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National Protected Rivers Assessment of the United States

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1. Executive Summary

Background: Healthy rivers are nature's life support system. Two-thirds of all species in nature spend part of their lives along rivers. These ribbons of life also provide two-thirds of drinking water to all Americans and the forests and lands along their banks help naturally recharge groundwater sources essential to growing our food. Unfortunately, rivers and all of us who rely on them are at risk. Scientific experts estimate that over one third of animal and plant species are at risk of extinction in the U.S. Alarmingly, freshwater and riverine species are disappearing at twice the rate of that of terrestrial or marine species due to the numerous threats from human activities, including habitat loss, pollution, and climate change. To stem this loss and preserve the benefits rivers provide, scientists, non-governmental organizations, and nations have committed to dramatically scaling up conservation by protecting 30 percent of nature by 2030 and half the planet by 2050. American Rivers has partnered with Conservation Science Partners to develop the Protected Rivers Assessment of the United States, a data-driven nationwide inventory of present-day river protection status for river conservation practitioners and policymakers to understand the current state of river protection and identify opportunities to expand protection in the coming years.

Key findings: The Protected Rivers Assessment reveals that many mechanisms seek to protect America's rivers. Of over the 4.4 million miles of rivers analyzed in the United States, 19.3% of the rivers are classified as displaying a viable degree of protection whereby at least one-quarter of 5 key freshwater ecological attributes are intended for protection [Class 1: Comprehensive protection (0.9%), Class 2: Efficient protection (8.4%) or Class 3: Limited protection (10.0%)], for a total of 846,372 river miles, according to the Protected River Index. Considering only the contiguous U.S., 11.9% are classified as displaying a viable degree of protection [Class 1: Comprehensive protection (1.1%), Class 2: Efficient protection (4.7%) or Class 3: Limited protection (5.9%)], for a total of 383,702 river miles. This assessment captures clear inequalities in the degree of protection through space, with watersheds located in Alaska as well as the northwestern and northeastern states and regions displaying a consistently higher degree of protection than in the central parts of the country. In summary, the Protected Rivers Assessment demonstrates the successes of past protection efforts while concurrently highlighting the need to scale up and introduce new mechanisms for river protection.

Approach: This assessment leverages an array of datasets capturing the different mechanisms conferring protection to rivers, including river conservation (e.g., Wild and Scenic River designations, Outstanding National or Tribal Resource Waters), riparian and floodplain conservation (e.g., Riparian National Conservation Areas, Emergency Watershed Protection – Floodplain Easements, Northwest Forest Plan Riparian Reserves), policies focusing on endangered species (Endangered Species Act Critical Habitat), and terrestrial protected areas that incidentally protect rivers (e.g., National Wilderness Preservation System, National Parks, Areas of Critical Environmental Concern). The Protected River Index of the United States (PRI) is developed by attributing different weights to each protection mechanism according to their potential conservation of five key ecological processes that are essential for the long-term persistence of socio-environmental values (hydrologic regime, connectivity, water quality, habitat, biotic composition).

Total protected river miles in the U.S. according to different mechanisms of intended protection		
Category of protection	Contiguous U.S.	U.S.
River conservation	106,986 (3.3%)	117,819 (2.7%)
Riparian and floodplain conservation	225,923 (6.9%)	231,306 (5.3%)
Endangered species critical habitat	38,788 (1.2%)	38,836 (0.9%)
Terrestrial protected areas (strict)	102,447 (3.1%)	316,193 (7.2%)
Terrestrial protected areas (other)	116,979 (3.6%)	355,319 (8.1%)
Multiple land use (special management)	81,815 (2.5%)	136,300 (3.1%)
Multiple land use (other)	237,771 (7.2%)	271,166 (6.2%)
Unprotected	2,377,971 (72.3%)	2,910,750 (66.5%)
Total river protection intent (all mechanisms)	**910,709 (27.7%)**	**1,466,939 (33.5%)**
Total river length analyzed	**3,288,680**	**4,377,689**

Total protected river miles in the U.S. according to the categories of the Protected River Index		
Mechanism of protection	Contiguous U.S.	U.S.
Comprehensive protection (3.75 > PRI ≥ 5.0)	35,892 (1.1%)	40,124 (0.9%)
Efficient protection (2.5 > PRI ≥ 3.75)	152,967 (4.7%)	369,435 (8.4%)
Limited protection (1.25 > PRI ≥ 2.5)	194,843 (5.9%)	436,813 (10.0%)
Inadequate protection (0 > PRI ≥ 1.25)	527,007 (16.0%)	620,567 (14.2%)
No protection	2,377,971 (72.3%)	2,910,750 (66.5%)
Total river protection (PRI > 0)	**910,709 (27.7%)**	**1,466,939 (33.5%)**
Viable river protection (PRI ≥ 1.25)	**383,702 (11.7%)**	**846,372 (19.3%)**
Total river length analyzed	**3,288,680**	**4,377,689**

2. Introduction

Streams and rivers provide a myriad of intrinsic, ecological, social, economic, and cultural services to human societies (Lynch et al. 2023) but are also among the most threatened ecosystems in the world (Reid et al. 2019). The 2020 Living Planet Report estimated that freshwater vertebrate populations (among which are river-dependent species) declined by an average of 84% in recent decades; a rate more than two times greater than for terrestrial and marine vertebrates (WWF 2020). Poorly planned dams, land use conversion, habitat loss and deteriorating water quality also threaten the multitude of benefits provided by rivers to people, with nearly 80% of the world's population threatened with water insecurity affecting our global food production system and many livelihoods (Vörösmarty et al. 2010).

To efficiently curb the freshwater biodiversity crisis and provide equitable access to healthy rivers for local communities, improved and coordinated conservation actions are needed to mitigate the pressures associated with the many human activities acting directly on rivers. These include water pollution, extraction, or regulation, and impacts on the surrounding landscapes such as floodplain disconnection by levees, urbanization and agricultural development, and ongoing climate change (Reid et al. 2019, Tickner et al. 2020). Ensuring that rivers are healthy for future generations requires protection measures that are dedicated, secure and enforceable. By doing so, many of the following benefits will be realized, thereby supporting diverse and productive ecosystems:

- supplying clean and reliable water
- protecting against droughts and flooding
- preserving cultural and historical heritage
- supporting recreational opportunities
- offering opportunities for fishing and wildlife viewing
- providing food and livelihoods to people
- maintaining diverse and abundant biological communities robust to environmental change

To help bend the curve of freshwater biodiversity loss, the Biden administration recently committed to protect 30% of U.S. lands and waters by 2030 ('America the Beautiful' initiative; Executive Order 14008). Achieving this ambitious conservation target requires understanding how and where rivers are currently being protected and strategically identify priorities for future protection. This raises the question: what is the current extent of protection for rivers across the nation? Protected areas are the cornerstone of conservation strategies, but due to the unique spatial characteristics of and specific threats to freshwater habitats, what confers efficient protection to streams and rivers may differ from the conservation mechanisms traditionally deployed to protect terrestrial biodiversity (Abell et al. 2007, Juffe-Bignoli et al. 2016, Acreman et al. 2020, Higgins et al. 2021, Flitcroft et al. 2023).

The goal of the Protected Rivers Assessment of the United States was to identify the different mechanisms conferring protection to rivers in the U.S., estimate the current extent of river protection according to these mechanisms, and develop the Protected River Index of the United States (PRI) to assess the degree to which key ecological attributes of rivers are being protected by explicitly accounting for the management objectives associated with different mechanisms.

3. Methods

3.1. Individual mechanisms of protection

River protection in the U.S. involves a combination of regulatory frameworks, conservation policies and management practices implemented by different federal, state, tribal and local governmental agencies, as well as private organizations to achieve the long term and effective in-situ conservation of rivers, either explicitly or incidentally (TNC 2021). In this assessment, we considered seven categories of protection, each composed of one or more individual protection mechanisms (Table 1). Datasets were compiled through the curation of river specific datasets (several digitized for the first time for this assessment) and various protected area databases. The overall workflow and mechanisms are summarized in Figure 1 and Box 1 and further described below. Data sources and maps are provided in Appendix A.

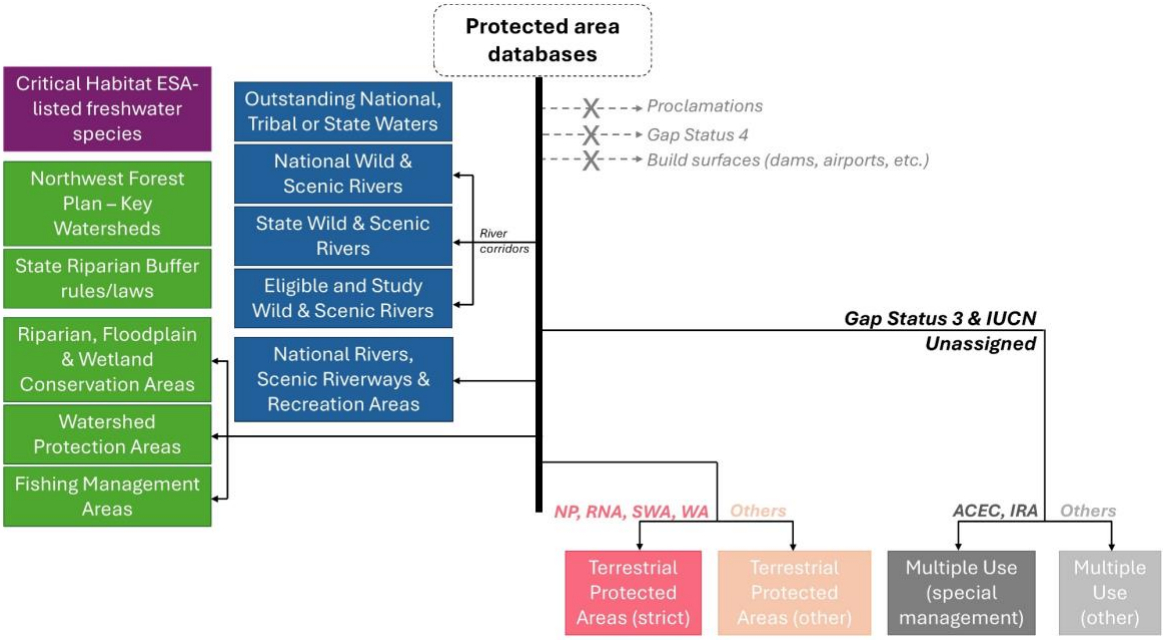

Figure 1. Overview of the workflow and mechanisms of river protection considered in this assessment: river conservation [blue], riparian and floodplain conservation [green], ESA-listed endangered freshwater species critical habitat [magenta], terrestrial protected areas (strict) [pink], terrestrial protected areas (other) [beige], multiple land use (special management) [dark grey], and multiple land use (other) [grey]. Abbreviations: International Union for Conservation of Nature (IUCN), Areas of Critical Concern (ACEC), Inventoried Roadless Areas (IRA), National Parks (NP), Research Natural Areas (RNA), State Wilderness Areas (SWA), Wilderness (and study) Areas (WA).

