Conservation Value of Subwatersheds for Native Fishes in Montana and Northern Wyoming

Daniel C. Dauwalter, Louis W. Jochems,
Emma R. Lundberg, Matthew W. Mayfield

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Trout Unlimited report to BLM

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Report by Trout Unlimited to the U.S. Bureau of Land Management (Agreement #L22AC00490)

Daniel C. Dauwalter, Louis W. Jochems, Emma R. Lundberg, Matthew W. Mayfield

Trout Unlimited, Science Program, 910 Main Street, Suite 342, Boise, Idaho 83702

Decision Support Web Application: [LINK]

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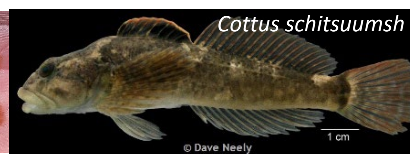

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Executive Summary

Limited resources for conservation require that conservation be strategic. One such strategy uses spatial conservation prioritization, which focuses on identifying networks of conservation areas that efficiently maximize the representation of species or other biodiversity features of interest by leveraging the concept of complementarity. That is, the conservation areas complement each other to achieve efficient representation of species or biodiversity features. The algorithms and software underlying spatial prioritization can now account for the dendritic and connected nature of freshwater systems. As such, spatial prioritization approaches have been applied to native fishes, in part to identify high value watersheds that, if considered together as a set, maximize the representation of species or within-species diversity (e.g., genetic or life history diversity) across a landscape, region, or river basin.

The U.S. Bureau of Land Management (BLM) manages 245 million acres of land across the United States based on the Federal Land Policy and Management Act (FLPMA) of 1976. The Act emphasizes multiple use and sustained yield, which requires balancing the conservation of fish and wildlife resources with development of natural resources important to the Nation's vitality. Assessment of natural resources is needed, then, to inform BLM's land use planning efforts to effectively meet the multiple use mandate. An assessment of the conservation value of watersheds for native fishes can aid land management planning processes toward fulfilling this mandate.

For this project, a spatial conservation assessment approach was used to determine the relative conservation value of subwatersheds for native fishes throughout Montana and northern Wyoming. The assessment used Core-Area Zonation across 5,724 subwatersheds (Hydrologic Unit Code 12) and data for 51 native fish species or subspecies, including life history diversity and abundance of native trout. The assessment accounted for the upstream and downstream connectivity of subwatersheds, including when it was interrupted by large dams, because the conservation value of a subwatershed depends, in part, on the value of connected streams and rivers in subwatersheds upstream and downstream.

The assessment highlighted individual subwatersheds and aggregations of subwatersheds with high conservation value for regional native fish diversity. Tributaries to the Clark Fork River had high value because the Cedar Sculpin occurs only in those tributaries, reflecting the species' rare distribution. Likewise, the Columbia River Basin in northwest Montana had subwatersheds with high value because its native species pool is unique from the Missouri River Basin. The Missouri River mainstem and some direct tributaries have high value because large river species of conservation concern primarily reside in the mainstem: Pallid Sturgeon, Shovelnose Sturgeon, Paddlefish, and others. All subwatersheds in the Big Hole watershed have high value because Arctic Grayling and other species occur there, and the Grayling has strong connectivity needs. Likewise, the South Fork Flathead River has high value because of its species composition and presence of adfluvial Bull Trout that also has strong connectivity needs.

The subwatershed conservation values can be used to inform land protection and restoration of riverscape health to conserve the regional diversity of native fishes across Montana and northern Wyoming. The results are served in a web application to facilitate their use in land management planning processes. Native fishes are one component of biodiversity that is in decline, and the assessment herein provides science and data to help inform land management to protect and restore native fish diversity and aquatic habitats across the region.

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Introduction

Finite resources require conservation to be strategic and efficient, and part of being strategic is deciding where to invest in conservation. Conservation of biodiversity as a field has yielded a suite of data-driven analytical tools to identify sets of areas (e.g., a network of protected areas or priority watersheds) that most efficiently represent biodiversity features, such as species, and these tools often underlie what is referred to as spatial conservation prioritization (Moilanen et al. 2009). Some prioritization algorithms, and the software that implement them, maximize the representation, redundancy, and resiliency (3 Rs; Shaffer and Stein 2000) of species among a set of conservation areas most efficiently (Ferrier and Wintle 2009; Moilanen et al. 2009). For this reason, spatial prioritization has often been used to identify networks of protected areas and wildlife reserves (Moilanen et al. 2009).

More recently, spatial conservation prioritization has been used for other forms of conservation assessment, such as identifying high-value areas of a landscape on which to focus conservation resources. This includes prioritizing landscapes and watersheds based on aquatic biodiversity because the tools can now account for the connectivity of dendritic river systems (Moilanen et al. 2008; Strecker et al. 2011; Dauwalter et al. 2019). These technical resource assessments can be integrated with other conservation planning processes for stakeholder engagement and implementation of conservation actions (Knight et al. 2006; Birdsong et al. 2019; Garrett et al. 2019).

While systematic conservation planning has often focused on the 3 Rs - representation, redundancy, and resiliency - of species to design effective conservation area networks, the 3-R concept has been applied to other aspects of biodiversity. Haak and Williams (2012) applied the 3-Rs to inland Cutthroat Trout *Oncorhynchus clarkii* by focusing on representation and redundancy of life history diversity (resident, fluvial, and adfluvial), geographic diversity (core and peripheral populations; Haak et al. 2010), and genetic purity within habitats large enough for long-term population persistence and, thus, resilience. They argued that managing for a portfolio of these three elements of within-species diversity will give Cutthroat Trout subspecies the best chance of persisting in an uncertain future. This framework has been integrated into multi-agency conservation agreements to plan and prioritize conservation efforts for native trout (UDNR 2019).

