of BMPs, which minimize or avoid current impacts associated with land use authorizations (i.e., livestock grazing management, road construction/maintenance, forestry BMPs, etc.). There may be scattered, individual physical restoration projects authorized on a case-by-case basis. However, few physical restoration projects would be implemented to address historical impacts that continue to affect the health of riverscapes and their capacity to repair themselves. Not only would this limit the scope of restoration, it would often cause lengthy delays between the identification of an issue/opportunity and the implementation of the corrective action. As a result, the consequences of structural starvation, grazing by livestock and wildlife, invasive and disclimax plant communities, headcuts, and climate change will continue to impair the health of riverscapes. Although most impacted systems will recover naturally in the absence of further anthropogenic disturbance via erosional and depositional processes associated with successive flow events, it may take centuries to millennia (or longer) without intervention, especially where the supply of the requisite "building blocks" (i.e. wood, sediment, water, beaver, etc.) has been highly altered and channel incision has occurred. Meanwhile, the riverscapes' functions that support associated resource values will remain diminished or wholly unsupported. These impacts will be amplified by the effects of climate change, further limiting the rates of riverscape recovery and the ecosystem services they historically supported. The rate and magnitude of recovery would therefore not be sufficient for the BLM to meet or exceed some of the associated goals and objectives in our resource management plans (RMPs), the Montana/Dakotas Standards and Guidelines for Rangeland Health, or the Fundamentals of Rangeland Health (43 CFR 4180.1).

Beaver populations would be maintained or expand to new areas as riverscapes recover slowly or areas that contain beaver approach their maximum population capacity. However, the combined influence of riverscape degradation and climate change on the timing and distribution of water and vegetation would slow or even halt recovery in some areas. Since riverscape recovery would occur much slower than under the Proposed Action, beaver populations and distributions would correspondingly increase at a slower rate, especially where the probability for human bever conflict is low. Where human beaver conflict is high, revery rates would be similar to the Proposed Action because beaver dam building activity would not be promoted in these areas via either alternative. Where undesirable flooding or tree removal occurs, beaver mitigation strategies would not be applied to minimize or avoid these impacts. Instead, nuisance beaver would typically be removed via lethal practices. Therefore, they would not be allowed to remain in place to sustain ecological processes that improve riverscape health. However, where expansionary beaver populations exist nearby and suitable habitat for dam building activity is present, the effects of lethal removal on undesirable flooding and tree removal may be short-lived. This is because new beaver would likely re-occupy the niches that are left behind, leading to a re-current cycle of undesirable flooding, tree removal, and the subsequent lethal removal of beaver. Without the application of beaver mitigation strategies to minimize or avoid undesirable dam building activity and tree removal, while allowing beaver to remain in place, riverscape recovery would occur more slowly, while undesirable flooding and tree removal may persist.

Impacts to Hydraulics: The distribution of structural elements would not be increased to restore hydraulic diversity to oversimplified, structurally starved riverscapes. Without more hydraulic diversity, degraded streams will erode, disconnect from, or not re-develop the complex array of geomorphic features that historically existed. As a result, residence time, length of hydrologic flow paths, and riparian plant communities will remain far below the reaches' potential. Impacted streams will therefore provide fewer and less diverse habitat niches for native flora and fauna, making it more difficult for species to meet their lifecyle needs, particularly when the impacts are amplified by climate change.

Impacts to Geomorphology: Without the Proposed Action to restore the distribution of structural elements and riparian vegetation, structurally starved riverscapes will not have the hydraulic diversity needed to create gradients in flow energy that amplify geomorphic processes of erosion, deposition, transport, and storage of sediment. As a result, oversimplified, homogeneous plan-bed stream types will persist, which lack the diversity of geomorphic units (e.g., bars, pools) that historically supported habitats and distributed water across the valley bottom through longer and more diverse hydrologic flow paths. Similarly, more heterogeneous and complex in-channel and floodplain habitats will not develop. Impacted reaches will have less miles of primary/secondary channel, fewer confluences and difluences, lower diversity of pools, mid channel bars, and riffles; and large portions of the historically active valley bottom will not be engaged frequently enough to support extensive riparian-wetland and aquatic zones. These impacts will amplify impacts to water availability and the resistance and resilience of riverscape ecosystems to the predicted increase in drought, flood, and wildfire.

Impacts to Hydrology: Without the Proposed Action to restore the distribution of structural elements and riparian vegetation, there will not be sufficient flow obstructions to disrupt longitudinal connectivity (from upstream to downstream) and increase lateral and vertical connectivity between the stream, streambed, and floodplain aquifer. Water and sediment will be confined to the channel rather than spread across the floodplain; floodplain aquifer levels will not be restored; and the spatial extent of the riparian zone will remain diminished. These impacts will be amplified by the effects of climate change on flooding and drought. Specifically, as the occurrence and intensity of drought increase, less water will be stored within the valley bottom and slowly released to support ecological processes during dry periods. The energy associated with large floods will also be concentrated within steeper, less complex channels, rather than distributed across multiple channels and/or large proportions of the valley bottom that support deep-rooted riparian vegetation. These attributes will predispose impacted streams to flood impacts that could further unravel ecological processes that maintain or improve riverscape conditions.

Impacts to Vegetation: Vegetation treatments would not be implemented to ensure sufficient native vegetation (types and amounts) is present to sustain the processes of beaver dam building activity and wood accumulations. Livestock and wild ungulates would continue to browse riparian vegetation and, in some locations, may limit the growth and expansion of native deciduous trees and shrubs. Shrubs and trees would not be strategically planted to riparian-wetland areas where they are absent/limited and needed to support recovery. Disclimax conifer and invasive plants would continue to displace native riparian plants and increase competition for water, nutrients, and light. As a result, the woody materials that riverscapes need to recover through natural processes may not be available. This would slow or halt the evolution of streams from degraded stages in the stream evolution sequence to healthier stages that historically supported riparian vegetation across most of the valley bottom. As a result, large proportions of the valley bottom will continue to support upland, disclimax, and non-native plants that are better adapted to valley bottom areas no longer influenced by the fluvial processes that historically supported diverse arrays of native riparian-wetland plants.

Riverscape degradation, combined with the impacts of climate change, will further impact vegetation. This is because increased temperatures will correspondingly increase plant water demands. At the same time, the frequency of warm season droughts is expected to increase, as will the intensity of both seasonal and prolonged drought. Since riverscape processes that historically spread water across the floodplains and maintained high water tables will not be restored, there may be even less water to meet the demands of riparian-wetland and aquatic plants. This could cause an even greater shift towards upland plants, invasive and disclimax species, as well as a reduction to the native deciduous plants that historically sustained beaver dam building activity and wood accumulations.

3.1.2.1 Cumulative Effects — No Action Alternative

Past, present, and future impacts (Section 3.1.1) from a diverse array of people, organizations, and management actions within watersheds in which the Proposed Action would be applied will cumulatively impact the conditions of riverscapes at the scale of the reach or entire stream network. Impacts from beaver trapping to supply the fur trade, mining, railroad construction, agricultural development (crop, pasture, and rangelands), logging, channel modification, roads, invasive species, livestock grazing, and consequences of climate change (Rieman et al., 2015) will continue to affect the health and productivity of riverscapes throughout the project and surrounding area. Improved forestry practices, riparian grazing management, travel management, weed control, road maintenance, and the application of BMPs to new land use authorizations will minimize or avoid many of impacts that existing and future land uses have on riverscapes. However, historical impacts that have caused structural starvation, channel incision, and diminished riparian-wetland zones will continue to impair the capacity of riverscapes to heal themselves. Consumptive and non-consumptive water uses, coupled with the impacts of climate change on temperatures, evapotranspiration demands, snowpacks, the timing and duration of streamflow, and expectations for increased water demands during the warm season will further stress riparian vegetation that already lacks sufficient access to water. This could cause the replacement of native riparian plants with upland or non-native species, which are less capable of stabilizing soils or supplying the types and amounts vegetation needed for beaver dam building activity and wood accumulations. These impacts will degrade riverscapes further or limit recovery rates. More frequent and intense wildfires, drought, and flooding may further impair degraded riverscapes, as they will be less resistant and resilient to the disturbances than reaches that were restored via application of the Proposed Action.

Scattered, individual physical restoration projects authorized on a case-by-case basis would continue to improve the conditions on BLM and non-BLM lands. However, the scope of degradation would continue to far exceed the scope of restoration. Degraded conditions on BLM administered riverscape reaches will continue to impact the health of reaches downstream. Water would not spread across the historically active floodplain areas to buffer the impacts of flooding (within and downstream of the reach), sustain complex valley bottom attributes, recharge floodplain aquifer, or support the growth of more extensive riparian-wetland areas. Instead, water, sediment, nutrients, and organic matter from upstream reaches would be quickly routed through BLM administered reaches, where the high flow velocities and sediment loads could wash out physical stream attributes and further impair downstream segments. Without high water tables and abundant woody material to sustain wood accumulations and beaver dam building activity, downstream segments may not receive the supply of wood, water, and sediment when and where it is needed to support recovery of the processes that maintain or improve riverscape health. Similarly, degraded riverscape reaches and land use practices on non-BLM administered areas of the watershed(s) would continue to alter the supply of water, sediment, and wood that BLM administered stream reaches need to recover. Without the application of the Proposed Action to ameliorate these issues, improvements to BLM administered stream segments may be slow or not occur. In some areas, riverscape conditions will deteriorate further.

3.1.3 Environmental Effects - Proposed Action

The Proposed Action will mimic, promote, and sustain natural riverscape processes that historically maintained the health of most alluvial stream segments in the project area. The primary impacts are to the hydraulic, hydrologic, geomorphic, and vegetative processes and attributes of the valley bottom, which change when streams recover from less complex/healthy to more complex/healthy stages in the stream evolution sequence ((Section 3.1.1, as well as *Cluer and Thorne, 2013, Table II: Physical and Vegetative Attributes for Each Stage in the Stream Evolution Model*). Although all four types of actions (addition of structural elements, vegetation management, headcut control, and beaver mitigation) target the general impairment of structural starvation, each will address separate, but related issues that are limiting the ability of the systems to maintain or repair themselves. These impacts will maintain the health of riverscapes that are at-risk of degradation and/or accelerate and sustain the transition of degraded riverscapes that no longer support many of the associated ecosystem services; to healthier stages in the stream evolution sequence, which can and previously did support those resource values. Specifically, the Proposed Action will create wetter riverscapes with more geomorphic, vegetative, hydraulic, and hydrologic complexity, as well as more extensive riparian-wetland and aquatic zones (Appendix E, Figures 25-26) This will make the riverscapes more ecologically productive, as well as resistant and resilient to disturbances such as drought, flood, climate change, disclimax and invasive species, and grazing by livestock and wildlife.

Impacts will occur over time, according to the rate over which the stream and floodplain processes can do the work. Given this reliance on natural processes, there is an inherent level of uncertainty over the magnitude and rate of change associated with each treatment. Many of the expected changes will occur episodically (largely in response to successive flood events) and vary between riverscape reaches (due to differences in physiographic settings and hydrogeomorphic attributes), as well as over time (due to differences in weather and associated streamflows). Recovery may be slower in riverscapes with streams that are more resistant to lateral erosion, are in a highly degraded state, experience less frequent or intense flood pulses, contain limited amounts of the type of vegetation needed to sustain recovery, are disconnected from existing beaver populations, contain human development within the valley bottom that constrains stream-floodplain interactions, and/or are located in watersheds in which the supply of water and/or sediment has been highly altered by other human disturbances (i.e. stock impoundments, water diversions, groundwater depletion, etc.). Conversely, recovery will be faster where the opposite is true. Some treatments may produce smaller, slower, or even different effects than initially anticipated. To compensate, adaptive management strategies (Appendix H) will help to ensure that project goals and objectives described in this analysis are achieved and that the potential for adverse impacts are minimized or avoided. In the long run, the overall benefits for riverscape ecosystems are expected to greatly exceed any unintended or undesirable impacts, which would be minor (relative to the No Action Alternative), temporary, and mitigated via adaptive management.

Impacts will vary over the short and long-term. Although each type of treatment will have correspondingly unique impacts (as described below), in the short-term, beaver mitigation, vegetation management, and headcut control techniques will minimize or avoid the fluvial processes that create simplified streams and concentrated flow within the channel. They will also help to maintain the conditions that riverscapes need to recover. Relative to the No Action Alternative, these impacts will halt, slow, or reverse riverscape degradation and the unravelling of ecologic processes. Conversely, the addition of structural elements (BDAs and PALs) will immediately increase hydraulic complexity and associated hydrogeomorphic adjustments (channel widening, bed aggradation, sediment sorting, hydrologic connectivity, nutrient cycling, etc.), accelerating the rate at which degraded streams develop more complex morphologies; frequent, extensive, and diverse types of floodplain inundation; and higher floodplain water table elevations. During these periods of transition, geomorphic, vegetative, hydraulic, and hydrologic disturbances would be greater in frequency and magnitude than would occur under the No Action Alternative. However, accelerating riverscape recovery will correspondingly accelerate the rate at which they can provide desirable ecosystem services. Furthermore, the addition of structural elements will reduce stream power, capture sediment, and prevent or reverse streambed incision; thereby minimizing or avoiding the unravelling of ecological processes that commonly occur when structurally starved riverscapes experience large floods. In the long run, all the treatments will function individually and collectively to maintain or improve riverscape health.

These impacts will increase the ecosystem services that riverscapes provide and help them to buffer the effects of climate change. As the frequency, intensity, and duration of drought, flood, and wildfire increase, the Proposed Action will help to sustain the associated resource values by elevating water tables, the relative abundance of standing water (e.g., Hood and Bayley, 2008; Fairfax and Whittle, 2020), and geomorphic complexity. Sediment pulses that can severely damage dysfunctional channels in the aftermath of wildfire or extreme floods would be distributed and attenuated across more complex and hydrologically connected valley bottoms, resulting in less significant impacts. Resistance to adverse impacts from severe flooding will also increase because wide, vegetation-stabilized floodplains and, in some cases, the presence of multiple channels, will attenuate flood peaks and reduce hydraulic force per unit area exerted against the channel and floodplain boundaries (e.g., Hillman, 1998; Nilsson et al., 2018). For similar reasons, the Proposed Action will lessen the effects of drought by increasing subsurface water storage, potentially supporting, or enhancing local and downstream base flows (Wegener et al., 2017).

Some projects/treatments would mimic, promote, and sustain beaver dam building activity. As noted in Section 3.1.1 and Appendix E, Figures 13-16) some stream reaches contain human infrastructure or alternative uses that could be adversely impacted by flooding or undesirable tree removal. However, the risk is rated negligible or minor along 95% of the reaches (4,175 miles). The probability for adverse impacts to infrastructure on these reaches would be correspondingly low and if they were to arise, they would be minimized or avoided via application of the beaver mitigation strategies and through coordination with state wildlife management agencies. Of the remaining 220 miles of stream for which dam building is possible, 170 miles are rated considerable risk, while 382 miles are rated major risk. The Proposed Action would not be applied to these reaches if field observations validate these determinations. Consequently, these reaches are unlikely to be impacted, but by avoiding these areas, impairments to riverscape health would continue.

Organization of the analysis: The impacts analysis is divided by treatment type. However, since impacts will be caused primarily by an increased supply of structural elements (artificial and natural), associated impacts are the focus of the analysis. As a result, the following section emphasizes and subdivides the hydraulic, hydrologic, geomorphic, and vegetative processes and attributes that change when structural elements are increased and sustained through the Proposed Action. Impacts from vegetation management, headcut control, and beaver mitigation techniques are also analyzed, but the corresponding impacts for hydraulic, hydrologic, geomorphic and vegetation riverscape attributes are lumped.

Addition of structural elements (i.e., artificial beaver dams and wood accumulations): Beaver dam analogs (BDAs) will mimic and promote the processes of beaver dam building activity, while post-assisted log structures (PALS) will mimic and promote accumulation of large woody debris (LWD). Both types of structural elements will have similar impacts as their natural/historic counterparts. Conceptually, they will create more healthy, complex riverscapes by forcing more diverse hydraulics; which will create gradients in flow energy that amplify geomorphic processes of erosion, deposition, transport, and storage of sediment; which will shape and build more diverse geomorphic units (e.g., bars, pools); which will provide more heterogeneous and complex in-channel and floodplain habitats; which will provide more niches and biodiverse riverscape ecosystems. These impacts are further described below. They will occur at or near the individual structures, but more importantly, the complex of structures will complement one another to collectively mimic and promote the hydraulic, hydrologic, geomorphic, and vegetative changes at the reach-scale.

Impacts to Hydraulics: BDAs will create slow-moving, deep water upstream of the structure. They will also increase stream roughness (resistance to flow), create variable hydraulics, increase sediment sorting, promote bar development, and form complex topography. In homogenized and simplified streams (degraded streams in which the Proposed Action would be applied), sediment deposited behind the BDAs will be sorted from larger to smaller as water approaching the dam face slows, diminishing the capacity to suspend larger sediment. This deposition will also aggrade the streambed and further increase stream-floodplain interaction. Cumulatively, these impacts will increase vertical and lateral connectivity between the stream, floodplain, and groundwater, while reducing flow velocity and extending flow duration. Furthermore, by immediately creating deep water, BDAs will create an important habitat feature for beaver to re-occupy the system (McKinstry and Anderson, 2002) and sustain recovery processes.

PALS will create more variable flow patterns and force areas of high and low velocity and shallow and deep water (Camp, 2015a). Channel-spanning PALS will force deeper, slower velocity water upstream of the structure and increase velocity as water flows over the top of the structure. Over time, some may rack up material that reduces their permeability to provide a similar function as a BDA. Mid-channel PALS will force flow to split into two separate flow paths, where it will often create eddies in the lee of the structure. Water split around a mid-channel structure is often faster and shallower initially but may force scour pools on either side of the structure or channel widening. Bank attached PALS will shunt flow to the opposite side of the stream from the bank to which it is attached, causing water to converge, increase in velocity and depth. As flow moves past a bank-attached structure, it will diverge and form eddies, where flow is slower and often shallower. The force of these hydraulic responses will be influenced by the size, shape, degree of channel constriction, and orientation of the PALS. Diverse hydraulics will provide important habitat characteristics (e.g., energy refugia, predation refugia, prey delivery, oxygen delivery) for fish and other aquatic species that enable them to satisfy their specific life-stage needs. In general, as flows become constricted, the energy dissipated on the stream bed or bank will become higher per unit area (i.e., increase in unit stream power), increasing the ability of the water to scour localized pools.

Impacts to Hydrology: BDAs will restore the historic timing and magnitude of streamflow by forcing temporary storage in ponds and groundwater. They will also increase channel-floodplain (i.e., lateral) connectivity by influencing the frequency, duration, and extent of overbank flows. BDAs may increase overbank flows both by channel aggradation and increased instream roughness. Where side channels or high flow channels are present, BDAs will re-activate their hydrologic connections to the main channel, increasing total stream length and diversifying residence time of water. Depending on the local geomorphic setting and BDA design, they may produce channel-floodplain connectivity and overbank flows during baseflow or high flow conditions. Increased overbank flow will often recharge ground water and raise the water table, providing the water resources necessary to promote riparian expansion; attenuate peak flows and increase baseflow. Water recharge and an increase in the hydraulic head of surface waters may also force the exchange of water and nutrients between the stream, bed, and banks (hyporheic flow), which can produce cool zones of upwelling that provide temperature refugia for aquatic species (Weber et al., 2017) and sequester pollutants via microbial activity within the hyporheic zone.

PALS will increase instream roughness, which promotes channel-floodplain connectivity. Like BDAs, PALS will divert flows into side-channels or high-flow channels. By increasing water depth or diverting flows into stream banks, PALS may also force increased surface-groundwater interaction and produce areas of upwelling downstream by slowing water and increasing water depth (i.e., surface water and groundwater exchange). The hydrologic impact of PALS will typically be most pronounced during high flow conditions; however, channel-spanning PALS, which have sufficiently racked up material to decrease porosity, may force overbank flows even at low discharges.

Impacts to Geomorphology: BDAs will increase sediment retention, channel aggradation, and sediment sorting. Increased sediment retention, especially of fine sediment, may improve water quality. Deposition of sediment behind the dams will cause channel aggradation, leading to increased channel-floodplain connectivity and accelerated channel incision recovery. BDAs that breach may lead to geomorphic changes such as increased channel width and sinuosity (Pollock et al 2014), as well as a source of sediment to aggrade the bed or form new geomorphic surfaces downgradient. This is natural during the widening phase of stream evolution and is often essential to reduce stream power, retain sediment, and build geomorphic features like inset floodplains and bars with well sorted sediments on which diverse riparian plant communities can grow. Additionally, where bed incision is limited or a new inset floodplain is forming, BDAs may re-connect relic channels and even create new ones. In some locations, BDAs may even force new flow paths onto a floodplain surface, leading to the eventual formation of a new channel when return flows head-cut back to the structure. Some BDAs will be occupied, expanded, and maintained by beaver. Geomorphic processes will be accentuated by the dam building activity, but also by the channels and tunnels that beaver often dig, which can lead to further side channel formation and water storage.

Like beaver dams, BDAs may be breached during high flow events. The outcome of a breach will depend on how the BDA is breached, the type of BDA and the local geomorphic setting. BDAs may breach in the center of the structure by overtopping or along the bank by endcuts. The type of breach will therefore control the local geomorphic response; overtopping will result in a scour pool below the structure, while endcuts will promote bank erosion, channel widening and an increase in sinuosity. While individual

BDAs may breach and/or force erosion locally, sediment that is mobilized will generally be captured at downstream structures, where it will be sorted and used to create new geomorphic features.

PALS will create more complex patterns of erosion and deposition, which will increase the diversity and abundance of geomorphic units. Depending on the specific location and structure type, PALS may force: bank erosion, channel widening, lateral migration, channel avulsions, scour pools, plunge pools, bar creation, sediment sorting, and channel aggradation. Some processes, such as channel avulsions and bank erosion, are essential processes for the ongoing recruitment of natural large woody debris necessary to sustain physical complexity. In the long-term, PALS will increase overbank flows, recruit new wood to the system from banks and floodplains, increase the movement of wood within the system, and kickstart the biophysical feedback loops that sustain wood accumulations and associated ecosystem benefits.

Impacts to Vegetation: Hydrogeomorphic complexity created by the addition of structures will improve habitat quantity and quality for riparian-wetland and aquatic flora and fauna. It will also increase the diversity and abundance of deep-rooted riparian-wetland vegetation, which preferentially grow on different geomorphic surfaces associated with topographically complex and/or well sorted sediment deposits with correspondingly variable, but persistent periods of inundation and soil moisture gradients. Aquatic and riparian-wetland habitat will also expand throughout the valley bottoms, as surface and subsurface water area (Bouwes et al., 2016b) increases the frequency, duration, and extent of saturated soils. Over time, the development of new geomorphic features and re-hydration of historic riparian-wetland areas will expand the supply of plant species that historically sustained beaver dam building activity, wood accumulations, and functional riverscape ecosystems.

Where the frequency, extent, and duration of inundation increases, disclimax conifer communities may decline. Invasive species may increase, decline, or remain stable as the hydrologic, geomorphic, and hydraulic attributes change. In some locations, invasive species may colonize new geomorphic surfaces that are created during the recovery processes but decline over time as the riverscape attributes become meta-stable, better resemble the historic conditions in which the native species evolved, and subsequently experience more competition from the native plants. In other riverscapes, the total amount of riparian-wetland adapted plants may increase as previously inactive valley-bottom areas become re-activated by fluvial processes. This could involve an increase in both native and non-native species. The project-specific adaptive management plans will help to minimize the growth of non-native and/or disclimax plants, while increasing the diversity and spatial extent of native riparian-wetland plants.

Vegetation management actions: will minimize or avoid the effects of livestock grazing and wildlife, depleted sources of native riparian trees/shrubs, and plant competition from disclimax conifer and invasive vegetation on the distribution and abundance of native riparian plant communities. Although the issues that each type of vegetation action addresses will differ, each technique will help native riparian plants to expand throughout the valley bottom, especially where complimentary practices associated with the Proposed Action maintain/improve stream, floodplain, and groundwater connectivity. Where the plantings expand, they will occupy and stabilize new geomorphic features, capture sediment, slow down floodwaters, and supply woody materials to sustain the processes of beaver dam building activity and wood accumulations. As distribution and abundance of native deciduous trees and shrubs increases, riverscapes will be able to sustain larger and more extensive beaver dam complexes, as well as wood accumulations. For a summary of the role of beaver dams and wood accumulations on riverscape health, refer to Section 3.1.1. Vegetation management actions will help to ensure that these processes are self-sustaining.

Where non-native species are present, their abundance and distribution could also increase, remain static, or decline. Since plant community dynamics vary according to a wide array of complex biotic (e.g., presence/absence of nearby invasive or disclimax plants) and abiotic factors (e.g., soil characteristics, stream condition, flow regime, weather), outcomes for vegetation could be highly variable over space and time. These factors would be considered, evaluated, and addressed through site-specific adaptive management actions to ensure that the Proposed Action maintains or improves riverscape health. Impacts that are specific to each type of vegetation management action are summarized below:

Project Protection Fences: will minimize or avoid impacts to the stream morphology and community composition of vegetation associated with consumption, selection, and trampling by livestock and wildlife. As the duration, frequency, and intensity of browse declines, riparian vegetation will retain more above ground biomass to photosynthesize, which will allow plants to store more carbohydrates in their roots, thereby expanding root structures. With stronger, more extensive, and deeper roots, riparian plant vigor is expected to increase, as is their ability to withstand flooding and drought. These attributes will enable riparian-wetland plants to increase or achieve their maximum potential extent (cover and total biomass), augmenting the supply of woody material for beaver dam building activity and wood accumulations. It will also prevent the combined influence of ungulate browse and beaver dam building activity from adversely impacting plant health, which could lead to a decline in the preferred browse species.

Project protection fences will also reduce physical impacts to riparian-wetland soils by reducing trampling, soil compaction, and the formation of areas with bare ground or thin vegetation from excessive or preferential use. This will protect geomorphic features and complex topographic attributes, which is especially important when the addition of structural elements are used to accelerate stream evolution to a healthier state. It will also increase vegetation growth and density around areas that previously experienced high levels of disturbance by ungulates, while reducing opportunities for weeds to grow on trampled areas.

Shrub & Tree Plantings: where suitable niches exist, but historical impacts have depleted the types and amounts of such vegetation, will help to ensure that sufficient types and amounts of native plants are available within the system to maintain or recover the physical and ecological processes that create healthy riverscapes. In the short-term, the plantings will grow and reproduce where existing conditions are suitable. However, in the long-term, the plantings will expand throughout new areas in the valley bottom, as the Proposed Action restores stream, floodplain, and groundwater connectivity.

Removal of Disclimax & Invasive Woody Plants: will reduce plant competition for water, nutrients, and sunlight, thereby allowing the surrounding or planted native riparian species to increase in abundance and distribution. In the short-term, removal of these plants could correspondingly reduce the supply of woody material to the system. In some locations, such as where the removal of disclimax or invasive woody plants is incomplete or other non-native species exist, undesirable plants may re-occupy some of the newly created niches. However, because the disclimax and invasive woody plants are typically ecologically inferior substitutes for the native plants that they displace (beaver preferentially select native plants over invasive and disclimax plants for forage and dam building), these short-term impacts would likely be negligible, relative to the long-term benefits associated with an increased supply of native trees and shrubs. Irrespective, these potentially adverse impacts would be minimized or avoided via the application of BMPs (i.e. leaving dead, sterile woody material from the removal projects within the floodplain; completing removals concurrent with the addition of structural elements, shrub/tree plantings, and/or project protection fencing) and adaptive management plans. In the long-term, native plants will re-occupy most of the resulting niches and support more of the ecological processes that create healthy riverscapes than the disclimax and invasive woody plants that would persist via the No Action Alternative.

***Headcut Control*:** Will halt streambed incision, as well as the formation of larger, more destructive, and difficult to repair erosional features where: (a) the BLM lacks sufficient control of the watershed processes that are causing the vertical instability, and (b) the issues that originally caused the erosional feature(s) to develop have been addressed. This will help to maintain the health of riverscape segments located above the erosional features by preventing further streambed incision and the associated unraveling of ecological processes. Where restoration projects are located upstream of headcuts, stabilizing the erosional features will greatly increase the probability that the associated processes and attributes will become self-sustaining. Relative to the No Action Alternative, stream segments located above headcut control structures will maintain more frequent and extensive stream-floodplain interactions and correspondingly more of the associated processes that create complex physical and vegetative attributes.

Preventing further streambed incision will prevent floodwaters from becoming confined to the channel, where steamflow velocities would increase and wipe out complex geomorphic features and adjacent riparian-wetland habitats. It will also reduce the delivery of sediment from eroded streambeds and banks to downstream reaches, which could have both positive and negative impacts. Specifically, reducing sedimentation could improve water quality in both the short and long-term. However, if the downstream segments lack sufficient sediment from other sources to reconstruct new geomorphic features and an inset floodplain, recovery rates in the segments that have already incised could be slowed. However, because headcut control techniques would typically be used in conjunction with other restoration efforts, 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, the ecosystem benefits would largely exceed any potential adverse impacts.

Beaver Mitigation Strategies*:* Beaver dam building activity will increase, as the Proposed Action improves riverscape conditions near streams that contain expansionary beaver populations. Beaver will remove deciduous woody trees for forage and dam building material, typically within approximately 300 meters of a waterbody. They will also construct dams that cause water to pond and flood portions of the active channel and/or valley bottom. Although the Proposed Action would be applied where the potential for human-beaver conflict is low or negligible (~95% of all BLM administered stream segments; *Appendix E, Figure 13),* it would mimic, promote, and sustain beaver dam building activity in some places. If these impacts expand where human development or other land uses are present, undesirable tree removal and flooding could occur, which may adversely impact those uses/users. For example, beaver could remove shade trees at recreation sites or build dams that restore the hydrology of a valley bottom, causing infrastructure that was emplaced when the area was dry, to flood. The Proposed Action would minimize or avoid these undesirable outcomes, while allowing beaver to remain in place (where possible) to sustain some of the processes that create and maintain healthy riverscapes.

Beaver mitigation strategies that prevent undesirable tree removal would reduce the supply of dam building material, which would correspondingly limit the vegetation dam building capacity within the reach. Techniques to mitigate undesirable flooding would generally reduce the elevation of water levels within beaver ponds, and/or the associated magnitude of ecosystem services. However, compared to the No Action Alternative, the Proposed Action would allow beaver dam building activity to occur in more locations, where it can restore riverscape health, while minimizing or avoiding adverse impacts to other resource values within the valley bottom.

3.1.3.1 Cumulative Effects — Proposed Action

Cumulative Impacts: past, present, and future impacts from a diverse array of people, organizations, and management actions (See Section 3.1.1) within watersheds in which the Proposed Action would be applied will cumulatively impact the conditions of riverscapes at the scale of the reach or entire stream. Impacts from beaver trapping to supply the fur trade, mining, railroad construction, agricultural development (crop, pasture, and rangelands), logging, channel modification, roads, invasive species, livestock grazing, and consequences of climate change (Rieman et al., 2015) will continue to affect the health and productivity of riverscapes throughout the project and surrounding area. Improved forestry practices, riparian grazing management, travel management, weed control, road maintenance, and the application of BMPs to new land use authorizations will minimize or avoid many of impacts that existing and future land uses have on riverscapes. Application of the Proposed Action will minimize and reverse many of the historic and residual impacts. However, given the scope of the issue, relative to the scope of restoration that is possible with typical BLM budgets and staffing, the opportunities for restoration will continue to exceed the scope of restoration for the reasonably foreseeable future. Irrespective, given the efficient and effective nature of the techniques included in the Proposed Action, the scope of restoration will far exceed what would occur under the No Action Alternative. This will allow the BLM to make significant progress towards meeting or exceeding the goals and objectives in our resource management plans (RMPs), the Montana/Dakotas Standards and Guidelines for Rangeland Health, as well as the Fundamentals of Rangeland Health (43 CFR 4180.1).

Consumptive and non-consumptive water uses, coupled with the impacts of climate change on temperatures, evapotranspiration demands, snowpacks, the timing and duration of streamflow, and expectations for increased water demands during the warm season will further stress riparian vegetation that already lacks sufficient access to water. This could cause the replacement of native riparian plants with upland or non-native species, which are less capable of stabilizing soils or supplying the types and amounts vegetation needed for beaver dam building activity and wood accumulations. These impacts will degrade riverscapes further or limit recovery rates. More frequent and intense wildfires, drought, and flooding may further impair degraded riverscapes, as they will be less resistant and resilient to the disturbances than reaches that were restored via application of the Proposed Action. The Proposed Action would minimize or avoid these impacts by increasing inundation extent and type, groundwater elevations, channel complexity, and the health of riparian areas.

Stream restoration projects that utilize techniques which differ from the Proposed Action would continue to be implemented on BLM and non-BLM lands, as needs arise and resources become available. These projects would typically have an additive, complementary effect to the Proposed Action. However, the scope of degradation would continue to exceed the scope of restoration at the watershed-scale, particularly where the BLM manages only a small fraction of the total watershed area. Where impaired riverscape reaches persist, downstream segments may be adversely impacted by the altered supplies of water, sediment, and woody material. However, by restoring riverscape health in some reaches, the Proposed Action will: (a) limit the contribution of BLM administered reaches to the impairment of downstream segments and (b) reduce the effects of upstream degradation on impaired reaches that are downstream by buffering the effects of flood and drought.

Fire intensity, frequency, and size will continue to increase, affecting plants and animals throughout the project area. By increasing beaver dam building activity and the storage of water throughout the valley bottom, the riparian areas will be less likely to burn because the extent of surface water inundation will increase greatly, and adjacent riparian plants will have enough water to make it energetically unfavorable to burn. Consequently, riparian plants will become more resistant and resilient to the impacts of climate change and land management practices that have exacerbated wildfire. This will improve their ability to withstand impacts from the floods that often follow, while increasing their capacity to maintain or improve water quality after a burn.

3.2 Resource Issue 2: How Would Implementation of the Alternatives Affect Water Quality and Water Quantity

3.2.1 Affected Environment – Water Quality and Quantity within Valley Bottoms

There are approximately 45,400 miles of intermittent/ephemeral stream and 1,100 miles of perennial stream (National Hydrography Dataset, Version 3.1) administered by the BLM in Montana/Dakotas. These streams support riverscapes, which are made up of a series of interconnected surface water, groundwater, floodplain, and associated riparian-wetland and aquatic habitats that modulate the flow, storage, and quality of water. Some of these streams are in relatively steep, narrow valley bottoms that primarily supply and/or transport water, sediment, and organic material downstream (called source and transport reaches). Other reaches are in relatively broad, low-gradient valley bottoms, which capture, store, and slowly release water, sediment, nutrients, and organic materials. These are called response reaches and the focus of the Proposed Action. When they are functioning properly, the entire valley bottom constantly exchanges water with and is therefore, a part of the stream (Wohl et. al, 2021). Where this occurs, the floodplains are inundated frequently (even during low flows) and high water tables are maintained. As a result, they support riparian-wetland and aquatic vegetation across all or most of the valley bottom. These attributes create a positive feedback loop between ecological and physical processes that maintain clean and abundant water on the landscape. To sustain these hydrologic conditions, they require structural elements (i.e. beaver dams and/or wood accumulations), riparian vegetation, water, sediment, sufficient room to adjust laterally across the valley bottom, and frequent stream-floodplain interactions.