Table 1. Mechanisms of river protection considered in this assessment.

Protection Category	Protection Mechanism
River conservation	
	Outstanding National, Tribal or State Waters (ONRW/OTRW)
	National wild and scenic rivers
	Eligible and study wild and scenic rivers
	State wild and scenic rivers
	Scenic riverways, national rivers, and recreation areas
Riparian and floodplain conservation	
	Riparian buffers
	Watershed protection areas
	Riparian, floodplain, and wetland conservation areas
	Key Watersheds - Northwest Forest Plan
	Fishing management areas
Endangered species critical habitat	
	Critical habitat for ESA-listed freshwater-dependent species
Terrestrial protected areas	
	Terrestrial protected areas (strict). E.g., Research Natural Area, Wilderness (and study) Area, State Wilderness, National Park
	Terrestrial protected areas (other). E.g., National Wildlife Refuge, National Recreation Area, State Conservation Area, Conservation Easement, Private Conservation, State Park
Multiple land use	
	Multiple land use (special management). E.g., Inventoried Roadless Areas, Area of Critical Environmental Concern
	Multiple land use (other). E.g., National Forest, National Grassland, Conservation Easement, Forest Stewardship Easement, Private Conservation, Local Recreational Area, Local Park

Box. 1. Incorporating protected area databases into the Protected Rivers Assessment of the United States.

We used the Protected Area Database of the United States (PAD-US version 3.0), representing the official national inventory of U.S. terrestrial and marine protected areas that are dedicated to the preservation of biological diversity and to other natural, recreational, and cultural uses, managed for these purposes through legal or other effective means. We updated PAD-US with the most recent version of the National Conservation Easement Database (NCED, accessed July 4, 2023), after removing cases of overlapping designations. From PAD-US, we retained only 'fee', 'designation' or 'easement' features, and excluding 'proclamation' features describing where each agency has authority to acquire lands as voluntary opportunities arise. From NCED, we further selected only permanent easements and easements whose primary purpose is related to the conservation of biodiversity, excluding temporary as well as agricultural, historical preservation, recreation and education or unknown easements. We also excluded all the protected areas associated with significant amount of development based on the description provided in the unit name and local designation type (e.g., "access area", "airport", "battlefield", "boat ramp", "hatchery", "dam", "fishing pier", "parking", "penitentiary") or with unknown or unclear purposes (e.g., "private - restriction unknown", "undesignated state land"). Finally, we used the Gap classification system to filter protected areas according to their management intent with respect to biodiversity conservation:

- GAP Status 1 - Areas managed for biodiversity where natural disturbances are allowed to proceed
- GAP Status 2 - Areas managed for biodiversity where natural disturbance is suppressed
- GAP Status 3 - Areas protected from land cover conversion but subject to extractive uses such as logging and mining
- GAP Status 4 - Areas with no known mandate for protection

More specifically, we excluded all the protected areas classified as Gap Status 4 and assigned the remaining areas to either: (i) protected areas classified as Gap Status 1 or 2 or (ii) protected areas classified as Gap Status 3. Considering Gap Status 3 as a separate category in the assessment allows some flexibility to reconcile international guidelines regarding what constitutes a protected area. For example, the United Nations Environment Program and the International Union for Conservation of Nature (IUCN) do not consider Gap Status 3 as 'protected areas' (Dietz et al. 2023) and not all Gap Status 3 may qualify as Other Effective Area-based Conservation Measure (OECM). Furthermore, this approach recognizes that Gap Status 3 lands and rivers managed for multiple land use have potential to advance biodiversity conservation (Dreiss and Malcolm 2022).

3.1.1. River-specific protection mechanisms

River-specific protection mechanisms seek to prevent threats to the river channel, including water quality regulatory programs and legislation focusing on preserving the free-flowing character of rivers (Abell et al. 2007, Moir et al. 2016, Higgins et al. 2021). In particular, the Federal Antidegradation Policy adopted as part of the Clean Water Act offers a regulatory framework for states and tribes to protect outstanding waterways, maintain water quality, protect fish and other wildlife, and support recreation (EPA 2012, CSP 2021). Another widely known form of federal legislation for river protection is offered by the National Wild and Scenic Rivers Act which aims to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations (Public Law 90-542, U.S.C 1271; Perry et al. 2017, 2021). Additional river protections are adopted through state-level Wild and Scenic Rivers programs (Probst and Dawson 2008), as well as a variety of protected area designations centered on river conservation and recreation. In this assessment, we considered the following individual mechanisms:

- **Outstanding National, Tribal or State Waters (ONRW/OTRW)**
  Outstanding National, Tribal or State Waters datasets were either obtained through state or tribal agencies or digitized based on legislative information, for a total of 39 state-specific (including the District of Columbia) and 13 tribal-specific datasets (not all the existing designations could be obtained). We considered both Tier 3 (i.e., stringent protection where no degradation is allowed, except on a short term or temporary basis, often referred to as Outstanding National Resource Waters or Outstanding Resource Tribal Waters, ONRWs or OTRWs) and Tier 2.5 (i.e., very high level of water quality protection without precluding unforeseen future economic and social development considerations, often referred to as Outstanding State Resource Waters or Exceptional Waters) waters. Although not explicitly mentioned in EPA guidance, “Tier 2.5” waters is an application of the antidegradation policy that has implementation requirements that are more stringent than for "Tier 2" (high-quality waters), but less stringent than the prohibition against any lowering of water quality in "Tier 3".

- **National wild and scenic rivers**
  We included wild, scenic, and recreational designated rivers and considered protection of both the river channel (river segments) and surrounding lands (river corridors). Designated river segments and corridors were obtained from a multi-agency effort led by the U.S. Forest Service, National Park Service, Bureau of Land Management, and the U.S. Fish and Wildlife Service. River corridors were supplemented by agency-specific datasets (National Park Service and Bureau of Land Management) as well as protected areas curated from PAD-US and NCED.

- **Eligible and study wild and scenic rivers**
  We included eligible, suitable and study designated rivers (including permanent study rivers) and considered protection of both the river channel (river segments) and surrounding lands (river corridors). Designated river segments were obtained from a multi-agency effort led by the U.S. Forest Service, National Park Service, Bureau of Land Management, and the U.S. Fish and Wildlife Service. River corridors were obtained from PAD-US and NCED.

Snake River, ID, Area of Critical Environmental Concern.

- **State wild and scenic rivers**
  State-specific wild and scenic river programs (or equivalent) that were complementary to the federal program were either obtained through state agencies or digitized based on legislative information, for a total of 29 state-specific programs. We considered protection of both the river channel (river segments) and surrounding lands (river corridors). Due to the paucity of available river corridor datasets, most river corridors were estimated by digitizing buffers based on legislative information (e.g., minimum width of the corridors according to the type of designation) around the designated river segments clipped to conservation lands, and further supplemented with protected areas curated from PAD-US and NCED.

- **National rivers, scenic riverways and recreation areas**
  National rivers, scenic riverways and recreation areas and other river-specific protected areas aiming to protect both the river and land areas surrounding them and managed by various government agencies and private groups were compiled from PAD-US and NCED. These include national rivers (Buffalo National River, New River Gorge National Park and Preserve), national scenic riverways (Ozark National Scenic Riverway, Lower Saint Croix National Scenic Riverway), national scenic and recreation areas (Gauley River National Recreation Area), national lakeshores (e.g., Sleeping Bear Dunes National Lakeshore) and state river and conservation areas (e.g., Upper Green River Biological Preserve).

3.1.2. Riparian, floodplain, and wetland conservation areas

Maintaining intact riparian and floodplain habitats is critical to sustaining river ecosystem processes and biodiversity (Naiman and Decamps 1997; Wenger and Fowler 2000, Jones et al. 2006) and a variety of protection mechanisms exist at local, state, or federal levels that target the surrounding riparian land areas to enhance biodiversity, water resources or recreational opportunities. Likewise, land trusts, conservation easements, and private reserves can play a key role in contributing to preserving tracts of riparian habitat, notably in areas where most of the land is private (Rissman et al. 2006; but see Roddewig 2019). In this assessment, we considered the following individual mechanisms:

- **Riparian, wetland, and floodplain conservation areas**
  Protected areas focusing on riparian, wetland and floodplain conservation were compiled from PAD-US and NCED, including units of the National Wildlife Refuge System that target the conservation of riverine or riparian-dependent species (e.g., waterfowl production areas), riparian-focused conservation areas managed by local, state or federal agencies (e.g., San Pedro Riparian National Conservation Area), and conservation easements designed to protect, restore, and enhance riparian forests (e.g., Forest Riparian Easement Program - Washington Department of Natural Resources), freshwater wetlands (e.g., U.S. Department of Agriculture's Natural Resources Conservation Service [NRCS] Wetlands Reserve Program), or the functions of the floodplains (e.g., Emergency Watershed Protection and Floodplain Easement Program).

- **Watershed protection areas**
  Watershed protection areas were compiled from protected areas curated from PAD-US and NCED. These correspond to often sporadic local or regional protection programs that establish watershed-wide regulations and groundwater protection regulations around wellhead areas for drinking water to address pollution, land use or other human activities impacting the watershed. Protection mechanisms generally include preserving the watershed in the most natural state possible by minimizing development (e.g., forest reserves), protecting habitats around wells (e.g., watershed preserves) and implementing stormwater management practices (e.g., temporary storage and treatment of stormwater runoff).

- **Fishing management areas**
  Fishing management areas were compiled from protected areas curated from PAD-US and NCED. These correspond to special management areas aiming to enhance fish production and recreational fishing experience, usually through the protection of critical shoreland habitat (e.g., aquatic management areas in Minnesota) and fishing regulations (e.g., no-take zones).

- **Key Watersheds - Northwest Forest Plan**
  The key watersheds of the Aquatic Conservation Strategy of the Northwest Forest Plan were collected through the Regional Ecosystem Office. We considered both Tier 1 (aquatic conservation emphasis) and Tier 2 watersheds corresponding to watersheds located on federal lands throughout Northwest U.S. forests that are crucial for the maintenance of at-risk fish species and high-quality waters, respectively. These watersheds represent the highest priorities for watershed restoration where in-stream flow and habitat conditions are managed to maintain or restore riparian resources and channel integrity.

- **Riparian buffers**
  We collated a variety of datasets depicting riparian buffer protection through federal- (i.e., riparian reserves of the Northwest Forest Plan) and state-level legislative acts (e.g., Chesapeake Bay Critical Area Protection Act), administrative rules (e.g., North Carolina Riparian Buffer Rules), agricultural and forestry regulatory best practices (e.g., Washington Forests and Fish Law), for a total of 25 datasets.