The U.S. Bureau of Land Management (BLM) manages 245 million acres of land across the United States. The management of these lands, particularly in western states, is based on the Federal Land Policy and Management Act (FLPMA) of 1976. The FLPMA stipulates that public lands be managed based on multiple use and sustained yield, which includes protecting the quality of ecological, environmental, and other resources, including water, in their natural condition. The Act also speaks to providing habitat for fish and wildlife, opportunities for human uses like outdoor recreation, and the Nation's need for domestic supply of natural resources (e.g., minerals, food, timber). As such, public lands are periodically and systematically inventoried, and their use is projected through a land use planning process in coordination with other state and federal planning processes. Thus, the conservation of native fishes is needed to fully realize the BLM's multiple use and sustained yield mandate. This includes balancing development of natural resources important to the Nation's vitality with conserving native fishes and their habitats so they persist for the public in perpetuity. An assessment of natural resources is needed to inform BLM's land use planning efforts. One such assessment estimates the conservation value of watersheds for native fishes, which provides important information, then, to inform land management planning processes.

Project Goals

The two goals of this region-based spatial conservation assessment for native fishes were to:

- **Goal #1**: Assess the landscape-scale conservation value of subwatersheds based on their representation of native fish diversity in Montana and northern Wyoming basins, while accounting for the life history diversity of native trout. The assessment will highlight important watersheds for native fish conservation and aquatic habitat restoration decision-making on BLM and other lands.
- **Goal #2**: Develop a webmap application that serves as a decision support tool for users to access the assessment information and understand the conservation value of watersheds for native fishes to help identify native fish conservation and habitat restoration opportunities.

Study Domain

Montana and Northern Wyoming

Montana is comprised of two major river basins. The headwaters of the Columbia River Basin head in northwest Montana, and the headwaters of the Mississippi River Basin, through its major tributary the Missouri River, head in southwest Montana. Many of the major tributaries of the Missouri River head in northern Wyoming: the Yellowstone River, Wind River, Bighorn River, Tongue River, and Powder River. These river systems represent the diverse physiography of Montana and northern Wyoming that, along with hydrography, influences native fish distributions and assemblages. The region is characterized by mountains, plains, and intermontane river basins. Elevations range from 3,100 feet near the South Dakota Border to 13,804 feet at Gannett Peak in the Wind River Mountains in Wyoming (Baxter and Stone 1995). As such, the hydrology of regional streams and rivers is influenced by snowmelt. Many natural lakes are small montane lakes, and Yellowstone Lake (90,000 acres) is the largest natural lake. Additionally, many reservoirs have been constructed for water storage and flood control, which influence the hydrology and fragmentation of rivers and streams.

Methods

General Approach

The native fish conservation value of subwatersheds (12-digit Hydrologic Unit Code) in Montana and northern Wyoming was assessed using Core Area Zonation (Di Minin et al. 2014). Core Area Zonation results in a conservation value (aka, rank) for each watershed in the analysis landscape that ranges from 0 (no value) to 1 (highest value in landscape). The conservation value is based on the Core Area Zonation algorithm. Core Area Zonation is a hierarchical analysis that integrates species data and the upstream and downstream connectivity of planning units (subwatersheds in this study) to maximize the representation of native fish species, subspecies, life history diversity, and their weighting in the analysis. The analysis was implemented using the core-area function in Zonation 4.0 conservation planning software (Moilanen et al. 2008; Moilanen et al. 2014).

Core Area Zonation

Core Area Zonation is an algorithm that ranks planning units (subwatershed) from 0 to 1 based on their conservation value. To do so, it iteratively removes the planning unit that results in the smallest aggregate loss in value across all species inputs while accounting for the species weights and species-specific connectivity needs (Moilanen et al. 2008). This removal process continues until one planning unit remains in the analysis domain. This unit is considered the most important one based on the collective species inputs. The iterative removal process through Core Area Zonation results in the hierarchical ranking of planning units that are then scaled from 0 to 1.

More specifically, the ranking is hierarchical and based on the minimum marginal loss across species specific input values (see below):

$$\delta_i = max_j \frac{q_{ij} w_j}{c_i}$$

where δ_i= the marginal loss across all *j* species for watershed planning unit *i*; c_i= is the cost associated with the planning unit *i*, set at 1 for all planning units (i.e., it has no influence in the analysis for this study); w_j=the weight for species *j*, which in this case was based on State Heritage Rank using the NatureServe framework (natureserve.org) as reported by Montana Field Guide (fieldguide.mt.gov/; Table 1); and q_{ij}= the proportion of the remaining distribution of species *j* located in planning unit *i* for a given set of planning units (subwatersheds in this assessment). The species inputs were scaled from 0 to 1 as described below for each data source. The equation selects the planning unit (subwatershed) with the highest species input values across all species while also retaining biodiversity-poor subwatersheds that have high occurrence values for rare (and highly weighted) species (Di Minin et al. 2014). The planning unit removal process was repeated iteratively until only one subwatershed remained on the landscape during the last iteration. This last subwatershed was the most important across all watersheds in representing native fish diversity across the regional analysis domain and received the highest rank.

"Subwatersheds with high conservation value have many native species that are abundant OR are species poor but have rare and highly weighted species or have populations with unique life histories"

Table 1. Species weights used for State Heritage ranks. After Labay et al. (2019).

Heritage Rank	Status	Species Weight
SX	Presumed extirpated	0
SH	Possibly extirpated	0
S1	Critically imperiled	6
S2	Imperiled	5
S3	Vulnerable	4
S4	Apparently secure	3
S5	Secure	2
SNR	Species not recorded (but present)	1
SNA	Not applicable	--

Planning Units

Core Area Zonation is a grid cell-based removal algorithm, but it allows the use of planning units so that all cells within a planning unit are removed together. This assessment used the 12-digit hydrologic unit code subwatersheds (HUC12) as planning units. All grid cells within a planning unit were removed simultaneously during the iterative removal algorithm based on the total marginal loss associated with all cells in each planning unit. All input grids had a cell size of 300m.

Fish Species Data

The 3 Rs for Native Trout

The 3 Rs of representation, redundancy, and resiliency have provided a foundation for efficient conservation planning. They have also provided a framework for understanding the status of a species (Smith et al. 2018). Haak and Williams (2012) applied the 3 R framework into a conservation portfolio for western native trout management. They purported that maximizing the representation and redundancy of the ecological elements of life history diversity, geographic diversity, and genetic purity across populations, and managing for a high likelihood of population persistence conferring resilience (high abundance and occupancy of large habitat patches), would provide the best hedge for Cutthroat Trout in an uncertain future.