As discussed in Section 3.1.1, many current and historic land use practices have impacted water resources directly (i.e., water impoundments or withdrawals) or indirectly (by impairing the processes that maintain healthy riverscapes and abundant clean water). Of the mapped riparian-wetland and aquatic areas that currently exist in the valley bottom, less than 1% (47 acres) contain beaver dams, while approximately 25% (30,0086 acres) contain artificial impoundments or excavations. The absence of beaver dam building activity and abundance of artificial structures have profoundly impacted water resources and riverscape health in many areas. This is because hydrologic modifications alter the water and sediment budget in ways that can impair the processes, which create and maintain healthy riverscape attributes, while beaver dam building activity promotes riverscape health and biophysical processes that improve the quality, timing, and distribution of water. These artificial features are most common in streams that are currently intermittent or ephemeral, as they are often needed to store water for uses like livestock watering later in the year. However, prior to historical impacts from settlers and beaver trappers, many of these streams flowed more consistently because attributes such as beaver dams and debris jams obstructed flows, forced variable flow paths with longer and more variable residence times, sorted sediments to create complex channel attributes, and spread water and sediment across the valley bottom where it was stored like a natural sponge, used to support ecological functions, then slowly released downstream. Although quantitative estimates of the historic flood regimes are not widely available for valley bottoms in the project area, it is reasonable to assume that prior to beaver trapping and other human impacts, the frequency, extent, duration, and type of inundation was greater than it is today. Approximately 65% of the aquatic and wetland areas that exist today are temporarily or seasonally flooded, while approximately 20% are semi-permanently or permanently flooded (Montana Natural Heritage Program, 2020).

Although healthy riverscapes maintain or improve water quality; store large quantities of water and sediment, and can buffer the effects of flooding, drought, and wildfire on water resource and associated ecosystem services, unhealthy riverscapes can impair water quality, reduce their ability to perform hydrologic functions and diminish their resistance and resilience to disturbance. This is especially true for structurally-starved riverscapes because when flow resistance declines, channel capacity tends to increase via bed incision and associated erosional processes deliver large amounts of the stored sediment, nutrients, and water back into the stream, where it can impair water quality and cause previously wet riparian-wetland areas to dry. As described in Section 3.1.1, approximately 11% of the BLM administered valley bottoms are classified as riparian-wetland or aquatic. Since these plant communities require saturated conditions through most of the growing season, their absence from large portions of the valley bottom often indicates floodplain desiccation, which is commonly associated with a decline in the floodplain water table, as well as the frequency, extent, and duration of inundation. This has reduced the impacted riverscapes' ability to improve the quality and spatiotemporal distribution of water, as well as their resistance/resilience to future disturbances like extreme flood, drought, fire, some invasive species and disclimax plant communities, as well as use by livestock and wildlife.

Water Quality: Water quality in streams and rivers varies naturally due to physiographic, climatic, and hydrologic variability, as well as human impacts that directly or indirectly contribute pollutants or impair a riverscape's capacity to ameliorate pollution. It also varies throughout and between years, largely in response to annual and interannual variability in precipitation and temperature, both of which influence water quality by impacting hydrologic attributes such as streamflow, the relative contribution of surface and groundwater in a waterbody, and the occurrence of floods and drought. Impacts of climate and climate change on water quality are discussed in Appendix G.

Water quality standards are the fundamental regulatory and policy foundation to protect and restore water quality. They are developed by states in accordance with the Clean Water Act and consist of three elements: (1) designating beneficial uses; (2) establishing narrative and numeric standards to protect those uses; and (3) implementing regulations to prevent water quality degradation. States classify surface waterbodies according to present and future beneficial uses they are expected to support (Table 5). Beneficial uses include aquatic life and fish, recreation, human health, agriculture, and industry. The existing uses and the level of water quality necessary to protect those uses must be maintained and protected. State agencies responsible for water quality management (Montana Department of Environmental Quality, South Dakota Department of Water and Natural Resources, and North Dakota Department of Environmental Quality) then inventory, monitor, and assess waterbodies to determine whether they are meeting the water quality standards for the associated beneficial uses. These standards are expressed as pollutant concentrations and narrative statements. When the standards are met in a water body, the beneficial uses are considered protected. Conversely, a waterbody is impaired when any one of its standards are violated. However, determining whether a specific use is supported is independent of all other designated uses. For example, a waterbody may partially support aquatic life because of excess nutrients, not support drinking water because of arsenic, but fully support agriculture and industrial uses.

As of 2020, 1,622 miles of BLM administered streams have been assessed for their attainment of beneficial use standards. Of these, 23 miles are classified as A-1, 535 miles are B-1, 28 miles are B-2, 420 miles are B-3, and 616 miles are C-3. Beneficial uses that each Water Use Class must achieve are listed in Table 5.

Table 5: Designated beneficial uses by waterbody class

Beneficial Use	**Water Use Classification (by waterbody class)**								
	A-Closed	**A-1**	**B-1**	**B-2**	**B-3**	**C-1**	**C-2**	**C-3**	**I**
Aquatic Life/Fish (salmonid)		X	X	M		X	M		
Aquatic Life/Fish (non-salmonid)					X			X	
Aquatic Life/Fish	X								X
Drinking Water (human health)	Xst	XcNI	Xc	Xc	Xc			M	
Recreation	X	X	X	X	X	X	X	X	X
Agriculture	X	X	X	X	X	X	X	M	X
Industry	X	X	X	X	X	X	X	M	X

X = Supports beneficial use; M = Marginal support for beneficial use; Xst = Supports beneficial use with simple water treatment; XcNI = Supports beneficial use with conventional water treatment for naturally occurring impurities; Xc = Supports beneficial use after conventional treatment

Water quality standards for one or more of the associated beneficial uses are not being met along 1,240 miles of assessed stream. These waters are considered threatened or impaired and constitute 76% of all BLM administered streams in the planning area that have been assessed for standards attainment. The remaining 381 miles of assessed stream are meeting standards for all beneficial uses or plans to mitigate impairments have been developed and approved.

The majority of these impaired water bodies have been impacted by non-point source (NPS) pollutants such as sediment, temperature, and nutrients. Additional water bodies have been impacted by "non-pollutants," including "alterations of streamside vegetative cover" (due to livestock grazing) and "flow alterations. Seven major human land uses contribute to these impairments: agriculture, forestry, hydrologic modification, mining and industry, recreation, transportation, and urban and suburban development. However, agricultural (e.g., farming and ranching) impacts and hydrologic modifications (e.g., water storage, withdrawal, and transfer or physical alterations in floodplain, riparian-wetland, and channel structure) are most reported in the project area. These activities occur within BLM administered lands (especially livestock grazing), as well as on lands administered by others located upstream of the BLM. Associated impacts are increased water temperature, impaired riparian-wetland and aquatic habitat, and increased concentrations of nitrogen, phosphorus, salinity, and pathogens. Hydrologic modifications are further impairing water quality by altering the supply of water/sediment, reducing their capacity to dilute, capture, and/or ameliorate pollutants from upstream sources; and increasing the propensity of associated riparian areas to unravel during periods of flood and drought.

Pollutants can be reduced, ameliorated, or assimilated when riparian ecosystems have the vegetation, water, and soil/landform needed for riparian functions. Loss of physical form and ecological function unravels assimilation processes, increasing supply and transport of pollutants. Water quality and aquatic organisms are response measures of accumulated upstream discharges, and ultimately of changes in riverscape functions. Thus, water quality monitoring often fails to identify or lags many causes of pollution or remediation from riverscape degradation. As a result, land and water resource managers often seek to maintain or improve water quality by maintaining or improving the health of riparian-wetland ecosystems and reach-scale projects are prioritized and implemented throughout the state(s). However, the effectiveness of such actions is largely dependent on the scope of the water quality impairment, relative to the scale and scope of riverscape restoration. The BLM often administers only a small proportion of the total watershed and/or valley bottom associated with surface waterbodies. Therefore, water quality impairments on BLM administered reaches often reflects degradation higher in the watershed, which is commonly beyond the control of BLM's managers. In such instances, our ability to influence water quality may be limited to the application of BMPs, which avoid further impairment, or restoration of riverscape processes and attributes that prevent degradation of the BLM administered reaches and capture, retain, and sequester pollutants from upstream sources. These ecosystem services are provided when riverscapes are healthy.

Healthy riverscapes improve water quality by dissipating energy associated with high waterflow, thereby reducing vertical instability, while developing floodplains and complex hydrogeomorphic features with captured sediment and nutrients. Slowing flood water enables aquifer recharge, deposition, and plant nutrient uptake. Water-loving, densely rooted streambank stabilizing vegetation and/or wood helps integrate riparian functions to maintain channel characteristics for a diversity of habitats, and structural elements (beaver dams and wood accumulations) distribute water through more complex flow paths and longer residence times. A complex food web helps slow the nutrient spiral with uptake and storage within the valley bottom. Temperature fluctuations are dampened by delayed discharges, narrower and deeper active channels, surface/groundwater exchange caused by substrate heterogeneity and deeper pools, and shade from riparian vegetation. Collectively, these riverscape functions impact sediment and nutrient loads, dissolved oxygen (DO), and water temperature to sustain beneficial uses and values (fisheries, recreation, etc.) and ecosystem services (e.g., reduced water treatment costs).

Small surface water impoundments have impacted water quality throughout the project area, particularly in the arid/semi-arid regions of Eastern Montana and the Dakotas. Many of these impoundments were designed to capture runoff when it exists, so that it can be used for livestock and wildlife later in the year. Most were constructed over 50 years ago and have been infilling with sediment that otherwise would have been routed downstream to support riverscape processes. This has impacted water quality in some places by increasing total dissolved solids, evapotranspiration, and water temperatures, as well as by impairing the health of riparian habitats downstream. As a result, some of these altered waterbodies no longer support one or more of the beneficial uses.

Water Quantity (surface and ground): Riverscapes receive (from precipitation, snowmelt, or groundwater), transmit, and store water within the interconnected stream channel(s), floodplain aquifers, and wetland features that exist throughout the valley bottom. They occur across a diverse range of climatic, physiographic, geologic settings, and each has its own landscape and development history. These factors influence natural reach attributes and existing conditions and therefore exert tremendous influence over their capacity to modulate the flow of water from upstream sources to downstream sinks. When stream reaches that can or could interact regularly with their floodplains (the focus of the Proposed Action) have sufficient structure, they support more diverse types of inundation (pools, channels, etc.); experience more frequent, extensive, and longer periods of flooding; sustain high floodplain aquifers; develop more complex channel attributes, and regularly exchange water between surface and subsurface flow paths. This is because structural elements (obstructions to flow) amplify and force this interaction beyond what the flow regime alone can do during high flow events. They cause flow velocity vectors (depth, direction, and velocity of flow) to converge and diverge as they shunt around, flow over, back-up behind, split around, flow through, and separate into shear zones as flow moves past the obstruction(s). In terms of hydrologic connectivity within the valley bottom, riverscapes with adequate structure in their channel(s) and floodplain obstruct flow and disrupt longitudinal connectivity, but increase vertical and lateral connectivity (Covino, 2016) by forcing flooding at lower flows. Moreover, these vertical increases in connectivity are not just upward in terms of forcing flows up and over, but the increased hydraulic head (height of the water) also increases pressure gradients that cause surface-groundwater exchange (Zhou and Endreny, 2013). The resulting geomorphic and hydrologic complexity increases variability in the time it takes for water and sediment to move through the system (i.e., residence time), which is natural and healthy.

Structural starvation of wood and beaver dams is one of the most common impairments affecting hydrologic processes that modulate the occurrence and distribution of water on the landscape. At a basic level, a riverscape starved of structure drains too quickly and efficiently, lacks connectivity with its floodplain and has simpler more homogenous habitat. By contrast, a riverscape system with an appropriate amount of structure provides obstructions to flow, which create more diverse flow paths, longer residence times, and increased stream-floodplain connectivity. These processes fill the "valley bottom sponge" with water, slowly release it when it's dry, and create more abundant and complex riparian-wetland and aquatic habitat. This helps to reduce flood peaks, sustain minimum flows during dry periods, and distribute water across the landscape, so that it is available when and where it is needed to meet human and ecosystem needs. These functions will be increasingly necessary to buffer the effects of climate change on water resources (Appendix G). Although direct measurements of structural starvation are not available for the project area, field observations, as well as aerial and satellite data indicate that channel incision, disconnected floodplains, and diminished riparian-wetland habitat are commonplace and have reduced the amount of water that was historically stored and slowly released through the valley bottom (Section 3.1.1).

Water supplied to the region is controlled largely by variability in seasonal temperature and precipitation. Most of the water used comes from surface water sources. Groundwater use, although small compared to surface water, provides much of the water used for public supply and self-supplied domestic and industrial uses. Groundwater also provides a significant source of irrigation water in some areas. While the demand for water continues to grow, water availability varies from year-to year and often changes dramatically within a given year. As a result, coping with supply and demand imbalances is a constant feature of water management. Although water use varies by basin, irrigation accounts for approximately 12.4 percent of the water withdrawn and approximately 68 percent of the water consumed in Montana (USGS, 2015). This water is needed most in the summer, when the days are long and temperatures are hot, and streamflows are often declining. Reservoir evaporation such as water evaporated from lakes and ponds also accounts for a large portion of water consumed, although the water is not technically diverted. Specifically, approximately 1.2 million acre-feet, or 28 percent of the total water consumed, evaporates from reservoirs.

All waters in Montana, above and below the surface of the earth, are held by the state on behalf of its citizens. Montana's economy and quality of life rely on water for everything from agriculture, livestock, industry, fisheries, and recreation, to municipal and domestic uses. In 2015, the Montana Department of Natural Resources and Conservation (DNRC) and their Four Basin Advisory Council finalized the state Water Plan. This plan includes several recommendations for maintaining or improving the abundance and distribution of water (see page xxx), including but not limited for society to:

- use natural storage and retention (i.e. riparian, floodplain, and wetland areas) to benefit water supplies and ecosystems
- prepare to adjust to seasonal changes in water supply and demand as well as longer term climatic changes
- prepare to endure droughts in watersheds across the state
- be better able to supply water to serve the needs of a growing population and thriving economy as well as the natural systems, habitats, and species that our state is renowned for

Demand for water is a function of many factors that are inherently uncertain. Population may grow or decline and agriculture and industry may demand more water or make do with less through greater efficiency. Changing and variable climatic conditions compound this uncertainty. To forecast the potential effects of climate trends on future water supplies in Montana, DNRC modeled a range of climate scenarios, and the 2017 Montana Climate Report was compiled (https://montanaclimate.org/). They project warmer temperatures, shifts from snow to more rain (especially at mid elevations), accelerated snowmelt, more intense flooding and drought, earlier onset of low flow conditions, and modest precipitation increases. Although annual stream flow volumes are expected to stay the same or increase, there will be a shift in the timing of runoff due to earlier snowmelt and an increase in rain as a percentage of precipitation during late winter and early spring. See Appendix G for further information regarding the impacts of climate, climate change, and riverscape conditions on water resources within the project area.

The availability of water for new appropriations varies across the state and is subject to both physical water availability and existing legal demands. Many of the basins located in the western third of the state are generally closed to new surface water appropriations. Opportunities for new appropriations for surface water or hydraulically connected groundwater also may be limited outside of closed basins because of existing legal demands including irrigation claims, hydroelectric rights, or instream water rights for fisheries, wildlife, and recreational use. Given the scarcity of legally available surface water, the reallocation of existing water rights to new uses will play a key role in meeting future demands. As part of that reallocation, the ability to put water to a beneficial use is limited as much by water quality as physical availability. Water quantity and water quality are closely intertwined because, as water quality becomes impaired and no longer meets the standards for a beneficial us, less is available to meet that need. See Appendix E, Figures 22-24 for a summary of beneficial uses in the project area, as well as the status of water quality standards determinations.

3.2.2 Environmental Effects—No Action Alternative

The BLM would not apply the Proposed Action to maintain or restore riverscape processes and corresponding attributes that historically sustained the quality, as well as spatial and temporal distribution of water in the valley bottom. Instead, the BLM would continue to apply BMPs and site-specific mitigation to minimize or avoid impacts to water resources from past, present, and future land use authorizations (i.e., livestock grazing management, road construction/maintenance, forestry BMPs, etc.) that could otherwise adversely impact water resources. There may be scattered, individual physical restoration projects authorized on a case-by-case basis. However, few physical restoration projects would be implemented to address historical impacts that continue to affect the health of riverscapes, their capacity to repair themselves, and/or their resistance and resilience to future disturbances. As a result, the consequences of structural starvation, grazing by livestock and wildlife, invasive and disclimax plant communities, headcuts, and climate change will continue to impair water quality and diminish the spatial and temporal distribution of water.

Structurally starved riverscapes that have incised and become disconnected from their floodplains will remain in a degraded stage of the stream evolution sequence. Without flow obstructions, geomorphically complex channel and floodplain attributes, or extensive riparian areas; water, sediment, nutrients, and organic matter will be rapidly transported downstream, rather than spread across the valley bottom, where it can recharge aquifers and flow through longer, more diverse hydrologic flow paths. These attributes and impaired processes will limit the spatial and temporal distribution of water within the valley bottom, prevent the recovery of riparian vegetation, and contribute to water quality impairments. Although most impacted systems will recover naturally in the absence of further anthropogenic disturbance via erosional and depositional processes associated with successive flow events, it may take decades to centuries (or longer) without intervention, especially where the supply of the requisite "building blocks" (i.e., wood, sediment, water, etc.) has been highly altered. Meanwhile, the riverscapes' hydrologic functions that historically maintained the distribution and quality of water across the landscape will remain diminished or wholly unsupported. As a result, many of the existing water quality impairments are likely to persist and beneficial uses will not be fully supported. These impacts will be amplified by the effects of climate change, further limiting the rates of riverscape recovery and the ecosystem services they historically supported. Furthermore, impaired stream reaches would continue to be less resistant and resilient to future disturbances and impacts from administered uses, which could cause additional unraveling of

hydrologic processes that further impair the quality and distribution of water. The rate and magnitude of recovery would therefore not be sufficient for the BLM to meet or exceed some of the associated goals and objectives in our resource management plans (RMPs), the Montana/Dakotas Standards and Guidelines for Rangeland Health, or the Fundamentals of Rangeland Health (43 CFR 4180.1).
Water Quantity: Without application of the Proposed Action to minimize or reverse the impacts of structural starvation on riverscape health, hydrologic efficiency will continue to be much higher than the potential of impacted systems. Longitudinal connectivity (between upstream and downstream reaches) will remain high, while vertical and lateral connectivity between the streams, floodplains, and floodplain aquifers will remain low (Covino, 2016). Streams will only inundate their floodplains during high flow events. They will also transport water rapidly out of the valley bottom through a physically simple single thread channel, rather than distribute flows through a network of secondary channels across the valley bottom. These impacts will reduce inundation type and extent, as nearly all the water will be constrained as free flow within the margins of stream banks, rather than distributed more frequently across the broader valley bottom area in the form of ponded, overflow, and free flowing zones. As a result, floodplain aquifers will not be adequately recharged when water is abundant, base flows will be lower and occur sooner in the year, zones of upwelling and downwelling will occur less frequent and extensively, and some streams will dry up sooner.

Valley bottoms that have dried because of structural starvation and channel incision would not be re-saturated and riparian vegetation would not expand towards the potential valley bottom extent. With large proportions of the historic valley bottom inactive (i.e., not regularly influenced by stream processes), the spatial and temporal extent of soil saturation and vigorous, water loving vegetation would remain diminished or decline further. This would reduce evapotranspiration below what would have historically occurred and may leave more total water to be routed downstream (relative to historic conditions or those created by the application of the Proposed Action). However, the impacts are likely below our capacity to measure with typical stream gauge equipment. Irrespective, the timing and distribution of water is often far more important for ecosystems and water users than total annual streamflow. Since water would not be stored in the valley bottom when it is abundant and slowly released later in the year when conditions dry, there would be less water to support economic and ecologic water demands in the warm season and more water in the system when demand is low and flood risks are high. This could adversely impact ecosystems and most water users, which typically require less water during early season runoff (because temperatures are lower, precipitation is higher, and crops need less supplemental water) and more water during the warm season. As climate change causes a shift to the type and intensity of precipitation, increased weather variability, shallower snowpacks that melt earlier, increased evapotranspiration demands, and the need for additional water consumption, the loss of natural water storage and late season flows associated riverscape degradation will amplify the impacts on ecosystems and water users.
Flooding: The frequency and extent of floodplain inundation would not be increased where the ecosystem benefits are high and the risk to infrastructure and alternative land uses is low. Instead, flood waters would be confined to relatively simple channels and rapidly transmitted downstream, where incompatible land uses and infrastructure may occur. As a result, flood risks would remain elevated. Furthermore, without the application of the Proposed Action to spread water across the valley bottom through zones with deep-rooted riparian vegetation and more complex channel networks, stream power would be high. The risk of channel incision and further unraveling of ecological process would be correspondingly high. This could further impair water quality and reduce the spatial and temporal distribution of water on the landscape.

Since structural elements would not be added and the processes of beaver dam building activity would not be mimicked, promoted, or sustained, the potential for the associated wood or beaver dams to plug water conveyance structures or cause undesirable flooding would not be increased. However, undesirable flooding caused by beaver that naturally disperse into areas where the potential for conflict is high may occur. These beaver would typically be removed through lethal practices because beaver mitigation strategies would not be applied to minimize or avoid these impacts. This may ameliorate the flooding issues, but it would not allow for the ecological processes that improve water distribution or buffer downstream flooding. However, where expansionary beaver populations exist nearby and suitable habitat for dam building activity is present, the effects of lethal removal on undesirable flooding may be short-lived. This is because new beaver may re-occupy the niches that are left behind, leading to a re-current cycle of undesirable flooding and the subsequent lethal removal of beaver.

Drought: The Proposed Action would not be applied to dampen the effects of flooding and drought on water resources by spreading it across the valley bottom when it's abundant (often early season, when water demands are relatively low) and slowly releasing it later in the year (when water demands often peak). Instead, structurally starved riverscapes would continue to rapidly transmit water out of the valley bottom. This will amplify adverse impacts from drought on water resources and associated ecosystem services. The lack of natural water storage will be increasingly detrimental as snowpacks melt earlier; the form of precipitation shifts from snow to rain (causing flashier streamflows and earlier runoff); a greater proportion of precipitation falls in fewer, but more intense storms (causing large peaks and troughs in streamflow patterns); and warmer temperatures increase the intensity and occurrence of both persistent and warm season droughts. Streams that historically received large amounts of water from low to mid elevation snowpacks, which are expected to be among the most impacted by warming temperatures (Section XXX, Climate Change), will experience particularly large changes to streamflow dynamics, lower base flows, and longer periods with no flow. Furthermore, without application of the Proposed Action to increase connectivity between surface and groundwater sources and elevate base flows, zones of downwelling and upwelling that improve water quality and create cool zones for aquatic species would not occur as frequently or extensively. With the predicted increase in temperatures and drought intensity, the loss of surface-groundwater exchange to provide zones of temperature refuge could adversely impact beneficial uses such as aquatic life.

Water Quality: Riverscapes impacted by structural starvation and channel incision will remain less resistant and resilient to disturbance and distribute water through shorter, faster, less complex hydraulic flow paths. By not applying the Proposed Action, the distribution of structural elements, riparian vegetation, and geomorphic complexity would be low and unable to effectively distribute flows throughout the valley bottom. Therefore, the exchange of water between the stream, streambed, floodplain, and floodplain aquifer will be far less than historically occurred. Without engaging these processes, riverscapes will not adequately capture, retain, or cycle nutrients from upstream sources, nor develop floodplains and complex hydrogeomorphic features with the sediment and nutrients that flow into the reach. This will prevent riverscapes from using sediment and nutrients from the watershed to support processes that improve riverscape health and water quality. Instead, the sediment and nutrients will be concentrated and routed through the stream channel, where it may further impair water quality. By not increasing flow path complexity and residence time, plant nutrient uptake and biogeochemical processes that can ameliorate pollutants will not be restored. Temperatures will be homogeneous and prone to high daily/seasonal temperature fluctuations because geomorphic complexity, pool frequency and depth, and surface/groundwater exchange will be low. Consequently, there will be more sediment and nutrient impairments to ecological processes, less diverse aquatic attributes, as well as fewer and less extensive zones of downwelling and upwelling between the stream, streambed, and floodplain aquifer. This will create areas with low dissolved oxygen (DO) and elevated water temperatures that fail to sustain beneficial uses and values. These water quality impairments will be amplified by the increased occurrence and severity of drought, flood, fire, and high temperatures associated with climate change.

Erosional and depositional processes that must occur for incised stream channels to recover would not be accelerated. Without application of the Proposed Action to accelerate these processes and ensure the delivered sediment and wood is used by the riverscape to construct more complex channel and floodplain attributes, temporary increases to sediment and nutrients would not occur. However, the recovery of hydrologic processes that improve water quality would take decades to centuries, as the geomorphic changes will instead occur episodically in response to major flood events. During this transition period, water quality will remain impaired. Furthermore, most of the sediment delivered during major floods would be routed far downstream and less would be distributed across floodplains or used to form more complex physical attributes. Relative to the Proposed Action, water quality impairments would persist longer and impact areas further downstream.

3.2.2.1 Cumulative Effects – No Action Alternative

Past, present, and future impacts from a diverse array of people, organizations, and management actions within watersheds in which the Proposed Action would be applied will cumulatively impact water resources at the scale of an individual stream reach, as well as the entire stream network (Sections 3.1.1 and 3.2.1). Impacts from agriculture, forestry, hydrologic modification, mining and industry, recreation, transportation, and urban and suburban development will continue to directly impair water quality in many places. Improved forestry practices, riparian grazing management, travel management, weed control, road maintenance, and the application of BMPs to land use authorizations will minimize or avoid many impacts that existing and future land uses will have on riverscapes and water resources. However, historic impacts that have reduced the distribution of riparian vegetation, beaver dam building activity, and wood accumulations will continue to cause channel incision and a loss of complex hydrologic, hydraulic, geomorphic, and vegetative attributes. These impacts will prevent riverscapes from maintaining or improving water quality, as well as the spatial and temporal distribution of water.

Consumptive and non-consumptive water uses, coupled with the impacts of climate change on temperatures, evapotranspiration demands, snowpacks, the timing and duration of streamflow, and expectations for increased future water demands during the warm season will further reduce the distribution of water and amplify the impacts of riverscape degradation on water distribution and quality. These impacts may prevent the full recovery of hydrologic processes that historically promoted the support of beneficial water uses. More frequent and intense wildfires, drought, and flooding will further impair degraded riverscapes and exacerbate water quality and distribution challenges. Without Application of the Proposed Action to restore riverscape processes that store water on the landscape, ameliorate pollutants, and increase their resistance and resilience to disturbance, existing water resource impairments will persist, and some may become more severe.

Water quality improvement projects authorized on a case-by-case basis would continue to be implemented on BLM and non-BLM lands. However, the scope of degradation would continue to far exceed the scope of restoration and the processes that historically sustained the quality and distribution of water would not be restored. Degraded conditions on BLM administered riverscape reaches will continue to impact the health of reaches downstream. Water would not spread across the historically active floodplain areas to buffer the impacts of flooding (within and downstream of the reach), recharge floodplain aquifers, or improve riparian health. Instead, water, sediment, nutrients, and organic matter from upstream reaches would be quickly routed through BLM administered reaches, where the high flow velocities and sediment loads could wash out physical stream attributes, causing additional water resource impairments downstream. Without high water tables and abundant woody material on BLM administered reaches to sustain wood accumulations and beaver dam building activity, downstream reaches may not receive the supply of wood, water, and sediment when and where it is needed to support recovery of the processes that maintain or improve water resources. Similarly, degraded riverscape reaches and land use practices on non-BLM administered areas of the watershed(s) would continue to alter the supply of water, sediment, and wood that BLM administered stream reaches need to recover. Without the application of the Proposed Action to ameliorate these issues, stream recovery may be slow or not occur. In some areas, riverscape conditions will deteriorate further.

Without application of the Proposed Action to naturally retain water in the valley bottom over larger areas for longer periods, the need for artificial impoundments to support wildlife and livestock may increase due to climate change and increased consumptive demands. If the size or number of artificial hydrologic modifications increases, streamflow and sediment transport dynamics would be adversely impacted, which would further impair riverscape health and prevent recovery of hydrologic processes. This would impair water quality and limit the broad suite of beneficial uses that are otherwise supported when water is stored and slowly released through natural processes.

3.2.3 Environmental Effects—Proposed Action

The Proposed Action will maintain or restore riverscape processes and corresponding attributes that historically sustained the quality, as well as spatial and temporal distribution of water in the valley bottom. Although each of the four types of treatment will target specific issues affecting riverscape health and influence water resources in correspondingly different ways (as described below), all will maintain or increase riparian-wetland vegetation, the distribution of structural elements, and the complexity of riverscape attributes. These impacts will spread water and sediment across the valley bottom more frequently and over larger areas, while forcing more variable flow paths with longer and more variable residence times. These processes will store more water, organic matter, and sediment; slowly release it to sustain ecological processes; and increase nutrient cycling. This will maintain or improve water quality and increase the distribution of water through space and time. Having cleaner water dispersed through larger areas in the riverscape for longer periods will benefit ecosystems and most water users.

The scale and magnitude of impacts will vary at the reach and watershed scale. They will be greatest at the reach-scale because that is the scale over which restoration can most directly influence the processes and attributes that sustain hydrologic processes within that area. Impacts will be smaller at the watershed scale, as the scale of restoration, relative to the scale of processes and attributes that control watershed-scale hydrologic processes will be correspondingly smaller. In general, as the scale of projects increase, relative to the scale of a watershed, impacts will correspondingly increase (and vice versa). Water resource impacts will also vary over time and will typically lag changes in riverscape health. Where streams are minimally incised and still engage floodplains during moderately high flows, hydrologic changes would be fastest. This is because treatments would quickly amplify stream-floodplain interactions and induce hydrologic processes that improve water quality and the distribution of water. Conversely, where streams are highly degraded (i.e., actively incising or highly incised) and require large lateral adjustments and the development of inset floodplains, restoration of the processes that historically maintained the quality and distribution of water within the reach would take correspondingly longer. This is because major geomorphic adjustments to the stream channel and floodplain would need to occur before stream-floodplain interactions could increase enough to restore hydrologic connections throughout the valley bottom. During this transition period, disturbances associated with stream evolution would increase, particularly in response to high flows.

Water Quantity: The Proposed Action will impact water quantity by increasing or maintaining hydrologic inefficiency, which can be expressed as relatively longer water residence times and be calculated by dividing a control volume of water by the sum of outflow discharge from that control volume. By increasing flow obstructions in the channel and floodplain, longitudinal connectivity (between upstream and downstream reaches) will be disrupted, while vertical and lateral connectivity between the streams, floodplains, and floodplain aquifers will increase (Covino, 2016). This will force flooding at lower flows and increase the temporary storage of water in the floodplain aquifer and inundated valley bottom areas. It will also force degraded, single-thread channels to reform their historic multithreaded channel characteristics, causing water to flow from the main channel and across the floodplain or through newly formed secondary channels. These overflow areas will increase water residence time by decreasing velocity because the relative flow length that water will travel downstream is longer and more complex. Furthermore, roughness, which is inversely related to velocity, will increase as water flows across floodplain surfaces that are often vegetated. These impacts will increase inundation type and extent, as there will be a shift from nearly all the water being constrained as free flow within the margins of stream banks to a much broader area with ponded, overflow, and free flowing zones. Collectively, these impacts will transport nearly the same amount of water downstream as before treatment, but through more variable surface and subsurface flow paths that span a much larger portion of the valley bottom (increasing the control volume). As treated streams progress to healthier states in the stream evolution sequence, floodwaters will be increasingly attenuated and distributed throughout the valley bottom, base flows will rise in some areas, zones of upwelling and downwelling may increase (between the stream and streambed), and the duration of flow may extend longer during dry periods.

Re-saturating the valley bottom could temporarily (hours to days after implementation of BDAs or PALs) reduce flow to downstream reaches, as some of the water that previously flowed rapidly down a degraded (shorter, straighter, and less physically complex) stream network will re-fill the historically wet zones surrounding the streambed and banks. Furthermore, as the spatial extent of valley bottom inundation and/or riparian vegetation increase and approach their historic extent, evapotranspiration would correspondingly increase beyond what occurred when conditions were degraded. This is because more water will be available on/near the valley bottom surface to evaporate and sustain plant respiration. However, these losses would likely be negligible (i.e., too small to measure with typical stream gauges) and primarily occur because the Proposed Action will restore hydrologic processes that historically retained more water within the valley bottom. Furthermore, since ecologic and economic (i.e. agriculture and grazing) water demands are typically lower during early season runoff and greater in the warm season, when climate change and riverscape degradation will likely have the biggest impact on water availability, saturating the valley bottom when flows are relatively high, so it can be released later in the year when conditions dry, would benefit most ecosystems and water users. By coordinating with downstream water users and avoiding or staging project implementation when potential streamflow declines could adversely impact downstream water users or ecosystems, corresponding impacts would be minimized or avoided, and benefits would be maximized.

Flooding: The Proposed Action will increase the frequency and extent of flooding within the valley bottom (even during low flows) where projects occur. It will also reduce stream power and temporarily store water in floodplains of small streams with little/no surrounding infrastructure or incompatible uses. This could reduce the effects of flooding on downstream reaches (commensurate with the scale of the project, relative to the scale of the watershed), where incompatible land uses and infrastructure are more common. These processes, in combination with an increase of deep-rooted riparian plants, would minimize or avoid channel incision throughout the stream network during future floods, preventing the associated unravelling of ecological processes that naturally keep water on the landscape and improve water quality.

Where water conveyance infrastructure such as small bridges and culverts are present, woody material from the BDAs and PALs could be transported downstream, accumulate on the conveyance structures, and cause undesirable flooding. Furthermore, by mimicking, promoting, and sustaining beaver dam building activity, beavers would construct dams within the project areas, as well as expand to new areas. These dams could re-wet areas that contain infrastructure or incompatible land use practices, causing undesirable flood impacts. However, these impacts would be minimized or avoided by avoiding restoration where the risks are high or not easily avoided (Appendix E, Figures 13-15 and Appendix H), by applying beaver mitigation strategies, maintaining the projects, and using adaptive management strategies. With the risk of undesirable dams rated as negligible (3,780 miles) and minor (390 miles) along 95% of streams for which beaver dam building is possible, and land use intensity rated as low (474 miles) or very low (3,890 miles) along 99% of potential stream miles, the Proposed Action is not expected to significantly increase the occurrence of undesirable flooding. Instead, by restoring hydrologic processes that slow flow velocities and distribute floodwaters across valley bottom segments in which risks are low/negligible, the Proposed Action may reduce undesirable flood impacts by dampening flood forces in downstream reaches, which often contain more infrastructure and incompatible land uses.