3.1.3. Policies that focus on endangered species

Designation of critical habitat for freshwater listed species through the Endangered Species Act may also contribute to the protection of in-stream and riparian habitats, although critical habitat designations are meant to facilitate cooperation within the federal government to avoid activities that could adversely affect imperiled species, rather than to formally establish conservation areas (USFWS 2017). In this assessment, we collated river segment- and land-based critical habitat for 129 ESA-threatened or endangered freshwater dependent species (i.e., amphibians, reptiles, mollusks, crustaceans, and fishes).

3.1.4. Terrestrial protected areas that incidentally protect rivers

Although many, if not most, protected areas were not originally designed to protect river systems, their management objectives often align explicitly or implicitly with the conservation of freshwater resources. Therefore, terrestrial protected areas remain a fundamental strategy for river biodiversity protection, despite some potential limitations (Box 2). For instance, by protecting large tracts of surrounding lands from most human activities, wilderness areas (e.g., implemented through the Wilderness Act) can participate in shielding rivers from water quality degradation on public lands (Abell et al. 2007, BLM 2012). Similarly, national parks, which are congressionally designated protected areas operated by the National Park Service, have the dual management objectives of protecting lands and waters within the park boundaries (NPS 2006). Other protected areas that are more often associated with cultural, recreational, and sustainable development goals (e.g., state parks, national monuments, national wildlife refuges, state resource management areas) may provide additional conservation benefits to freshwater ecosystems, albeit entailing some trade-offs between biodiversity conservation and human development objectives (Flitcroft et al. 2023). Because streams and rivers are often the primary focus of recreational (e.g., boating, swimming, whitewater rafting) or resource exploitation (e.g., fishing, hydropower) activities taking place within the protected area boundaries, these protected areas may confer weaker effective protection to freshwater biodiversity (Acreman et al. 2020). Here, we considered two distinct mechanisms of protection according to their designation type:

- **Terrestrial protected areas (strict)**
  Terrestrial protected areas (strict) are composed of Research Natural Areas (i.e., areas that the Forest Service has designated to be permanently protected and maintained in natural condition), federal and state wilderness areas (including study wilderness areas) and national parks, all compiled from PAD-US and NCED.

- **Terrestrial protected areas (other)**
  Other incidental protected areas are composed of all the other designation types compiled from protected areas curated from PAD-US and NCED and being classified as Gap Status 1 and 2 (areas managed for biodiversity where natural disturbances are allowed to proceed or suppressed), which includes national wildlife refuges, national, state and local conservation areas, national monuments, state parks, state and local resource management areas, national, state or local recreation areas, national scenic, botanical and volcanic areas and the variety of conservation easements and private conservation areas associated with these designations.

Clinch River, VA, Critical habitat for the ESA-listed endangered rabbitsfoot *Theliderma cylindrica* (bivalve).

Box 2. The role of terrestrial protected areas in supporting freshwater biodiversity conservation.

Protected areas are the cornerstone of conservation strategies, yet for the most part have been designed to protect terrestrial biodiversity and may not fully fulfill their conservation potential with regards to freshwater biodiversity (Abell et al. 2007, Acreman et al. 2020). There are at least four reasons why terrestrial protected areas may not provide the same conservation benefits as protected areas explicitly designed with freshwater biodiversity in mind ("freshwater protected areas").

- Terrestrial protected areas have not been designed to promote longitudinal (upstream-downstream), lateral (river-floodplain) or vertical (surface-groundwater) connectivity, which may compromise the flow of energy, materials and organisms across space and time in freshwater systems and thus fail at supporting freshwater biodiversity (Pringle 2001, Juffe-Bignoli et al. 2016). For example, lateral connectivity is particularly important for the exchange of nutrients as well as providing seasonal and life stage specific-habitats for freshwater dependent-species (Junk et al. 1989, Tockner et al. 2020), whereas longitudinal connectivity enables meta-population dynamics and long-distance migration within and between basins (Vannote et al. 1980, Fausch et al. 2002).

- Terrestrial protected areas do not necessarily protect from freshwater-specific threats occurring within park boundaries. For instance, Thieme et al. (2020) estimated that about 20% of all known large dams are currently located within terrestrial protected areas, including within wilderness areas, national parks, and national monuments, and many more are planned or under construction.

- Fresh waters within terrestrial protected areas may be exposed to threats that originate outside of protected areas, such as upstream water contaminations or spread of invasive species (Abell et al. 2007). For example, Mancini et al. (2005) found that water quality within terrestrial protected areas does not always differ from outside of the protected areas but instead largely reflects the degree of land use changes within the broader upstream catchment. Similarly, Lawrence et al. (2011) showed that a major constraint to utilizing national parks as freshwater protected areas for fishes is that their ecological integrity is subject to anthropogenic disturbances that occur outside of park boundaries, including impervious land cover, flow regulation and presence of invasive species.

- The locations and boundaries of terrestrial protected areas may not always align with the distribution of freshwater biodiversity (Leal et al. 2020) and may provide insufficient protection for freshwater species of conservation concern. For instance, although almost two-thirds of freshwater fish species in the U.S. occur within national parks, imperiled fish species only occur within less than one-fifth (18%) of them (Lawrence et al. 2011).

Despite these challenges, a global analysis of the effectiveness of protected areas for freshwater biodiversity showed a higher proportion of positive (65%) rather than negative (10%) or neutral (25%) conservation outcomes for fresh waters located in terrestrial protected areas compared to those outside (Acreman et al. 2020). Moreover, this study reported no major difference in effectiveness between terrestrial and freshwater protected areas, but rather a high context-dependency related to the size and degree of threat within and outside protected areas. These results point to the potentially positive role that terrestrial protected areas can play in conserving freshwater ecosystems and associated biota in certain contexts, despite the aforementioned limitations.

3.1.5. Multiple land use landscapes/riverscapes

Although not officially recognized as 'protected areas' by international agencies, lands and rivers managed for multiple use represent promising targets to scale up the current protected area estate through regulatory changes that would tip the balance towards biodiversity protection over other uses. This is especially so as Gap Status 3 often encompasses large tracts of lands and rivers, including in biodiversity hotspots, thus offering enhanced opportunities to prevent large-scale land use changes and securing opportunities for climate adaptation (Dreiss and Malcom 2022). However, protection effectiveness can vary across land ownerships and the extent to which biodiversity protection is emphasized over other uses. For example, whereas land management laws often seek to equilibrate extractive uses and damage to natural ecosystems (e.g., National Forest Management Act), administrative designations such as Inventoried Roadless Areas and Areas of Critical Environmental Concern implement special management to limit damaging activities such as logging and road building. Here, we considered two distinct mechanisms of protection according to their designation type:

- **Multiple land use (special management)**
  Multiple land use (special management) is composed of Inventoried Roadless Areas and Areas of Critical Environmental Concern compiled from PAD-US and NCED, all classified as Gap Status 3 (areas protected from land cover conversion but subject to extractive uses such as logging and mining).

- **Multiple land use (other)**
  Other multiple land use (other) is composed of all the other designation types compiled from protected areas curated from PAD-US and NCED and classified as Gap Status 3. In addition to the Gap Status 3 (categorized as "Other Conservation Areas" by the International Union for the Conservation of Nature [IUCN]), we also reported all the "Unassigned" protected areas from the IUCN category, irrespective of the Gap Status 1-3, in the Multiple land use (other) category to reflect uncertainty around these designation types. Multiple land use (other) includes national forests and grasslands as well as many of the same designation types included in the terrestrial protected area category (e.g., state parks, local and state conservation areas or resource management areas, conservation easements, private conservation) as well as protected areas focused on rivers (e.g., Mississippi National River And Recreation Area, Chattahoochee River National Recreation Area) and riparian conservation (e.g., waterfowl production areas, Wetlands Reserve Program conservation easements).

3.2. Assessing the extent of river protection

3.2.1. Geospatial framework to assess segment-level protection

To perform a national assessment of river protection, we adopted a standardized geospatial framework so data collected at a variety of spatial scales (e.g., local, state, national) and for different mechanisms (e.g., National Wild and Scenic Rivers, ONRW, state-level riparian buffer ordinances) could be

summarized using a common analytical approach. For this assessment, we used the National Hydrographic Dataset version 2.1 (NHDPlus v2.1; 1:100,000 scale) for the contiguous U.S. and Hawaii (USGS 2022) and the National Hydrography Dataset Best Resolution for the state of Alaska (USGS 2023; the only currently available dataset for the state). Although a higher resolution hydrographic network has been developed by the U.S. Geological Survey (NHDPlus HR; 1:24,000 scale), the NHDPlus HR is in various stages of completion for the different river basins and currently in production in Alaska (estimated completion around 2030). In addition, because of its longer existence (the NHDPlus v2 was initially developed in 2016 and updated in 2019), many connectivity issues and Value Added Attributes (VAA) errors that are still present in the NHDPlus HR (see https://www.usgs.gov/index.php/national-hydrography/known-issues-nhdplus-hr-datasets) have been resolved, therefore providing a robust analytical framework for geospatial analyses. From this nation-wide network, we selected only river segments laying within U.S. borders, corresponding to flowing water bodies (irrespective of the hydrological type: perennial, intermittent or ephemeral), excluding segments overlapping with lakes (defined as water bodies with area > 0.5 hectares and mean depth > 0.5m; Richardson et al. 2022), as well as human-made features such as aqueducts or stormwater canals and ditches, pipelines, underground conduits as well as coastlines, and connectors (at the exclusion of canals fully integrated into the river network). This network represents 3.3 million miles of rivers in the contiguous U.S. alone, and 4.4 million river miles when including Alaska and Hawaii.

As different federal and state agencies may use different underlying hydrographic networks, all the segment-level protection layers (i.e., ONRW/OTRW, national and state wild and scenic rivers) were cross-walked with the nation-wide hydrographic network using a 150 m buffer to accommodate for inherent spatial discrepancies between layers. We also applied buffers to all the protected areas (using 50 m for linear-shaped polygons such as wild and scenic river corridors and riparian buffers and 100 m for other polygon-shaped protected areas) before performing spatial overlap with the river segments to circumvent potential issues coming from potential misalignment between the river segments and the protected area polygons. This approach also accommodates the fact that protecting surrounding lands (as opposed to targeting the river channel) is an integral part of river protection (Jones et al. 2006, Fremier et al. 2015).