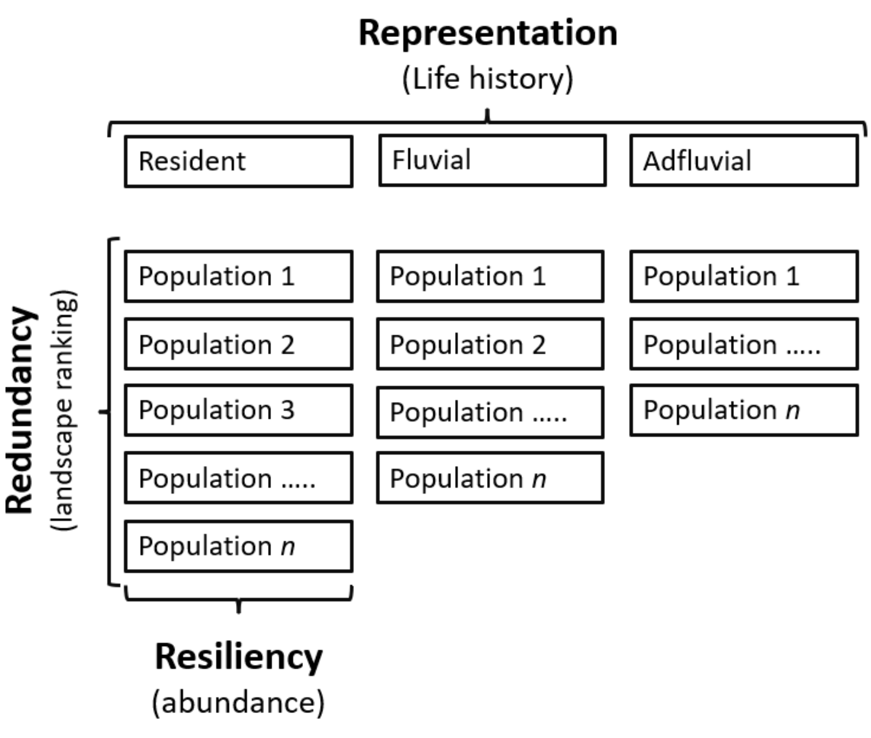

Figure 1. The 3 Rs – representation, redundancy, and resiliency - showing conceptually how life histories are represented for a native trout species across populations, how they are redundant by being represented by multiple populations. Resiliency is conferred by abundance within a stream or lake population.

The representation of life history diversity among different populations of native trout species, and a measure of abundance as a surrogate for resiliency, were integrated into a native fish conservation assessment for Montana and northern Wyoming (Figure 1). Information on native trout populations was obtained from Montana Fish, Wildlife & Parks (MTFWP) or rangewide databases developed for the species (e.g., Gresswell 2011; Muhlfeld et al. 2015). For the latter, populations were delineated using field data and professional judgment on 1:24,000 National Hydrography Dataset (NHD) flowline and waterbody feature classes. Each database contained population information on life history (resident, fluvial, adfluvial). Because the assessment analysis was built on representation and redundancy concepts, the unique life histories of populations were considered as separate biodiversity features (i.e., species) in the analysis (see Table 2).

Table 2. Family, common name, scientific name, Heritage Ranks (Global, State), data source and weight for fish species and subspecies included in the Montana and northern Wyoming multispecies aquatic assessment. All species were represented by stream and river data, except where noted by footnote: [a]lake data in addition to stream data. [b]lake data only.

Family / Common name	Scientific name	Heritage Rank	Species Weight	Connectivity Curve (up, down)
Acipenseridae				
Paddlefish[a]	*Polydon spathula*	G3, S1	5.00	5, 5
Pallid Sturgeon	*Scaphirhynchus albus*	G2, S1	6.00	5 ,5
Shovelnose Sturgeon[a]	*Scaphirhynchus platorynchus*	G4, S4	3.00	5, 5
White Sturgeon	*Acipenser transmontanus*	G3, S1	6.00	4, 4
Lepisostidae				
Shortnose Gar	*Lepisosteus platostomus*	G5, S3	4.00	2, 2
Catostomidae				
Bigmouth Buffalo[a]	*Ictiobus cyprinellus*	G5, S4	3.00	3, 3
Smallmouth Buffalo[b]	*Ictiobus bubalus*	G5, S5	2.00	3, 3
Blue Sucker	*Cycleptus elongatus*	G3G4, S2S3	4.50	5, 5
Ictaluridae				
Channel Catfish	*Ictalurus punctatus*	G5, S5	2.00	1, 1
Stonecat	*Noturus flavus*	G5, S4	3.00	1, 1
Salmonidae				
Redband Trout[a]	*Oncorhynchus mykiss gairdneri*	G5T4, S1		
	resident		6.00	3, 3
	fluvial		6.00	5, 3
	adfluvial		6.00	5, 4
Westslope Cutthroat Trout[a]	*Oncorhynchus clarkii lewisi*	G4, S2	5.00	3, 3
	resident		5.00	5, 3
	fluvial		5.00	5, 4
	adfluvial			
Yellowstone Cutthroat Trout[a]	*Oncorhynchus clarkii bouvieri*	NR, S2	5.00	
	resident		5.00	3, 3
	fluvial		5.00	5, 3
	adfluvial			5, 4
Bull Trout[a]	*Salvelinus confluentus*	G5, S2	5.00	4, 3
Arctic Grayling[a]	*Thymallus arcticus*	G5, S1	5.00	5, 5
Mountain Whitefish	*Prosopium williamsoni*	G5, S5	2.00	4, 2
Pygmy Whitefish	*Prosopium coulterii*	G4, S3	4.00	3, 3
Gadidae				
Burbot[b]	*Lota lota*	G4, S4	3.00	3, 3
Cottidae				
Cedar Sculpin	*Cottus schitsuumsh*	G3G4, SU	4.00	1, 1
Mottled Sculpin	*Cottus bairdii*	G5	0.00	1, 1
Rocky Mountain Sculpin	*Cottus bondi*	GNR, SU	4.00	1, 1
Slimy Sculpin	*Cottus cognatus*	G5, S5	2.00	1, 1
Torrent Sculpin	*Cottus rhotheus*	G5, S3	4.00	1, 1
Atherinidae				
Brook Stickleback	*Culaea inconstans*	G5, S4	3.00	1, 1
Hiodontidae				