Drought: By reducing hydrologic efficiency, the Proposed Action will dampen the effects of both flooding and drought on water resources because more water will be retained in the valley bottom when it's abundant (often early season, when water demands are relatively low) and slowly release it later in the year (when water demands often peak). This will reduce adverse impacts from drought on water resources and associated ecosystem services. This will be increasingly beneficial as snowpacks melt earlier in the season; the form of precipitation shifts from snow to rain (causing flashier streamflows and earlier runoff); a greater proportion of precipitation falls in fewer, but more intense storms (causing large peaks and troughs in streamflow patterns); and warmer temperatures increase the intensity and occurrence of both persistent and warm season droughts. Relative to the No Action Alternative, the Proposed Action will lessen the severity of these impacts on hydrologic and ecologic drought, while providing more water, later in the year, when it is often needed most to sustain ecosystems and water users. This will be particularly important for streams that historically received large amounts of water from low to mid elevation snowpacks, which are expected to be among the most impacted by warming temperatures (Appendix G). Furthermore, since the Proposed Action will increase connectivity between surface and groundwater sources and elevate base flows, it could create cooler zones of water, and improve water quality; thereby minimizing or avoiding the associated impacts on beneficial uses such as aquatic life.

Water Quality: The Proposed Action will maintain or improve water quality by increasing riverscapes' resistance and resilience to disturbance, while forcing water to travel through longer, more complex hydrologic flow paths. Increasing the distribution of structural elements and riparian-wetland vegetation will force flooding at lower flows, increase the type and extent of valley bottom inundation, increase the exchange of water between the stream, streambed, and floodplain aquifer; and reduce flow velocity. This will increase the resistance and resilience of riverscapes to disturbances such as floods, drought, livestock grazing, and other resource uses; thereby minimizing or avoiding the unravelling of ecological processes that historically maintained water quality. These processes will also capture, retain, and cycle pollutants from upstream sources, while developing floodplains and complex hydrogeomorphic features with captured sediment and nutrients. By increasing flow path complexity and residence time, plant nutrient uptake and biogeochemical processes that can ameliorate pollutants may increase. Temperature heterogeneity may increase, and temperatures may rise in some areas, but the magnitude of daily/seasonal fluctuations will be dampened by delayed discharges, narrower and deeper active channels, surface/groundwater exchange caused by substrate heterogeneity and deeper pools, and shade from riparian vegetation. Collectively, these riverscape functions will reduce sediment and nutrient impairments to ecological processes, create more heterogeneous aquatic attributes and zones of downwelling and upwelling between the stream and shallow groundwater. This will create areas with higher dissolved oxygen (DO), and lower water temperatures to sustain beneficial uses and values (fisheries, recreation, etc.), as well as ecosystem services (e.g., reduced water treatment costs). It will also buffer water quality impairments that will be amplified by the increased occurrence and severity of drought, flood, fire, and high temperatures associated with climate change.

To restore riverscape health, the Proposed Action will increase bed aggradation and lateral widening of incised stream channels by increasing hydraulic diversity and the corresponding rate, magnitude, and variability of erosional and depositional processes. These changes must occur for degraded streams and riparian-wetland zones with associated water quality impairments to regain their historic form, function, and attributes that will improve water quality. However, promoting and sustaining these geomorphic and hydrologic adjustments will involve sorting and resorting bed, bank, and floodplain materials, which could increase the supply of sediment, nutrients, and organic material. This could impact water quality in the short term by infilling pools, covering gravels with fine sediment, and increasing stream temperatures. However, these impacts would be temporary, minimized or avoided through the application of BMPs, and reversed over time as hydrologic processes that improve water quality are restored. Emplacing structural elements strategically downstream of erosional features would slow water velocity and increase hydraulic diversity. This would increase sediment sorting and deposition, correspondingly increasing heterogeneity of streambed sediments, the development of geomorphic features that increase stream-floodplain connectivity and channel complexity, expand the distribution of deep-rooted riparian plants, and increase the diversity and residence time of hydrologic flow paths. These impacts would improve water quality. Implementing treatments when streamflow conditions are suitable and unlikely to be impaired by these activities would further minimize or avoid any potential short-term impacts to water quality and associated beneficial uses. Relative to the No Action Alternative, water quality would improve in both the short and long term. This is because treatments would be applied to streams in which water quality is already diminished by channel incision, structural starvation, and riparian health.

3.2.3.1 Cumulative Effects – Proposed Action

Past, present, and future impacts from a diverse array of people, organizations, and management actions within watersheds in which the Proposed Action would be applied will cumulatively impact water resources at the scale of an individual stream reach, as well as the entire stream network (See Chapter 3.xxx for a summary of the impacts that are/will affect riverscape health). Impacts from agriculture, forestry, hydrologic modification, mining and industry, recreation, transportation, and urban and suburban development will continue to directly impair water quality in many places. Water quality improvement projects authorized on a case-by-case basis would continue to be implemented on BLM and non-BLM lands. These projects will complement the Proposed Action by targeting known sources of pollution. Improved forestry practices, riparian grazing management, travel management, weed control, road maintenance, vegetation health projects, and the application of BMPs to land use authorizations will minimize or avoid many impacts that existing and future land uses will have on riverscapes and water resources. However, resource management practices that have reduced the distribution of riparian vegetation, beaver dam building activity, and wood accumulations will continue to cause channel incision and a loss of complex hydrologic, hydraulic, geomorphic, and vegetative attributes. These impacts will prevent riverscapes from maintaining or improving water quality, as well as the spatial and temporal distribution of water. The Proposed Action will minimize or avoid these impacts to BLM administered stream reaches, but hydrologic processes at the watershed-scale will continue to function below the historic potential if the issues are not also addressed in those areas (e.g. on reaches not administered by the BLM). Water resource improvements will be greatest at the scale of individual stream reaches and where the scope of restoration is large, relative to the size of the stream, watershed, and magnitude of the corresponding water resource issue.

Consumptive and non-consumptive water uses, coupled with the impacts of climate change on temperatures, evapotranspiration demands, snowpacks, the timing and duration of streamflow, and expectations for increased future water demands during the warm season will further reduce the distribution of water and amplify the impacts of riverscape degradation on water distribution and quality. These impacts may prevent the full recovery of hydrologic processes that historically promoted the attainment of beneficial use criteria. More frequent and intense wildfires, drought, and flooding will further amplify the impacts of riverscape degradation on water resources. However, the Proposed Action will minimize these impacts by restoring riverscape processes and attributes that store water on the landscape, ameliorate pollutants, and increase their resistance and resilience to disturbance.

Beaver populations are generally increasing throughout the project area, but lethal removal of beaver and degraded habitats will continue to limit the scope and scale of future dam building activity. Where suitable habitat exists near rivers with expanding beaver populations, some will construct new dams that spread water across the valley bottom, which will increase the distribution and quality of water. However, recreational/subsistence trapping and lethal removal of nuisance beaver will slow or halt re-occupation in some areas, especially if they move to reaches where the risk of human-beaver conflict is high. Applying beaver mitigation strategies and risk evaluations for project locations will minimize the need for lethal removal of beaver, while promoting dam building activity where ecological benefits are most needed. Although the BLM may coordinate with state wildlife agencies regarding beaver trapping policies (including potential closures for ecological purposes), beaver trapping will continue in accordance with the state laws. If beaver are trapped out of restoration project locations, recovery would not be self-sustaining and water quality and distribution would not improve. However, if beaver are allowed to remain in place, projects would become self-sustaining, hydrologic processes would be restored, and beaver may expand further throughout the drainage to increase the scope of impacts. Irrespective, historic degradation will limit the capacity for beaver dam building in many reaches. Bed incision will continue to confine high flows to the channel, diminish the amount and type of deciduous woody vegetation, and reduce floodplain aquifer levels and base flows. These conditions will prevent beaver dam building activity until the channel naturally evolves to a healthier state through a series of flood events. The Proposed Action will accelerate the requisite changes, while the increased water depth will provide the protection from predators that expansionary beaver will need to successfully reoccupy the sites. These impacts will increase the rate and scope of beaver dam building activity, which will correspondingly accelerate recovery of the hydrologic processes which historically maintained clean, abundant water throughout the valley bottom.

Impacts from climate change and future consumptive demands may increase the need to store water on the landscape. If the size or number of artificial hydrologic modifications increases, streamflow and sediment transport dynamics would be adversely impacted, which would further impair riverscape health and prevent recovery of hydrologic processes. This would impair water quality and limit the broad suite of beneficial uses that are otherwise supported when water is stored and slowly released through natural processes. The Proposed Action would naturally retain water in the valley bottom over larger areas for longer periods, which will benefit wildlife and livestock; therefore, reducing the need for artificial impoundments. Reducing the need and corresponding number of artificial impoundments will improve riverscape health, water quality, and water distribution.

3.3 Resource Issue 3: How would implementation of the alternatives affect fish and aquatic species that depend on riverscapes to meet their lifecycle needs (including sensitive status, candidate, threatened, or endangered species)?

3.3.1 Affected Environment – Fish and Aquatic Species

Channels and adjacent wetlands associated with 1,100 miles of perennial and 45,400 miles of intermittent/ephemeral stream support a wide array of aquatic species (**Appendix E;** https://fwp.mt.gov/fish/species; Fishes of South Dakota http://www.nativefishlab.net/library/textpdf/17260.pdf). This diversity reflects the correspondingly broad range of physiographic settings and riverscape processes and attributes that historically sustained the ecosystems in which the species evolved. Cold water species are most common in Western Montana and in waterbodies that are fed by snowmelt and/or high groundwater contributions. Streams in Eastern Montana and the Dakotas support both cold and warm water species, as most of the systems are transitional on a large scale between the cold-water fisheries in the western mountains and the warm water fisheries in the Midwest and southern states. Regionally, there are 57 native fish species that continue to exist throughout their ranges due in part to progressive habitat conservation and sustainable fisheries management. However, some species sensitive to habitat fragmentation, habitat degradation, climate change, and competition or hybridization with introduced species have seen their abundances decline and ranges contract. Some of these species are classified as “Special Status” because they: (i) are listed or proposed for listing under the Endangered Species Act (ESA) and/or (ii) require special management consideration to promote their conservation and reduce the likelihood and need for listing under the ESA. These and other natives found in or near BLM administered stream segments are identified in **Appendix F**, Tables 1 and 2.

The BLM's associated objectives are to: (a) conserve and/or recover ESA-listed species and the ecosystems on which they depend so that ESA protections are no longer needed and (b) initiate proactive conservation measures that reduce or eliminate threats to Bureau sensitive species to minimize the likelihood of and need for listing of these species under the ESA. Although special status species are prioritized for monitoring and management, land/habitat managers (e.g., the BLM) and other federal, state, and local fish/wildlife agencies strive to maintain viable populations of all native species. This includes the protection, maintenance, and restoration of native fish populations and their genetic diversity. To accomplish this, species are typically managed at the overall population and habitat level, as individual species and waterbodies are just one part of a much more complex, interconnected aquatic ecosystem.

Of the native species that lack special conservation status, state agencies differentiate between those with sport-fishing value (e.g.; catfish, shovelnose sturgeon, and mountain whitefish) and those without sport-fishing value (e.g. most minnows and suckers). Native and non-native species with sport-fishing value are typically managed similarly. Generally, sport-fish populations are managed to maximize fishing opportunities while limiting negative interactions with other species. Native species without sport-fishing value or special conservation status (e.g. longnose dace, Rocky Mountain sculpin, flathead minnow, and longnose sucker) are managed proactively to restore, maintain and protect populations and their habitat. Irrespective of the conservation status and sport-fishing values of a species, wild fish production is widely acknowledged as a central tenet for the management of the regions' fisheries and aquatic ecosystems. Given the scope of aquatic habitat degradation and increasing impacts associated with climate change, conserving and improving aquatic habitat is necessary to maximize native and non-native wild fish production, maintain or improve wild fish populations, and ensure that the resource values needed by all native species that depend on riparian-wetland and aquatic areas are supported by natural processes. Consequently, the BLM routinely seeks to implement projects that maintain or improve aquatic habitats, while working with other state, federal, and local fish/wildlife managers to address species specific issues (e.g., removal of non-native fish that compete with native populations, restocking of native species to restored habitats, protection of genetically pure populations for future use as brood stock, etc.).

Regionally, there are an estimated 34 non-native fish species and/or hybrid crosses. Most of these fish have been introduced to support recreational fishing opportunities, particularly warm water fish in the eastern portion of the project area. In fact, every major drainage has been stocked with non-natives (Montana Warm Water Fish Management Plan, 1987). Northern Pike, Green Sunfish, Common Carp, Black Bullhead, Brook trout, and Brown Trout are most common (https://fieldguide.mt.gov; see Appendix F, Tables 1 and 2 for preferred habitat descriptions). Many of these fish compete with native species for food resources, and can alter their genetics through inter-breeding, disrupt food chains, impair aquatic ecosystems, and ultimately reduce the populations of native species. For example, introduced brook trout are a major threat to the persistence of native bull trout in several western Montana watersheds (USDA 2013, https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5427869.pdf). Brook trout are more aggressive and out-compete bull trout for food and grow more rapidly. In addition, the two species can hybridize reducing the long-term reproductive potential of the bull trout. These issues are amplified by riverscape degradation and climate change, which have changed the riverscape processes and attributes that bull trout and other native species evolved alongside. Such impacts have reduced the capacity of riverscapes to meet the lifecycle needs of some native species and in some cases have improved the capacity for non-native species to persist. There are efforts underway to document these changes by researchers studying habitat drivers of native and non-native fish assemblages. To address fish management issues, while ensuring that regional waterbodies continue to support excellent recreation fishing opportunities, state agencies have developed management plans for individual waterbodies, collections of waterbodies, and species groups (Montana Fisheries Management Program and Guide, 2019 – 2027). In addition, the USFWS, USFS, and other federal and state partners have developed conservation plans for some Special Status species including bull trout (USDA 2013), and Yellowstone cutthroat trout (USDA 2009, https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5199582.pdf) . These types of management plans are prescriptive in that management actions are recommended when defined goals or thresholds are exceeded or not met. The BLM routinely coordinates with state agencies, federal and other external partners to manage aquatic ecosystems in accordance with the goals/objectives of these plans, as well as the prevention and control of other aquatic invasive species.

Fish Habitat Conditions and Food Webs

The capacity of riverscapes to support the diversity, abundance, and resilience of aquatic species has changed dramatically. Many of these changes are fully or partly attributed to riverscape degradation (Section 3.1.1), which largely began with the removal of beaver and wood. In general, the potential for a stream to support large, rich, diverse, and resilient aquatic ecosystems increases with scale (length, size, and connectivity of the aquatic zone), morphological diversity, and hydroperiod (frequency, type, and extent of inundation). Historically, most riverscapes supported more miles/acres of riparian-wetland and aquatic habitat; retained water longer, through more diverse types of inundation and hydrologic flow paths; and created more morphologically diverse channel and floodplain attributes than they currently do. They therefore provided more abundant and diverse habitats for aquatic species (e.g., Sayer, 2014; Entwistle et al., 2019), as well as corridors for species migration and dispersal (e.g., Antas, 1994). Although aquatic conditions are generally maintained or improving, historic impacts have exacerbated the occurrence of streambed incision, which has adversely impacted riverscape functions and aquatic species. Consequences for aquatic habitat include a lowering of the water table, decreased base flows, shorter duration of flow, warmer water temperatures, reduced morphological complexity, and a loss of secondary or overflow channels. These impacts have reduced the miles/acres of aquatic habitat (scale), washed out physically complex channel and floodplain attributes (morphological diversity), and diminished flow duration (hydroperiod). As a result, riparian plant biomass and diversity, as well as fish populations and other aquatic organisms have correspondingly declined. Many of the remaining habitats and associated species are therefore less resistant and resilient to large disturbances like flood, drought, wildfire, disease, invasive species, and the impacts of climate change.

Beaver dam building activity, wood accumulations, riparian vegetation, and frequent stream-floodplain interactions are needed to sustain aquatic habitat productivity, species diversity, and resilience along most low gradient streams within the project area. This is because the spatial and temporal sequence of disturbances associated with processes such as lateral channel movement, formation of logjams (Collins et al., 2012), and construction and then infilling of beaver ponds (Wright et al., 2002; Stevens et al., 2006) creates a patchy, shifting pattern of surface and subsurface habitats that historically sustained a broad array of aquatic ecosystem services. These habitats have diverse grain-size distribution, elevation, hydraulic conductivity, hydrologic connectivity, inundation regimes, organic carbon concentrations, and nutrient availability. Because of this diversity, they provide a rich source of food for juvenile fish (Katz et al., 2017), which can be acquired directly by the fish accessing the floodplain or through the channel network via floodplain return flows (Jeffres et al., 2020). Hydraulic complexity and the abundance of low-velocity areas within the functional riverscapes also facilitates retention of particulate organic matter (POM, e.g., Jones and Smock, 1991), especially where extensive backwater areas are created by logjams (Beckman and Wohl, 2014; Livers et al., 2018) or beaver dams (e.g., Naiman et al., 1986). This POM increases the riverscapes' capacity to support fish and wildlife because it provides habitat and food sources for the microbial and macroinvertebrate communities (Tank et al., 2010; Edwards et al., 2020) that feed other fish/aquatic species (Lindeman, 1942; Odum et al., 2005). These conditions currently are not widespread in the project area.

Historically, most response reaches supported a mix of lotic (fast moving water) and lentic (slow moving water) habitats across the valley bottom. Where present, these interconnected lentic-lotic habitats (known as river-wetland corridors) support lentic benthic invertebrates (aquatic insects) surrounding beaver dams, log jams, and adjacent wetland zones with slow moving water, as well as lotic benthic invertebrates that prefer riffles and other zones with fast flowing waters within the primary and secondary stream channels. As a result, these reach types historically did and in the future could support a correspondingly diverse array of fish and other aquatic species, as well as bigger fish and/or larger populations. However, many of these stream reaches have been impacted by structural starvation, channel incision, the disconnection of secondary channels, and the subsequent loss of lentic zones throughout the historic floodplain. As a result, lentic benthic invertebrates and the native species that feed on them have declined in many areas, causing population shifts that favor species adapted to lotic conditions (McDowell and Naiman, 1986). Despite the loss/reduction of lentic habitats and species, the diversity and abundance of lotic species have also likely declined in many areas. This is because channel incision and related impacts have reduced the total length of stream (by reducing sinuosity, while disconnecting the main channel from secondary channels and overflow zones), the duration of flow, physical habitat attributes, and the diversity of habitat zones that historically supported the lifecycle needs of native aquatic species.

Although channel incision has greatly reduced ponded, overflow, and free flow inundation types/extents, as well as the corresponding size, productivity, and diversity of aquatic habitats, non-native species have also been impacted. Throughout the project area, the American Bullfrog, Green Sunfish, Common Carp, Black Bullhead, Brook trout, and other non-native species that favor zones of slow moving/ponded water are present. In most instances, these species were released into artificial ponds/lakes to enhance fishing opportunities, but subsequently expanded through the stream network. Similarly, West Nile virus has been reported in mosquitoes that reproduce in slow/still water, particularly in the Northern Great Plains Ecoregion. Although researchers are just beginning to evaluate the link between riverscape degradation, restoration, and the ramifications for the population dynamics of native/non-native species, it is likely reasonable to assume that the loss of aquatic habitat, particularly lentic areas, has limited the distribution and abundance of both native and non-native species.

As described in the Climate Change and Water Resources Sections (Sections 3.0 and 3.2.1), climate change is impacting streamflows, water temperatures, as well as the duration and intensity of drought, flood, and wildfire. These impacts are expected to amplify the effects of riverscape degradation on native aquatic species; particularly those that require cold water temperatures, perennial water, and complex riverscape attributes. Increased water temperatures will affect cold water fish and aquatic insect communities directly by influencing metabolism and reducing the concentration of dissolved gasses. They are also expected to increase the growth of nuisance and toxic algae, as well as the persistence of pathogens that pose risks to aquatic species (and humans). These impacts will amplify the effects of riverscape degradation on aquatic ecosystems, especially the distribution and abundance of warm and cold-water species. Specifically, the suitable range for cold water species is expected to contract, while the potential range for warm water species is expected to expand. Longer, more frequent, and/or intense droughts will reduce the duration of streamflow and further increase the duration and intensity of warm temperatures, with potentially lethal impacts on many species. Extreme floods will stress species that lack sufficient backwaters and other refuges from high velocities. Healthy riverscapes will minimize or avoid many of these impacts, while species in degraded riverscapes will be more prone to population declines and shifts from non-native plants/animals that are better evolved to survive in the altered conditions. To minimize these impacts, there are efforts throughout the project area to maintain or restore instream flows, enhance riparian habitat to increase shading, prevent the spread of aquatic invasive species, and remove instream barriers to increase fish access to more habitat. However, given the extent of riverscape degradation and magnitude of impacts from climate change, the scope and scale of these projects are insufficient to avoid many of the deleterious impacts for aquatic species.

3.3.2 Environmental Effects—No Action Alternative

- None of the actions describe in Table 1, Section 2.2 would occur, so none of the outcomes associated with the Proposed Action would be realized at the reach or riverscape scales.
- Aquatic systems would remain in the current state or slowly improve, but impairments caused by habitat degradation would be amplified by the impacts of climate change.
- Streams impacted by structural starvation, channel incision, or disclimax and non-native species would continue to function below their potential, providing poor habitat conditions for species dependent on clean abundant water, complex physical attributes, abundant and diverse native riparian vegetation, and associated refugia from flood, drought, wildfire, and climate change.
- Habitat would not be improved for sensitive status or other native aquatic species. Instead, they would remain at risk from the impacts of habitat loss and degradation, climate change, and diminished connectivity to heterogenous habitat types that most biota need to stratify during various stages of their lifecycles.
- None of the following outcomes of riverscape restoration would be achieved:
    - Create more aquatic habitat (channel length, as well as type and extent of interconnected aquatic areas)
    - Increase stream-floodplain connectivity, flow duration, flow path complexity, and diversity of hydrologic conditions that sustain more abundant, resilient, and diverse assemblages of aquatic species.
    - Expand spatial extent of native riparian plants, as well as the diversity of species and age classes that maintain food sources and related aquatic conditions for aquatic species.
    - Increase hydraulic, hydrologic, geomorphic, and vegetative complexity to support diverse assemblages of aquatic species and provide refuge during variable flow and climatic conditions.
    - Create multi-threaded channels.
    - Capture and retain sediment and nutrients within the valley bottom to sustain riverscape processes, rather than impair water quality.
    - Mimic, promote, and sustain beaver dam building activity and wood accumulations
- Aquatic systems would continue to degrade, ground water replenishment would not occur, water quality would not be maintained or improved, water would not be stored in the valley bottom and slowly released to the stream, and the riparian-wetland and aquatic zones would not expand toward their potential extents.
- The distribution and diversity of native riparian vegetation would be lacking, stream-floodplain connectivity would not be restored and thus not support the growth of native riparian-wetland and aquatic plant communities (e.g., aspen, willow, cottonwood, red osier dogwood, alder) historically found in the region's valley bottom, which are better adapted to the physical attributes historically associated with these areas.
- Habitat connectivity for native and non-native species would not increase. Non-native species would continue to expand throughout the project area and adversely impact native species, but potentially at a slower rate. The spatial extent and productivity of riparian-wetland and aquatic areas would remain diminished and therefore, support

correspondingly smaller native and non-native aquatic species populations.

- Beneficial impacts from restored connectivity and habitat complexity would not occur. Instead, habitat connectivity and complexity would remain diminished; thereby constraining aquatic organisms' ability to access the habitats which best satisfy their seasonal and lifecycle needs or provide refuge during drought, floods, post-wildfire disturbances, and other major local/regional disturbances. This would reduce species survival, particularly as the impacts of climate change on aquatic habitats become more frequent, severe, and conditions within currently occupied habitats change beyond the thresholds in which the species evolved.
- Without restoration of hydrologic processes, disclimax species such as upland conifers would continue to expand across floodplains, consuming increasingly large quantities of water and reducing the supply of native riparian plants needed to support wood accumulations, beaver dam building activity, and related processes that historically created and maintained aquatic habitat attributes.
- Grazing by wildlife and livestock would continue to occur where the types and amounts of riparian vegetation need to increase to sustain recovery of hydraulic, hydrologic, geomorphic, and vegetative attributes.

3.2.2.1 Cumulative Effects—No Action Alternative

None of the processes described in the Water Resources and Riverscape Processes and Attributes Sections would be mimicked, promoted, or sustained to accelerate the recovery of degraded riverscapes. Furthermore, none of the historic impacts to riverscapes that have adversely impacted aquatic ecosystems and species would be restored. Where structural starvation and channel incision has occurred, the scale (length, size, and connectivity of the aquatic zone), morphological diversity, and hydroperiod (frequency, type, and extent of inundation) of the aquatic and riparian-wetland zones will remain diminished for decades (at best), centuries, or even millennia. The type and extent of valley bottom inundation will remain far below historic conditions and nearly all surface water that does exist will be free-flow. Lentic zones that were historically associated with ponded and overflow inundation types will not exist or be highly reduced in space and time. This will continue to limit the diversity, abundance, and resilience of sensitive status and other aquatic species, which could decline further due to the impacts of climate change. By not restoring the interconnected lentic-lotic zones that historically existed, non-native species that are adapted to lentic conditions would not increase. However, by not increasing the size, complexity, and flow duration within the aquatic zones, native aquatic species would not increase in size, abundance, or diversity and some may decline further due to the combined influence of climate change and riverscape degradation.

Other organizations such as State agencies and other federal and private entities may have and will continue to implement various aquatic restoration projects, which will typically benefit the aquatic species along stream reaches administered by the BLM. Additionally, several disparate riparian restoration projects have been implemented since 2018, but none have utilized the integrated strategy described in the Proposed Action and none have been scaled up beyond the scope of a single stream reach. Such activities on adjacent lands not managed by the BLM are not known to be occurring at this time, but it's reasonable to assume that some may occur in the future. Past projects that may have been implemented would continue to benefit hydrologic and biological processes.

3.3.3 Environmental Effects— Proposed Action

Increase the diversity, abundance, and resilience of aquatic species: The Proposed Action would increase the scale (length, size, and connectivity of the aquatic zone), morphological diversity, and hydroperiod (frequency, type, and extent of inundation) of the aquatic and riparian-wetland zones. This will increase the diversity, abundance, and resilience of aquatic species; including those that are identified as sensitive status. Wetlands and beaver ponds of varying age and size will be restored in some areas, which will support juvenile fish, but also create critical habitat diversity for wetland plants, amphibians, and other species that require a reliable water source (Stevens et al., 2006; Popescu and Gibbs, 2009). This increased "density diversity" will enhance the opportunity for aquatic species to find the appropriate life history habitat within a relatively small area, effectively reducing migration distances and energy expenditure. The hydraulic and habitat heterogeneity will also decrease the distances between various habitat niches so that aquatic and wetland species will not need to move as far to fulfill diverse thermal and trophic needs (Armstrong and Schindler, 2013). Spatial variations in flow depth and velocity associated with structural elements will increase, allowing aquatic and wetland species to self-segregate. For example, juvenile fish will be able to find refuge in shallow water areas away from predatory fish (Brown and Moyle 1991), while different species of pond-breeding amphibians may experience higher survival rates where beaver ponds of differing age and hydrologic connectivity provide habitats with and without fish (Cunningham et al., 2007). As riverscape processes and attributes are restored (Sections 3.1.3), expansive areas with higher densities of biomass and biodiversity will develop during successive flow events. Where beaver dam building activity and wood accumulations increase, biodiversity of aquatic and wetland plants (Wright et al., 2002), aquatic and terrestrial insects (e.g., Hood and Larson, 2014), amphibians (e.g., Karraker and Gibbs, 2009), fish (e.g., Smith and Mather, 2013), birds (e.g., Aznar and Desrochers, 2008), and mammals (Rosell et al., 2005; Hauer et al., 2016) will correspondingly increase. Greater biodiversity, coupled with the higher levels of habitat complexity and diversity will increase the stability of biological populations subject to significant environmental variability such as flooding, drought, and climate change (Bellmore et al., 2015). This in turn will increase the range, value, and reliability of aquatic ecosystem services (Ekka et al., 2020).

Increase abundance of native and some non-native species: All projects will maintain or increase the structural elements and/or riparian vegetation within riverscapes. These flow obstructions will increase hydraulic diversity, forcing water to flow through longer, more diverse hydrologic flow paths; creating more miles of primary and secondary channel habitat; increasing substrate heterogeneity, geomorphic complexity, and the diversity of habitat types; while expanding the distribution of interconnected wetland zones that are inundated by ponding and overflow. These impacts will increase the spatial extent of both lotic and lentic habitats, leading to increased population responses of aquatic species adapted to slow moving water, as well as those that are adapted to faster moving water. These attributes will benefit both native and non-native species. Where non-native species that thrive in the lentic zones are present, their populations may correspondingly increase, altering the population dynamics between native and non-native species. As a result, the abundance of Northern Pike, Green Sunfish, Common Carp, Black Bullhead, Brook trout, Brown Trout, Rainbow Trout, the American Bullfrog, and other non-native species could increase in some stream reaches. However, restoring the processes and attributes that historically maintained the health of aquatic ecosystems in which the native species evolved will generally also increase the abundance and resilience of those native species, even if the non-native species increase. By considering these factors during the planning and design phase; coordinating with state, federal, and local fish/wildlife managers to address them, and implementing an adaptive management framework (Appendix H) to ensure short- and long-term objectives are attained, potential adverse impacts to aquatic species and ecosystems would be minimized or avoided.

Increase Temperature Refugia: By increasing the diversity of hydraulic pathways and residence time of water, the Proposed Action will increase the spatial variability of water temperature and buffer daily temperature swings within and downstream of project areas. Previous studies indicate that the spatial variability of temperature could increase by 3° to 10° C by creating pockets of both much warmer and much cooler temperatures (Weber et al., 2017). The warm areas are likely to form in shallow ponded water areas, whereas the cool areas are likely to develop downstream of BDAs, PALs, and beaver dams. This is because water depth/pressure will increase above the flow obstructions, causing the displacement and subsequent upwelling of cool groundwater further downstream. These impacts will make aquatic ecosystems more resilient to thermal extremes by providing choices for biota (i.e., thermal refugia). Furthermore, as the Proposed Action increases the elevation of floodplain aquifers, increased groundwater will likely be released as base flows during the warm season. Since groundwater is typically cooler than surface water during the warm season, it's release to the stream during periods of low flow will help to cool streamflows. This will benefit the metabolisms of native aquatic species and increase the concentration of dissolved gasses like oxygen. Since water temperatures and the intensity of both persistent and warm season drought are projected to increase, restoring zones of cool water refuge will help native aquatic species to meet their lifecycle needs. The impacts of upwelling, groundwater, and hydrogeomorphic diversity will also benefit some aquatic species in the winter by creating zones that resist complete freeze.

Fish movement: BDAs, PALs and any subsequent beaver dams would increase habitat connectivity, especially in the long-run, but could temporarily slow the movement of fish and other aquatic species in some areas by interrupting longitudinal connectivity. However, adverse impacts to native fish are unlikely because beaver and native fish have co-evolved and fish can migrate upstream and downstream of beaver dams during certain times of the year or during certain flow conditions. Furthermore, these structures are temporary. Irrespective, there is the potential that during very low flows, beaver dams and BDAs could slow fish passage in some areas. By installing secondary BDAs below the primary BDAs, connectivity disruptions would be minimized or avoided because the associated pools would allow fish to jump over the primary dams. Furthermore, as ponds and pools fill and become deeper, the impoundments will force flow laterally, causing overbank flow onto floodplains and the creation of side channels (Westbrook et al. 2006). These side channels and distributaries would provide additional opportunities for aquatic movement throughout the stream network and laterally between diverse habitat zones within the valley bottom. By improving access to zones of refugia from flooding and drought, aquatic species will be more resilient to the impacts of climate change. Pond levelers used to mitigate undesirable flooding could reduce water levels in beaver ponds and slow fish passage. By installing fish-friendly designs that allow passage directly through the conduits where movement by native species may otherwise be slowed and likely to affect their populations, these impacts would be minimized or avoided. Although restoring habitat connectivity will generally help aquatic species meet their lifecycle needs and find refuge during floods, drought, post-fire disturbances, and other episodic habitat disturbances, it could similarly help some non-native species (i.e. Brook Trout) travel throughout a stream network. These non-native species could adversely impact native species by competing for food and habitat and reducing their genetic purity via interbreeding. Coordinating with state fish and wildlife management agencies to control the abundance and movement of non-native species, monitoring outcomes for aquatic species where such concerns exist, and implementing adaptive management strategies would minimize these impacts.

Increase Geomorphic and Hydraulic Complexity: Along most structurally starved streams, deep-water habitat (e.g., pools) is limited. BDAs, PALs and their natural counterparts will help the BLM to achieve habitat objectives for aquatic life by forcing dam pools that provide flow and temperature refugia for fish (Bouwes et al., 2016b), while increasing the exchange of water and nutrients between the stream, bed, and banks, which is often important for macroinvertebrates (food source for many aquatic species). These impacts would occur because beaver-made dams and BDAs will slow and increase the surface height of water upstream of the dams. Beaver ponds above, and plunge pools below dams will change the plane bed channel to a reach of complex geomorphic units providing resting and efficient foraging opportunities for juvenile fish and other aquatic organisms. Deep pools will allow for temperature stratification and greater hydraulic pressures will force downwellings to displace cooler groundwater to upwell downstream, increasing thermal heterogeneity and refugia. Dams and associated overflow channels will produce highly variable hydraulic conditions resulting in a greater diversity of sorted sediment deposits. Gravel bars will form near the tail of the ponds and just downstream from the scour below the dams, increasing spawning habitat for spawners and concealment substrates for juvenile fish. Complex depositional and erosional patterns will cause an increase in channel aggradation, widening, and sinuosity and a decrease in overall gradient, also increasing habitat complexity. More frequent inundation of inset floodplains will create side channels, high-flow refugia and rearing habitat for young juveniles, while increasing recruitment of riparian vegetation. Flows onto the floodplain during high discharge will dissipate stream power, and the likelihood of dam failure. The increase in pond complexes and riparian vegetation will increase refugia for beavers, their food supply and caching locations, resulting in higher survival, and more persistent beaver colonies. Beaver will maintain dams and the associated geomorphic and hydraulic processes that create increasingly complex and productive fish habitat. Vegetation management actions will reduce the consumption of riparian plants by livestock and wildlife, ensuring that sufficient amounts and types of riparian vegetation are available to sustain the recovery of riverscape processes and contribute organic inputs to the stream that support aquatic insects and the associated food chain.

The increase wood loading by adding PALS is expected to increase flow complexity, creating: deposit and erosion of different substrate sizes; areas of slow water above and behind structures that will provide resting areas; fast water where convergent jets can scour bottom substrate creating pools or undercut banks; and shear zones at the interface between fast and slow water that is energetically efficient for the foraging of most native fish that occupy habitats in which the processes of wood accumulation were historically important drivers of aquatic attributes. The deposition of gravels from scour or changes in water velocity will provide areas where juveniles can hide and adults can build redds to reproduce. Wood and undercut banks created by the structures will also provide cover from predators. The increase in geomorphic complexity including changes in the number and diversity of geomorphic units, channel sinuosity, overbank flows, and variable widths is expected to move the stream from a degraded stable state that is frequently locked in by dense young riparian vegetation, to a dynamic stable state (Stage 0) that is capable of recruiting more wood and maintaining more complex aquatic habitat; thereby sustaining the processes of wood accumulation and associated benefits for aquatic species.