3.2.2. Summarizing protection across U.S. rivers

We considered that a river segment in the National Hydrography Dataset was offered some level of protection if it benefited from a river-specific conservation system designation or if at least 5% of its length overlapped with a protected area (buffered using a 50 or 100m buffer; see above). This avoids including river segments in the calculation that only “touch” protected area boundaries and may thus not benefit from conservation efforts. The mechanisms of river protection are not mutually exclusive, however, and several designation types are likely to overlap for a given river segment. For instance, ONRW designations often seek to maintain the water quality and ecological uniqueness of wild and scenic rivers and congressionally-designated protected wilderness areas often overlap with fee-owned lands such as national forests. In this case, we attributed the final protection mechanism for each river

segment by first clipping the nation-wide hydrographic network to the buffered protected areas and then removing overlap among layers according to the following hierarchy:

ONRW/OTRW > Wild and Scenic Rivers > State Wild and Scenic Rivers > Eligible Wild and Scenic Rivers > Scenic Riverways, National Rivers and Recreation Areas > Riparian and Floodplain Conservation Areas > Northwest Forest Plan - Key Watersheds > Watershed Protection Areas > Fishing Management Areas > IUCN I > IUCN II > IUCN III > IUCN IV > IUCN V > IUCN VI > IUCN OCA > Critical Habitat (ESA) > Multiple use > Riparian Buffers

We acknowledge that this hierarchy is necessarily somewhat (but not entirely) subjective and note that it was adopted to summarize the extent of river protection using a common framework while avoiding the overestimation of overall length of rivers protected across the U.S. caused by river segments being 'counted' multiple times. For the terrestrial protected areas, we adopted the International Union for Nature Protected Areas categories (Dudley et al. 2008), ranging from strict nature reserves (category I) to other conservation areas (category OCA, also including unassigned protected areas), as opposed to designation types. We did this to avoid the difficulty in assigning a specific rank to each designation type separately, especially as a single designation type can appear in different IUCN categories and Gap Status, reflecting some context dependencies in their respective management objectives. When multiple designation types within a single layer overlapped with the same river segment, we assigned the final designation type according to the hierarchy above.

The total number of river miles protected for the different protection mechanisms was then reported for each mechanism using both the summed river length for each clipped layer independently from any overlap (in this case several designation types may be assigned to the same river segment, noting that individual designation types were flattened within a given layer) and after resolving the overlaps among layers (in this case several designation types may still be assigned to the same river segment if they occur at different places along this segment). In addition, we assessed the representation of different types of management by estimating the percentage of protected river length managed by federal, tribal, state, local, non-governmental, private, regional agency special district or joint management means. This was done before removing the overlaps between layers to more fully capture the extent of on-the-ground conservation capacity.

3.2.3. Spatial patterns in river protection

To explore spatial patterns in the level of protection afforded to rivers across the U.S., we summarized protection by calculating the percentage of rivers afforded protection according to each protection mechanism at the watershed, state, and regional scales. For the watersheds, we adopted the HUC 12 scale (Hydrologic Unit Code 12) from the NHD boundary dataset, corresponding to local sub-watersheds that capture tributary systems (approximately 103,000 nationwide). For the regions, we adopted the American Rivers regions that divide the country into 9 administrative regions.

3.3. Protected River Index (PRI) of the United States

We recognize that aggregating the different mechanisms of protection into the single PRI is challenging. Weighting schemes in freshwater health assessments, for example, are highly variable but typically involve expert-based opinion or literature-based evidence (Kuehne et al. 2017). In addition, an integrative index of protection should be faithful to the spatial dimensions of rivers (Abell et al. 2017, TNC 2022).

3.3.1. Estimating conservation effectiveness for key ecological attributes

We developed the PRI by attributing different weights to each protection mechanism according to their potential conservation effectiveness and accounting for the protection of surrounding lands beyond the river channel. Conservation effectiveness is used to describe the success of a protection mechanism (usually a protected area) in reducing threats and improving biodiversity/ecosystem outcomes compared with the counterfactual situation of no protection (Eklund and Cabeza 2016, Rodrigues and Cazalis 2020). It is a multifaceted concept that quantifies the extent to which a protection mechanism effectively contributes to conservation outcomes. In practice, however, quantifying realized effectiveness can be challenging as conservation outcomes can take many years to manifest and are dependent on contextual settings such as location, degree of external threat, etc. To overcome some of these challenges, here we focus on conservation effectiveness, estimated using general rules intended to capture the protection intent with respect to key ecosystem processes, rather than on management effectiveness intended to capture overall protection enforceability (i.e., the extent to which the intended management translates into practical enforcement, which includes input for staffing, infrastructure, and equipment, but also the capacity for enforcement, and related governance aspects).

Following the Durable Freshwater Protection Framework (Higgins et al. 2021), we considered the effectiveness of the different protection mechanisms with respect to the following five key ecological processes that are essential for the long-term persistence of socio-environmental values, and which are the focus of protection:

- Hydrologic regime
- Connectivity
- Water quality
- Habitat
- Biotic composition

Weighting schemes are illustrated in Figure 2 and briefly presented below.

- For ONRW/OTRW designations, a weight of 1 and 0.75 was applied to Tier 3 and Tier 2.5 waters, respectively, to reflect differences in management with regard to antidegradation policy, whereby Tier 3 waters require stringent protection where no degradation is allowed, except on a short term or temporary basis whereas Tier 2.5 waters require a very high level of water quality protection without precluding unforeseen future economic and social development.

- For national wild and scenic rivers, a weight of 1.0, 1.0 and 0.5 was applied to wild rivers, scenic rivers, and recreational rivers, respectively, to reflect differences in river accessibility (by road or railroad), shoreline development, and the degree impoundment or diversion occurring before designation. To account for the additional protection conferred by the protection of surrounding lands, higher weights for the connectivity key ecological attribute were attributed to designated river segments surrounded by a protected river corridor.

- For eligible and study wild and scenic rivers, weights were chosen as half of those of designated wild and scenic rivers to reflect the interim nature of protection. However, similar to the national wild and scenic rivers, higher weights for the connectivity key ecological attribute were attributed to designated river segments surrounded by a protected river corridor.

- For state wild and scenic rivers, the same weighting scheme was applied to all designated rivers due to inconsistencies in the categories recognized by the state-specific legislation. However, similar to the national wild and scenic rivers, higher weights for the connectivity key ecological attribute were attributed to designated river segments surrounded by a protected river corridor.

- For riparian buffers, weights for the state-level programs were chosen as a quarter of the weights of the Northwest Forest Plan riparian reserves but the same weighting scheme was applied to all state riparian buffer programs due to the common objective of these riparian land management policies to promote water quality and aquatic conservation as well as the difficulty in synthesizing conservation effectiveness across a variety of standards (Boijolie et al. 2019).

- No internal weights were applied among the different critical habitats of ESA listed species or among the different key watersheds of the Northwest Forest Plan.

- For all the other mechanisms a weight of 1.0, 0.75 and 0.5 was applied to protected areas classified as Gap Status 1, 2, and 3 respectively, to reflect differences in the management intent for the long-term protection of biodiversity, whereby all the protection mechanisms associated with Gap Status 3 were subsequently regrouped under the 'Multiple land use' protection category. For the terrestrial protected areas, IUCN categories (as opposed to designation types) were used as broad categories to assign weights intended to reflect the protected area conservation objectives with respect to the key ecological attributes, recognizing that the categories themselves may in fact have little to do with the management effectiveness of the protected areas (Elleason et al. 2021).

Anacostia River, MD, National Wild and Scenic River.

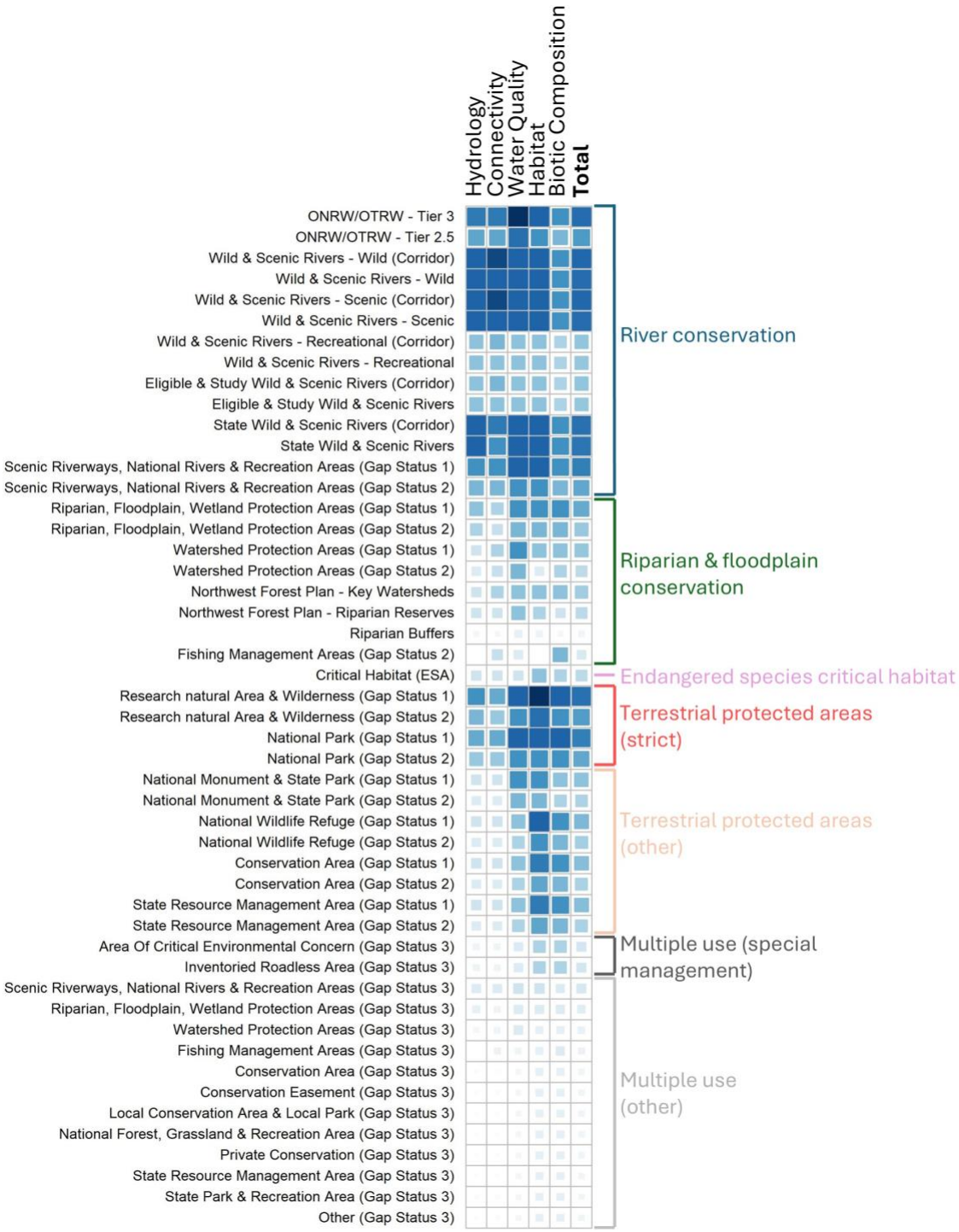

Figure 2. Heat map depicting the matrix of weights used to compute the PRI. The columns illustrate the five key ecological attributes considered as independent components of the index, with the weights varying from 0 (no protection intent; white) to 1 (high protection intent; dark blue), and the total weight calculated as the sum. The rows illustrate the different categories of protection; for simplicity, only the most frequent designation types are represented for the 'Terrestrial protected areas' and 'Multiple land use' categories.