Goldeye[a]	*Hiodon alosoides*	G5, S5	2.00	3, 3
Leuciscidae				
Redside Shiner	*Richardsonius balteatus*	G5, S5	2.00	1, 1
Emerald Shiner	*Notropis atherinoides*	G5, S5	2.00	1, 1
Sand Shiner	*Miniellus stramineus*	G5, S4	3.00	1, 1
Fathead Minnow	*Pimephales promelas*	G5, S4S5	2.50	1, 1
Creek Chub	*Semotilus atromaculatus*	G5, S4	3.00	1, 1
Lake Chub[b]	*Couesius plumbeus*	G5, S5	2.00	1, 1
Pearl Dace	*Margariscus nachtriebi*	G5, S2	5.00	1, 1
Northern Redbelly Dace	*Chrosomus eos*	G5, S3	4.00	1, 1
Longnose Dace	*Rhinichthys cataractae*	G5, S5	2.00	1, 1
Plains Minnow	*Hybognathus placitus*	G4, S4	3.00	1, 1
Brassy Minnow	*Hybognathus hankinsoni*	G5, S4	3.00	1, 1
Flathead Chub	*Platygobio gracilis*	G5, S5	2.00	1, 1
Sicklefin Chub	*Macrhybopsis meeki*	G3, S1	6.00	1, 1
Sturgeon Chub	*Macrhybopsis gelida*	G3, S2S3	4.50	1, 1
Peamouth	*Mylocheilus caurinus*	G5, S5	2.00	1, 1
Northern Pikeminnow[a]	*Ptychocheilus oregonensis*	G5, S5	2.00	2, 2
Catostomidae				
River Carpsucker	*Carpiodes carpio*	G5, S5	2.00	3, 3
Shorthead Redhorse	*Maxostoma macrolepidotum*	G5, S5	2.00	3, 3
Largescale Sucker	*Catostomus macrocheilus*	G5, S5	2.00	3, 3
Longnose Sucker	*Catostomus catostomus*	G5, S5	2.00	3, 3
White Sucker	*Catostomus commersoni*	G5, S5	2.00	2, 1
Mountain Sucker	*Catostomus platyrhynchus*	GNR, S5	2.00	2, 2
Sciaenidae				
Freshwater Drum[a]	*Aplodinotus grunniens*	G5, S4	3.00	3, 3
Percidae				
Sauger	*Sander canadensis*	G5, S2	5.00	3, 3
Iowa Darter	*Etheostoma exile*	G5, S3	4.00	1, 1

Montana Fish Wildlife and Parks Database

Inputs for most fish species, except as described below, were from Montana Fish Wildlife and Parks streams and lakes data made available to the public (downloaded 3 April 2024). Both datasets were developed from fish distribution data for Montana streams and lakes. The streams dataset was generated using GIS routing on the 1:100,000 NHD using begin and end measures and fish presence information from field surveys stored in the Montana Fisheries Information System (MFISH) SQL database, as well as information entered by fisheries staff into the internal fish distribution application. Both the streams and lakes datasets contain attributes such as genetic status, abundance, origin, and life history for salmonids. The life history field specifies whether the species at that location (stream segment or waterbody) is resident, fluvial, or adfluvial; a resident life history was assumed when the field was null. The three abundance categories were: rare, common, and abundant (Figure 2A), and these were given numeric values of 0.25, 0.5, and 1.0, respectively. If the field was null for a stream segment or species, it was assigned an abundance value of 0.5. These stream segments and waterbodies were converted to 300m grid cells for the cell-based removal algorithm in Zonation software.

Yellowstone Cutthroat Trout Portfolio Dataset

The data source used for Yellowstone Cutthroat Trout was based on a conservation portfolio framework that prioritizes populations on a resiliency scale of 0 (low) to 1 (high) based on a probability model of long-term persistence, climate vulnerability, and non-native species (Al-Chokhachy et al. 2018). Resiliency scores were applied to populations delineated on NHD hydrography (segments and waterbodies)(Figure 2B). As before, these values for each stream segment or lake were converted to 300m grid cells for input into Zonation.