Beaver dam building activity will be maintained or increased, which will increase primary productivity and aquatic invertebrates: Beaver dam building activity will improve habitat for many aquatic insect populations by increasing the input and storage of organic material and sediment (reviewed in Collen and Gibson 2000) and increasing primary productivity. Beaver ponds will boost primary productivity both by increasing the availability of organic nutrients (Francis et al. 1985) and by allowing sunlight to reach more water surface for photosynthesis. Primary producers such as periphyton, planktonic algae, and aquatic vascular plants will take advantage of the increased solar radiation. This will set the stage for the secondary producers—micro- and macroinvertebrates—which, in turn, will take advantage of the increase in detritus (i.e., the woody material, decaying leaves, and decaying in-situ vegetation produced in the pond). These micro and macroinvertebrates will increase the base of the food web that juvenile fish will rely on when rearing and overwintering in beaver ponds. As degraded, channelized streams recover and the processes of beaver dam building activity are restored, the community structure of aquatic invertebrates will also be restored through a shift from primarily lotic taxa to a larger presence of lentic taxa (McDowell and Naiman 1986). This will increase the abundance and biodiversity of aquatic insect communities by supporting both lotic and lentic populations.

Beaver dam building activity will increase the abundance, distribution, and diversity of fish: Most native fish evolved with beaver and will therefore benefit from their influence on riverscape processes and attributes. Because beaver ponds slow down stream flow and have very large edge-to-surface-area ratios, they will improve cover for fish and increase productivity for both vegetation and aquatic invertebrates that fish can use for food resources not found in un-impounded stream habitat (Hanson and Campbell 1963, Keast and Fox 1990, reviewed in Pollock et al. 2003). Additionally, fish will expend less energy foraging in the slow, productive waters of beaver ponds and side channels than they do in the faster flowing main channel. This will increase fish abundance and size (i.e., weight and length), as fish found in stream reaches that have beaver dams are both larger and more numerous than fish found in streams lacking slow water habitat. (see Gard 1961, Hanson and Campbell 1963, Murphy et al. 1989, Leidholt Bruner et al. 1992, Schlosser 1995, reviewed in Pollock et al. 2003, Sigourney et al. 2006). There has been extensive research on both the positive and negative effects of beaver modifications on fish species, which provides insight to the impacts that can be expected in the project area. Kemp et al. (2012) thoroughly reviewed the primary literature on this topic, focusing on North America, and completed a meta-analysis. They reported the most commonly cited positive and negative impacts to fish as shown in the table below.

Tables 6: Potential Impacts of Beaver Modifications on Fish Species (Adapted from Kemp et.al. 2012)

Potential Positive Impacts	Potential Negative Impacts
• Increased fish productivity/abundance	• Barriers to fish movement • Increased abundance of non-native species (i.e. brook trout) that compete with native species for food and/or produce hybrid offspring
• Increased habitat and habitat heterogeneity (which promotes biodiversity) (Smith and Mather 2013)	• Siltation of spawning habitat
• Increased rearing and overwintering habitat	• Low oxygen levels in beaver ponds
• Enhanced growth rates	• Altered temperature regime
• Providing flow refuge	
• Improved production of invertebrates	

Kemp et al. noted that many of the positive effects cited (51.5 percent) were supported by data, while many more of the negative impacts (71.4 percent) were speculative and not supported by data collected in the field. Furthermore, the most commonly cited negative impact of beaver dams—as barriers to fish movement—was highly speculative, as 78.4 percent of the studies did not support this claim with data. The authors report that 49 North American and European experts consider beaver to have an overall positive impact on fish populations, through their influence on abundance and productivity. By restoring the processes that historically maintained habitat attributes for native aquatic species; coordinating with state, federal, and local fish/wildlife managers to address potential concerns for aquatic species, and implementing an adaptive management framework (Appendix H) to ensure short and long term objectives are attained, potential adverse impacts to aquatic species and ecosystems associated with BDAs and beaver dams would be minimized or avoided. Consequently, the beneficial impacts from the Proposed Action for aquatic species are expected to far exceed any negative impacts.

3.3.3.1 Cumulative Effects— Proposed Action

By restoring the processes that historically created and maintained habitat attributes for native aquatic species, the Proposed Action will minimize or avoid many of the current and historic threats to aquatic ecosystems, while complimenting the water quality, habitat, and vegetation improvement projects completed by other state, federal, and private groups on BLM and non-BLM administered stream reaches. Habitat restoration and aquatic organism passage projects throughout the state will continue to improve the health of aquatic ecosystems. The Proposed Action would complement these projects by increasing the spatial extent, connectivity, and diversity of aquatic habitats; thereby increasing the density, diversity, and resilience of aquatic species.

Native and non-native species are routinely stocked in natural waterbodies, as well as artificial lakes and ponds. These fish have expanded beyond their original waterbodies and are naturally reproducing in many areas. The Proposed Action would increase the abundance and distribution of these fish by creating more miles and acres of complex aquatic habitat. Introduced and native fish that are well adapted to lentic conditions may particularly benefit from restoration, as free-flow conditions with few pools and physically simple, homogeneous habitat conditions are common in degraded streams where the Proposed Action would be applied. Increasing the type, extent, and duration of valley bottom inundation, as well as habitat heterogeneity would increase the distribution, abundance, and resilience of a broader array of aquatic species than are present in degraded reaches. This would benefit the native species because they evolved with these conditions but could also increase the miles/acres of riverscape that are suitable for introduced species; thereby creating food and habitat competition between native and introduced fish along more miles/acres of riverscape. This would correspondingly alter the dynamics of aquatic communities and reduce the magnitude of benefits from the Proposed Action for native species. However, planning, adaptive management, and collaboration will minimize potential effects from introduced fish and maximize the beneficial effects of healthy riverscapes for native species and aquatic resource values.

In some areas, fish and wildlife managers are installing physical barriers to isolate native and non-native species. Although these barriers prevent adverse effects of non-native fish on aquatic ecosystems, they correspondingly limit the amount and diversity of habitat that the native species can access, which is especially important during periods of drought, fire, flood, and related impacts from climate change. The Proposed Action, where applied above these barriers, would minimize these adverse effects by increasing the miles/acres of aquatic habitat within a valley bottom segment, as well as lateral and vertical connectivity between a diverse array of habitat types.

Artificial dams, culverts, water diversions, and other hydrologic modifications will continue to impact riverscape health and habitat connectivity throughout stream networks, isolating some populations from others. Human development is increasing in many watersheds, which is altering the delivery of water and sediment, which will impair water quality and associated aquatic habitat in many areas. Lethal removal of beaver will continue as a primary method for mitigating nuisance beaver, which will reduce the extent of mixed lotic/lentic aquatic habitats and reduce the effects of beaver dams (described above) on aquatic species. However, utilizing beaver mitigation strategies will provide an alternative to lethal removal of some nuisance beaver, which will minimize the impacts to aquatic resources that occur when beaver dam building activity is eliminated from an area. Habitat restoration projects and in-stream water rights will continue to be used in high priority areas to improve the abundance and resilience of aquatic habitat, particularly to support fishing opportunities in larger rivers or the survival of sensitive status species.

3.4 Resource Issue 4 – How would implementation of the alternatives affect the resources, objects, and values of national monuments, wilderness, wilderness study areas, and wild and scenic rivers?

3.4.1 Affected Environment – Resources, objects, and values associated with riverscapes within national monuments, wilderness, wilderness study areas, and wild and scenic rivers?

Approximately 3.5% (5,587 acres) of BLM administered riparian-wetland areas are within thirty-four Wilderness Study Areas (WSAs), Pompey's Pillar and the Upper Missouri River Breaks National Monuments (21 acres and 2,141 acres respectively)), the Lee Metcalf Wilderness, and ten areas designated through the land use planning process as Wilderness Characteristic Protection Areas or Other Lands with Wilderness Characteristics (heretofore referred as "similar designations"). These conservation areas are managed in a manner consistent with the designating proclamations, Acts of Congress, and/or RMP designations, all of which emphasize the maintenance or improvement of wilderness characteristics, resources, objects, and/or values (ROVs). Although the BLM administers uses within these areas accordingly, impacts to riverscape health described in Sections 3.1-3.3 are ubiquitous throughout the Project Area and continue to impair riverscape health, stream and vegetation succession, and related conservation objectives. Where present, these impacts have affected wilderness characteristics and ROVs by: (a) reducing or eliminating the processes of beaver dam building activity and wood accumulations that historically (prior to European Settlement) created and maintained natural attributes of riparian-wetland and aquatic areas; (b) perpetuating a successional departure from the riverscapes' historic and future potential natural conditions; (c) diminishing the riverscapes' capacity to support many of the natural ecosystem services, as well as the distribution and abundance of native species prioritized in the conservation areas; and (d) reducing the riverscape ecosystem's resistance and resilience to disturbances like flood, fire, drought, invasive species, and insect infestation, many of which are increasingly frequent and/or intense due to past, present, and/or reasonably foreseeable human activities that directly or indirectly influence these factors (see Appendix G and Section 3.1.1 on historic impacts that continue to affect riverscape health). Consequently, wilderness characteristics and ROVs that riverscapes historically created and maintained through natural ecological processes are not fully supported in many conservation areas and indirect impacts from human activities on the disturbance regime and successional pathways is expected to perpetuate or cause further departures from the potential natural conditions, wilderness characteristics, and related ROVs (Sections 3.1, 3.2, and 3.3). Since the absence of beaver dam building activity, wood accumulations, and/or natural flood regimes both causes degradation and limits recovery of the processes which create ecologically functional riverscapes, recovery without intervention to re-engage those processes will take decades to centuries (or longer), even where the initial land/resource uses that caused the impacts to have ceased due to the areas' recent (e.g. over the last 50 years) conservation designations.

Within these conservation areas, 521 miles of stream have been assessed via the Proper Functioning Condition Assessment Protocol. Of those, 121 miles were rated functioning-at-risk, 8 miles were rated non-functional, and 393 miles were rated proper functioning condition. Outputs from the Beaver Restoration Assessment Tool (BRAT) were also used to estimate the current and historic capacity of these riverscapes to support dam building activity, as well as opportunities to restore riparian vegetation and the processes of beaver dam building activity. Results show that the types and amounts of riparian vegetation that beaver historically used to construct dams has declined, correspondingly reducing the existing capacity of streams to support dam building activity by an average of 6.5 dams/kilometer. This decline continues to limit the capacity of riverscapes to resist degradation and the impacts of climate change or recover from previous impacts to the processes and attributes that create ecologically functional riverscapes. However, numerous restoration opportunities exist. Specifically, eighty-two miles of stream were rated "low hanging fruit," where activities which promote or sustain beaver dam building activity could rapidly improve riverscape processes and attributes with little risk for human conflict. Fifty-one miles are rated "quick return," where short-term vegetation restoration and the promotion of beaver dam building activity would quickly increase capacity for natural recovery. Forty-one miles are rated "long-term investments," where long-term riparian vegetation reestablishment is the only option for recovery, based on low existing dam capacity, high historic dam capacity, and low intensity land-use. Lastly, 154 miles of stream are unlikely suitable for restoration via beaver dam building activity because the risks to human development are greater than "negligible," there is insufficient capacity to support dam building activity, or high land use intensity has adversely impacted habitat suitability

Wilderness Study Areas and Similar Designations: There are thirty-four wilderness study areas that contain riparian-wetland and aquatic habitat (2,287 acres total). The BLM has reviewed thirty of the WSAs and recommended that twenty-four are unsuitable and six are suitable for wilderness designations. Recommendations have yet to be developed for the remaining four WSAs. Irrespective, Congress has mandated agencies to manage Wilderness Study Areas "*so as not to impair the* *suitability* *of such areas for preservation as wilderness*." The BLM therefore manages all thirty-four WSAs to protect their wilderness characteristics in the same or better condition than they were on October 21, 1976 (or for Section 202 WSAs not reported to Congress, the date the WSA was designated), until Congress determines whether they should be designated as wilderness. There are another ten areas with similar designations that contain riparian wetland habitat (1,137 acres). Six were designated by the BLM as Lands with Wilderness Characteristics and four were designated as Wilderness Protection Areas. These areas are similarly managed to maintain or improve their wilderness characteristics and/or ROVs.

Wilderness Areas: The Lee Metcalf Wilderness Area (Bear Trap Canyon Unit) was designated in 1983 and contains 159 acres of mapped riparian-wetland area. It is managed pursuant to the Wilderness Act, which requires the BLM to preserve its wilderness character. The Madison River is the main waterbody and the associated hydrogeomorphic processes have been highly impacted by the construction of the Madison Dam in the early 1900's. Monitoring to assess and adaptively respond to the associated impacts are ongoing, but altered flow, flood, and sediment regimes are expected to persist with corresponding changes to the hydrologic, geomorphic, vegetative, and hydraulic processes and attributes that historically maintained attributes of the riverscape. Several tributaries to the Madison River are also present. These tributary streams are undammed and generally less impacted by human activities. According to the BRAT model, approximately two miles are rated as "low hanging fruit" for restoration via beaver dam building activity and likely have most of the key attributes needed for beaver occupation and recovery of the associated processes. Another two miles are rated as Quick Return or Long-Term Investments and would likely require some additional human intervention to promote the growth of native riparian vegetation and associated beaver dam building activity. The remaining eleven miles of stream are rated "not suitable" for restoration via beaver dam building activity because stream power is too high or human development (e.g., the Madison Dam) is incompatible. However, wood accumulations and associated erosional/depositional processes are important processes that historically created many of the riverscape attributes but have been reduced via dam construction.

National Monuments: BLM administers two national monuments, which collectively support 2,162 acres of riparian-wetland area.

Pompey's Pillar National Monument: encompasses fifty-one acres along the Yellowstone River with a massive sandstone outcrop covering about two acres at its base, which rises one-hundred and twenty feet. The monument's premier location at a natural ford in the Yellowstone River, and its geologic distinction as the only major sandstone formation in the area, have made it a celebrated landmark and outstanding observation point for more than eleven thousand years of human occupation. Hundreds of markings, petroglyphs, and inscriptions left by visitors including William Clark and the Lewis and Clark Expedition have transformed this geologic phenomenon into a living journal of the American West.

Twenty-one acres of the monument are within the floodplain and have been mapped as riparian-wetland habitat. The riparian zone is highly influenced by fluvial processes and shallow groundwater, which support a mature cottonwood gallery. However, Russian Olive Trees and other non-native species are also present. Channelization and bank armoring for a highway bridge upstream of the site have reduced the influence of erosional and depositional processes on plant community succession. Flow diversions, bank armoring, levees, and the conversion of cottonwood stands to agricultural lands or other uses upstream from the monument have also impacted the supply of wood and associated processes of wood accumulation and channel migration, both of which historically created and maintained attributes of the riparian zone, particularly the disturbance regime under which cottonwood regeneration has evolved. As a result, the rate of geomorphic adjustments, hydraulic complexity, age class diversity, and cottonwood regeneration has likely declined, causing a shift towards disclimax plant communities that contain a high proportion of old, dead, or dying cottonwoods; diminishing rates of new cottonwood recruitment; and competition from invasive species like Russian Olive that further reduce cottonwood regeneration. To minimize associated impacts, the BLM has previously implemented Russian Olive removal projects and strategic cottonwood plantings, while removing dead/dying cottonwoods that pose a threat to life and property.

Upper Missouri River Breaks National Monument (UMRBNM): From Fort Benton downstream into the Charles M. Russell National Wildlife Refuge, the monument spans one-hundred and forty-nine miles of the Upper Missouri River, the adjacent Breaks country, and portions of Arrow Creek, Antelope Creek, and the Judith River. These areas currently support 2,141 acres of riparian-wetland habitat. In 1976, Congress designated the Missouri River segment a National Wild and Scenic River (Public Law 94-486, 90 Stat. 2327). Within the surrounding national monument, the BLM is mandated to maintain or improve the health of Cottonwood Gallery Forrest Ecosystems. Other objects of the monument that are influenced by riverscape processes and attributes include raptors (sparrow hawk, ferruginous hawk, peregrine falcon, prairie falcon, and golden eagle); shoreline areas that provide habitat for great blue heron, pelican, and a wide variety of waterfowl; forty-eight fish species, including: goldeye, drum, sauger, walleye, northern pike, channel catfish, and small mouth buffalo, paddlefish, blue sucker, shovel nose sturgeon, sicklefin, sturgeon chub, and the endangered pallid sturgeon; as well as recreation opportunities.

Although human development within the monument's river corridor is sparse, riverscape processes and attributes have been uniquely altered by human activities. Starting in the late 1800's, wood choppers decimated riparian forests to supply wood to steamboats for fuel and to a lesser extent, settlements. Since then, flow regulation from upstream dams has decreased the frequency of high flows and disconnected the system from large sediment sources, both of which are needed to sustain cottonwood recruitment. Noxious weeds, non-native and invasive plants are widespread. In fact, during a comprehensive assessment in 2010, noxious weeds were present on 93% of the sites evaluated and non-native species were found at 99% of the locations. Russian olive (*Elaeagnus angustifolia*) is particularly common in the upper half of the monument and Reed canarygrass (*Phalaris arundinacea*) was present in 66% of the assessed sites. Expansion of these species into areas historically dominated by native riparian-wetland vegetation is likely diminishing riparian functions and correspondingly modifying values like wildlife habitat, livestock forage production, water quality, and aquatic habitat. To minimize associated impacts, the BLM has planted cottonwoods where natural regeneration is insufficient or no longer occurs, installed livestock/wildlife fencing to limit herbivory, and routinely removes Russian Olive and other invasive species. Given the BLM's lack of control over the dams, historic removal of trees, and seed sources of non-native species from intermingled private lands, these projects are an ongoing effort and needed to mitigate the loss of processes and attributes that would otherwise sustain the associated ROVs.

3.4.2 Environmental Effects—No Action Alternative

None of the actions describe in Table 1 would occur, so none of the outcomes associated with the Proposed Action would be realized at the reach or riverscape scales. Historic impacts on the disturbance regime, as well as stream and vegetation successional pathways will cause further departures from the potential natural conditions (Sections 3.1.2, 3.1.2.1, 3.2.1, 3.2.2.1, 3.3.2, and 3.3.2.1), adversely impacting wilderness characteristics and ROVs (e.g. cottonwood galleries, natural landscape and vegetation evolution pathways, ecosystem attributes that are minimally altered by human activities, diverse and abundant native flora and fauna, clean water, etc.), which are created and maintained by natural riverscape processes and attributes when they are healthy. Areas that have been adversely impacted by structural starvation and the loss of riparian vegetation, but are not constrained by dams, roads, or other relatively permanent changes to the landscape, will take decades to centuries (or longer) to recover and remain susceptible to further degradation associated with climate change, fire, flooding, drought, and wildlife/livestock grazing. These areas will remain impaired and not support the wilderness characteristics and ROVs that existed prior to the impacts of human activities. Where the impacts of climate change, invasive species, and other land use activities cause further degradation, further declines to the ROVs and wilderness characteristics will occur.

3.4.2.1 Cumulative Effects—No Action Alternative

The BLM, private landowners, and other resource managers within the contributing watersheds will continue implementing individual projects (removal of non-native plants or vegetation plantings at the reach scale) and coordination efforts (environmental water releases from reservoirs) to address local (e.g., shade trees for a campground) and often species-specific resource objectives (e.g., sensitive status or threatened and endangered species). These projects will typically have a small footprint and require the design of solutions (not self-sustaining) rather than the restoration of processes which naturally create and maintain ROVs, wilderness characteristics, vegetation and riverscape evolutionary processes, and habitats for native species. Dams, flow diversions, climate change, human development, altered patterns of wildland fire, ongoing impacts from the removal of beaver and wood, and similar factors (See Sections 3.1.1, 3.1.2.1, 3.2.1, 3.2.2.1, 3.3.1, 3.2.2.1, 3.4.1 and Appendix G) will continue to impact riverscape processes and attributes. These impacts will continue to reduce the scope and magnitude of ROVs and wilderness characteristics that the BLM is responsible for maintaining or improving.

Cottonwood galleries, riparian areas, and native flora and fauna that are prioritized in the national monuments, Bear Trap Canyon section of the Lee Metcalf Wilderness Area, and other conservation areas will continue to decline. This is because flow and sediment impoundments, flow diversions, the effects of structural starvation, non-native species, disclimax plant communities, and climate change will increasingly alter the processes that historically sustained their abundance and distribution. Furthermore, these stressors are expected to persist into the reasonably foreseeable future. Without application of the Proposed Action to minimize the associated impacts on riverscape processes and attributes, ROVs and wilderness characteristics will not be minimized.

3.4.3.1 Environmental Effects—Proposed Action

Impacts to riverscapes within the NLCS and similar designations would be the same as described in Sections 3.1.3, 3.2.3, and 3.3.3. These impacts will maintain or improve wilderness characteristics and ROVs by: (i) mimicking, promoting, and sustaining the processes that historically (prior to European Settlement) created and maintained attributes of these areas, (ii) restoring the natural stream and vegetation successional pathways; (iii) providing the riparian vegetation and structural complexity that riverscapes need to achieve their potential natural condition; (iv) increasing the riverscape's capacity to support the natural diversity and abundance of ecosystem services and native species; and (iv) increasing the riverscape ecosystem's resistance and resilience to disturbances like flood, fire, drought, invasive species, and insect infestation. In the long-term, these impacts will minimize and/or reverse the deleterious influence of human impacts on riverscape health and associated ROVs, restore the productivity and yield of riverscapes within conservation areas, and improve the riverscapes' capacity to sustain ROVs and wilderness characteristics amidst climate change and other human impacts on the disturbance regime.

The removal of non-native and disclimax plants, installation of temporary project protection fences, use of beaver management strategies, addition of structural elements (BDAs and PALs) and headcut controls will temporarily disturb soils and plants in the immediate vicinity of the activities and be visible until the natural riverscape processes are promoted and sustained. This could temporarily affect the appearance of wilderness characteristics and related ROVs. However, these impacts would be temporary and the natural appearance and/or functions would recover naturally, typically after several floods and growing seasons. In the long-run, the appearance and ecological functions of treated reaches would be less impacted by human-caused disturbances than before treatment, as the Proposed Action will promote and sustain the processes and attributes that historically created and maintained natural attributes of these areas. This will increase the ROVs and wilderness characteristics.

3.4.3.1 Cumulative Effects—Proposed Action

Impacts to riverscapes within the NLCS and similar designations would be the same as those described in Sections 3.1.3.1, 3.2.3.1, and 3.3.3.1. Wilderness characteristics and ROVs associated with riverscapes would therefore remain diminished by the impacts described in the No Action Alternative portions of those same sections. In the long-run, ROVs and wilderness characteristics would decline further where current and historic impacts to riverscapes have diminished their resistance and resilience to disturbance and the effects of climate change, flood, fire, drought, invasive species, and insect infestation amplify the effects of existing degradation on riverscape health. However, short-term impacts to soil and vegetation within the immediate vicinity of degraded reaches during the installation of projects would not occur, as non-native and disclimax plants would not be removed to promote the growth of native woody plants that historically sustained wood accumulations and beaver dam building activity; and temporary project protection fences, beaver management strategies, structural elements (BDAs and PALs) and headcut controls would not be utilized to maintain or restore natural processes. Instead, the loss or decline of natural riverscape processes would continue to alter the successional pathways of streams and vegetation, causing the effects of past, present, and future human disturbance riverscape attributes and ROVs to persist or worsen.

4.0 Consultation and Coordination

4.1 Summary of Consultation and Coordination

- BLM presented the proposed action to USFWS in North Dakota, South Dakota, and Montana.

4.2 Summary of Public Participation

- Public Scoping – July 2020. BLM received two comments, both in support of the proposed action.

Appendices

Appendix A—List of Preparers

Name	Title	Resource Area
Alden Shallcross	Hydrologist – State Program Lead, Aquatic Habitat Management	Issue 1: How would implementation of the alternatives impact riverscape processes and attributes? And how would vegetation within the valley bottoms be affected? Issue 2: How would implementation of the alternatives affect aquatic species and ecosystems Issue 3: How would implementation of the alternatives affect water quality and water quantity? Issue 4 (co-author)
Alden Shallcross and Christopher Boone	Wildlife Biologist – State Program Lead: Wildlife Management	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)?
Ruth Miller	Planning and Environmental Coordinator – State Lead	Document planning and organization
Gary Smith	Branch Chief – Cultural Resources	Cultural Resources
Jamie Tompkins	Program Lead for National Conservation Lands/LNT/Environmental Ed & Youth	Issue 4: How would implementation of the alternatives affect the resources, objects, and values of national monuments, wilderness, wilderness study areas, and wild and scenic rivers?

Appendix B—Table of Resources Considered

IDT Member	**Issue**	**Determination* and Rationale**
Cecil Wervin	Access	NI
Tessa Wallace	Air Quality	NI
Jamie Tompkins	Areas of Critical Environmental Concern	NI
Gary Smith	Cultural Resources	NI
Marcia Pablo	Environmental Justice	NI
Floyd Thompson	Farmlands (Prime or Unique)	NI
Aaron Thompson	Fire Management	NI
Chris Boone & Alden Shallcross	Fish Habitat	PI
Alden Shallcross	Floodplains	PI
Floyd Thompson & Ken Reid	Forests and Rangelands	NI
Ken Reid	Forestry Resources and Woodland Products	NI
Dan Seifert	Human health and safety concerns	NI
C. Boone (aquatics), W. Velman (vegetation)	Invasive, Non-native Species	PI
Cecil Wervin	Lands and Realty	NI
Jamie Tompkins	Lands with Wilderness Characteristics	NI
Floyd Thompson	Livestock Grazing Management	NI
Chris Boone	Migratory birds and wildlife	
Marcia Pablo	Native American Religious Concerns	NI
John Carlson	Noise Resources	NI
Greg Ligget	Paleontological Resources	NI
Brian Smith	Recreation Resources	NI
John Carlson	Sage Grouse Habitat	NI
Scott Rickard	Socioeconomics	NI
Floyd Thompson	Soils	NI
Chris Boone	Threatened, Endangered or Candidate Plant or Animal Species	PI
Wendy Velman & Alden Shallcross	Vegetation	PI
Brian Smith	Visual Resources	NI
	Wastes, Hazardous or Solid	NI
Alden Shallcross	Water	PI
Alden Shallcross	Wetlands/Riparian Zones	PI
	Wild Horses and Burros	NI
Alden Shallcross	Wild and Scenic Rivers	NI
Jamie Tompkins	Wilderness and Wilderness Study Areas	PI
Chris Boone	Wildlife	PI

*NP = not present in the area impacted by the proposed or alternative actions.

NI = present, but not affected to a degree that detailed analysis is required.

PI = present and may be impacted. Will be analyzed in affected environment and environmental effects. For consistency, the term ‘effects’ is used throughout the EA, but we use the term ‘impacts’ just in this table. (NOTE: PI does not necessarily mean effects are likely to be significant, only that there are effects to this issue, resource or use. Significance will be determined through analysis and documented in a Finding of No Significant Impact or Environmental Impact Statement.)

Appendix C—Acronyms and Abbreviations

ACEC	Area of Critical Environmental Concern
AO	Authorizing/Authorized Officer
ARPA	Archeological Resources Protection Act
BBCS	Bird and Bat Conservation Strategy
BCC	Birds of Conservation Concern
BLM	Bureau of Land Management
BMP	Best Management Practice
DR	Decision Record
EA	Environmental Assessment
EO	Executive Order
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FLPMA	Federal Land Policy Management Act of 1976, as amended
FONSI	Finding of No Significant Impact
IDT	Interdisciplinary Team
LTPBR	Low-Tech Process-Based Restoration
MBTA	Migratory Bird Treaty Act of 1918
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NAGPRA	Native American Graves Protection and Repatriation Act
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
OHV	Off-Highway Vehicle
PEA	Programmatic Environmental Assessment
PFC	Proper Functioning Condition
RFFA	Reasonably Foreseeable Future Action
RMP	Resource Management Plan
ROD	Record of Decision
ROW	Right-of-way
SHPO	State Historic Preservation Office
T&E	Threatened and Endangered
USFWS	U.S. Fish and Wildlife Service
WSA	Wilderness Study Area

Appendix D—List of References

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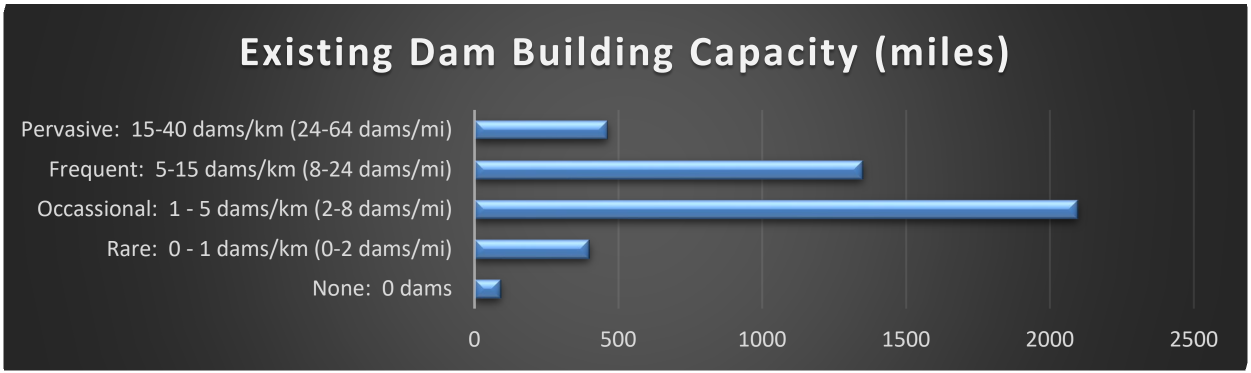
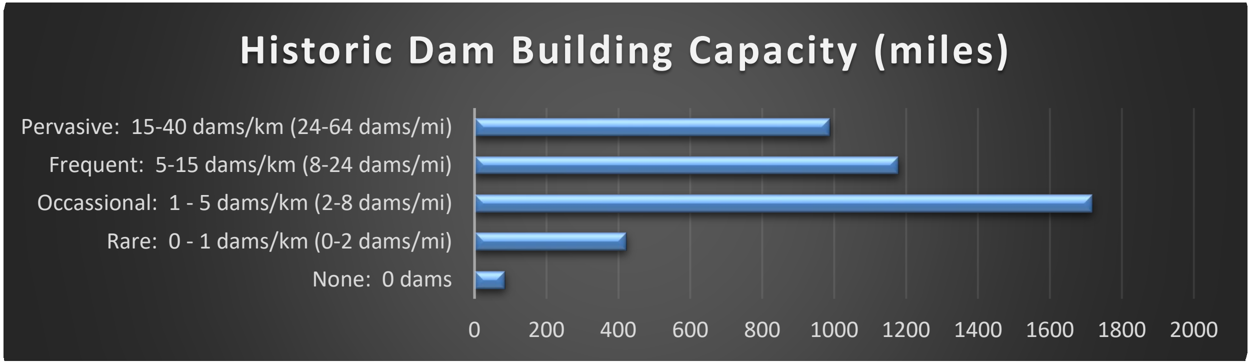
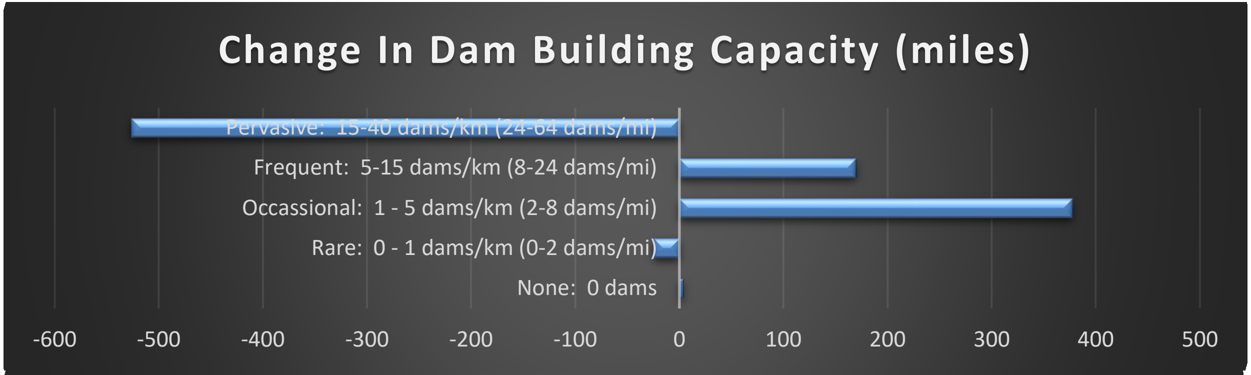
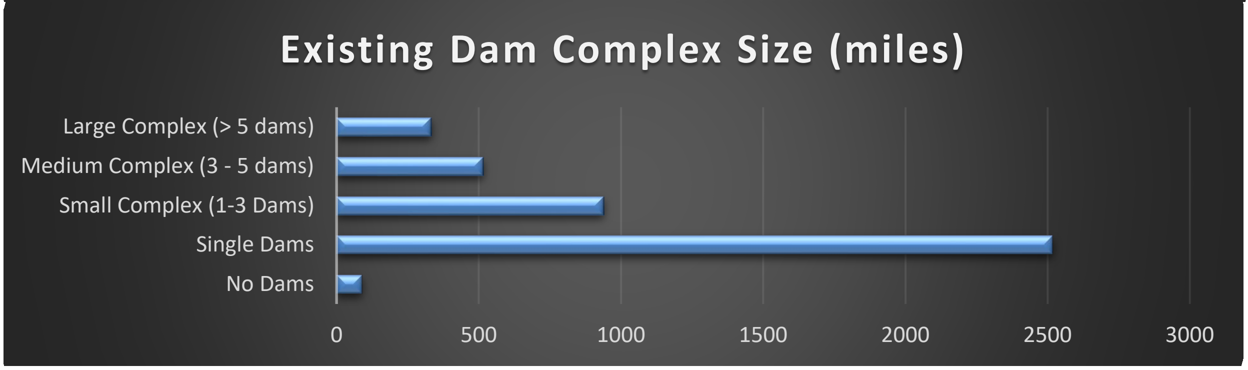
Appendix E—Figures