3.3.2. Computing the PRI

For each river segment, the weighting scheme with respect to each key ecological attribute was estimated by multiplying the weight associated with each individual protection mechanism/key ecological attribute combination (illustrated by the individual squares in Figure 2) with the percentage of the protected river length encompassed by this mechanism. Next, to accommodate the fact that a given river segment can be protected by more than one mechanism and that overlapping mechanisms are often intended as a way to effectively implement conservation objectives (e.g., protecting and maintaining water quality is a major conservation objective of the Wild and Scenic River Act and water quality is often managed through mechanisms provided by the Clean Water Act, such as Outstanding National Water, as federal agencies lack jurisdiction to prevent water quality degradation; Hunt et al. 2021), we used the maximum weight among all the protection mechanisms for each individual key ecological attribute as a relative measure of the conservation effectiveness associated with a particular key ecological attribute. The PRI was then estimated by summing the maximum weights across the five key ecological attributes (Figure 3).

The index can vary between 0 (no key ecological attribute is protected across the entire length of the river segment) and 5 (all five ecological attributes are fully protected across the entire length of the river segment). We therefore assigned protection categories according to data ranges (Table 2) and considering protection to be "viable" if the PRI was greater than 1.25 (i.e., indicating that at least a quarter of the maximum protection is achieved) for the purposes of mapping. The total percentage of protected river miles was then reported according to the PRI categories separately and in combination.

Table 2. Classification of river protection according to the Protected River Index.

Classification of river protection according to the Protected River Index (PRI)		
PRI Category	Quantitative Range	Interpretation
Comprehensive protection	PRI > 3.75	More than three quarters of the maximum protection is achieved
Effective protection	2.5 > PRI ≥ 3.75	At least half of the maximum protection is achieved
Limited protection	1.25 > PRI ≥ 2.5	At least a quarter of the maximum protection is achieved
Inadequate protection	0 > PRI ≥ 1.25	Less than a quarter of the maximum protection is achieved
No protection	PRI = 0	None of the key ecological attributes are protected

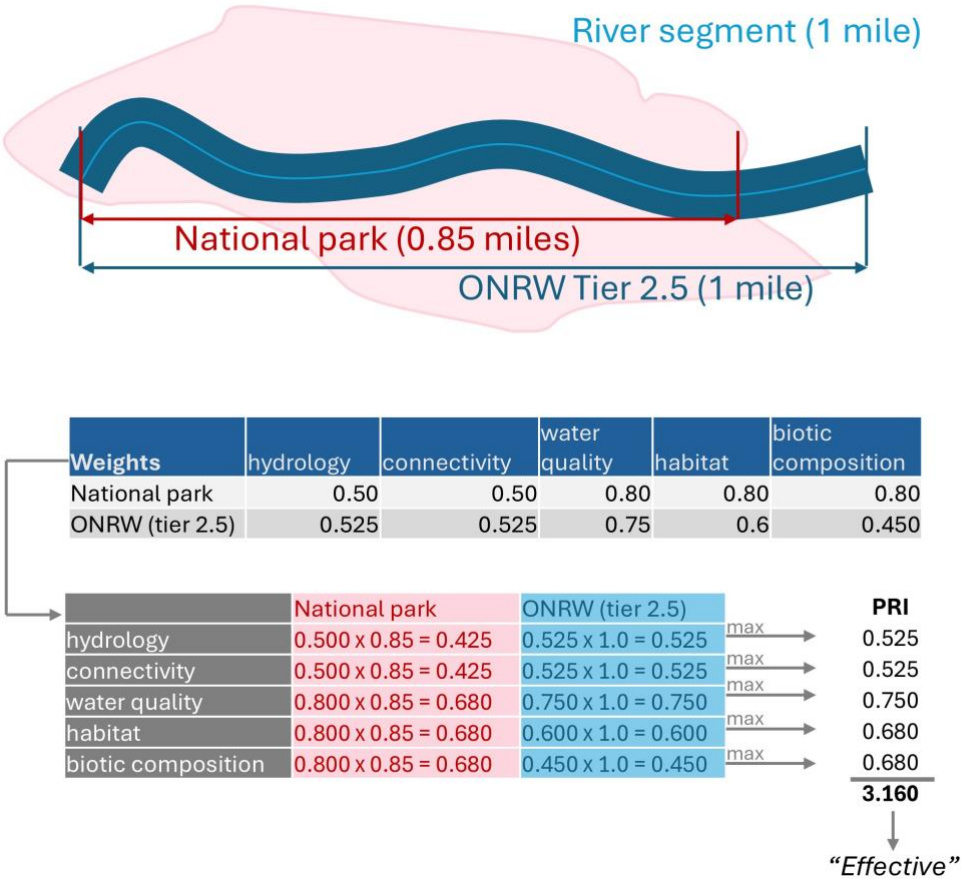

Figure 3. Example showing the computation of the PRI for a hypothetical, 1-mile-long river segment with two intersecting mechanisms of protection: a national park (Gap Status 1) and an Outstanding Resource Water (tier 2.5). In this example, the level of protection is classified as 'Effective'.

To explore spatial patterns in river protection with respect to the key ecological attributes of rivers, we estimated the percentage of river segments displaying a viable degree of protection across watersheds, states, and regions by dividing the estimated river miles of rivers classified as 'viable' (Classes 1-3) by the total length of rivers in each watershed, state, or region.

3.4. Considerations

We offer several cautionary notes to the Protected Rivers Assessment of the United States reported here. The PAD-US strives to be a complete inventory of public land and other protected areas, compiling "best available" data provided by managing agencies and organizations. However, although it includes the vast majority of land protection types and steward agencies, its estimated degree of completeness varies through space and stewardship (see http://www.protectedlands.net/data-stewards/). Likewise, the NCED database is estimated to contain about 60% of all U.S. easements held by government agencies, nonprofits, other land trusts and private entities (see https://site.tplgis.org/NCED/storymap/index.html). We collated additional datasets to fill some key gaps

in these databases with regards to river protection, including an inventory of federal and state wild and scenic rivers and associated land corridors, regional (through the Aquatic Conservation Strategy of the Northwest Forest Plan for federal forests) and state-level (through buffer ordinances and forest practices administrative rules) riparian protection. However, the estimates of river protection reported here are likely to change as new protected areas are added to the databases underlying the analyses and data quality continues to improve. Complementary datasets related to instream flow rules or related to groundwater protection could be incorporated in future updates as they become available.

We note that the underlying spatial framework adopted to depict river segments across the U.S. is likely to influence the total river miles considered as protected or not. Taking the example of the Outstanding National Resource Waters dataset, we can observe that differences exist in terms of the total miles of river length protected if using the original layers developed by different state agencies (76,493 miles) or the cross-walked layer used in this assessment (70,513 miles) because the medium resolution NHDPlus v2.1. does not always perfectly match the definition of the river segments (and especially small headwater tributaries) adopted by different state agencies. Despite these unavoidable differences, using a common framework (by integrating all the layers with the NHD when necessary) has the advantage of facilitating downstream analyses (e.g., overlap analysis) and avoiding biases towards certain mechanisms or datasets because of the nature of the underlying spatial layers used. For this reason, we accompanied all the estimates of river miles protected with their respective percentages.

It is also important to keep in mind that not all categories of protection mechanisms and designations meet the definition of what constitutes a protected area despite their potential importance to freshwater conservation (Flitcroft et al. 2023). For instance, Gap Status 3 landscapes/riverscapes designation types such as many river conservation areas, riparian conservation easements and most source water protection areas, are typically not considered protected. Furthermore, critical habitat areas due to their focus on the protection of single species may not contribute towards the 30 x 30 conservation target. Riparian buffers, although contributing to water quality improvement and providing habitat for wildlife, are more likely to qualify as other conservation measures rather than designated protected areas or OECMs (Dudley et al. 2008; IUCN WCPA Task Force on OECMs 2019).

Finally, we want to acknowledge that despite its sophistication, there are additional opportunities for further improvement of the PRI. Future versions of the PRI should strive to go beyond the conservation effectiveness of different mechanisms examined here by explicitly considering management effectiveness (or protection enforceability) and protection durability to more fully capture the ability of a protection mechanism to provide dedicated, secure, and enforceable protection into the future (Higgins et al. 2021). Together, conservation effectiveness, management effectiveness, and protection durability would provide a more holistic framework for weighting different mechanisms in the PRI. Structured expert elicitation to define these various weights is recommended in the future, especially considering uncertainties regarding the level of river protection afforded by different mechanisms.

4. Results and Discussion

4.1. Contribution of different mechanisms of protection

4.1.1. Independent contributions

The different mechanisms demonstrated varied contributions to the protection of rivers across the U.S. Among them, terrestrial protected areas (i.e., protected areas whose management purpose primarily focuses on preserving the land rather than on the rivers flowing through them) represent the major mechanism by which rivers are intended for protection (Figure 4). In particular, wilderness areas and national wildlife refuges intend to protect 6.3 and 6.0% of the total U.S. river network, respectively, when the different mechanisms of protection are considered independently of any potential overlapping designation. Multiple use landscapes/riverscapes, and particularly national forests and Inventoried Roadless Areas, encompass 5.5% and 3.3% of the rivers at the national scale, respectively. Riparian buffers are also well represented, covering 9.4% of the nation's rivers. River specific mechanisms of protection are comparatively less represented. For instance, ONRW/OTRW designations and national wild and scenic rivers each intend to protect 1.6% and 0.3% of the nation's rivers, respectively. Nonetheless, incidental protected areas play a lesser role when considering only the contiguous states, such that the percentage of rivers flowing through wilderness areas and national wildlife refuges decreases to 2.8% and 0.7%, respectively.

Protection of the U.S. rivers is predominantly offered by federal (63.4% for the entire U.S. and 54.4% for the contiguous states) and state management agencies (33.5% for the entire U.S. and 41.1% for the contiguous states), totaling more than 95.0% of the total protected river miles (Figure 5).