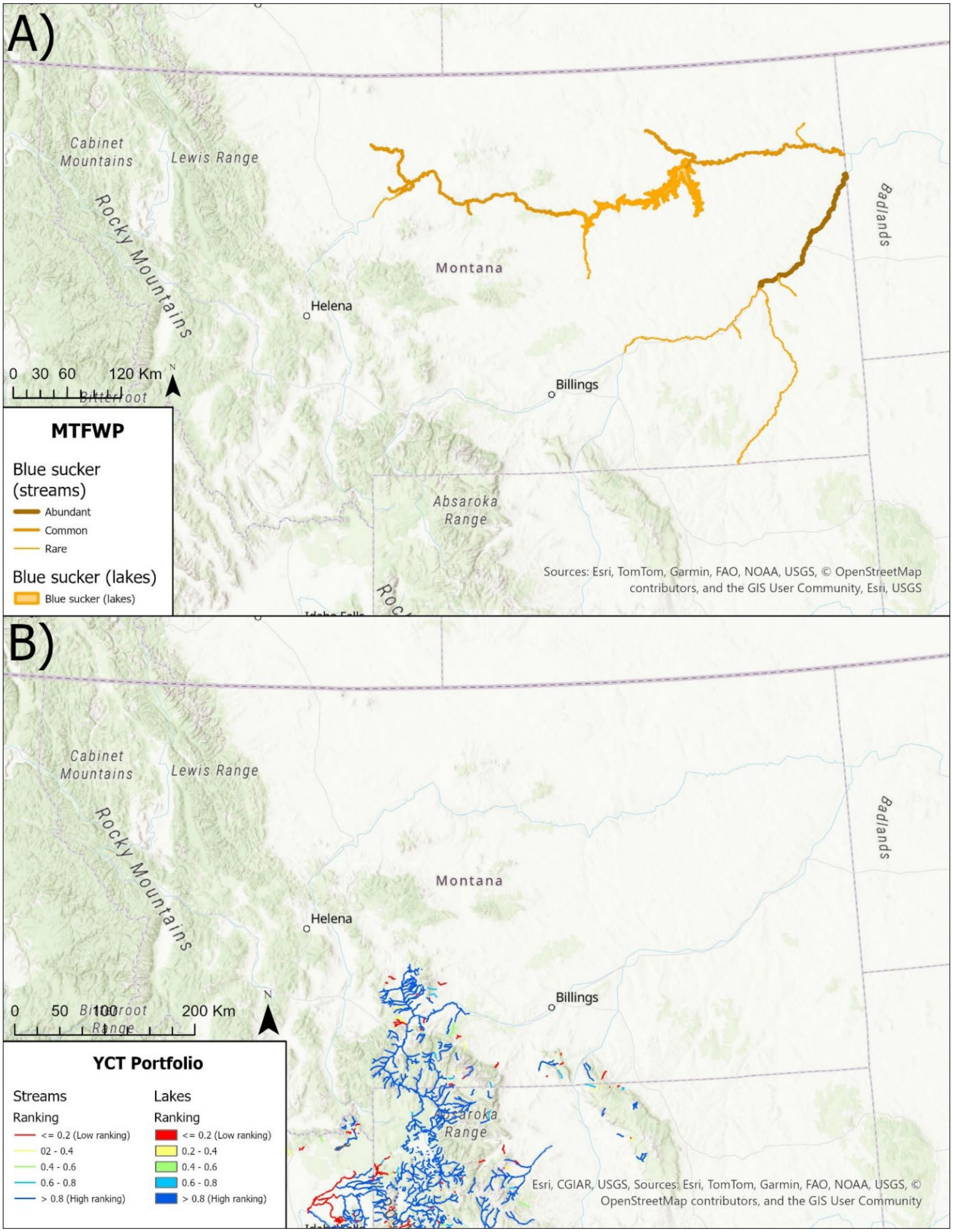

Figure 2. A) Montana Fish Wildlife and Parks streams and lakes datasets for Blue Sucker symbolized by abundance category. B) Yellowstone Cutthroat Trout (YCT) conservation portfolio ranking (Al-Chokhachy et al. 2018).

Redband Trout Rangewide Database

The data source for Redband Trout was the rangewide database developed for the species (Muhlfeld et al. 2015). This data source was used because it includes life history information for each population, similar to the MTFWP data, but it includes categories of linear density of Redband Trout for each stream population, as well as an areal density for lake populations on 1:24,000 NHD. These categories are: 0 to 35 fish/km, 36 to 100, 101 – 250, 251 – 625, and > 1250 fish/km that were converted to values at the midpoints of these ranges as 18, 68, 176, 438, 938, and 1500fish/km, respectively; nulls were converted to 250fish/km). Likewise, the densities for lakes categories: 0 to 500, 500 to 1500, 1500 to 2500, >2500 fish were converted to the midpoint values of 250, 1000, 2000, and 3000 fish, respectively; nulls were converted to 500. Again, these values for each stream segment or lake were converted to 300m grid cells for input into Zonation.

Aquatic Connectivity

Directed connectivity was used in Core Area Zonation to account for the dendritic nature of stream and river systems (Moilanen et al. 2008). Connectivity was accounted for in the analysis through a proportional loss function. The assessed value of a planning unit (δ_i; subwatershed) was penalized based on the proportion of subwatersheds upstream or downstream of the focal subwatershed that had already been removed during the removal process because of their lower value. The Watershed Boundary Dataset specifies which subwatersheds are upstream and downstream of focal subwatersheds. Different loss curves were used for different species depending on their connectivity needs (Table 2). For example, connectivity was unimportant for small-bodied fishes like the Sturgeon Chub and Cedar Sculpin (Curve 1 in Figure 3) but very important to adfluvial populations of salmonids that migrate between lakes and streams to meet life history requirements (Curve 5 in Figure 3). Penalties for upstream connectivity were sometimes slightly stronger than downstream to account for the fact that many fishes move upstream to spawn (Carlson and Rahel 2010). Downstream connectivity was still recognized as important, but less so, because the scope for growth can be higher in larger downstream habitats (Lundberg et al. 2026). However, connectivity was intentionally interrupted at large dams (>50,000 acre-feet of storage) in the National Inventory of Dams database (USACE 2008); smaller dams or other barriers were not used to break connectivity because they are more capable of being managed for fish passage (Williams et al. 2019).

Integration with Prior Assessments

A similar assessment of the conservation value of watersheds for native fishes had already been completed for northeast Wyoming that overlaps with the analysis domain for the assessment presented herein in the Cheyenne-Belle Fourche and Powder-Tongue superdrainages (Stewart et al. 2018). The outputs of this previous and similar assessment were integrated into the final conservation value outputs because this prior work was based on a comprehensive native fish dataset assembled for the region, whereas the assessment presented herein was data deficient in northeast Wyoming. The conservation value of subwatersheds was simply assigned the conservation value from Stewart et al. (2018) in a post-hoc analysis.