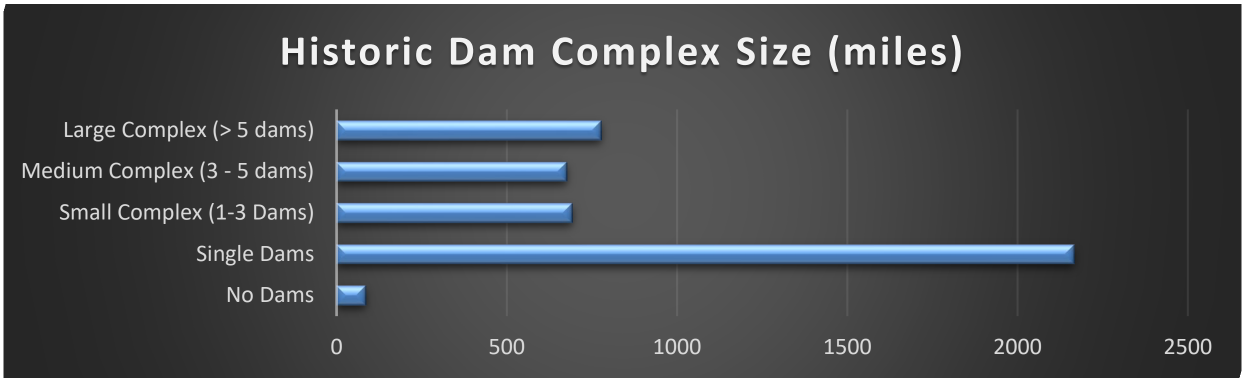
Figures 1-18: Beaver Restoration Assessment Tool (BRAT) Results

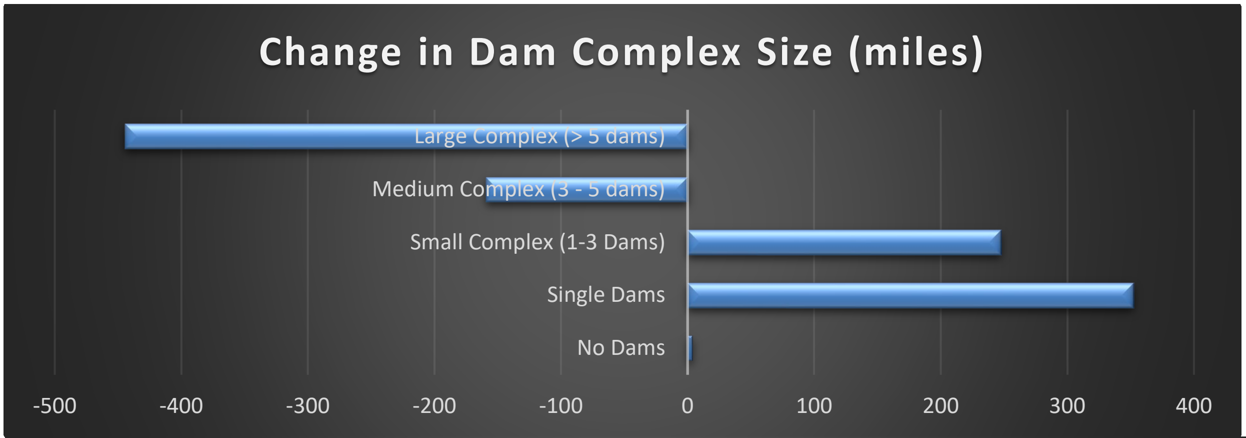


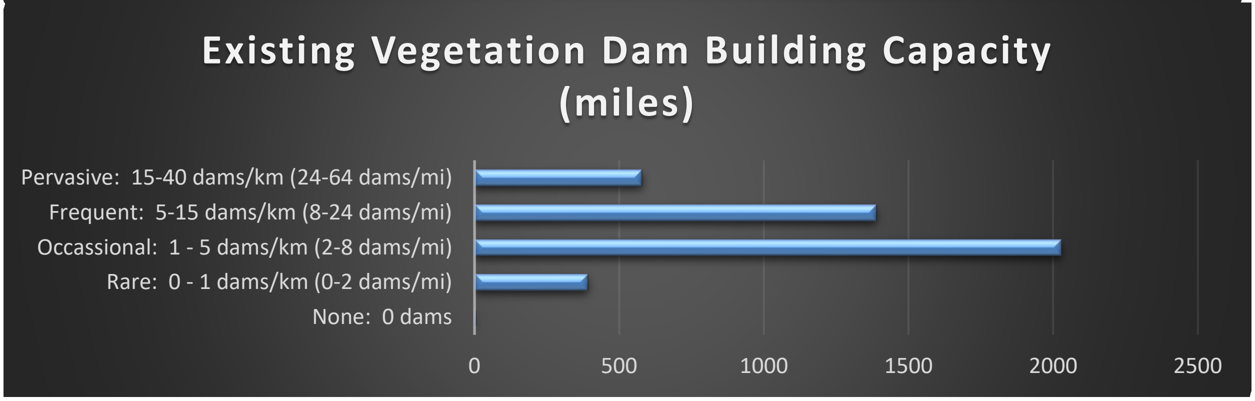


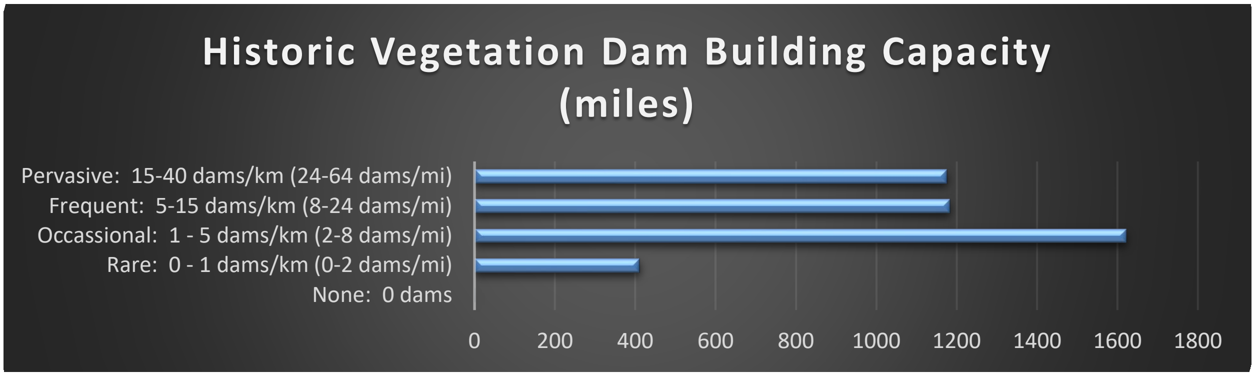


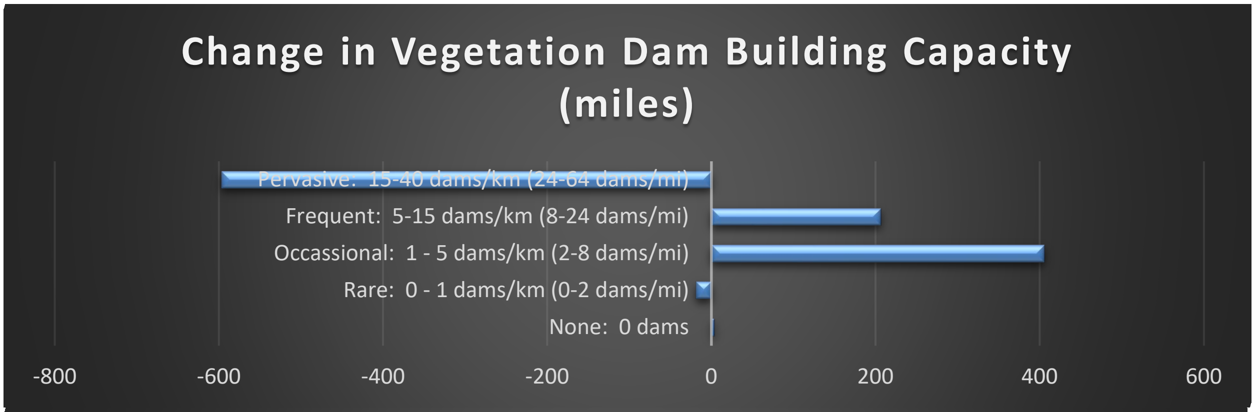



Historic Dam Complex Size (miles)
Large Complex (> 5 dams)
Medium Complex (3 - 5 dams)
Small Complex (1-3 Dams)
Single Dams
No Dams
0
500
1000
1500
2000
2500

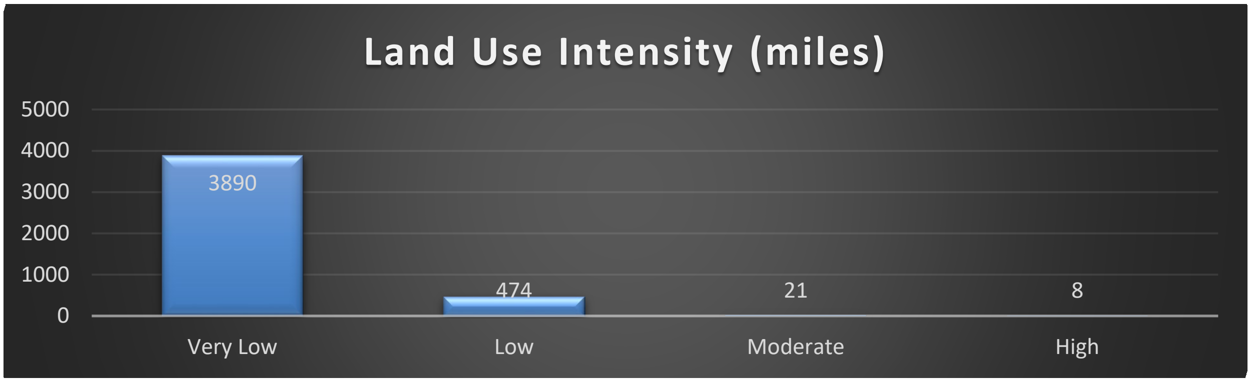

Change in Dam Complex Size (miles)
Large Complex (> 5 dams)
Medium Complex (3 - 5 dams)
Small Complex (1-3 Dams)
Single Dams
No Dams
-500
-400
-300
-200
-100
0
100
200
300
400

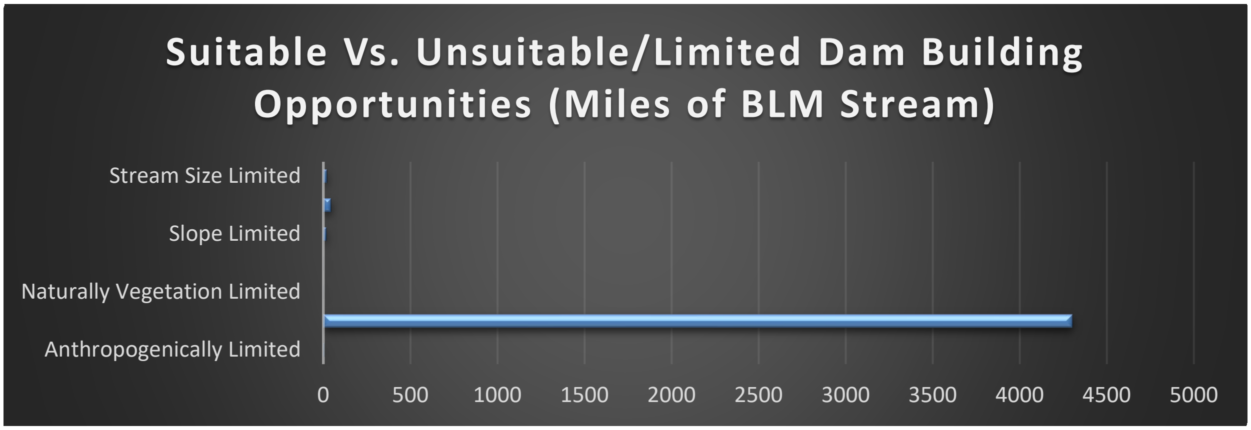

Existing Vegetation Dam Building Capacity (miles)
Pervasive: 15-40 dams/km (24-64 dams/mi)
Frequent: 5-15 dams/km (8-24 dams/mi)
Occassional: 1 - 5 dams/km (2-8 dams/mi)
Rare: 0 - 1 dams/km (0-2 dams/mi)
None: 0 dams
0
500
1000
1500
2000
2500

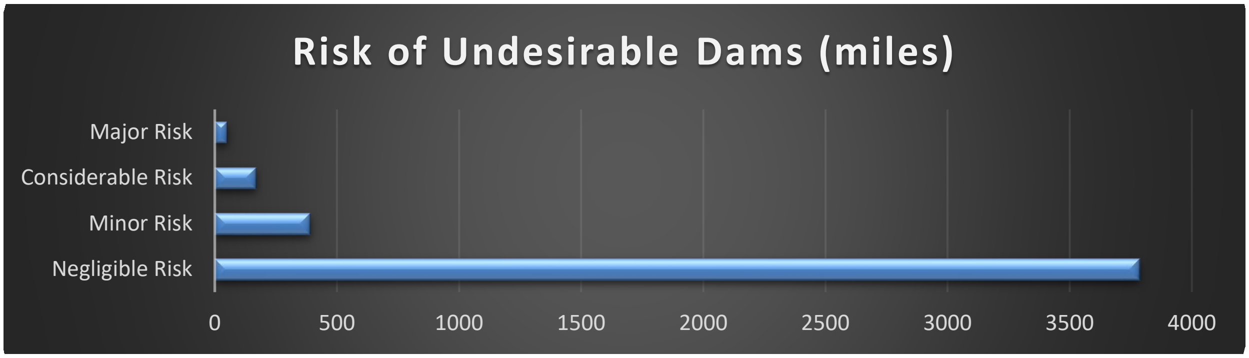

Historic Vegetation Dam Building Capacity (miles)
Pervasive: 15-40 dams/km (24-64 dams/mi)
Frequent: 5-15 dams/km (8-24 dams/mi)
Occassional: 1 - 5 dams/km (2-8 dams/mi)
Rare: 0 - 1 dams/km (0-2 dams/mi)
None: 0 dams
0
200
400
600
800
1000
1200
1400
1600
1800

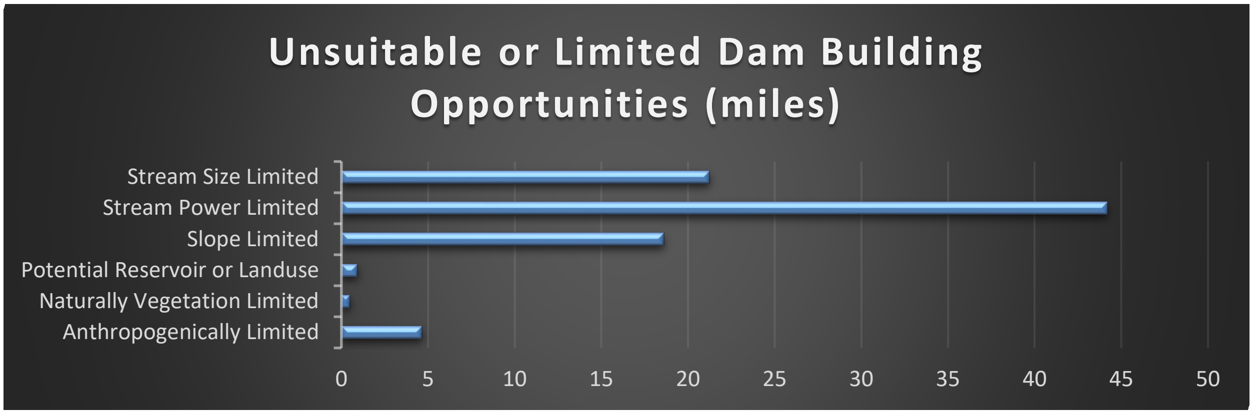

Change in Vegetation Dam Building Capacity (miles)

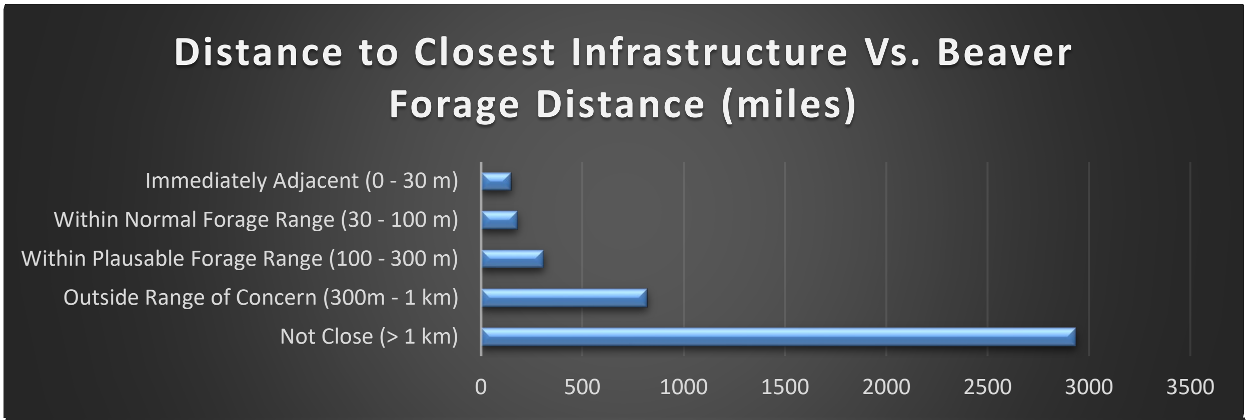

Restoration Conservation Opportunity (miles)

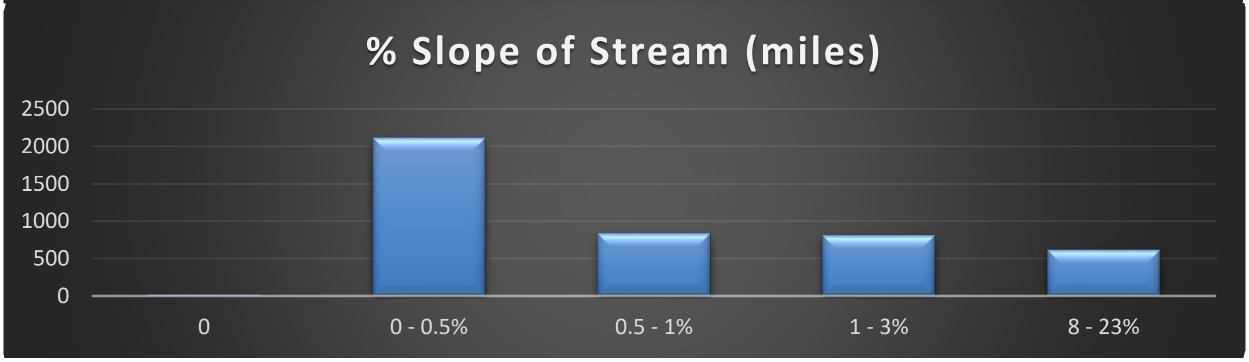

Land Use Intensity (miles)

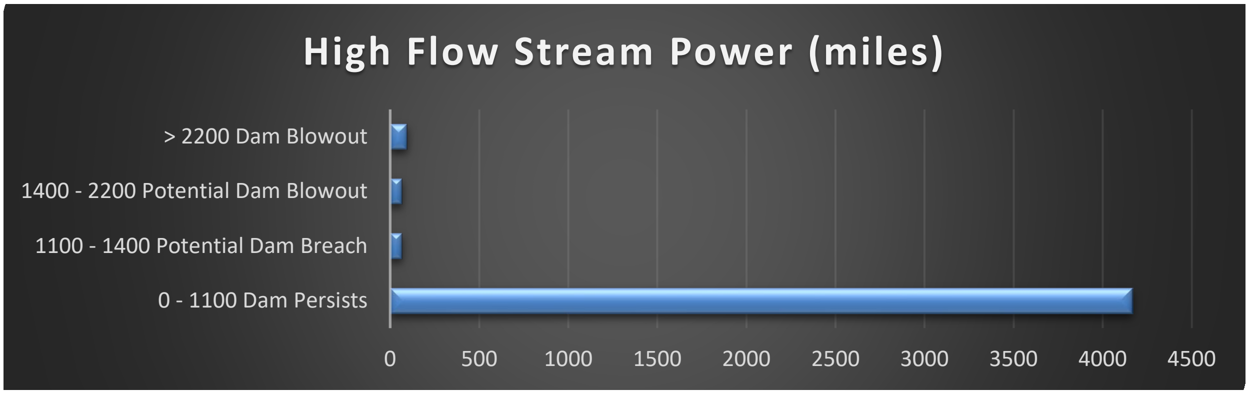

Suitable Vs. Unsuitable/Limited Dam Building Opportunities (Miles of BLM Stream)

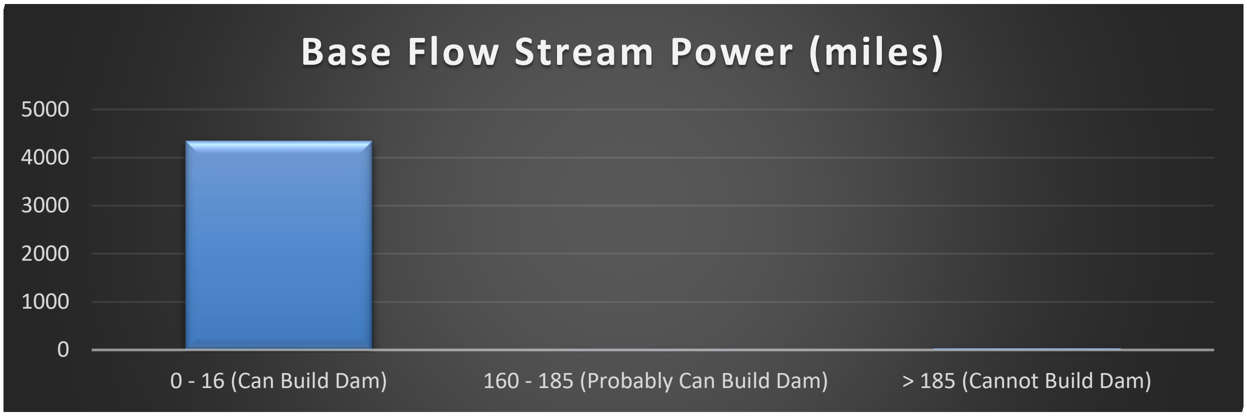

Risk of Undesirable Dams (miles)
Major Risk
Considerable Risk
Minor Risk
Negligible Risk
0
500
1000
1500
2000
2500
3000
3500
4000


Unsuitable or Limited Dam Building Opportunities (miles)
Stream Size Limited
Stream Power Limited
Slope Limited
Potential Reservoir or Landuse
Naturally Vegetation Limited
Anthropogenically Limited
0
5
10
15
20
25
30
35
40
45
50

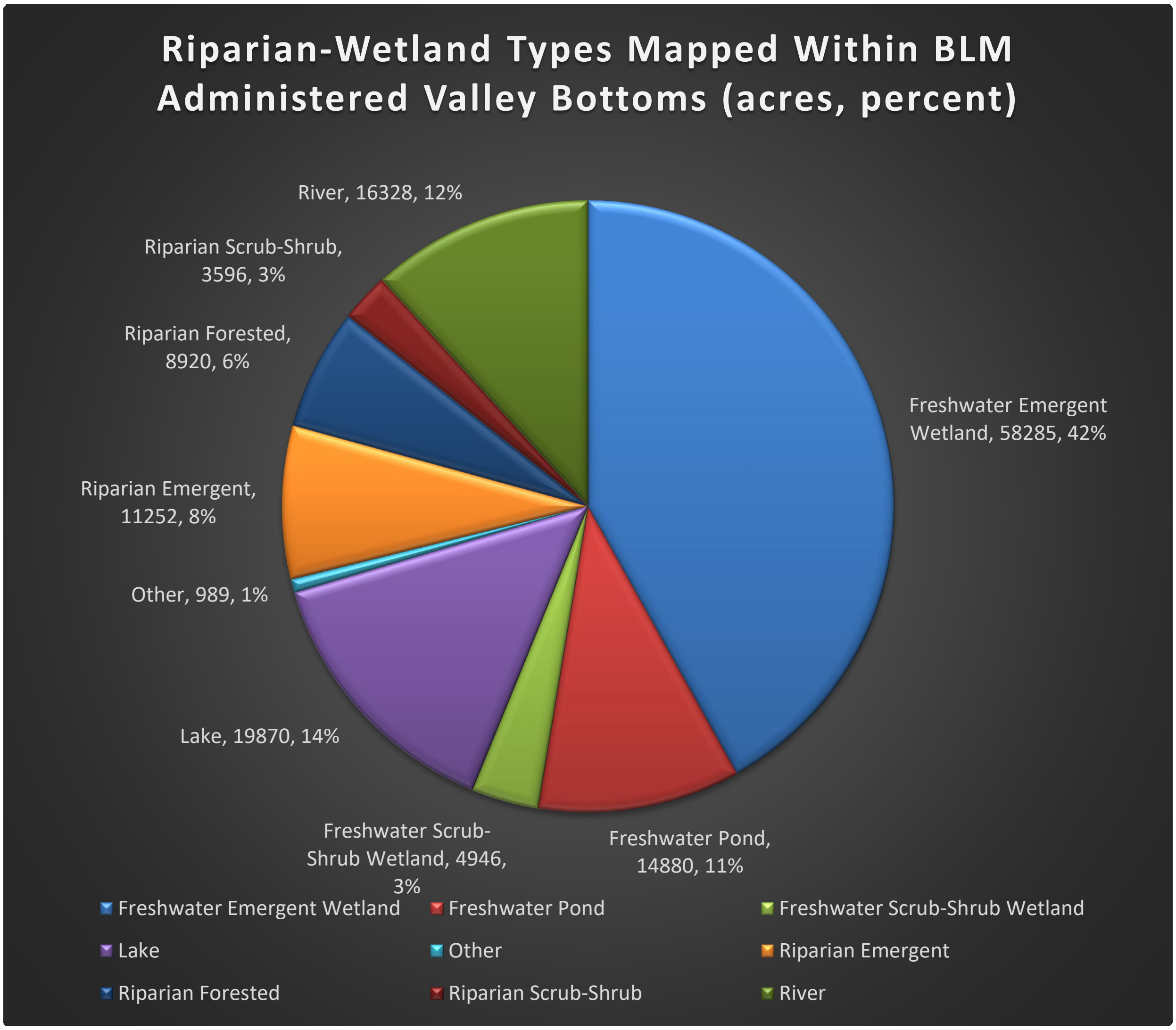

Distance to Closest Infrastructure Vs. Beaver Forage Distance (miles)
Immediately Adjacent (0 - 30 m)
Within Normal Forage Range (30 - 100 m)
Within Plausable Forage Range (100 - 300 m)
Outside Range of Concern (300m - 1 km)
Not Close (> 1 km)
0
500
1000
1500
2000
2500
3000
3500

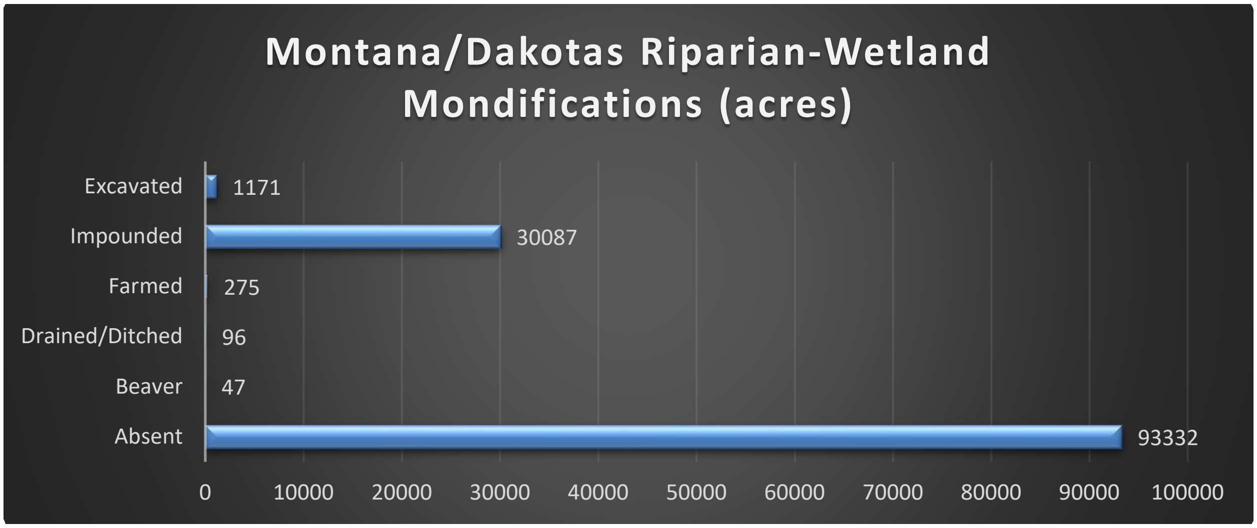

% Slope of Stream (miles)
2500
2000
1500
1000
500
0
0
0 - 0.5%
0.5 - 1%
1 - 3%
8 - 23%

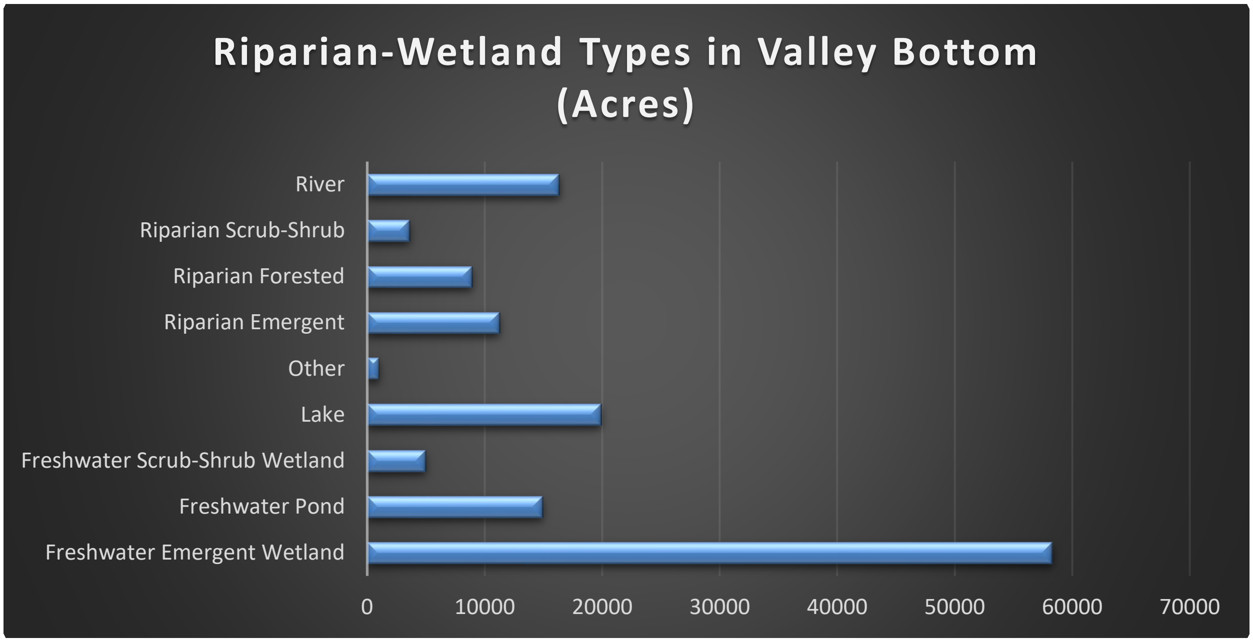

High Flow Stream Power (miles)
> 2200 Dam Blowout
1400 - 2200 Potential Dam Blowout
1100 - 1400 Potential Dam Breach
0 - 1100 Dam Persists
0
500
1000
1500
2000
2500
3000
3500
4000
4500


Base Flow Stream Power (miles)
5000
4000
3000
2000
1000
0
0 - 16 (Can Build Dam)
160 - 185 (Probably Can Build Dam)
> 185 (Cannot Build Dam)

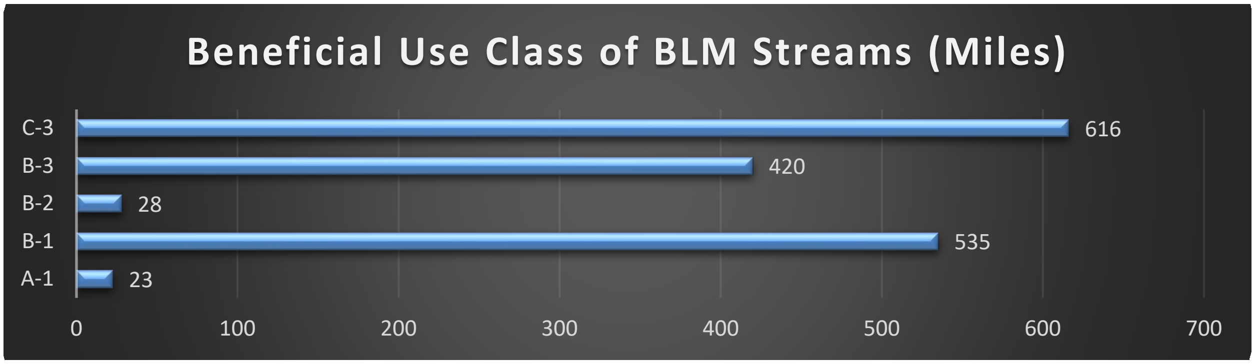
Figures 19-21: Riparian-Wetland Areas and Attributes

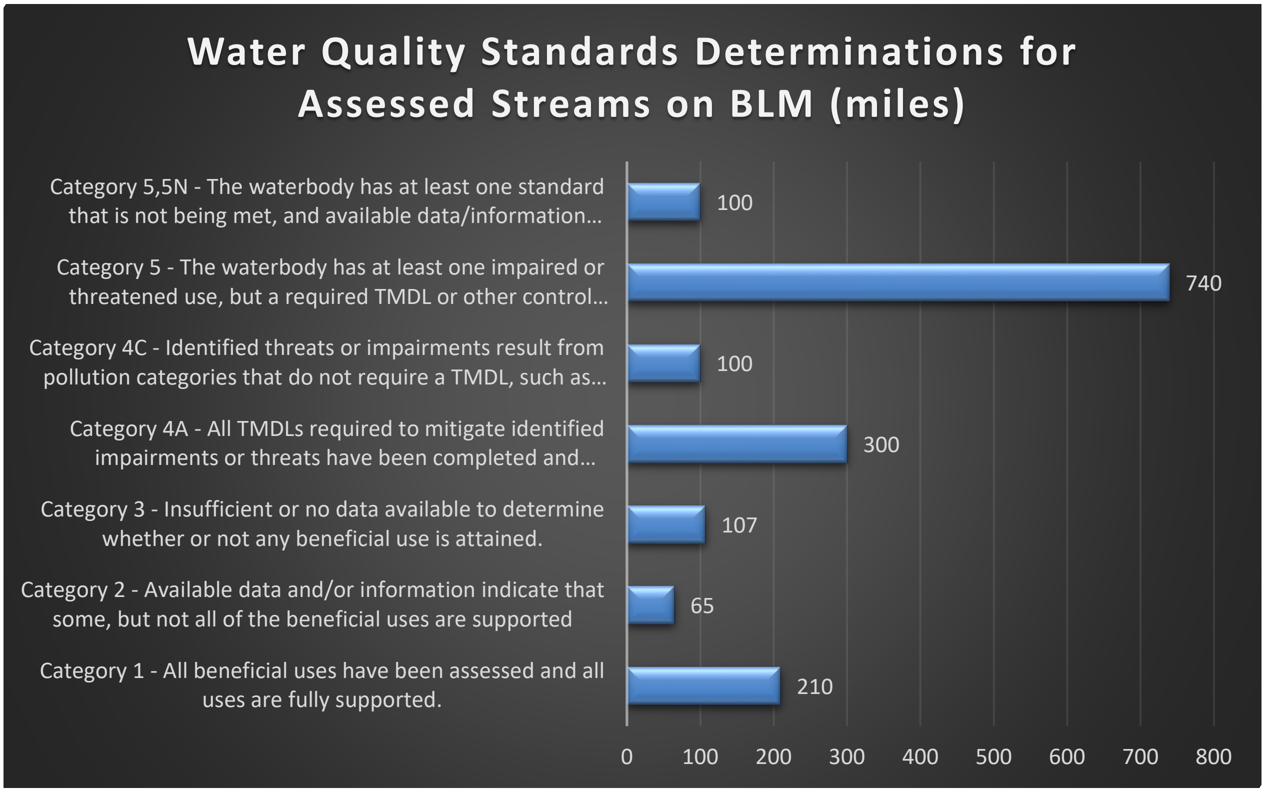






Figures 22-24: Water Quality Inventory and Assessment




Water Quality Standards Determinations for Assessed Streams on BLM (miles)