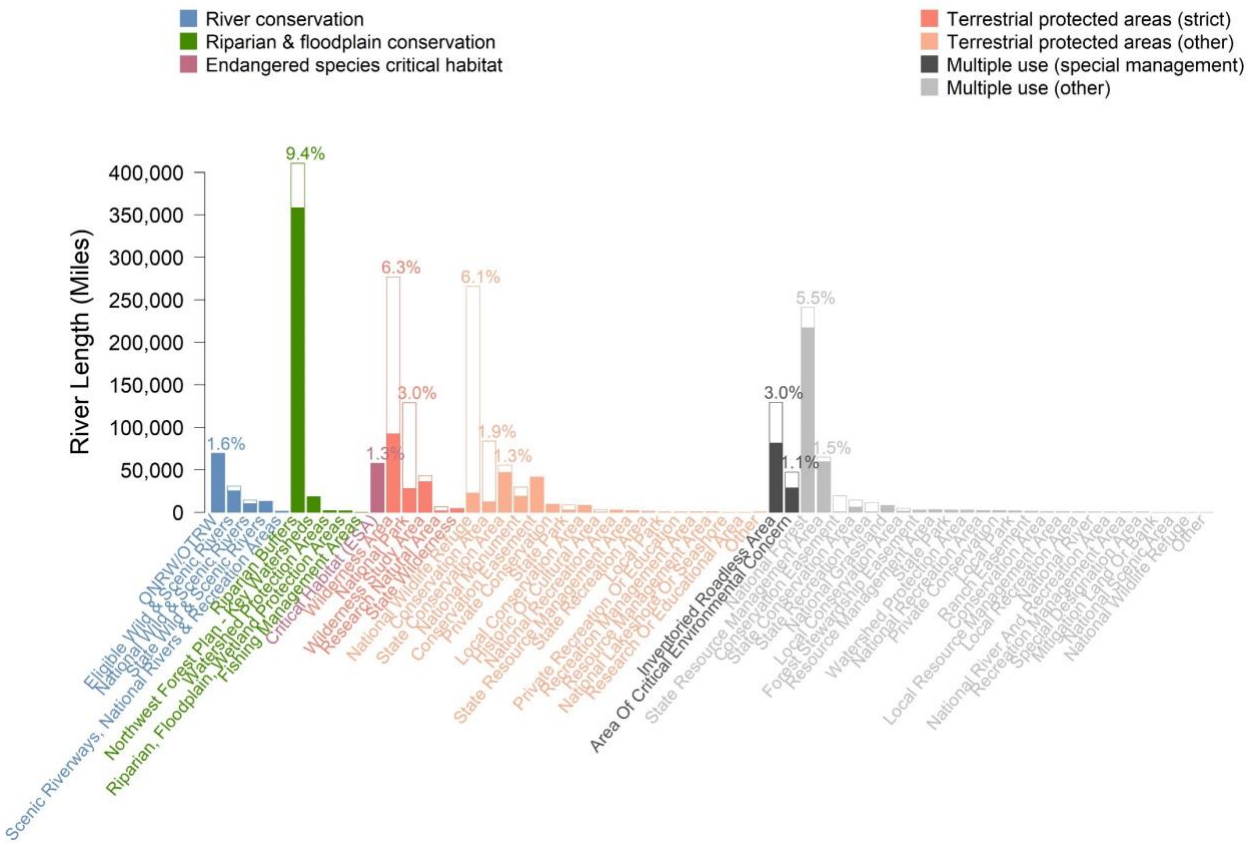

Figure 4. Independent contributions of river protection mechanisms in the U.S. Colors refer to major categories of protection, each composed of one or more individual mechanisms as represented by the bars. Filled bars indicate the total river miles protected in the contiguous U.S. and empty bars the total additional river miles protected in Alaska and Hawaii. The percentages are in reference to the total river length in the U.S. (including Alaska and Hawaii) protected by each individual mechanism (for clarity only percentages > 1.0% are represented).

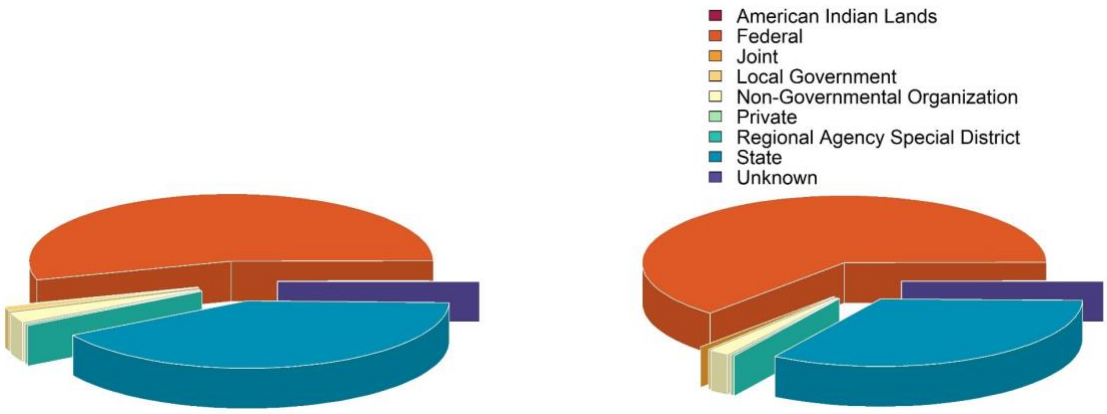

Figure 5. Proportional representation of different types of management to river protection for the contiguous U.S. (left) and the entire U.S. (right), including Multiples uses landscapes/riverscapes.

Rio Grande River, CO, Baca National Wildlife Refuge.

4.1.2. Combined contributions

Over a quarter of America's rivers are intended for protection by at least one mechanism, for a total of 1,466,939 river miles (33.5% out of 4.4 million river miles; Figure 6; Table 3). When considering only the contiguous U.S., approximately 27.7% of the river network or 910,709 river miles (out of 3.3 million river miles) is afforded intended protection by at least one mechanism.

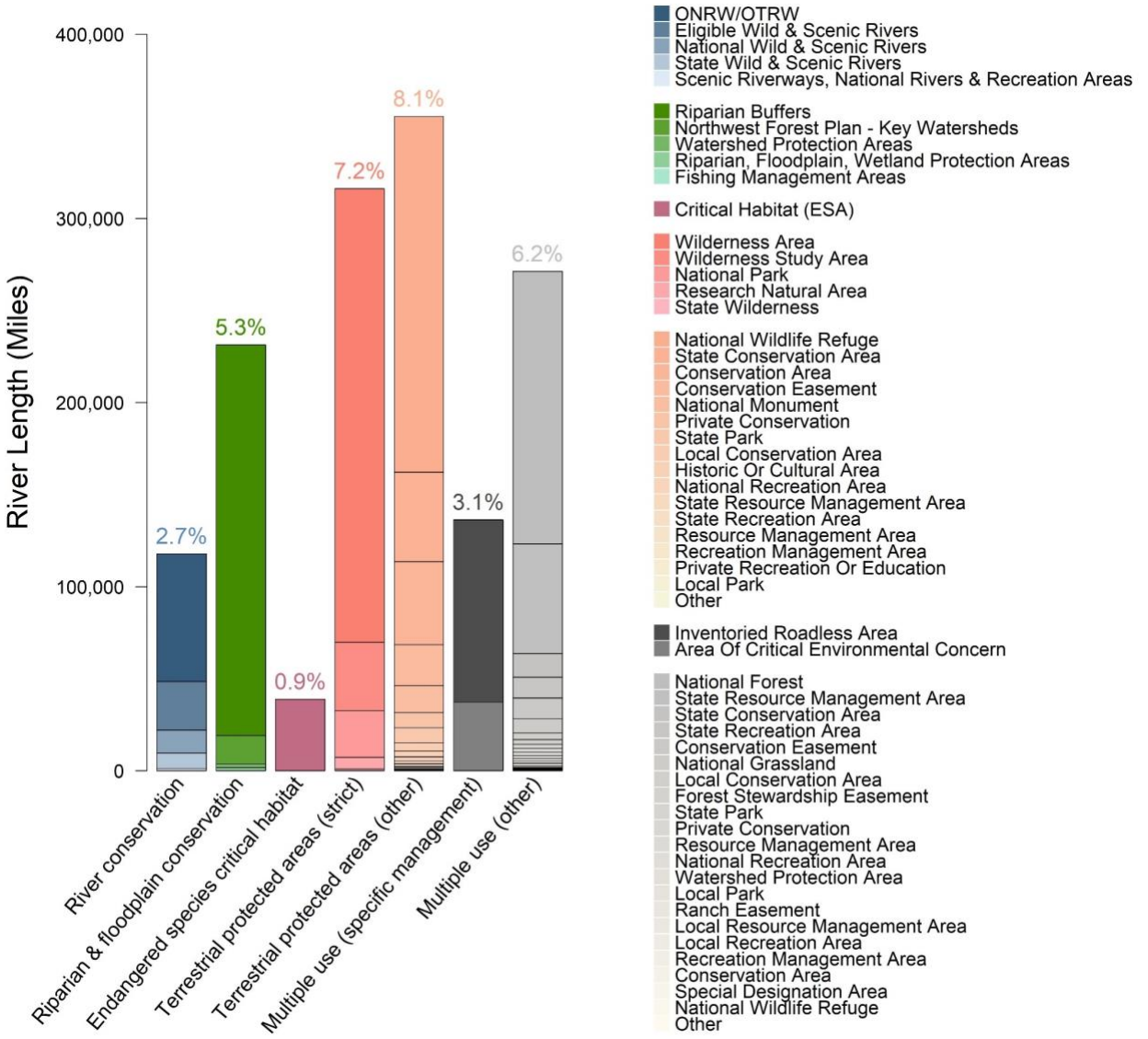

Figure 6. Total protected river miles in the U.S. according to different mechanisms of intended protection. Bars and associated percentages refer to major categories of protection, each composed of one or several individual protection mechanisms as represented by the different colors and associated legend (right). The percentages represent the percentage of river length across the U.S. (including Alaska and Hawaii) protected by each major mechanism.

Disparities appear with respect to the mechanisms of protection considered. River or riparian focused conservation are the dominant mechanisms of protection for 2.7% and 5.3% (3.3% and 6.9% for rivers in the contiguous states) of the nation's rivers, as compared to 7.2% and 8.1% (3.1% and 3.6% for rivers in the contiguous states) for the terrestrial protected areas whose management objectives align explicitly ('strict': research natural areas, wilderness areas and national parks) or not (all the other designation types classified as Gap Status 1 or 2) with the conservation of freshwater resources. However, among the riparian and floodplain conservation mechanisms, 4.8% of rivers nation-wide and 6.3% in the contiguous states are only protected through state-level riparian buffer rules and laws, calling for complementary mechanisms of protection in the future. ESA-listed critical freshwater species habitat and multiple use landscapes/riverscapes with an emphasis on biodiversity conservation ('special management': areas of critical environmental concern and inventoried roadless areas) are the dominant mechanism of protection for 0.9% and 3.1% (1.2% and 2.5% for rivers in the contiguous states) of the nation's rivers (Figure 6). An additional 6.2% of rivers nation-wide and 7.2% in the contiguous states have no other mechanism of protection other than flowing through multiple use landscapes/riverscapes with no emphasis on biodiversity conservation [multiple land use (other)], highlighting future opportunities for regulatory changes to enhance river protection.