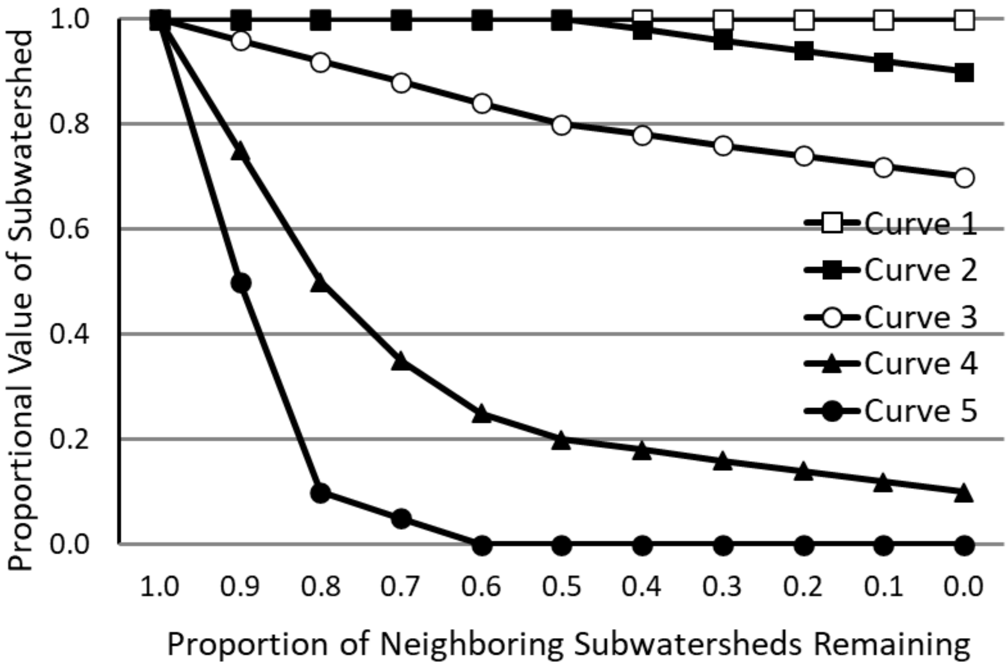

Figure 3. Proportional loss function curves specifying how the species-specific value of a catchment is reduced based on the proportion of neighboring catchments upstream and downstream of the focal catchment have been removed during the iterative removal process. Each species is assigned a connectivity curve to specify the importance of upstream and downstream connectivity.

Results

The conservation ranks for 5,724 subwatersheds in Montana and northern Wyoming based on the distribution and abundance of 51 native fish species – including the life history diversity, genetic purity, and abundance of Yellowstone Cutthroat Trout, Westslope Cutthroat Trout, and Redband Trout - using Core Area Zonation highlighted four main types of high value watersheds (Figure 4). First, subwatersheds with rare, and thus highly weighted, species such as Sicklefin Chub in the lower Yellowstone River and Missouri River in northeast Montana ranked high for that reason but also because of the other species and their abundance in those rivers. Second, the Missouri River mainstem has many species but is also where most of the imperiled and highly weighted big river fishes such as Shovelnose Sturgeon, Pallid Sturgeon, and Paddlefish occur (Figure 4). Third, many waters in the headwaters of the Columbia River in northwest Montana ranked high because it contains a novel species pool from that in the Missouri River Basin, meaning the Columbia Basin fishes only occur there and nowhere else in Montana (Figure 4). The White Sturgeon is an example of such a species. Fourth, the subwatersheds in the Big Hole River watershed all rank high because Arctic Grayling are mostly restricted to that watershed where Mountain Sucker and other species also reside (Figure 5). The Arctic Grayling's high connectivity needs resulted in high rankings for all subwatersheds within the larger watershed of the Big Hole River. Fifth, the Cedar Sculpin is found only in a few tributaries to the Clark Fork River (Cedar and Fish creeks, and the St. Regis River), resulting in high conservation value for a few individual subwatersheds where that species occurs in northwest Montana (Figure 4).