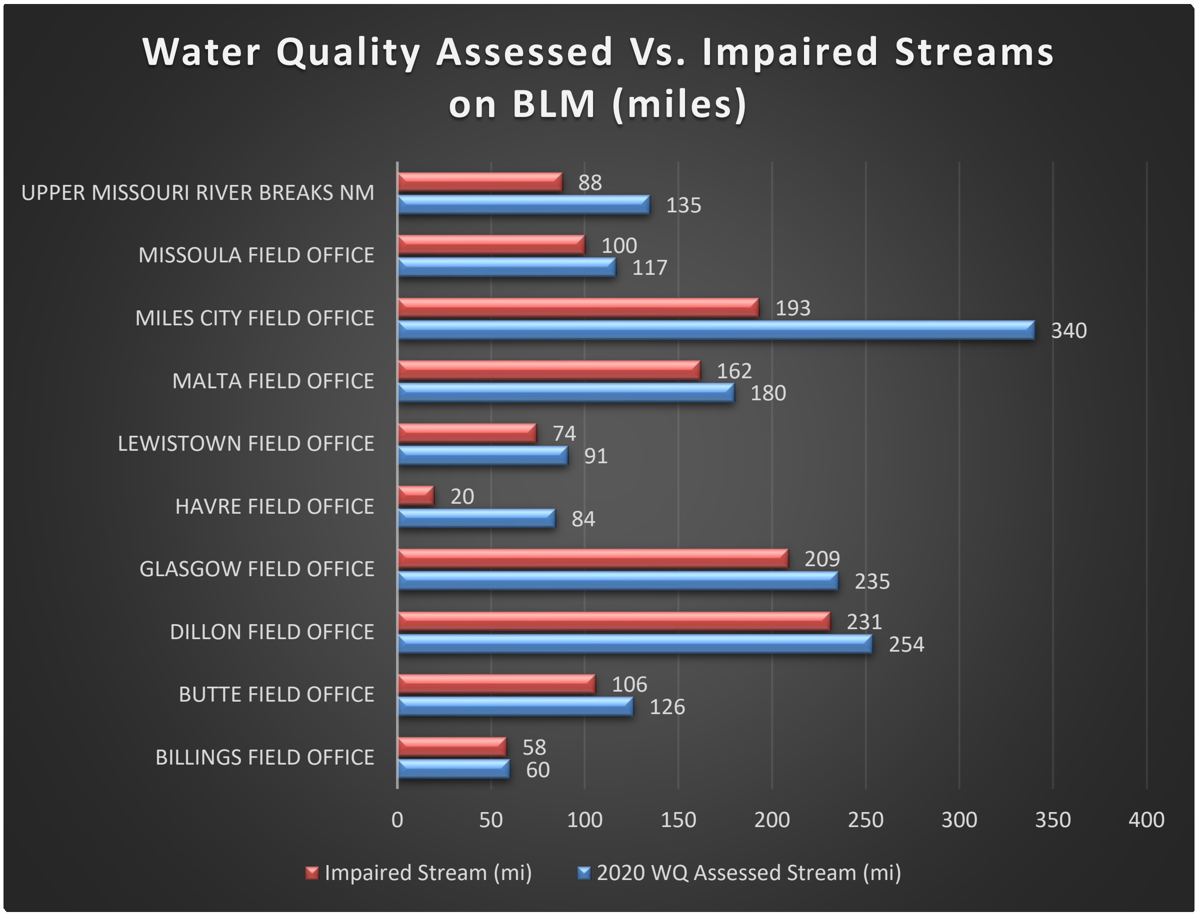
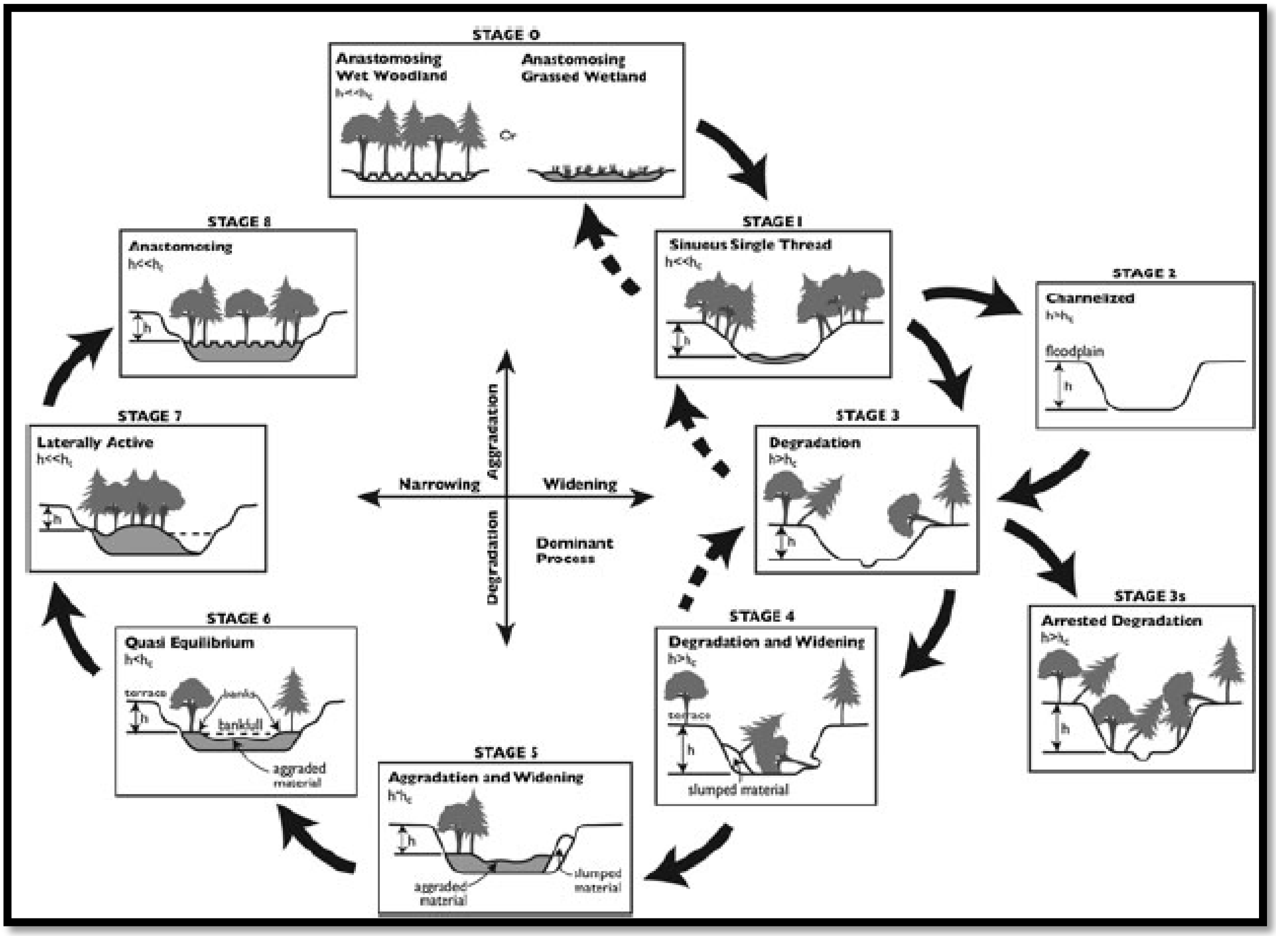
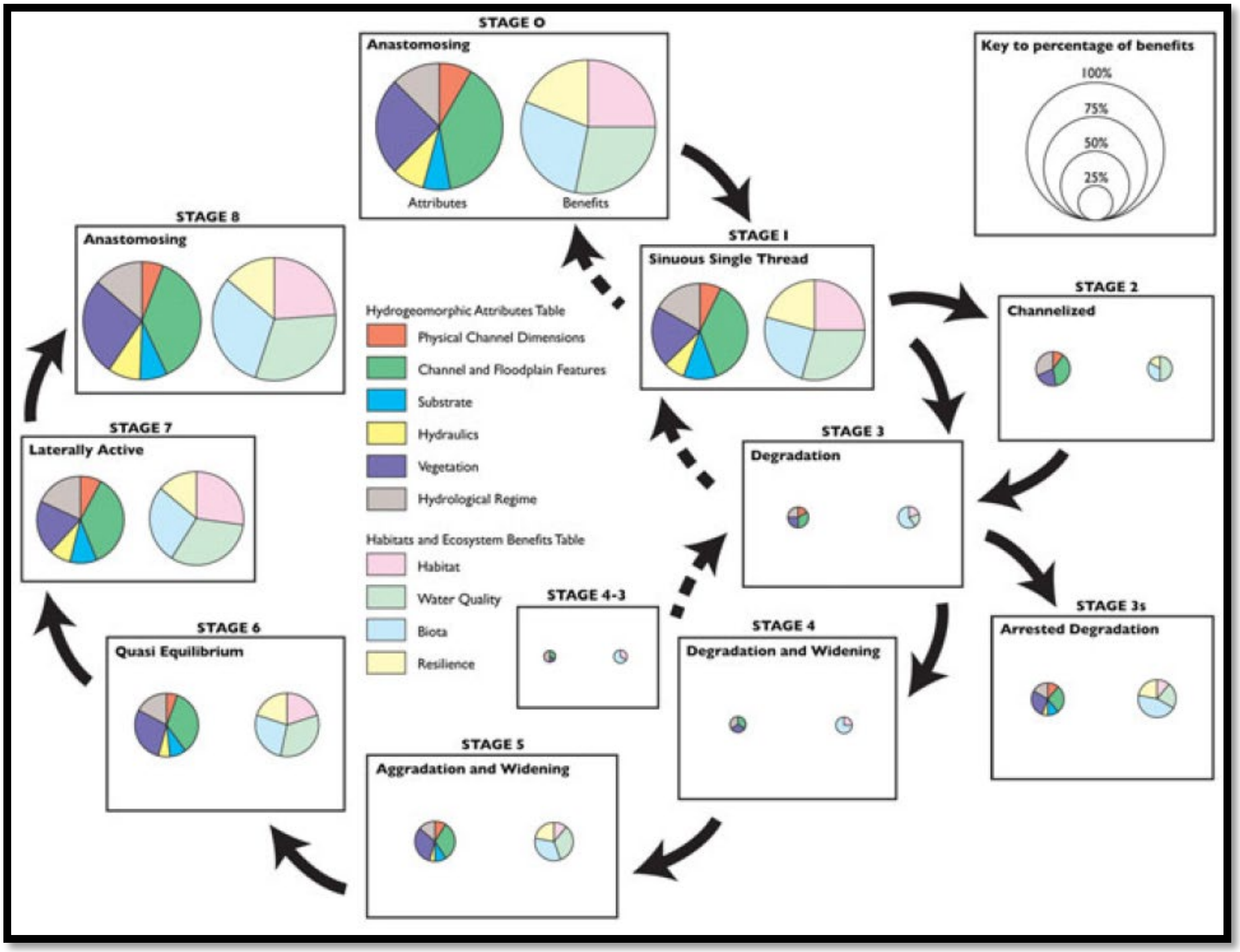

Water Quality Assessed Vs. Impaired Streams on BLM (miles)

Figure 25: Stream Evolution Model and Dominant Processes



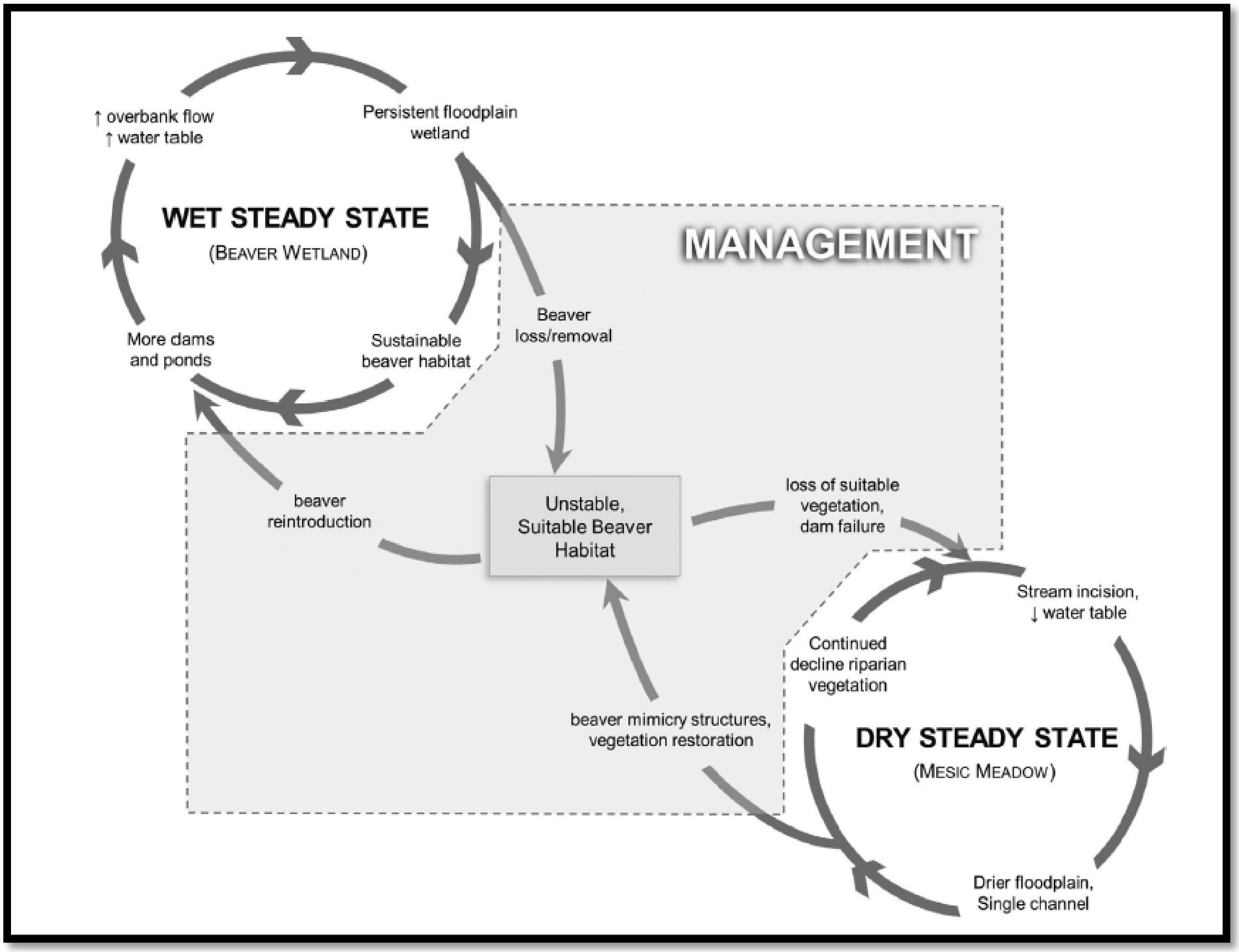
Stream Evolution Models (Cluer and Thorne, 2013) conceptually illustrate how riverscapes degrade and recover, as well as the dominant processes and attributes associated with each stage of the evolution sequence. Dashed arrows indicate 'short-circuits' in the normal progression, indicating for example that a Stage 0 stream can evolve to Stage 1 and recover to Stage 0, a Stage 4-3-4 short-circuit, which occurs when multiple head cuts migrate through a reach and which may be particularly destructive. Arrows outside the circle represent 'dead end' stages, constructed and maintained (2) and arrested (3s) where an erosion-resistant layer in the local lithology stabilizes incised channel banks

Figure 26: Stream Evolution Model with Habitat and Ecosystem Benefits



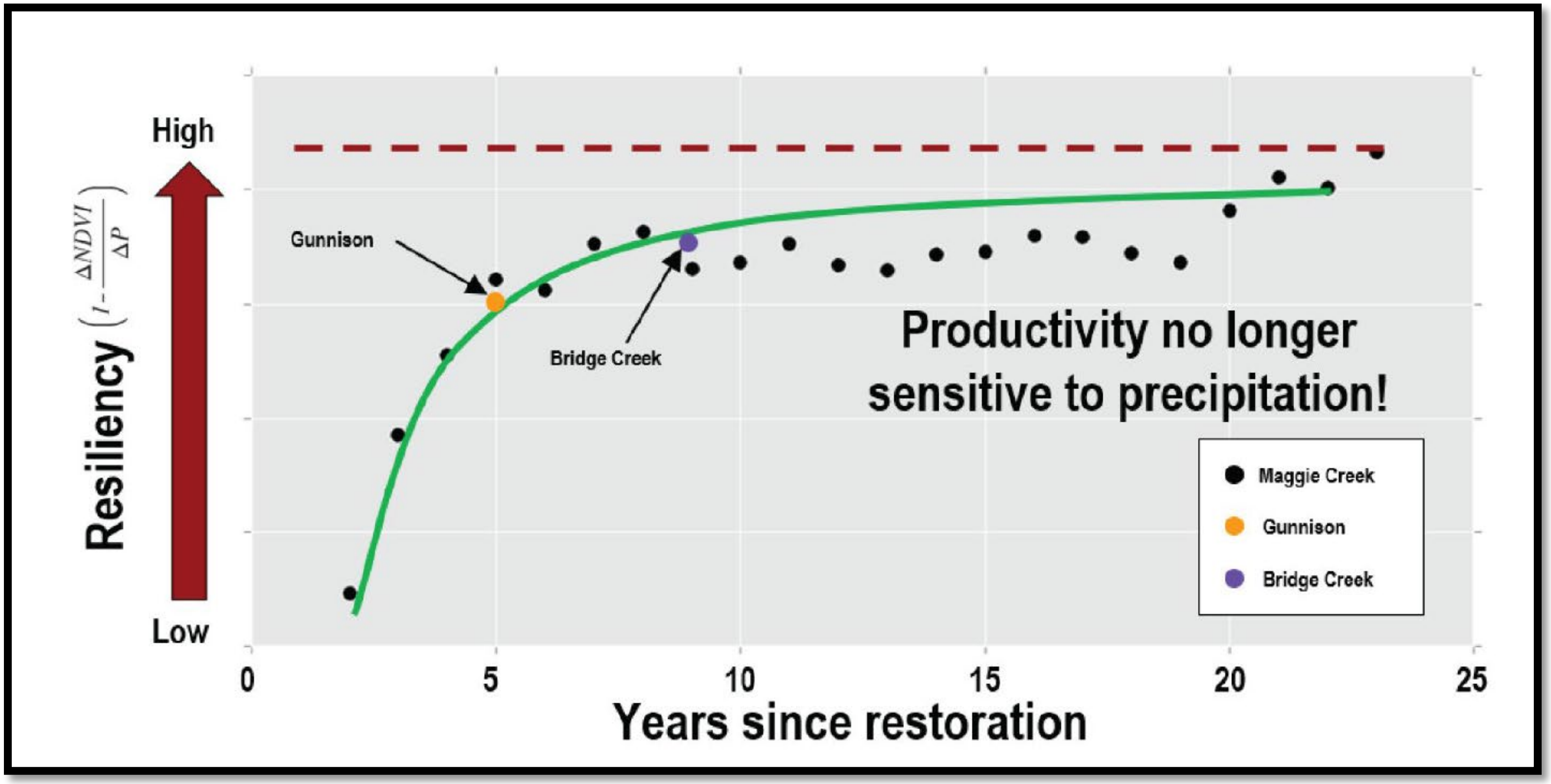
Habitat and ecosystem benefits provided in each stage of the Revised Channel Evolution Model (Cluer and Thorne, 2013). Each stage is represented by two pie charts whose diameters signify the relative percentage of maximum benefits as tabulated in Tables IV and V. For each stage, the pie chart on the left summarizes the richness and diversity of the hydromorphic attributes, whereas the pie chart on the right summarizes the associated habitat and ecosystem benefits

Figure 27: Wet and Dry Steady State Conceptual Model



Conceptual model illustrating the shift from a beaver-driven wet steady state to a dry steady state in which beaver are absent (adapted from Laurel and Wohl, 2019). Once streams fall into a dry steady state, the Proposed Action can be used to mimic, promote, and sustain beaver dam building activity and wood accumulations to kickstart the biophysical changes needed to recover to the wet steady state.

Figure 28: Resilience from Restoration



Evidence of resilience from structurally forced changes to valley bottoms using a variety of low-tech, process-based restoration methods caused by vegetation productivity (greenness as measured from satellite imagery) to no longer be a function of annual precipitation. Figure adapted from SGI Science Solutions and data published in Silverman et al. (2018).

Appendix F — Tables

Table 1: Fish of Eastern Montana

Origin: N = native, I = invasive; Trophic Category: CA = carnivore, HB = herbivore; IC = invertivore-carnivore, IN = invertivore, OM = omnivore; Feeding habitat: BE = benthic, GE = generalist, WC = water column; Reproductive Classification: LO = litho-obligate, TR = tolerant reproductive strategists not litho-obligates and use of parental care at the spawning site.

	Origin	Trophic Category	Feeding Habitat	Reproductive Classification	Status	Preferred Habitat
Acipenseridae						
Pallid Sturgeon (*Scaphirhynchus albus*)	N	IC	BE		Endangered, BLM Sensitive, MT Species of concern	large turbid rivers. In Montana, pallid sturgeon use the Yellowstone, Missouri, Milk, and Powder Rivers.
Shovelnose Sturgeon (*Scaphirhynchus platorynchus*)	N	IN	BE			Large rivers over sand or gravel, tolerates turbid waters.
Catostimdae						
River carpsucker (*Carpoides carpio)*	N	OM	BE	LO		Reservoirs/pools, spawns in larger streams backwaters
Longnose Sucker (*Catostomus catostomus)*	N	IN	BE	LO		Cold clear streams/lakes, spawns in gravel beds/riffles
White Sucker (*Catostomus commersonii)*	N	OM	BE	LO		Varied. Lakes/streams, avoids rapid current, spawns over rocky shoals
Mountain Sucker (*Catostomus platyrhynchus)*	N	HB	BE	LO		Cold clear streams, rubble, gravel, or sandy bottoms
Smallmouth Buffalo (*Ictiobus bubalus*)	N	OM	BE	LO		Rivers/impoundments, spawns in backwater areas of streams
Bigmouth Buffalo (*Ictiobus cyprinellus)*	N	IN	GE	LO		Large rivers/reservoirs, spawns in backwaters of large streams
Shorthead Redhorse (*Moxostoma macrolepidotum)*	N	IN	BE	LO		Moderately large rivers, gravel, sand, or rocky bottoms with swift current

	Origin	Trophic Category	Feeding Habitat	Reproductive Classification	Status	Preferred Habitat
Centrarchidae						
Green Sunfish (*Lepomis cyanellus)*	I	IC	GE			Slow streams, shallows of lakes turbid water, high temps., and low DO
Pumpkinseed (*Lepomis gibbosus)*	I	IC	GE	LO		Clear water, lots of aquatic vegetation/submerged brush, ponds, small lakes, slow streams
Bluegill (*Lepomis macrochirus*)	I	IC	GE	LO		Warm lakes/ponds abundant vegetation, quiet pools of streams
Smallmouth Bass (*Micropterus dolomieu)*	I	IC	GE	TR		Clear, cool water, w/rocky substrates, rivers/lakes. Riffles in streams w/clean bottoms. Rocky shorelines in lakes
White Crappie (*Pomoxis annularis*)	I	IC	WC	TR		Ponds, lakes, slow streams. Cover, turbid water
Cyprinidae						
Goldfish (*Carassius auratus*)	I	OM	BE			Low turbidity streams/ponds, abundant veg., little to no current 40-80 degree F
Lake Chub (*Couesius plumbeus)*	N	IN	WC			Creek type habitat
Common Carp (*Cyprinus carpio)*	I	OM	BE			Warm shallows of lakes/reservoirs, pools/backwaters of rivers. Tolerates turbid water and low DO, spawns in shallow weedy areas
Western Silvery Minnow (*Hybognathus argyritis*)	N	HB	BE			Large streams, sand or silt, pools and backwaters
Brassy Minnow (*Hybognathus hankinsoni*)	N	HB	BE			Clear slow streams preferred, can tolerate larger more turbid rivers
Plains Minnow (*Hybognathus placitus*)	N	HB	BE			Large streams, sand or silt, pools and backwaters
Sturgeon Chub (*Macrhybopsis gelida*)	N	IN	BE	LO	BLM Sensitive, MT Species	Turbid waters, moderate/strong current, rocks, gravel, and coarse sand

	Origin	Trophic Category	Feeding Habitat	Reproductive Classification	Status	Preferred Habitat
					of concern	
Pearl Dace (*Margarsiscus margarita*)	N	IC	WC		BLM Sensitive, MT Species of concern	Clear or turbid, small cool streams. Spawn in clear water, depths 1 to 2 feet in gravel or sandy bottoms
Golden Shiner (*Notemigonus crysoleucas)*	I	OM	WC			Weedy ponds, slow streams
Emerald Shiner (*Notropis atherinoides*)	N	IN	WC			Large streams channels and impoundments, avoids aquatic veg. and pelagic
Spottail Shiner (*Notropis hudsonius)*	I	IN	WC	LO		Large lakes/rivers, avoids strong currents, spawns over sandy shoals
Sand Shiner (*Notropis stramineus*)	N	OM	GE	LO		Clear water, rapid current, sand/gravel bottom of large and small streams
Northern Redbelly Dace (*Phoxinus eos)*	N	OM	WC		MT Species of concern	Clear, cool, slow streams, ponds, and lakes w/aquatic vegetation, sandy/gravel bottoms with silt
Northern Redbelly Dace x finescale dace (*P. neogaeus)*	N	OM	WC		BLM Sensitive, MT Species of concern	Quite waters of beaver ponds, bogs, and clear streams
Fathead Minnow (*Pimephales promelas*)	N	OM	GE	TR		Highly variable, mostly small turbid creeks/ponds. Tolerant of extreme conditions
Flathead Chub (*Platygobio gracilis)*	N	IN	GE			Moderate turbidity
Longnose Dace (*Rhinichthys cataractae*)	N	IN	BE	LO		Variable. Lakes/streams/springs. Prefer riffles w/rocky substrate

	Origin	Trophic Category	Feeding Habitat	Reproductive Classification	Status	Preferred Habitat
Creek Chub (*Semotilus atromaculatus*)	N	IC	GE	LO	MT Potential species of concern	Creek type habitat
Cyprinodontidae						
Plains Killifish *(Fundulus zebrinus)*	I	OM	GE			Clear creeks, w/slit-clay substrate
Esocidae						
Northern Pike (*Esox lucius*)	I	CA	WC			Bays of lakes/reservoirs, pools/backwater of streams w/dense vegetation
Gadidae						
Burbot *(Lota lota)*	N	CA	WC		MT Potential species of concern	Large rivers and cold, deep lakes and reservoirs. Spawn in shallow water, usually in rocky areas
Gasterosteidae						
Brook Stickleback *(Culaea inconstans)*	N/I	IN	GE	TR	MT Potential species of concern	Clear streams, shallows of lakes w/dense vegetation
Hiodontidae						
Goldeye *(Hiodon alosoides)*	N	IN	WC	LO		Adapted to turbid water, prefers calm waters for spawning
Ictaluridae						
Black Bullhead *(Ameiurus melas)*	I	IC	BE	TR		Turbid, mud bottomed lakes/ponds, pools/backwaters of streams. Tolerant of high temps. and low DO
Yellow Bullhead (Ameiurus natalis)	I	IC	BE	TR		Clear, slow moving streams and weedy, shallow, clear-water areas of lakes
Channel Catfish *(Ictalurus punctatus)*	N	IC	BE	TR		Tolerates turbid water, temps. >70 degrees F, large rivers and lowland lakes

	Origin	Trophic Category	Feeding Habitat	Reproductive Classification	Status	Preferred Habitat
Stonecat *(Noturus flavus)*	N	IC	BE	LO		Swift-water areas w/rocky substrate
Lepisosteidae						
Shortnose Gar (*Lepisosteus platostomus*)	N	CA	WC		MT Species of Concern	large rivers, quiet pools, backwaters, and oxbow lakes. High tolerance of turbidity
Moronidae						
White Bass (*Morone chrysops*)	I	CA	WC			Lakes, reservoirs, and pools in streams. Avoids turbid waters
Percidae						
Iowa Darter *(Etheostoma exile)*	N	IN	BE		BLM Sensitive, MT Species of concern	Clear Slow streams, solid bottoms
Yellow Perch (*Perca Flavescens*)	I	IC	WC			Clear, warm to cool lakes w/vegetation, slow, weedy streams. Adaptable
Sauger (*Sander canadensis*)	N	IC	GE	LO	BLM Sensitive, MT Species of concern	Large Turbid rivers, muddy shallows of lakes/reservoirs. Spawn in gravel/rocky areas of shallow water. Prefer turbid water
Walleye (*Sander vitreus*)	I	IC	GE	LO		Larger lakes/reservoirs, lesser extent rivers. Spawns over gravelly riffles and rocky areas on shallow water
Polyodontidae						
Paddlefish (*Polyodon spathula*)	N	IN	WC		BLM Sensitive, MT Species of concern	large rivers, prefer turbid waters
Salmonidae						
Cisco (*Coregonus artedi*)	I	IN	WC			Pelagic species found in deep lakes and large rivers.

	Origin	Trophic Category	Feeding Habitat	Reproductive Classification	Status	Preferred Habitat
Lake Whitefish (*Coregonus clupeaformis*)	I	IN	BE			Deep, coldwater lakes and large Rivers
Sciaenidae						
Freshwater Drum (*Aplodinotus grunniens*)	N	IN	BE			Deep pools of large streams, lakes, and reservoirs. Clean bottoms and moderate turbidity.

Source: Bramblett, R. G., Johnson, T. R., Zale, A. V., and Heggem, D. G. 2005. Development and evaluation of a fish assemblage index of biotic integrity for Northwestern Great Plains streams. *Transactions of the American Fisheries Society*. 134:624-640.
Montana Field Guide. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks. Retrieved on May 18, 2021, from http://FieldGuide.mt.gov

Table 2. Fish of Western Montana.

Origin: N = native, I = invasive; Trophic Category: CA = carnivore, HB = herbivore; IC = invertivore-carnivore, IN = invertivore, OM = omnivore; Feeding habitat: BE = benthic, GE = generalist, WC = water column; Reproductive Classification: LO = litho-obligate, TR = tolerant reproductive strategists not litho-obligates and use of parental care at the spawning site.

	Origin	**Trophic Category**	**Feeding Habitat**	**Reproductive Classification**	**Status**	**Preferred Habitat**
Salmonidae						
Westslope Cutthroat Trout **(***Oncorhynchus clarkii lewisi)*	N	IC	GE		BLM Sensitive, MT Species of concern	Cold mountain streams. Spawns in gravel substrate with low sediment on pool tailouts or riffle areas
Yellowstone Cutthroat Trout **(***Oncorhynchus clarkii bouvieri***)**	N	IC	GE		BLM Sensitive, MT Species of concern	Cold mountain streams/lakes. Spawns in pebble/ gravel substrate with low sediment on pool tailouts or riffle areas
Bull Trout (*Salvelinus confluentus)*	N	CA	GE		Listed Specie**s** **T**hreatened	Cold mountain streams/lakes/large rivers. Spawns in pebble/ gravel substrate with low sediment on pool tailouts or riffle areas
Brook Trout (*Salvelinus fontinalis*)	I	IC	GE		Non-native	Cold mountain streams/. Spawns in pebble/ gravel substrate with low sediment on pool tailouts or riffle areas
Rainbow Trout (*Oncorhynchus mykiss*)	I	IC	GE		Non-native	Cold mountain streams/lakes/large rivers. Spawns in pebble/ gravel substrate with low sediment on pool tailouts or riffle areas
Brown Trout (*Salmo trutta*)	I	IC	GE		Non-native	Lower gradient streams/lakes/large rivers. Spawns in pebble/ gravel substrate with low sediment on pool tailouts or riffle areas
Cottidae						
Rocky Mountain Sculpin (*Cottus Bondi)*	N	IC	BE			All habitat types. Prefers rocky substrate in riffles and runs
Slimy Sculpin (*Cottus cognatus*)	N	IC	BE			Cold rivers, streams and cobble lake habitat.

	Origin	Trophic Category	Feeding Habitat	Reproductive Classification	Status	Preferred Habitat
Catostimdae						
Longnose Sucker (*Catostomus catostomus)*	N	IN	BE	LO		Cold clear streams/lakes, spawns in gravel beds/riffles
White Sucker (*Catostomus commersonii)*	N	OM	BE	LO		Varied. Lakes/streams, avoids rapid current, spawns over rocky substrate
Mountain Sucker (*Catostomus platyrhynchus)*	N	HB	BE	LO		Cold clear streams, rubble, gravel, or sandy bottoms spawns over rocky substrate
Cyprinidae						
Red Side Shiner (*Richardsonius balteatus*)	N	OM	GE	LO		Slow areas of cold streams and rivers. Broadcasts spawns over rocky substrate
Longnose Dace (*Rhinichthys cataractae*)	N	IN	BE	LO		Variable. Lakes/streams/springs. Prefer riffles w/rocky substrate

Table 3. Fish species present in Western Montana but not likely affected from low tech projects.

	Origin	Trophic Category	Feeding Habitat	Reproductive Classification	Status	Preferred Habitat
Gadidae						
Burbot *(Lota lota)*	N	CA	WC		MT Potential species of concern	Rivers/larger streams and cold, deep lakes and reservoirs. Broadcast Spawn in shallow water in late winter/early spring, over rocky substrate
Cyprinidae						
Northern Pikeminnow (*Ptychocheilus oregonensis*)	N	CA	GE	LO		Slow river zones and lakes. Broadcast over rocky substrate
Peamouth (*Mylocheilus caurinus*)	N	IN	GE	LO		Slow river zones and lakes. Broadcast over rocky substrate
Salmonidae						

Arctic Grayling (*Thymallus arcticus)*	N	IC	GE		BLM Sensitive, MT Species of concern	Rivers. Broadcast spawns over gravel substrate in riffles
Mountain Whitefish (Prosopium williamsoni)	N	IN	BE			Rivers/larger streams. Broadcast spawns over rocky substrate

Source: Montana Field Guide. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks.