Table 3. Total protected river miles in the U.S. according to different mechanisms of intended protection reported separately for the contiguous U.S. and the entire U.S.

River length protected in the U.S. (miles):		
Category of protection	Contiguous U.S.	U.S.
River conservation	106,986 (3.3%)	117,819 (2.7%)
Riparian and floodplain conservation	225,923 (6.9%)	231,306 (5.3%)
Endangered species critical habitat	38,788 (1.2%)	38,836 (0.9%)
Terrestrial protected areas (strict)	102,447 (3.1%)	316,193 (7.2%)
Terrestrial protected areas (other)	116,979 (3.6%)	355,319 (8.1%)
Multiple land use (special management)	81,815 (2.5%)	136,300 (3.1%)
Multiple land use (other)	237,771 (7.2%)	271,166 (6.2%)
No protection	2,377,971 (72.3%)	2,910,750 (66.5%)
Total river protection intent (all mechanisms)	**910,709 (27.7%)**	**1,466,939 (33.5%)**
Total river length analyzed	**3,288,680**	**4,377,689**

4.1.3. Spatial patterns in river protection

River protection is represented through space by a complex patchwork of protection mechanisms, with some emergent patterns in the degree of protection and contribution of different mechanisms across the U.S. rivers (Figure 7).

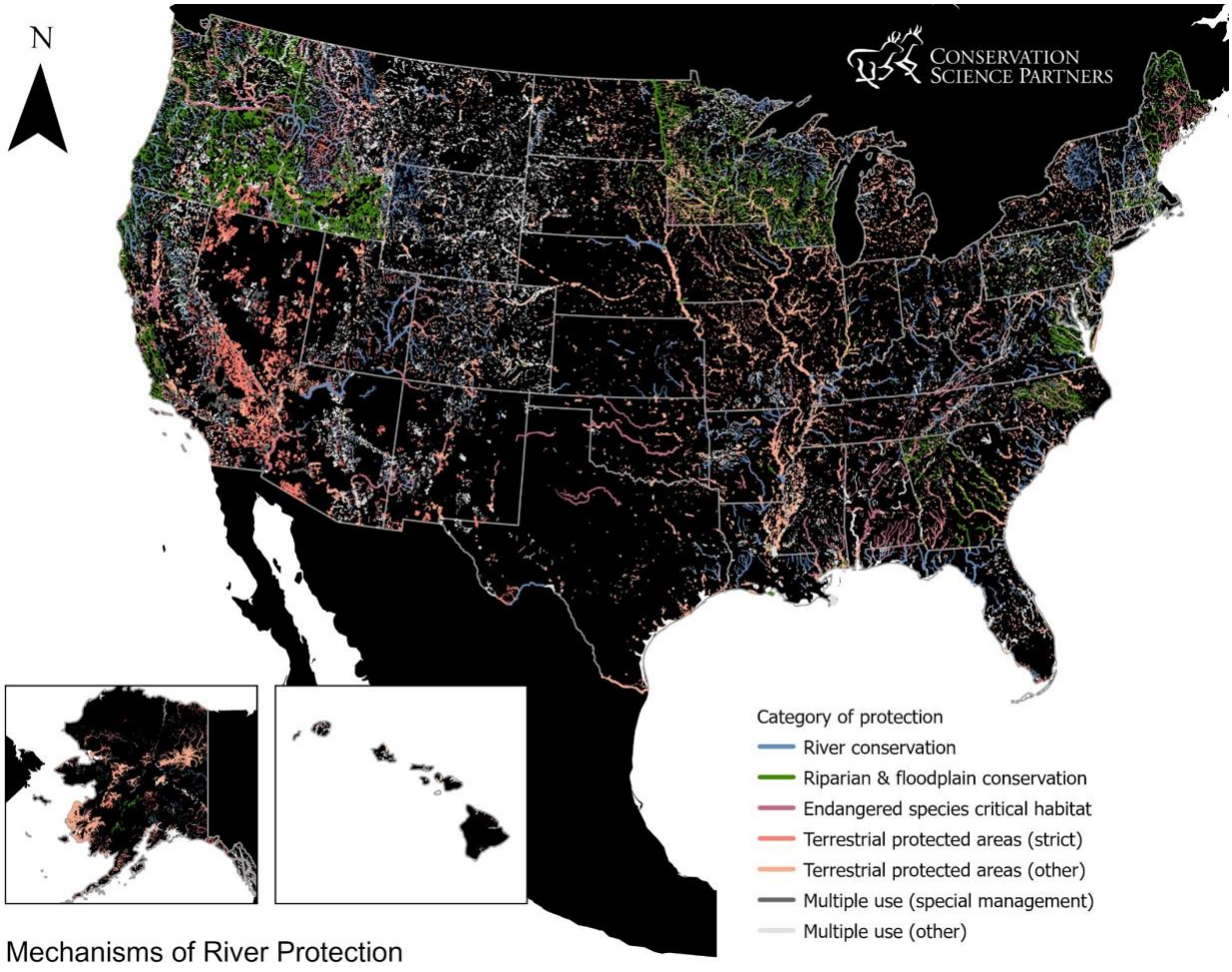

Figure 7. Protected river segments in the U.S. where different colors represent major categories of protection mechanisms. River thickness is scaled according to stream order to improve interpretation.

At the state level, protection varies from a little more than 2% up to 93% of rivers (Figure 8). Eleven states have at least 50% of their rivers managed for conservation, although this result is influenced by the consideration of riparian buffers for these states (all these states have riparian rules, laws or regulatory best practices in place). For instance, New Jersey has a riparian buffer administrative rule in place to protect riparian habitats (Highlands Water Protection and Planning Act Rules), and many ONRW designations, in addition to a natural areas system that encompasses over 40,000 acres. Washington

State also benefits from extensive riparian protection through the Northwest Forest plan (key watersheds and riparian reserves) as well as forestry regulatory best practices (e.g., Washington Forests and Fish Law), in addition to extensive critical habitat for Pacific salmonids and 31 wilderness areas and 3 national parks that cover more than 4.3 million acres. Noticeably, a large proportion of Alaskan rivers are protected through terrestrial protected areas, which is expected given that approximately 60% of the land of the state is federally owned, among which one third contributes to the wilderness preservation system. Of the remaining states, nine display less than 10% of protected rivers, and two – Nebraska, and Kansas – display less than 3% of protected rivers.

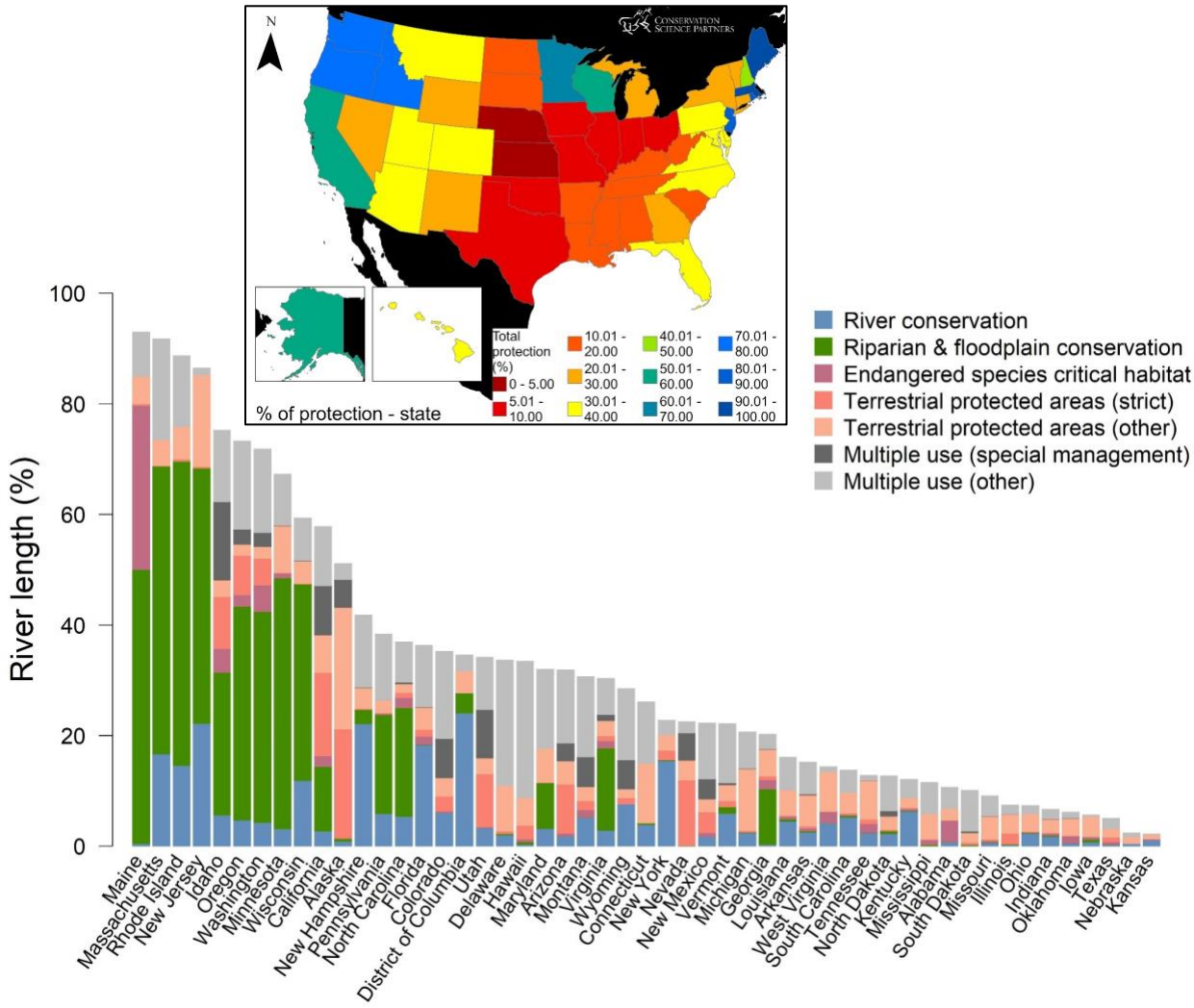

Figure 8. State-level degree of protection according to major categories of protection mechanisms. To account for differences in the total river miles across states, protection is expressed in percentage of the total river miles for each state. The inset shows the overall percentage of protection across states in the U.S. across all mechanisms with a color scale varying from red (less than 5% of rivers protected) to blue (more than 80% of rivers protected).