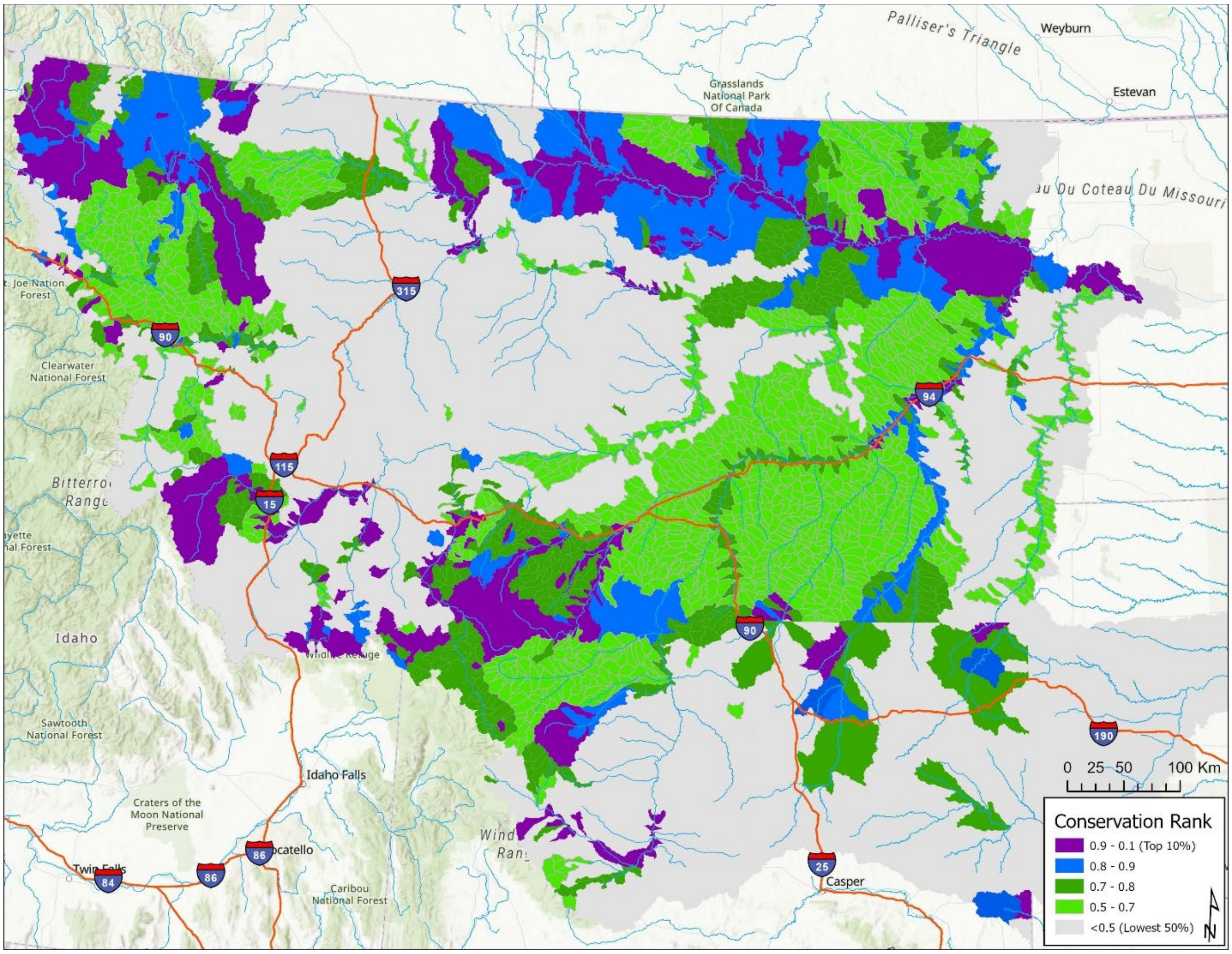

Figure 4. Subwatershed (HUC12) conservation rankings (0 [low] to 1 [high]) for native fishes in Montana and northern Wyoming.

Figure 5. Mountain Sucker. Credit: R. Lee.

Discussion

The subwatersheds with high conservation value (rank) in Montana and northern Wyoming play a disproportionate role in representing regional (beta) native fish diversity due to the distribution and abundance of native fishes, and life histories and genetic purity of native trout populations, that occur in them. The high rankings highlight watersheds with high richness of native fishes, watersheds occupied by rare species with small distributions found nowhere else or native trout populations with unique life histories, and clusters of high value watersheds due to their hydrologic connectivity and species present with high connectivity needs (e.g., migratory life histories).

Subwatershed conservation values for native fishes can support strategic conservation planning and habitat restoration decisions. The FLPMA specifies that public lands be managed for multiple uses, which necessitates balancing the need for clean water, sufficient wildlife habitats, and cultural sites with resource development and use to ensure the Nation's vitality. The native fish conservation assessment developed herein thus provides an inventory (FLPMA Sec. 102 [a-2]) of native fishes and their habitats as one piece of information when land management planning for multiple uses. For example, the purple subwatersheds in Figure 4 represent the top 90% of subwatersheds for representing native fish diversity in the region and can be used to focus watershed-scale initiatives to conserve multiple native fishes (Williams 2019). Montana's State Wildlife Action Plan (SWAP) identifies 13 aquatic focal areas for which to focus conservation that can benefit multiple aquatic species beyond just native fishes (MTFWP 2015). The focal areas overlap with high value subwatersheds identified for native fishes. Native Fish Conservation Areas (NFCAs) were proposed as a watershed-scale concept focused on conservation of entire aquatic communities while allowing for compatible uses (Williams et al. 2011) and has been used in various ways for strategic conservation planning initiatives. The concept has been used to direct state-based conservation funding and action in Texas (Birdsong et al. 2019; Garrett et al. 2019), and it has been used to identify focal areas for conservation of native fishes in the Rio Grande basin, Great Plains, and in the Lahontan and Central Nevada basins by fish habitat partnerships (Labay et al. 2018; Labay et al. 2019; Dauwalter et al. 2023).

The concept of riverscape health draws on several important multidisciplinary principles (Glassic et al. 2025). The concept has been used to guide the restoration of streams and rivers using low-tech process-based restoration (LT-PBR), an approach that has seen widespread application over the last decade (Wheaton et al. 2019). Decisions on where to implement restoration actions, like LT-PBR and beyond, should be guided by the geomorphic setting (Wohl et al. 2024) but aimed at protecting high quality habitats while restoring areas with high conservation potential, including promoting longitudinal, lateral, and vertical connectivity. Geospatial datasets indicative of geomorphic context, channel incision, stream gradient, riverscape health, and the capacity of a stream to support beaver dams for beaver-mimicry restoration approaches (Macfarlane et al. 2017) are being used to determine where habitat restoration is needed and whether low-tech process-based restoration using beaver mimicry may be beneficial at scale. The native fish conservation value of subwatersheds presented herein can be one additional layer to identify if habitat restoration has the potential to aid in the conservation of regional native fish diversity beyond a single-species focus as advocated by Williams (2019)(Figure 6). That is, it can provide one layer of biodiversity information to be used with others to help identify and prioritize riverscape restoration needs, as a complement to professional judgement and local knowledge, to most efficiently conserve regional native fish diversity, as has been done in a decision support tool to inform process-based restoration in eastern Oregon and Washington (LINK).