Table 4: Overview of the types of BDAs and their typical applications

Low-Tech Structure	Design Variations	Purpose of Structure
Beaver Dam Analog (BDA): permeable, channel-spanning structure with a constant crest elevation, constructed with a mixture of woody debris and fill material to form a pond and mimic a natural beaver dam.	Postless BDA	• Increase dynamism and ecological benefits associated with dam formation, maintenance, breaching/blow-out, and infilling. • Increase water depths so that nearby beaver can overtake restoration. • Enable BDA installation where the transport of post-pounders may not be feasible
	Post Assisted BDA	• Prolong ecological benefits associated with dam building activity • enable the installation of BDAs in streams with flashy, high magnitude floods (i.e., streams that have incised)
	Post-Line Wicker Weave	• Mimic beaver dam activity where material that is suitable for wicker weaving is readily available

Table 5: Overview of the types of PALS and their typical applications

Low-Tech Structure	Design Variations	Purpose of Structure
Post Assisted Log Structure (PALS): woody material of various sizes pinned together with untreated wooden posts driven into the substrate to mimic natural wood accumulations	Bank-Attached PALS - Variation 1: To Force A Constriction Jet	• Force more variable hydraulics and the formation of new & complex aquatic habitat features • Promote structurally-forced pool, riffle growth, and eddy bar formation • Promote further processes of wood accumulation.
	Bank-Attached PALS - Variation 2: Bank Blaster	• Accelerate lateral widening and channel migration to recover incised streams • Force more variable hydraulics to create a backwater eddy upstream of the structure, an eddy downstream of structure, and a temporary jet of water aimed at opposing bank • Recruit wood to channel and promote additional wood accumulation.
	Mid-Channel PALS	• Force more variable hydraulics, including an eddy downstream of structure. • Promote mid-channel bar development in place of planebed morphologies • Encourage diffluences, convert riffles into mid-channel bars, & dissipate flow energy • Promote wood accumulation to enhance associated hydraulic and geomorphic adjustments
	Channel-Spanning PALS	• Increase water depth and decrease velocity upstream of PALS to encourage wood accumulation, organic accumulation, and sediment deposition • Increase floodplain connectivity, force new diffluences, and/or promote avulsions that accelerate channel evolution. • widen the channel around (one or both sides of) the structure to accelerate channel evolution

Table 6: Vegetation Management Actions

Objective	Action (applied within 300 feet of each stream bank)	Purpose
Vegetation Management: Promote re-growth of sufficient woody vegetation (types and amounts) within riverscapes to supply the quantities and types of vegetation required to sustain the processes of wood accumulation and beaver dam activity without the installation of additional structures.	**Project Protection Fencing**	Manage livestock and ungulate browse of woody plants, especially during the riverscape recovery phase, to promote regrowth and a sustained supply of woody material.
	Shrub & Tree Plantings	Re-introduce a source of native riparian trees/shrubs where adequate niches exist (i.e. due to the addition of structural elements and corresponding biophysical adjustments), but historical impacts have depleted the source for maintenance and recovery.
	Remove Disclimax & Invasive Woody Plants from Project Area	Increase the extent and composition of the native riparian tree/shrub communities that historically occupied the project area by reducing the composition of disclimax or invasive plants.

Table 7: Headcut Control Actions

Objective	Headcut Control Technique	Purpose
Headcut Control: Maintain the health of riparian-wetland systems that are at risk of incision from headcut advancement by stabilizing the erosional feature and stepping the water down into the channel to minimize the erosive power.	**Zuni Bowl**	Halt incision from in-channel headcuts
	Rock Run Down	Halt incision from low energy headcuts

Table 8: Beaver Mitigation Strategies

Objective	Action	Purpose
Beaver Mitigation Strategies: Mitigate flooding impacts or damage from undesirable harvest of trees, while allowing the beaver to remain in place. Balance both the ecological needs of beaver and benefits to public lands users, while protecting public and private property	**Breach Dam**	Mitigate potential flooding impacts associated with abandoned beaver dams, while still allowing some of the habitat benefits and ecosystem services to persist.
	Install Pond Leveler to Control Stage	Control pond stage heights and flooding, while allowing beaver to continue to build their dams higher and inhabit the area
	Install Culvert Barrier to Prevent Culvert Clogging	Deter beaver from clogging water culverts
	Right-Sizing Culverts to Prevent Clogging	Minimize the probability that beaver will clog culverts
	Install Fencing to Protect Important Trees	Deter beaver from harvesting trees that are more important to other multiple use management objectives (e.g. shade at a campground) than riverscape restoration
	Apply Paint Mixed with Sand to Protect Sensitive Trees	Deter beaver from harvesting sensitive trees or those which serve an important function (i.e., shade at a campground)

Table 9: Special Status Species Plants

PLANTS		
MONTANA		
Common Name	**Scientific Name**	**Habitat**
Idaho Sedge	*Carex idahoa*	Idaho sedge inhabits moist alkaline meadows, often along streams (Vanderhorst and Lesica 1994). It most often occupies ecotonal areas between wet meadow and sagebrush steppe (Lesica 1998), and appears to be restricted to nearly level sites in the high valleys of southwest Montana. It is commonly found on terraces of headwaters streams above 6000 feet elevation. Small populations may occur at lower elevations or along larger streams. Soils tend to be silty, with high organic content and little or no coarse material (Lesica 1998). Most documented Montana populations are in areas with calcareous parent material, however a few occupy non-calcareous sites. Idaho sedge consistently occurs in subirrigated soils associated with low-gradient streams or springs and seeps. These soils are wet early in the growing season but are only moist later in the summer. In wetlands where part of the habitat was saline (as indicated by the presence of *Distichlis* and *Puccinellia*), it is usually limited to non-saline areas, although it has been found in salt-encrusted soils (Lesica 1998).
Meadow Lousewort	*Pedicularis crenulata*	Montana's populations of Scallop-leaf Lousewort are only known to occur in native riparian meadows along the upper Beaverhead River. Reported threats refer to extremely limited habitat, and the potential for future losses to agricultural development (MTNHP Threat Assessment 2021). A large proportion of potential habitat has been converted to hay production, and some has recently been displaced by an impoundment. A portion of an extant population occurs on private land and is at risk of similar losses to land conversion or consequences of surface water manipulation.
Alkali Primrose	*Primula alcalina*	Idaho primrose is known from east-central Idaho and adjacent Montana. Six populations have been documented in Clark, Custer and Lemhi counties, Idaho, and one in Beaverhead County, Montana. A second Beaverhead County population, observed at Monida in 1936, is presumed extinct. Primula alcalina is found in moist to wet alkaline meadows near headwaters streams at 6,300 to 7,200 feet elevation. The soil surface often displays hummock-hollow topography. Soils in the meadows are alluvial, alkaline, fine-textured, light-colored soils are derived from outwash of predominantly carbonate rocks of the Beaverhead, Lemhi, and Lost River ranges. Soil pH averaged 8.9-9.6 at study sites in Idaho (Moseley 1995).

		Common associates include Juncus balticus, Deschampsia cespitosa, Carex scirpoidea, Carex nebrascensis, Carex praegracilis, Agropyron trachycaulum, Muhlenbergia richarsonis, Senecio debilis, Crepis runcinata, Triglochin maritima, Dodecatheon pulchellum and Thalictrum alpinum. Potentilla fruticosa is common at some sites, primarily those with hummocks. Primula alcalina occurs in the lowest topographic positions in the meadows, where subirrigated soils are saturated to the surface throughout the growing season. Plants occur on low, relatively level benches immediately adjacent to creeks and spring heads, often on the inside of meander loops, and also on low benches with hummocky topography. Primula alcalina is often most abundant of the tops and sides of hummocks where the density of graminoids is lowest.
NORTH DAKOTA		
Heartleaf Buttercup	*Ranunculus cardiophyllus*	Moist meadows and grasslands often associated with wetlands in the foothill zone.
SOUTH DAKOTA		
Tulip Gentain	*Eustoma exaltatum*	Wet meadows and pond margins on the plains. Single recent occurrence in s B Hills.
Streamside Bluebells	*Mertensia ciliata*	Wet meadows, thickets, moist open forest, talus, often along streams; montane, lower alpine. Few collections from riparian zones in w SD.
Northern White Orchid	*Platanthera dilatata*	Wet soil of meadows, fens, thickets, open forest, often along streams, ditches; valleys to lower subalpine. Rare in wetland habitats of the n B Hills.
Round-leaved Orchid	*Platanthera orbiculata*	Moist coniferous forest; valleys to lower subalpine. Forested habitats of the n Black Hills.
One-flower Wintergreen	*Moneses uniflora* *(Pyrola uniflora)*	Moist, deeply shaded coniferous forests, often in moss of riparian spruce forest; valleys to subalpine. Mature spruce forests of the n B Hills.
Shining Willow	*Salix lucida*	Along rivers, streams; plains, valleys, montane. Single recent collection from cent B Hills.
Western Saxifrage	*Micranthes occidentalis* *(Saxifraga occidentalis)*	Rock outcrops, vernally moist, usually stony soil of grasslands, meadows, turf; valleys to alpine. Few collections from n Black Hills.

1. Plant names in ( ) are the State of Montana recognized name for the species. All other names are the federally excepted names from USDA Plants.
2. See Attachment 3 and the hyperlinks above for individual species information.

Appendix G — Climate: Implications for Riverscape Processes, Attributes and Water Resources[10]

Temperature (air): Since 1950, average temperatures in Montana have increased by 0.5°F/decade (0.3°C/decade), with greatest warming in spring; projected to increase by 3-7°F (1.7-3.9°C) by midcentury, with the greatest warming in summer and winter. Maximum temperatures have increased most in spring and are projected to increase 3-8°F (1.7-4.4°C) by midcentury, with the greatest increases in the southeast during August. These changes are affecting how water enters the region (e.g., as rain or snow), how it is distributed among the major storage pools (groundwater, surface water, soil moisture, water vapor, etc.), and how it moves or changes from one component of the water cycle to another. For instance, elevated temperatures will correspondingly increase the relative distribution of water that falls in the form of rain versus snow, alter the frequency and intensity of storm events, accelerate the timing and rate of snowmelt, and amplify the effects of drought.

Temperature (water): Researchers have recently developed high-resolution stream climate maps (Isaak et al. 2016) based on extensive stream temperature data. The maps show that summer stream temperatures vary considerably throughout the state, but generally reflect patterns in average air temperatures—usually being coldest in the high mountains and warmest at low elevations and in the eastern plains. Changes in climate, especially declining summer flows (Rood et al. 2008; Leppi et al. 2012) and increasing air temperatures (Pederson et al. 2010), have caused water temperatures to increase in the state's rivers and streams at the rate of 0.18-0.36°F (0.1-0.2°C/decade) (Isaak et al. 2012). Stream warming rates are slower than air temperature warming rates due to the buffering effects of groundwater, but any temperature increase can be important for water quality and cold-blooded aquatic species. Healthy riverscapes will buffer the temperature increases more than unhealthy riverscapes. This is because healthy riverscapes exchange more water between the stream, streambed/banks, and floodplain aquifer and this surface-groundwater exchange: (i) cools water, (ii) constrains the range of daily temperature fluctuations, (iii) creates more variable temperature profiles and (iv) promotes the storage of water underground, where it is released back to the stream later in the year to support higher base flows (Weber et. al, 2017). This is especially true of beaver modified reaches.

Precipitation, Snowpack, and Streamflow: The influence of climate on precipitation form (rain vs. snow), snow distribution, and snowmelt is one of the major linkages between climate change, water supply, and riverscape conditions. This is largely because increased temperatures reduce winter snow accumulation, shift the snowline to higher elevations, and accelerate snowmelt. These trends are already occurring and projected to become more severe in the coming decades. However, the type and severity of these impacts on streamflow will vary by the relative contribution of snowmelt to streamflow and the degree to which snowpacks in the contributing area are affected by increased temperatures.

Long-term snow course data in Montana for April 1 (period of near maximum snow accumulation) show that the amount of water held in the snowpack has already declined roughly 20% over the last 80 years. Researchers have also documented shifts toward earlier snowmelt and spring runoff, which are greater among low to mid elevation snowpacks and the waterbodies that they supply, than high elevation snowpacks and associated streams (Regonda et al., 2005). These differences occur because lower elevation sites tend to be warmer, with temperatures that are closer to the melt/freeze point, so temperature increases associated with climate change have a much greater influence on snowmelt, as well as the proportion of precipitation that falls as rain versus snow. As a result, riverscapes that receive a

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[10] Since 96% of the BLM administered surface estate is in Montana, and the 2017 Montana Climate Assessment (https://montanaclimate.org/) is among the most detailed and comprehensive climate assessments currently available for the region, it is used here as the primary source of information on climate change for the project area.

greater percentage of their water inputs from mid and low elevation snowpack (particularly common in Western Montana) are more susceptible to water supply related impacts of climate change than those for which high elevation snowpack is a primary source of streamflow. While some of these impacts are already occurring, modeled projections indicate that the upward trend in temperatures will continue, and that the magnitude of these changes will vary by season. Of particular concern is the trend towards more frequent and earlier spring and winter warm spells because even modest warming during these periods can lead to large changes in snowmelt and runoff dynamics (Regonda et al. 2005; Stewart et al. 2005; Klos et al. 2014). Consequently, a larger percentage of the water is expected to leave the snowpack during the winter and early spring, leaving much less water to support streamflow later in the year during summer and early fall.

In a normal year, most (62–65%) of western Montana's annual precipitation falls as winter snow, which is the primary driver of year-to-year variability in streamflow. This is typical of most streams in the project area with headwaters above 7000 ft (2100 m) elevation. In contrast, many BLM administered streams in central and eastern Montana, as well the Dakotas, receive most of the annual precipitation as spring and summer rain (warm season), which can be episodic and intense, causing high spatial and temporal variability in streamflow. These two generalized precipitation regimes (spring and summer rain vs. snowmelt driven) influence riverscape characteristics, streamflow patterns, and the susceptibility of these systems to the impacts of climate change. In general, streams that receive more of their precipitation as rain are correspondingly more susceptible to declining summer precipitation, as well as changes to the timing, frequency, and intensity of storm events. Conversely, snow-melt driven streams are more susceptible to declining snowpacks and earlier snowmelt. Irrespective, maintaining healthy riverscapes with longer hydrologic flow paths and diverse residence times will help to buffer these impacts.

Groundwater: Groundwater plays a critical role in sustaining streamflow throughout the year (in a typical Montana stream, groundwater contributes 50% of the annual flow [MT DNRC 2015]) and therefore, exerts tremendous control over the attributes of riparian-wetland and aquatic ecosystems. Although the effects of climate change on groundwater resources are relatively uncertain, projections generally indicate that it is likely to reduce recharge, increase water demand, and alter interactions between groundwater and surface-water systems (Earman and Dettinger 2011; Green et al. 2011; Huntington and Niswonger 2012; Taylor et al. 2013). Reductions in recharge to mountain aquifer systems is especially likely because of decreased snowpack and changes to patterns of infiltration. The gradual character of snowmelt is more favorable to infiltration than rainfall events; therefore, as an increasing percent of precipitation falls as rain instead of snow (due to rising temperatures), infiltration is likely to decrease, despite projected increases in winter and spring precipitation. Rising temperatures will also lead to a longer growing season, in turn increasing evapotranspiration and further reducing recharge (Meixner et al. 2016). These expected reductions in recharge might appear contrary to projected increases in total annual streamflow. However, changes in the character of precipitation (e.g., shifts from snow to rain or increases in extreme precipitation events) may cause more water to run off into streams and less to infiltrate into groundwater aquifers. Thus, surface water contributions and annual flow in a particular watershed may increase, even as recharge and baseflow contributions to streamflow decline. Streams in broad, low gradient, alluvial valley bottoms will be particularly vulnerable to these impacts, especially where structural starvation has caused channel incision; reduced the frequency, extent, and duration of inundation; and diminished the elevation of floodplain aquifers. Conversely, riverscapes with extensive beaver dams, wood accumulation, and/or channels to slow the downstream transport of water/sediment, spread flow across the floodplain (where it can be stored on the surface/subsurface and slowly released to the riparian-wetland and aquatic zone), and maintain high floodplain water tables will be less affected by the impacts of climate change on groundwater.

Drought: A complex interplay of climate, hydrologic and ecosystem processes, and human impacts influences drought. Natural variability in precipitation and temperature will continue to characterize the regional climate in the future, resulting in droughts of varying duration and intensity. However, within the context of this natural variability, human-driven changes in temperature and precipitation will alter and amplify future patterns of drought, which can be coarsely divided into the categories of seasonal and persistent. Persistent drought, which occurs after multiple years of below-average streamflow (within which individual seasons of above-average flow may occur) can have the most severe consequences for water resources, riverscapes, and associated flora/fauna, largely due to the cumulative effect of water deficits on hydrologic systems. Seasonal droughts are shorter in duration and occur when streamflow falls below average for a period of months. Although seasonal droughts typically do not cause as severe hydrologic impacts as persistent droughts, they occur more frequently and often cause water deficits in the warm season, when economic and ecological water demands are greatest. These impacts are predicted to be more severe (for both seasonal and persistent drought) in the future, as climate change continues to increase temperatures and alter patterns of precipitation. Consequences include earlier peak flows and the onset of dry/low flow conditions, increased water losses to evaporation and vegetation demands (evapotranspiration), lower base flows and diminished floodplain aquifers, elevated water temperatures and pollutant concentrations, reduced dissolved oxygen, and a greater propensity for algal blooms and undesirable microbial activity. These changes will adversely impact riverscapes and native aquatic/riparian-dependent species; stress riparian vegetation (reducing productivity, resilience to beaver/livestock/wildlife use, and resistance to disease/insect infestation); increase wildfire severity, occurrence, and spread across valley bottoms; and cause streams, floodplain wetlands, and other surface waters to dry sooner, for longer periods, and over larger areas. The associated economic and ecologic impacts will be more severe in degraded riverscapes, which have a diminished capacity to store water in the valley bottom, where it was historically cleaned/cooled by natural processes, available for use by riparian and aquatic plants/animals, and slowly released as streamflow later in the season.

There is widespread agreement that rising temperatures will exacerbate both persistent and seasonal droughts when and where they occur. This is because rising temperatures will impact various components of the water budget in a manner that generally reduces the availability of surface and groundwater resources. Among the most significant impacts will be an increase in evaporation and plant transpiration (evapotranspiration). In the absence of increased precipitation, higher rates of evapotranspiration will reduce streamflow, soil moisture, and groundwater recharge. Furthermore, as snowpacks decline and the onset of snowmelt and runoff shift to earlier in the spring/winter, the frequency, severity, and duration of drought during later summer and early fall is expected to increase. Therefore, a more rapid onset and increased intensity of both persistent and seasonal drought are expected (Strzepek et al. 2010; Peterson et al. 2013; Lukas et al. 2014; Trenberth et al. 2014).

The effects of climate change on precipitation patterns and corresponding droughts are less well understood than those which can be attributed locally to rising temperatures, especially for the occurrence of persistent drought. This is because the factors that control long-term regional precipitation patterns involve complex, large-scale atmospheric circulation patterns connected to changes in sea-surface temperatures for which a deeper understanding is required for more accurate predictions (Cook et al. 2007; Trenberth et al. 2014). Irrespective, summer precipitation is projected to decline throughout much of the project area and strong evidence exists that climate change will increase the occurrence and severity of warm season drought (Cook et al. 2004; Sheffield and Wood 2008; Pederson et al. 2011), which can occur during years of persistent drought as well as years of average total precipitation. In fact, predictions show that even small decreases in summer precipitation could exacerbate the occurrence and severity of drought, especially in streams at low to mid elevation or those fed by small watersheds, largely because: (a) many smaller watersheds in eastern Montana and the Dakotas are fed more by spring and summer precipitation than by winter snowpack (MT DNRC 2014), and (b) low August flows are highly correlated with summer precipitation. Projections also indicate that a higher proportion of the annual flow will leave regional watersheds earlier in the year, resulting in lower flows and warmer temperatures during the summer months. This is likely to have catastrophic impacts on some aquatic species, with ripple effects on important river-based recreation industries (Luce and Holden 2009). Even if total annual precipitation increases (predicted with low to medium certainty in some areas), warm season droughts are still expected because the frequency, intensity, type (rain vs. snow), and seasonality of precipitation (Sheffield and Wood 2008) are more important determinants of warm season drought, and climate change is expected to impact these factors. For example, shifts from snow to rain in headwater areas, earlier snowmelt, or an increased contribution of total precipitation from higher intensity storms for which a smaller proportion of water can infiltrate the soil or be stored in local watersheds, will likely reduce the supply of water in the warm season. Furthermore, if there is an increase in interannual variability of precipitation, which is widely accepted as the primary climate factor driving drought, the frequency, duration, and/or severity of drought could also increase.

Flood: flooding has occurred regularly throughout the state's history and will continue to cause loss of life and substantial damage to property, infrastructure, and riverscape ecosystems. However, attribution studies and associated flood projections are difficult due to the complex interplay of climate and human-related factors, both of which play a significant role in modifying flood regimes. For example, activities such as urbanization, forest clearing, wetland drainage, and stream channelization, tend to amplify flooding. Conversely, water management practices (e.g. reservoir storage operations) and watershed attributes (e.g. healthy riverscapes) that capture, store, and slowly transmit water downstream can prevent or moderate the peak flows that lead to large floods (Kunkel at al. 2003; Rood et al. 2016). However, natural variability in precipitation, sometimes in combination with rain-on-snow events, also influences the occurrence and severity of flooding. To disentangle the compounding influence of human and climate factors on floods, most regional studies have focused on precipitation-related drivers of flooding (Karl and Knight 1998; Kunkel 2003; McCabe et al. 2007). These studies suggest that change in flood risk during the latter half of the 20th century has been a function of both precipitation (increased variability) and temperature (warming in mid-winter). Climate-driven changes in both these variables will continue to affect flood risk in the future.

Warming will continue to reduce mountain snowpack, and this could reduce flood risk related to rain-on-snow events by reducing the quantity of water available for release stored as snow (Cohen et al. 2015). Yet warming is also likely to increase the amount of winter and spring precipitation that falls as rain (particularly in rain-snow transition zones), which will accelerate snowmelt and could increase flood risk, depending on antecedent snowpack, soil moisture, and other conditions. As such, rising temperatures alone will influence flood risk, regardless of trends in precipitation (Salathé et al. 2014); yet the effects will likely be location and event-specific and therefore difficult to predict (Cohen et al. 2015).

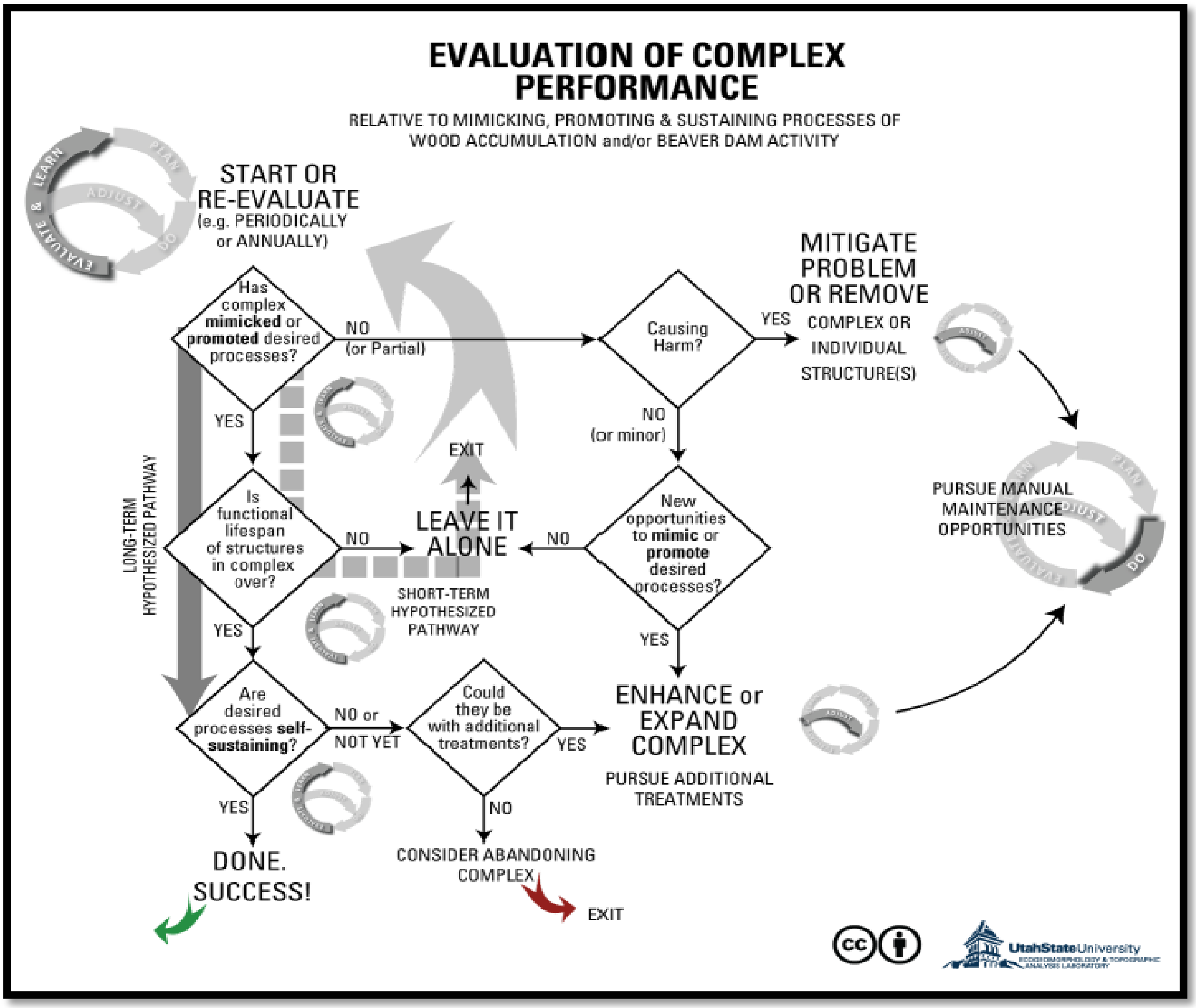
Future precipitation projections show a general increase in extreme events at a global scale (Min et al. 2011; Rood et al. 2016), and regional climate models also consistently predict increases in extreme precipitation in the northwestern US. In the project areas, the frequency of wet events (days with more than 1 inch [2.5 cm] of rain) and variability in interannual precipitation are both projected to increase slightly by mid to late century. However, there is considerable uncertainty surrounding the associated flood risks and some research suggests that extreme precipitation events will intensify more quickly than what is projected by general circulation models (Min et al. 2011). Additionally, flood risk depends on specific storm characteristics that are difficult to capture in most models (Salathé et al. 2014) and the effects of projected changes in temperature and precipitation on flood risk will depend on location, elevation, and antecedent weather conditions, as well as human practices that impact flooding.

Irrespective of the type and magnitude of these changes, healthy riverscapes will moderate downstream flooding better than unhealthy riverscapes. This is because they convey water and sediment less efficiently due to more flow obstructions, geomorphic complexity, and channels that dissipate energy, as well as more frequent and extensive connectivity between the stream and floodplain (Riverscape Principle 4). These attributes slow down flood waters, spread it across the valley bottom, and temporarily store it until flood peaks decline, while unhealthy riverscapes confine more water to a simplified channel, which quickly routes it downstream where it contributes to major flood peaks in the larger river systems. Healthy riverscapes will also be more resistant and resilient to flooding, as they are more complex, experience lower flow velocities and distribute potentially damaging hydraulic forces across larger proportions of the valley bottom (Riverscape Principles 1 and 2).

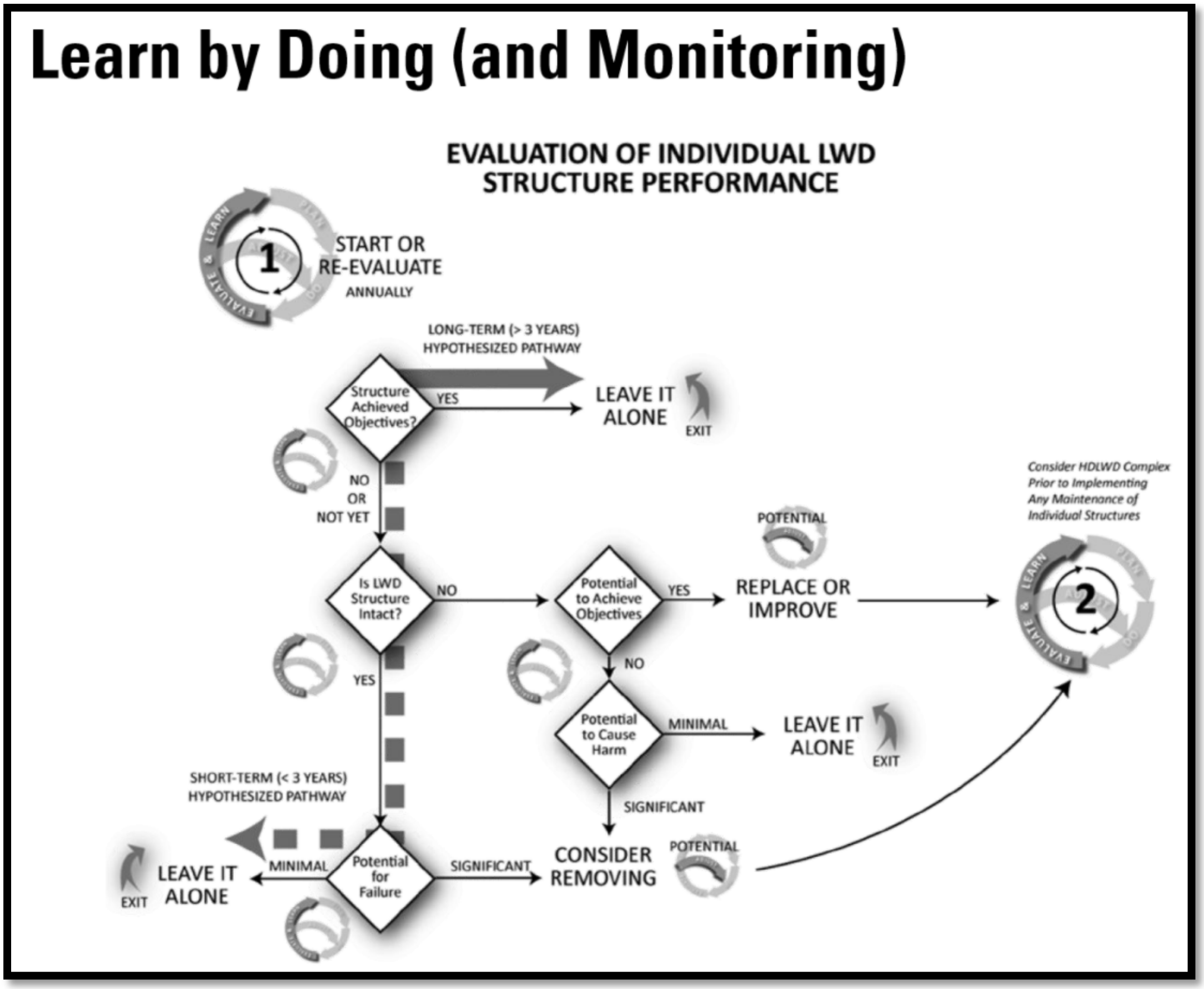
Appendix H —Adaptive Management Framework

Overview: The BLM would utilize an iterative, adaptive management approach when implementing projects to maintain alignment between the actions and corresponding project objectives (LTPBR Design Manual, Chapter 3, pages 1-57). 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.

Evaluation of Complex Performance:



Evaluation of Individual LWD Structure Performance



Learn by Doing (and Monitoring)

EVALUATION OF INDIVIDUAL LWD STRUCTURE PERFORMANCE

1 START OR RE-EVALUATE ANNUALLY

LONG-TERM (> 3 YEARS) HYPOTHESIZED PATHWAY

Structure Achieved Objectives?

YES

LEAVE IT ALONE

EXIT

NO OR NOT YET

Is LWD Structure Intact?

NO

Potential to Achieve Objectives

YES

POTENTIAL

REPLACE OR IMPROVE

Consider HDLWD Complex Prior to Implementing Any Maintenance of Individual Structures

2

NO

Potential to Cause Harm

MINIMAL

LEAVE IT ALONE

EXIT

SIGNIFICANT

YES

SHORT-TERM (< 3 YEARS) HYPOTHESIZED PATHWAY

Potential for Failure

MINIMAL

LEAVE IT ALONE

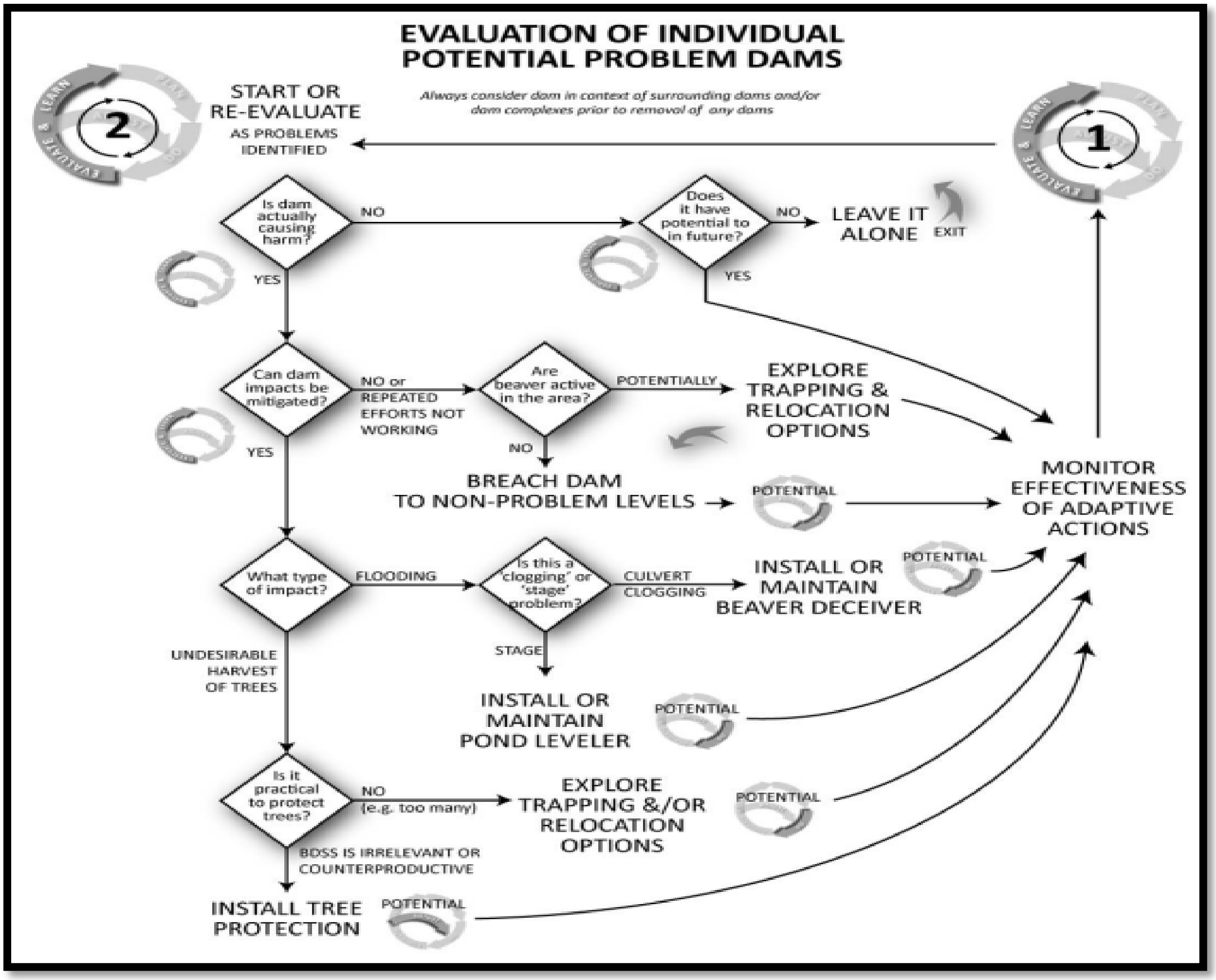
EXIT

SIGNIFICANT

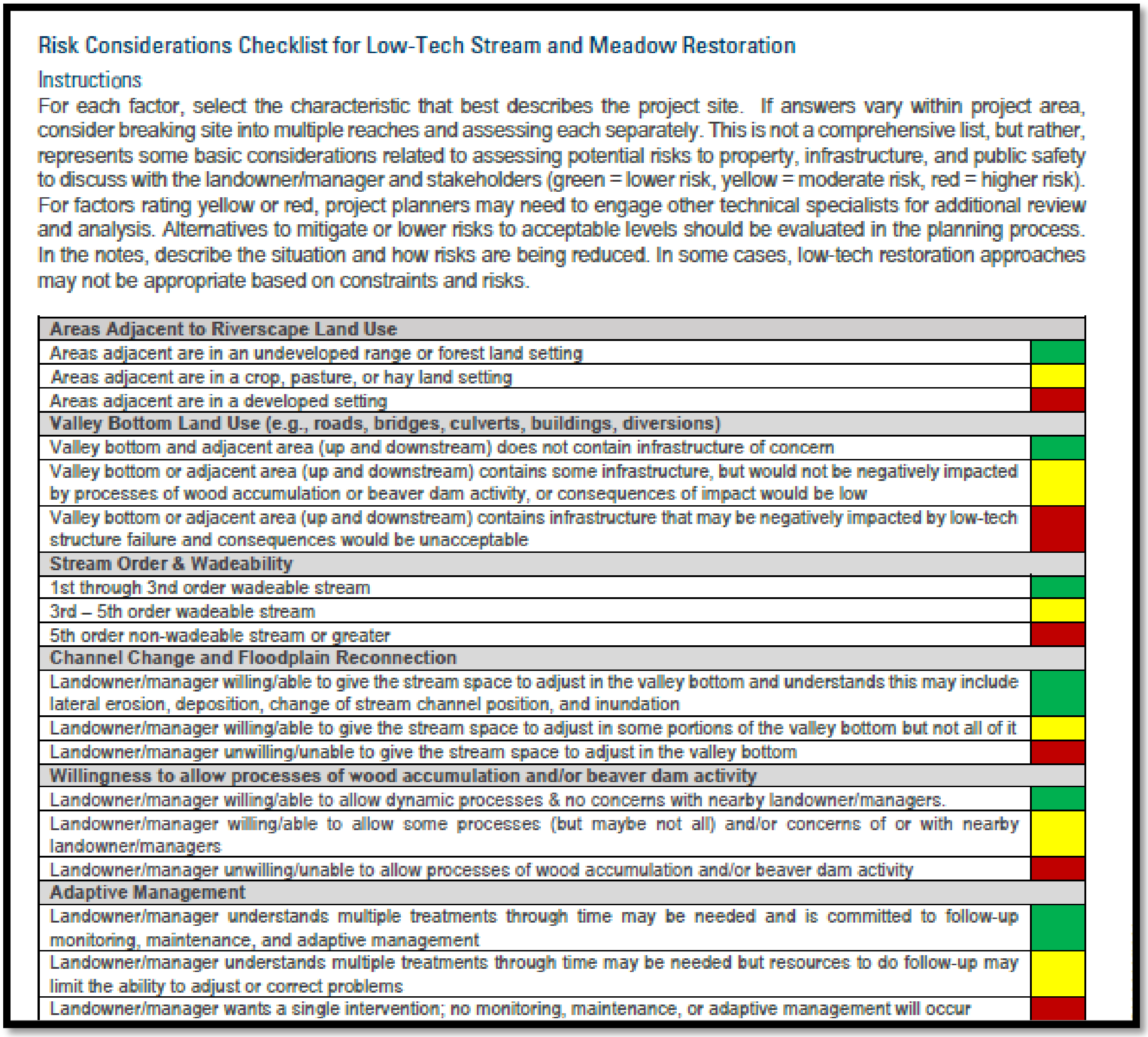
CONSIDER REMOVING

POTENTIAL

Evaluation of Individual Potential Problem Dams



Risk Considerations Checklist for Low-Tech Stream and Meadow Restoration:



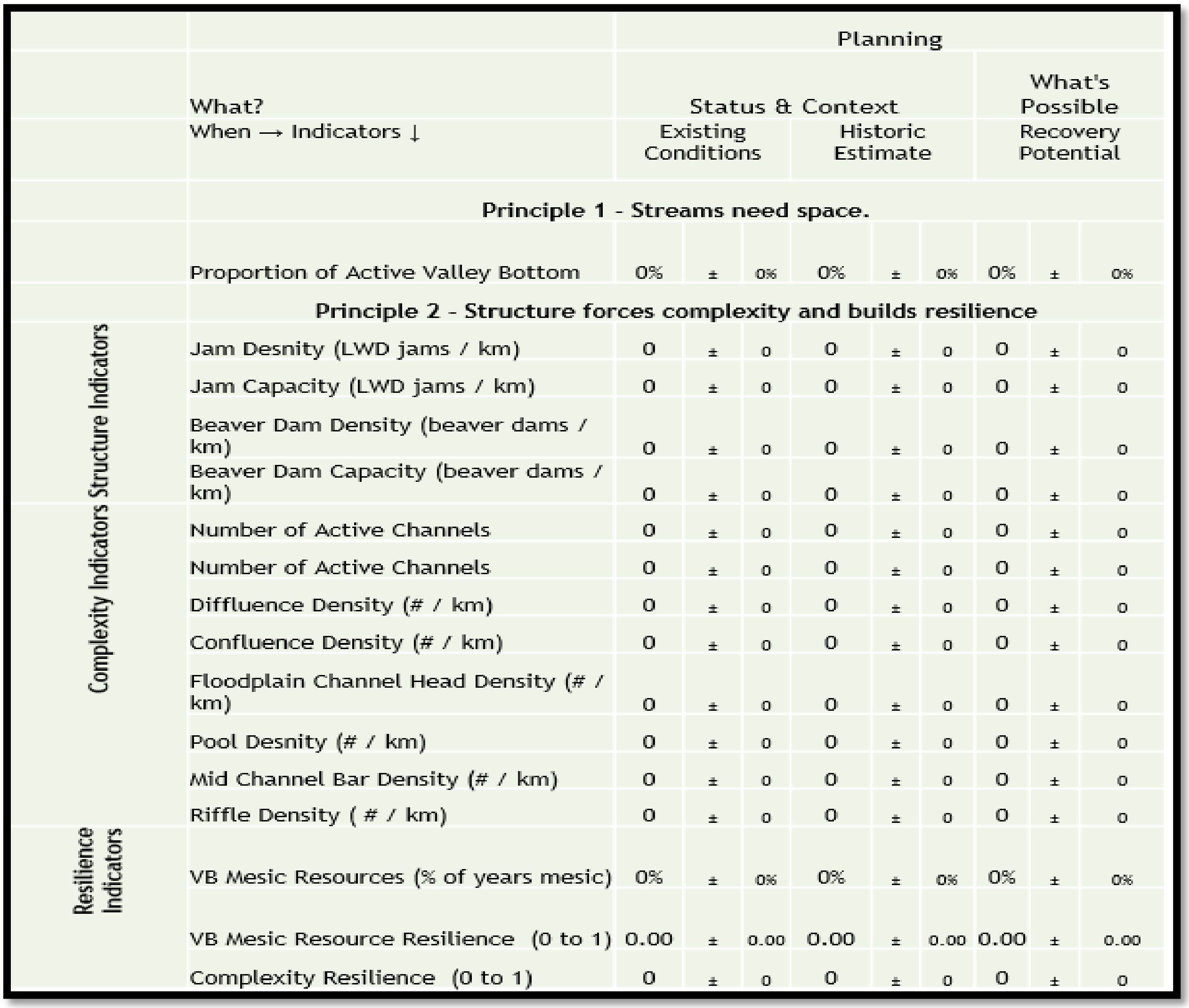
Risk Considerations Checklist for Low-Tech Stream and Meadow Restoration

Instructions

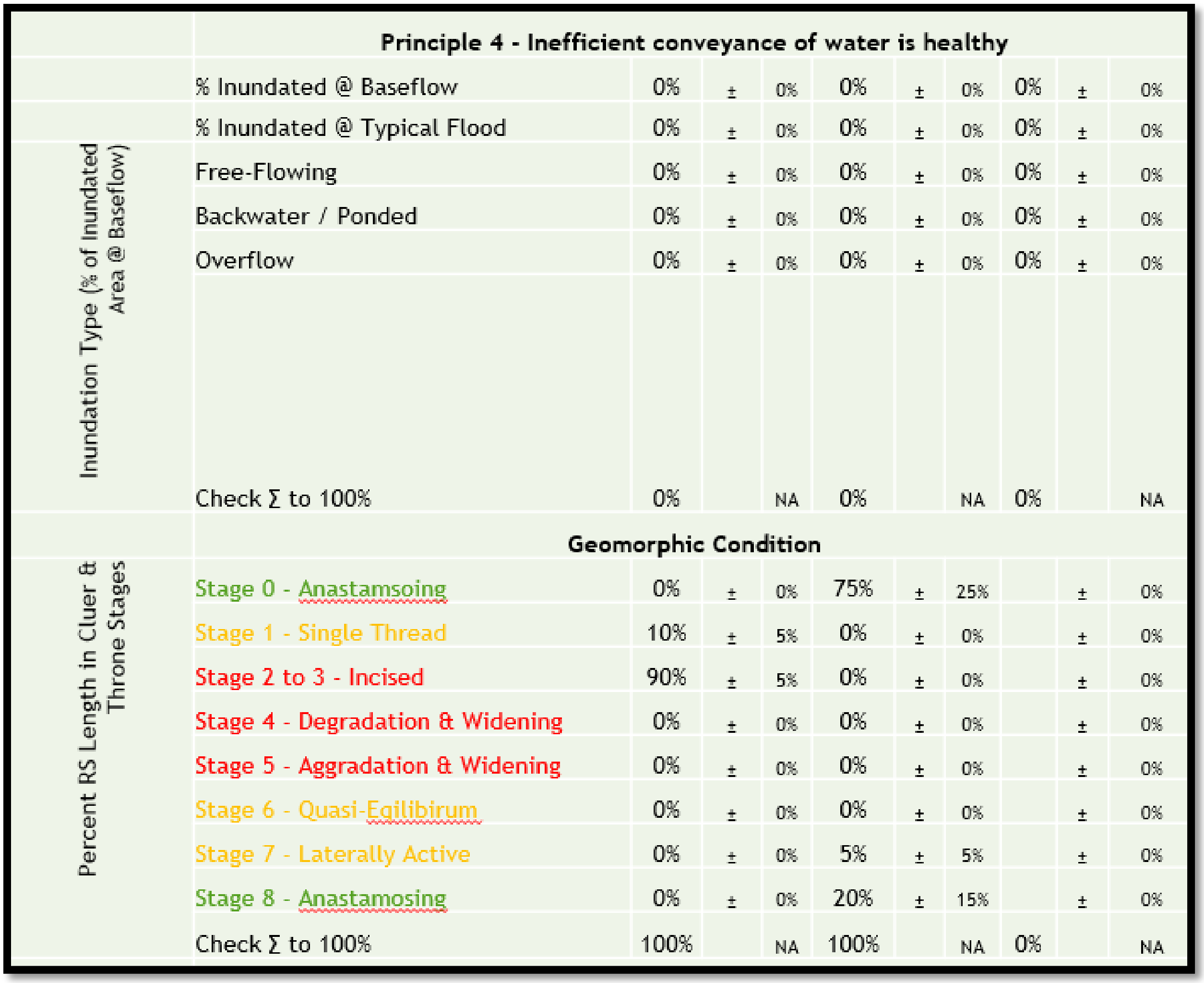
For each factor, select the characteristic that best describes the project site. If answers vary within project area, consider breaking site into multiple reaches and assessing each separately. This is not a comprehensive list, but rather, represents some basic considerations related to assessing potential risks to property, infrastructure, and public safety to discuss with the landowner/manager and stakeholders (green = lower risk, yellow = moderate risk, red = higher risk). For factors rating yellow or red, project planners may need to engage other technical specialists for additional review and analysis. Alternatives to mitigate or lower risks to acceptable levels should be evaluated in the planning process. In the notes, describe the situation and how risks are being reduced. In some cases, low-tech restoration approaches may not be appropriate based on constraints and risks.

Areas Adjacent to Riverscape Land Use	
Areas adjacent are in an undeveloped range or forest land setting	🟩
Areas adjacent are in a crop, pasture, or hay land setting	🟨
Areas adjacent are in a developed setting	🟥
Valley Bottom Land Use (e.g., roads, bridges, culverts, buildings, diversions)	
Valley bottom and adjacent area (up and downstream) does not contain infrastructure of concern	🟩
Valley bottom or adjacent area (up and downstream) contains some infrastructure, but would not be negatively impacted by processes of wood accumulation or beaver dam activity, or consequences of impact would be low	🟨
Valley bottom or adjacent area (up and downstream) contains infrastructure that may be negatively impacted by low-tech structure failure and consequences would be unacceptable	🟥
Stream Order & Wadeability	
1st through 3nd order wadeable stream	🟩
3rd – 5th order wadeable stream	🟨
5th order non-wadeable stream or greater	🟥
Channel Change and Floodplain Reconnection	
Landowner/manager willing/able to give the stream space to adjust in the valley bottom and understands this may include lateral erosion, deposition, change of stream channel position, and inundation	🟩
Landowner/manager willing/able to give the stream space to adjust in some portions of the valley bottom but not all of it	🟨
Landowner/manager unwilling/unable to give the stream space to adjust in the valley bottom	🟥
Willingness to allow processes of wood accumulation and/or beaver dam activity	
Landowner/manager willing/able to allow dynamic processes & no concerns with nearby landowner/managers.	🟩
Landowner/manager willing/able to allow some processes (but maybe not all) and/or concerns of or with nearby landowner/managers	🟨
Landowner/manager unwilling/unable to allow processes of wood accumulation and/or beaver dam activity	🟥
Adaptive Management	
Landowner/manager understands multiple treatments through time may be needed and is committed to follow-up monitoring, maintenance, and adaptive management	🟩
Landowner/manager understands multiple treatments through time may be needed but resources to do follow-up may limit the ability to adjust or correct problems	🟨
Landowner/manager wants a single intervention; no monitoring, maintenance, or adaptive management will occur	🟥

Typical Implementation and Effectiveness Monitoring Indicators for Adaptive Management:



		Planning								
	What?	Status & Context						What's Possible		
	When → Indicators ↓	Existing Conditions			Historic Estimate			Recovery Potential		
	Principle 1 - Streams need space.									
	Proportion of Active Valley Bottom	0%	±	0%	0%	±	0%	0%	±	0%
	Principle 2 - Structure forces complexity and builds resilience									
Structure Indicators	Jam Desnity (LWD jams / km)	0	±	0	0	±	0	0	±	0
	Jam Capacity (LWD jams / km)	0	±	0	0	±	0	0	±	0
	Beaver Dam Density (beaver dams / km)	0	±	0	0	±	0	0	±	0
	Beaver Dam Capacity (beaver dams / km)	0	±	0	0	±	0	0	±	0
Complexity Indicators	Number of Active Channels	0	±	0	0	±	0	0	±	0
	Number of Active Channels	0	±	0	0	±	0	0	±	0
	Diffluence Density (# / km)	0	±	0	0	±	0	0	±	0
	Confluence Density (# / km)	0	±	0	0	±	0	0	±	0
	Floodplain Channel Head Density (# / km)	0	±	0	0	±	0	0	±	0
	Pool Desnity (# / km)	0	±	0	0	±	0	0	±	0
	Mid Channel Bar Density (# / km)	0	±	0	0	±	0	0	±	0
	Riffle Density (# / km)	0	±	0	0	±	0	0	±	0
Resilience Indicators	VB Mesic Resources (% of years mesic)	0%	±	0%	0%	±	0%	0%	±	0%
	VB Mesic Resource Resilience (0 to 1)	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00
	Complexity Resilience (0 to 1)	0	±	0	0	±	0	0	±	0



	Principle 4 - Inefficient conveyance of water is healthy									
	% Inundated @ Baseflow	0%	±	0%	0%	±	0%	0%	±	0%
	% Inundated @ Typical Flood	0%	±	0%	0%	±	0%	0%	±	0%
Inundation Type (% of Inundated Area @ Baseflow)	Free-Flowing	0%	±	0%	0%	±	0%	0%	±	0%
	Backwater / Ponded	0%	±	0%	0%	±	0%	0%	±	0%
	Overflow	0%	±	0%	0%	±	0%	0%	±	0%
	Check ∑ to 100%	0%		NA	0%		NA	0%		NA
	Geomorphic Condition									
Percent RS Length in Cluer & Throne Stages	Stage 0 - Anastamsoing	0%	±	0%	75%	±	25%		±	0%
	Stage 1 - Single Thread	10%	±	5%	0%	±	0%		±	0%
	Stage 2 to 3 - Incised	90%	±	5%	0%	±	0%		±	0%
	Stage 4 - Degradation & Widening	0%	±	0%	0%	±	0%		±	0%
	Stage 5 - Aggradation & Widening	0%	±	0%	0%	±	0%		±	0%
	Stage 6 - Quasi-Eqilibirum	0%	±	0%	0%	±	0%		±	0%
	Stage 7 - Laterally Active	0%	±	0%	5%	±	5%		±	0%
	Stage 8 - Anastamosing	0%	±	0%	20%	±	15%		±	0%
	Check ∑ to 100%	100%		NA	100%		NA	0%		NA

Appendix I – Biological Evaluation

BLM Montana/Dakotas
Biological Evaluation Summary Table for BLM Special Status Fish and Wildlife Species.
Form Updated April 2022

Project: Low-Tech, Processed-Based Riverscape Restoration (LTPBR) projects across the BLM Montana/Dakotas

Step 1a.	**Step 1b.**	**Step 1c.**	**Step 2**	**Step 3.**	**Step 4.**	**Step 5.**	**Step 5.**
List of all Special Status Species that are known or suspected to occur on the DFO. **FEDERALLY LISTED SPECIES**	**Current Management Status of the Species.**	**Does the species occur on BLM managed lands?**	**Is the species or its habitat found within the affected environment/ action area?**	**Could this proposal have any effect?**	**Irreversible or Irretrievable Resources involved?**	**Alt 1 level of effect**	**Alt 2 level of effect**
Canada lynx *Lynx canadensis*	Threatened (ESA)	Yes	Yes	Yes	No	NLAA	NLAA
Grizzly Bear *Ursus arctos* (GYE) and (NCDE)	Threatened (ESA)	Yes	Yes	Yes	No	NLAA	NLAA
Piping Plover *Charadrius melodus*	Threatened (ESA)	Yes	Yes	Yes	No	NLAA	NLAA
Red Knot *Calidris canutus*	Threatened (ESA)	Not confirmed	No	No	No	N/A	N/A
Whooping Crane *Grus americana*	Endangered (ESA)	Yes	Yes	Yes	No	NLAA	NLAA
Yellow-Billed Cuckoo *Coccyzus americanus* *Western Distinct Population Segment	Threatened (ESA)	No	Yes	Yes	No	NLAA	NLAA

Bull Trout *Salvelinus confluentus*	Endangered (ESA)	Yes	Yes	Yes, but will be analyzed per project under a separate Section 7 (a)(2) consultation	No	N/A	N/A
Pallid Sturgeon *Scaphirhynchus albus*	Endangered (ESA)	Yes	No but adjacent	Yes	No	NLAA	NLAA
Dakota Skipper *Hesperia dacotae*	Threatened (ESA)	Not confirmed	No	No	No	N/A	N/A
Northern Long-Eared Bat (Northern Myotis) *Myotis septentrionalis*	Threatened (ESA)	Yes	Yes	Yes, but will be analyzed under the 4 (d) rule or if uplisted, a separate Section 7 (a)(2) consultation	No	N/A	N/A
Black-footed ferret *Mustela nigripes*	Endangered (ESA)	Yes	No	No	No	N/A	N/A
Whitebark Pine *Pinus albicaulis*	Proposed (ESA)	Yes	No	No	No	N/A	N/A
Step 1a.	**Step 1b.**	**Step 1c.**	**Step 2**	**Step 3.**	**Step 4.**	**Step 5.**	**Step 5.**
List of all Special Status Species that are known or suspected to occur on the DFO. **BLM SENSITIVE SPECIES**	**Current Management Status of the Species.**	**Does the species occur on BLM managed lands?**	**Is the species or its habitat found within the affected environment/ action area?**	**Could this proposal have any impact?**	**Are Irreversible or Irretrievable Resources involved?**	**Alt A level of impact**	**Alt B level of impact**
Amphibians							
Great Plains Toad *Anaxyrus cognatus*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Northern Leopard frog *Lithobates pipiens*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI

Western Toad *Anaxyrus boreas*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Birds							
American Bittern *Botaurus lentiginosus* (MBTA) and (BCC) Regions 11 & 17	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Bairds Sparrow *Centronyx bairdii* (MBTA) and (BCC) Regions 11 & 17	Sensitive	Yes	No	No	No	N/A	N/A
Bald Eagle *Haliaeetus leucocephalus* (BGEPA), (MBTA) and (BCC) Regions 10, 11 & 17	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Black Tern *Chilodonias niger* (MBTA) and (BCC) Region 11	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Black-backed Woodpecker *Picoides arcticus* (MBTA)	Sensitive	Yes	No	No	No	N/A	N/A
Black Billed cuckoo *Coccyzus erythropthalmus* (MBTA) (BCC) BCR Regions 11 & 17	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Brewer’s Sparrow *Spizella breweri* (MBTA) and (BCC) Regions 10 & 17	Sensitive	Yes	No	No	No	N/A	N/A
Burrowing Owl *Athene cunicularia* (MBTA) and (BCC) Region 17	Sensitive	Yes	No	No	No	N/A	N/A
Caspian Tern *Hydroprogne caspia* (MBTA)	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Chestnut –collared Longspur *Calcarius ornatus* (MBTA) and (BCC) Regions 11 & 17	Sensitive	Yes	No	No	No	N/A	N/A
Common Tern *Sterna hirundo* (MBTA)	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI

Ferruginous Hawk *Buteo regalis* (MBTA) and (BCC) Regions 10 & 17	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Flammulated Owl *Psioscops flammeolus* (MBTA) and (BCC) Region 10	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Forster’s Tern *Sterna forsteri* (MBTA)	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Franklin’s Gull *Leucophocus pipixcan* (MBTA)	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Golden Eagle *Aquila chrysaetos* (BGEPA), (MBTA) and (BCC) Region 17	Senstive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Grasshopper sparrow *Ammodramus savannarum* (MBTA) and BCC, Regions 11 and 17	Sensitive	Yes	No	No	No	N/A	N/A
Great Gray Owl *Strix nebulosa*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Greater Sage-Grouse *Centrocercus urophasianus*	Sensitive	Yes	No	Yes	No	MIIH	MIIH/BI
Horned Grebe *Podiceps 54uratus* (MBTA) and (BCC) Regions 11 & 17	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Least Tern *Sternula antillarum* (MBTA)	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Lewis's Woodpecker *Melanerpes lewis* (MBTA) and (BCC) Region 10	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Loggerhead Shrike *Lanius ludovicianus* (MBTA) and (BCC) Regions 10 & 17	Sensitive	Yes	No	No	No	N/A	N/A
Long-billed Curlew *Numenius americanus* (MBTA) and (BCC) Regions 10, 11 & 17	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
McCown's Longspur	Sensitive	Yes	No	No	No	N/A	N/A

Rhychophanes mccownii (MBTA) and (BCC) Regions 10, 11 & 17							
Mountain Plover *Charadrius montanus* (MBTA) and (BCC) Regions 11 & 17	Sensitive	Yes	No	No	No	N/A	N/A
Peregrine Falcon *Falco peregrinus* (MBTA) and (BCC) Regions 10, 11 & 17	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Red-headed Woodpecker *Melanerpes erythrocephalus* (MBTA) and (BCC) Regions 11 & 17	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Sagebrush Sparrow *Artemisiospiza nevadensis* (MBTA) and (BCC) Regions 10 & 17	Sensitive	Yes	No	No	No	N/A	N/A
Sage Thrasher *Oreoscoptes montanus* (MBTA) and (BCC) Regions 10 & 17	Sensitive	Yes	No	No	No	N/A	N/A
Sprague's Pipit *Anthus spraugueii* (MBTA) and (BCC) Regions 11 & 17	Sensitive	Yes	No	No	No	N/A	N/A
Trumpeter Swan *Cygus buccinator* (MBTA)	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Veery *Catharus fuscescens* (MBTA)	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
White-faced Ibis *Plegadis chihi* (MBTA)	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI

Yellow Rail *Coturnicops noveboracensis* (MBTA) and (BCC) Regions 11 & 17	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Fish							
Arctic Grayling *Thymallus arcticus montanus*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Iowa Darter *Etheostoma exile*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Northern Redbelly X Finescale Dace *Chrosomus eos x Chrosomus neogaeus*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Paddlefish *Polyodon spathula*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Northern Pearl Dace *Margariscus nachtriebi*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Sauger *Sander canadensis*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Sturgeon Chub *Macrhybopsis gelida*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Invertebrates							
A Mayfly *Raptoheptagenia cruentata*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI

Monarch Butterfly *Danaus plexippus*	Sensitive/ESA Candidate	Yes	Yes	Yes	No	MIIH	MIIH/BI
Western Bumble Bee *Bombus occidentalis*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Western Pearlshell *Margaritifera falcata*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Regal Fritillary *Speyeria idalia*	Sensitive	Yes	No	Yes	No	MIIH	MIIH/BI
Mammals							
Black-tailed Prairie Dog *Cynomys ludovicianus*	Sensitive	Yes	No	No	No	N/A	N/A
Eastern Red Bat *Lasiurus borealis*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Fisher *Pekania pennanti*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Fringed Myotis *Myotis thysanodes*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Gray Wolf *Canis lupus*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Pallid Bat *Antrozous pallidus*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Pygmy Rabbit *Brachylagus idahoensis*	Sensitive	Yes	No	No	No	N/A	N/A
Spotted Bat *Euderma maculatum*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Swift Fox *Vulpes velox*	Sensitive	Yes	No	No	No	N/A	N/A
Townsend's Big-eared Bat *Corynorhinus townsendii*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI

White-tailed Prairie Dog *Cynomys leucurus*	Sensitive	Yes	No	No	No	N/A	N/A
Wolverine *Gulo gulo*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Reptiles							
Greater Short-horned Lizard *Phrynosoma hernandesi*	Sensitive	Yes	No	No	No	N/A	N/A
Western Milk Snake *Lampropeltis gentilis*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Smooth Green Snake *Opheodrys vernalis*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Snapping Turtle *Chelydra serpentina*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Spiny Softshell *Apalone spinifera*	Sensitive	Yes	Yes	Yes	No	MIIH	MIIH/BI
Plains Hog-nosed Snake *Heterodon nasicus*	Sensitive	Yes	No	No	No	N/A	N/A

Step 6. Are there any specific recommendations to avoid significant effects (if any)? These are measures needed to avoid determinations of: LAA, LJ, WIFV. (*See below for pre-analysis assumptions and avoidance and minimization measures for the proposed action).*

Pre- Analysis Assumptions of the Proposed Action:

The assumptions provide a fundamental premise and are explicit to draw an initial conclusion and understanding prior to the analysis of consequences and subsequent determinations for BLM SSS as compared to the no action alternative.

1) Under this programmatic, site-specific locations and riverscape restoration methods applied are not known until assessment of potential restoration sites are performed.
2) Restoration methods are designed to be simple, cost effective, low risk and highly beneficial to all natural resources including BLM SSS associated with riverscape systems. Methods employed are not designed to force the reconstruction of a stream, they allow streams to repair themselves over time. See Chapter 3 for further detail regarding the environmental effects of the proposed action.
3) Restoration projects are expected to assist the BLM in meeting or exceeding the associated goals and objectives in our resource management plans (RMPs), the MT/DK's Standards and Guidelines for Rangeland Health, as well as the following Fundamentals (notably fundamental d.) 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, 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.

4) Adaptive management strategies implemented where necessary (Appendix H) will help to ensure project goals and objectives are achieved for BLM SSS.
5) Projects implemented w/I the scope if this programmatic may have short term minor effects on BLM SSS but they are expected to be insignificant and in most cases unlikely to occur.
6) Short, and long-term benefits for all species associated with low-gradient riverscape systems are expected.
7) The restoration methods and associated project design features (PDFs), best management practices (BMPs) discussed in the proposed action, and strategic framework and guiding principles will help promote and sustain processes that historically maintained the attributes and resource values of riverscapes, including those of BLM SSS. Additionally, avoidance and minimization measures common to all species below have been designed and incorporated into the proposed action to avoid or minimize potential impacts from the proposed action that may impact the biological requirements of listed species to such an extent these impacts are expected to be insignificant and, in most cases, unlikely to occur within the scope of this analysis. In the long-term, implementation of low-tech riverscape methods and subsequent restorative function is expected to benefit and support conservation of BLM SSS.

BLM SSS Avoidance and Minimization Measures

- A BLM biologist shall be consulted with and perform a site assessment to ensure avoidance and minimization measures are considered at the onset of each project assessment, incorporated into all phases of project design, and any constraints, are resolved early, prior to implementation.
- Protective fences will not be placed in areas that may inhibit use or cause a barrier to BLM SSS, if discernible.
- Any short-term storage or stockpile areas will be done in a way that limits any disturbance to species and or habitat
- Wherever possible incorporate measures that favor bird habitat such as, but not limited to, leaving dead vertical tree clusters and vertical complexities, especially in areas where riverscape restoration will have an effect over a larger area.
- In suitable breeding habitat for BLM special status birds, adjust project timing where practical to avoid disruption within riparian areas of suitable habitat between June 1 through July 31, annually.
- The need and use of heavier equipment is unknown but will be allowed on a case-by-case basis such as the equipment shall not result in effects beyond the scope of this programmatic
- Projects staff shall follow Montana Fish, Wildlife and Parks guidelines for disinfecting equipment, prior entering streams.
- Only native seed/vegetation will be used for restoration
- Erosion Control: If straw or hay is used for erosion control purposes, it would be certified to be weed free.
- Terrestrial and aquatic connectivity will not be impeded in any way.
- If hollow pipes, such as those used for signs, fences, and gates, are used, they will be capped to prevent trapping of small wildlife.

- Protective fencing or enclosures shall be constructed to wildlife friendly standards as outlined in "*A Landowner's Guide to Wildlife Friendly Fences"* (Montana Fish, Wildlife and Parks, 2012; Appendix B).
- Field Offices will be required to follow all reporting requirements

Step 7. Documentation: This short form is intended to follow a seven-step process to provide basic biological evaluations. Judgments must not be arbitrary but should be reasoned. This form provides a "road map" of that reasoning and assumes the judgments are drawn from numerous sources. Any species-specific impacts should be discussed in the NEPA document or below under the Narrative of Potential Impacts. **Discussed in NEPA document, DOI-BLM-MT-0000-2020-0006-EA, and Biological Assessment for ESA Section 7 (a)(2) Compliance.**

The signature below certifies that:

1. The wildlife biologist has reviewed the proposed action and its alternatives but may or may not have provided input to alternative design, depending on the issues.

2. The wildlife biologist understands the specific conditions found in the affected area. Column 1a lists all possible Special Status Species in the Montana / Dakotas Field Offices. Column 1b identifies the species' current management status. Column 1c indicates whether the species occurs on this portion of the Field Office, Yes (Y) or o (N), or if there are no records (N/A). Step 2 is satisfied by field visits or knowledge of local conditions from previous visits resulting in enough information to determine if the area is potential habitat for species listed in Step 1. Extensive surveys are not necessary if the conservative approach is taken that: "suitable habitat" means the potential for occupancy.

3. The wildlife biologist has an understanding of the species habitat needs and other attributes important to the determination. This can be a combination of literature review, professional experience, and consultation with others.

4. The wildlife biologist has assimilated the above information in making the "determinations" (i.e. final judgments about the scientific significance of the effects).

DEFINITIONS OF ABBREVIATIONS FOR THE SHORT FORM

N/A – "Not Applicable." Indicates this species does not occur in the project area or that the project would have no bearing on its potential habitat. These species were removed from detailed analysis after field review of existing and potential habitats and consideration of distribution records.

FEDERALLY LISTED SPECIES

NE - No Effect
***LAA** - May Affect - Likely to Adversely Affect (formal consultation required)
NLAA - May Affect, Not Likely to Adversely Affect (informal consultation - concurrence with determination - required)
BE - Beneficial Effect (informal consultation - concurrence with determination - required)

SPECIES PROPOSED FOR LISTING

NE - No Effect
NLJ - Not likely to Jeopardize the continued existence of the species or result in the destruction or adverse modification of proposed critical habitat
***LJ** - Likely to Jeopardize the continued existence of the species or result in the destruction or adverse modification of proposed critical habitat

SENSITIVE SPECIES

NI - No Impact
MIIH - May Impact Individuals or Habitat but will not likely contribute to a trend towards federal listing or cause a loss of viability to the population or species.
***WIFV** - Will Impact Individuals or habitat with a consequence that the action may contribute to the need for federal listing or cause a loss of viability to the population or species.
BI - Beneficial Impact

* Triggers formal consultation process

Additional Information: Provided through hyperlinks of scientific names above.

1) (GYE) = Greater Yellowstone Ecosystem and (NCDE) = Northern Continental Divide Ecosystem.

2) (MBTA) = Denotes species also protected under the Migratory Bird Treaty Act https://www.fws.gov/birds/policies-and-regulations/laws-legislations/migratory-bird-treaty-act.php
3) (BGEPA) = Denotes species also protected under the Bald and Golden Eagle Protection Act

4) (BCC) = Birds of Conservation Concern. Identifies species of migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act (ESA) of 1973