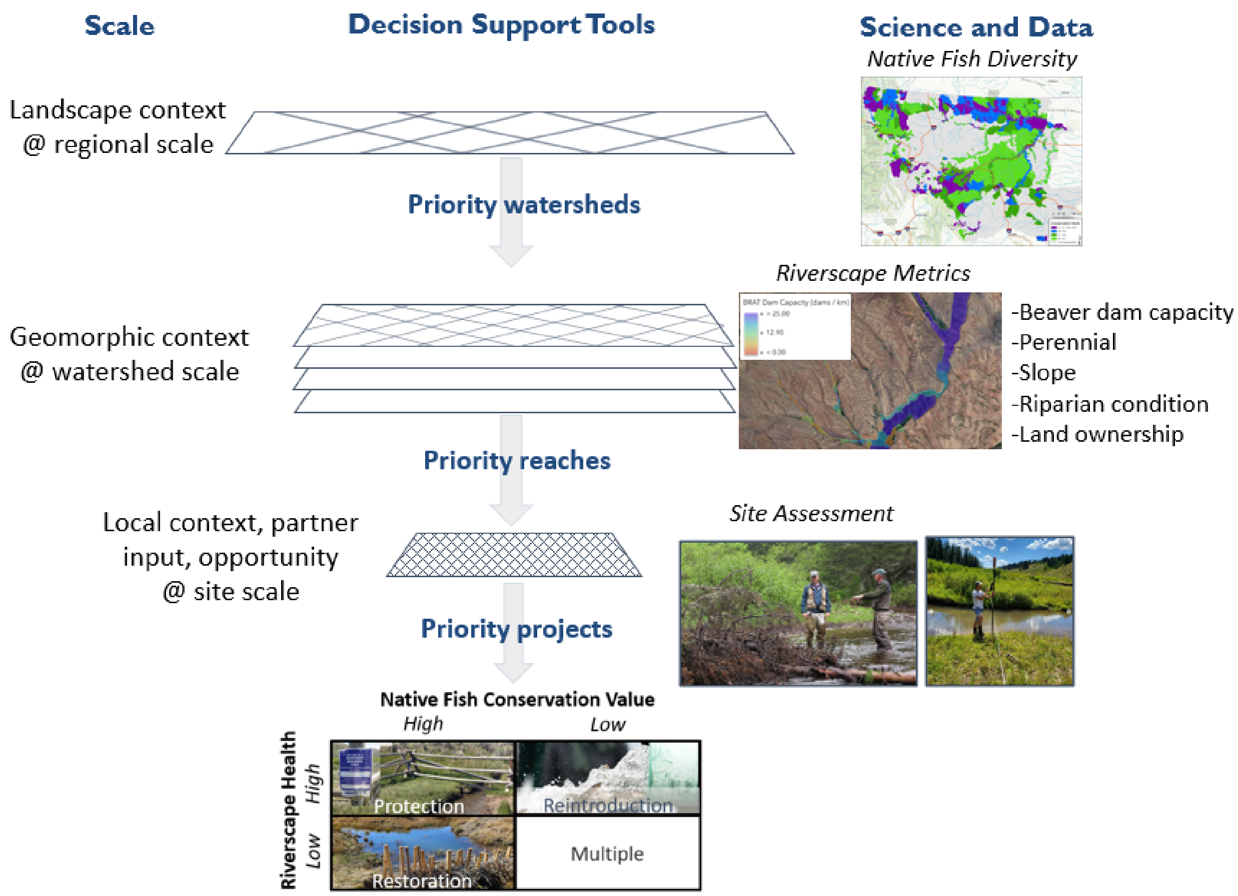

Figure 6. Tools, science, and data to identify native fish conservation and habitat restoration opportunities to conserve native fishes and protect and restore riverscape health.

Decision Support Tool: Web Application (LINK)

The landscape conservation value of subwatersheds for native fishes in Montana and northern Wyoming has been integrated into a web application that can serve as a decision support tool. The web application facilitates the accessibility of conservation value of subwatersheds for use in aquatic habitat restoration and native fish conservation planning (Figure 7). The web application allows users to pan around and zoom in to understand the conservation rankings in specific watersheds or how the conservation value for native fishes varies across the focal landscape. It also allows the user to click on the native fish datasets used to inform the assessment to help understand what is driving the underlying conservation value of a specific subwatershed. The user can also upload a .csv file of potential locations for conservation action to plot them on the web application. The .csv file simply needs to have a Latitude field and a Longitude field in decimal degrees (e.g., Latitude: 41.04262, Longitude: -109.73700).

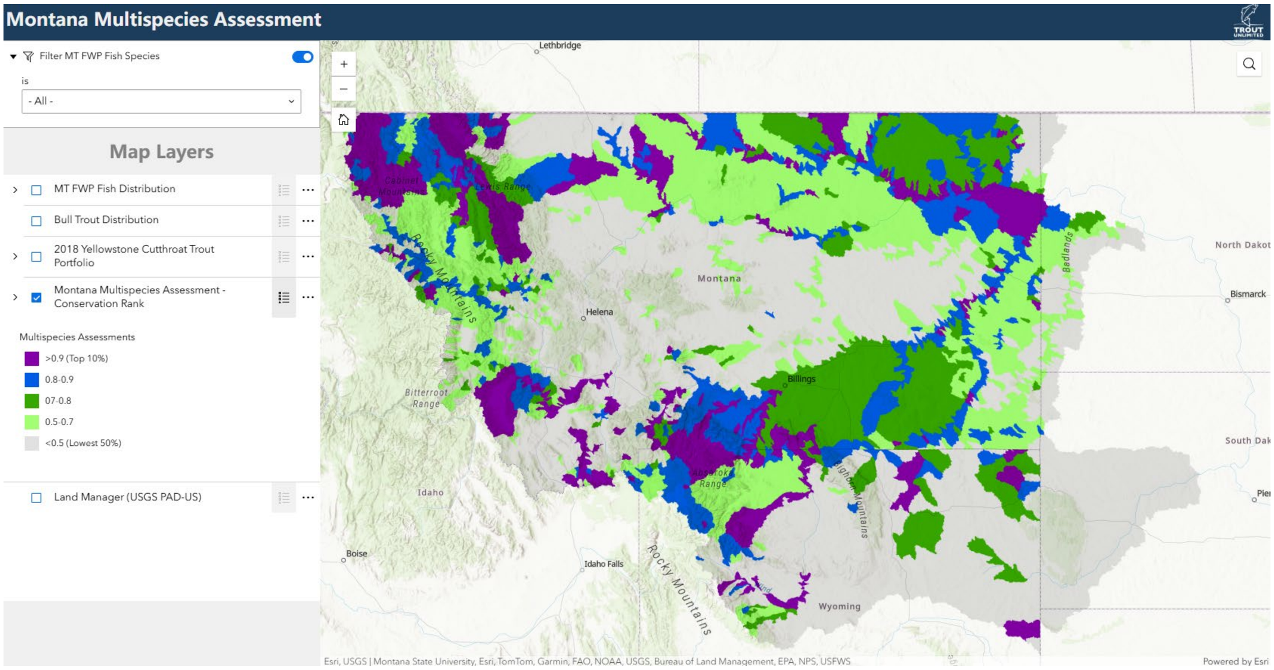

Figure 7. Interactive web application that serves the Montana and northern Wyoming assessment results and underlying data inputs. The user can upload a .csv file with spatial coordinates (latitude and longitude) that will plot over the assessments. Webmap developed by M. Mayfield, Trout Unlimited.

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