These state-level trends are also apparent at the regional level where clear differences exist in the degree of protection between the Pacific coastal regions (Northwest and California/Hawaii regions, which also include Alaska and Hawaii, respectively) and the northeastern regions (Northeast and Mid-Atlantic regions) that display a higher proportion of protected rivers than in the central (Central and Great Lakes regions) and southeastern (region 4) regions, especially if multiple land use (other) is excluded (Figure 9).

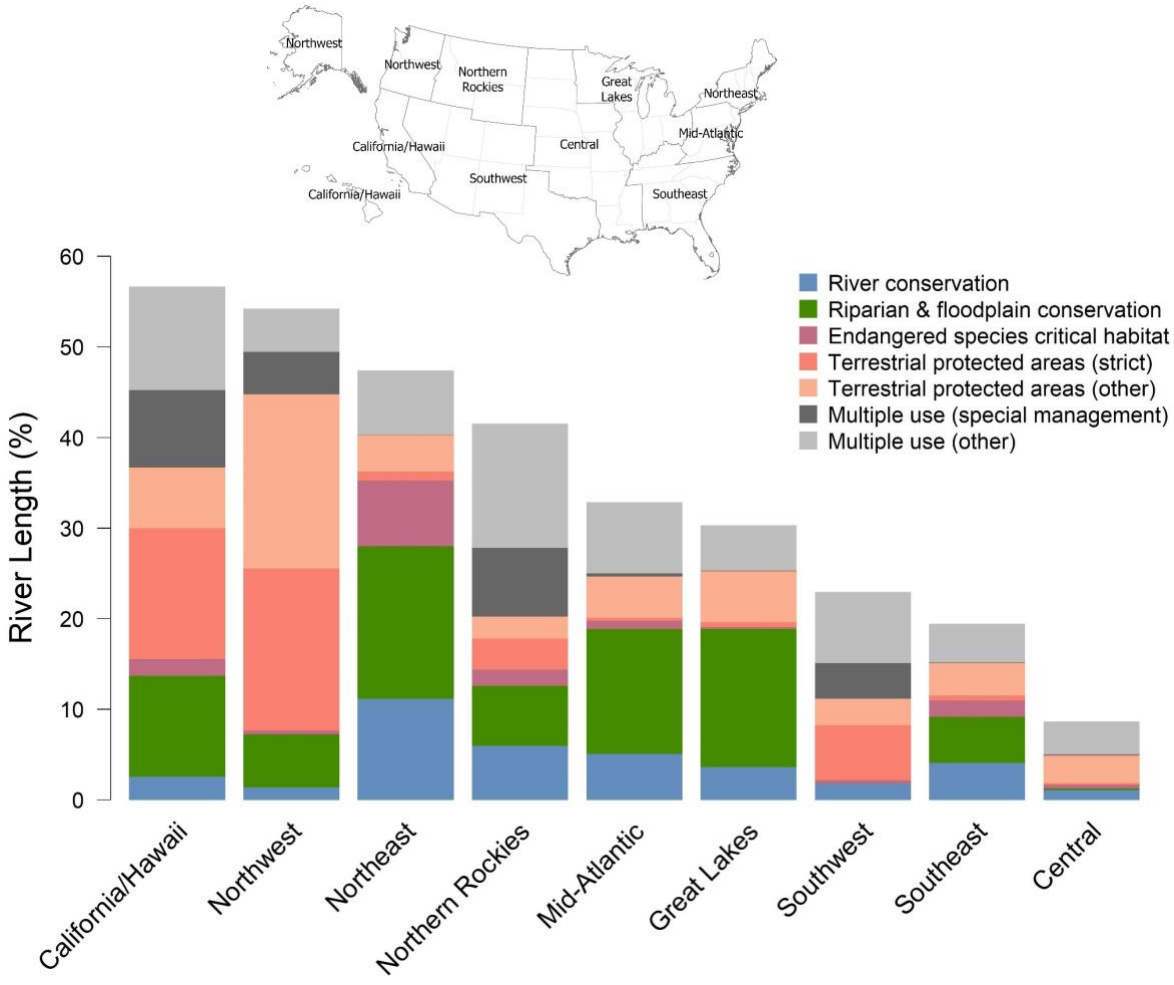

Figure 9. Region-level degree of protection according to major categories of protection mechanisms. To account for differences in the total river miles across regions, protection is expressed in percentage of the total river miles for each region. The inset illustrates the spatial distribution of the regions.

4.2. Protection of key ecological attributes according to the PRI

4.2.1. Protection of key ecological attributes

The PRI reveals considerable variability in the degree to which key ecological attributes are being protected across U.S. rivers (Table 4; Figures 10 and 11). About 19.3% of the rivers demonstrate a viable

degree of protection nation-wide, corresponding to the categories Class 1: Comprehensive protection (0.9%; at least three-quarters of 5 key freshwater ecological attributes are intended for protection), Class 2: Efficient protection (8.4%; at least half of 5 key freshwater ecological attributes are intended for protection) and Class 3: Limited protection (10.0%; at least one-quarter of 5 key freshwater ecological attributes are intended for protection), for a total of 846,372 river miles. In the contiguous U.S., the viable degree of protection drops to 11.7% of the rivers analyzed, for a total of 383,702 river miles. An additional 14.2% or 620,567 river miles (16.0% or 527,007 river miles for the contiguous U.S.) are classified as Class 4: Inadequate protection, where less than one-quarter of 5 key freshwater ecological attributes are intended for protection. This analysis highlights the need to consider the effectiveness of protection in addition to the proportional extent of protection in expanding river protection in view of the 30% conservation target by 2030. Importantly, it also underscores the fact that opportunities may exist to reinforce collaboration among agencies to enhance the protection of different key ecological attributes through complementary mechanisms of protection.

Table 4. Total protected river miles in the U.S. according to the categories of the PRI reported separately for the contiguous U.S. and the entire U.S.

Protected River Index per categories (miles):		
Mechanism of protection	Contiguous U.S.	U.S.
Comprehensive protection (3.75 > PRI ≥5.0)	35,892 (1.1%)	40,124 (0.9%)
Efficient protection (2.5 > PRI ≥ 3.75)	152,967 (4.7%)	369,435 (8.4%)
Limited protection (1.25 > PRI ≥ 2.5)	194,843 (5.9%)	436,813 (10.0%)
Inadequate protection (0 > PRI ≥ 1.25)	527,007 (16.0%)	620,567 (14.2%)
No protection	2,377,971 (72.3%)	2,910,750 (66.5%)
Total river protection (PRI > 0)	**910,709 (27.7%)**	**1,466,939 (33.5%)**
Viable river protection (PRI ≥ 1.25)	**383,702 (11.7%)**	**846,372 (19.3%)**
Total river length analyzed	**3,288,680**	**4,377,689**

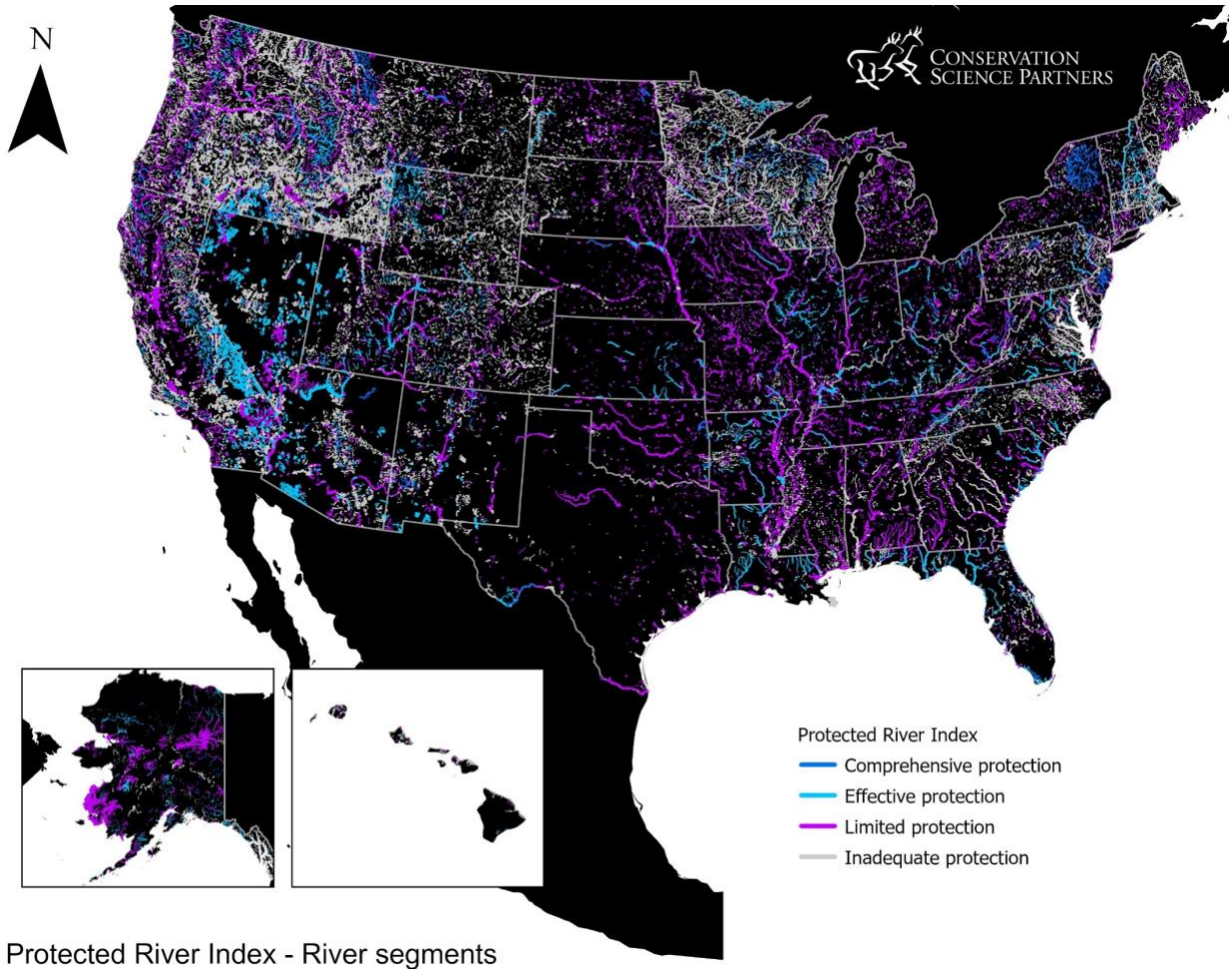

Figure 10. Protected river segments in the U.S. where segments are colored according to the categories of the PRI. River thickness is scaled according to stream order to improve interpretation.

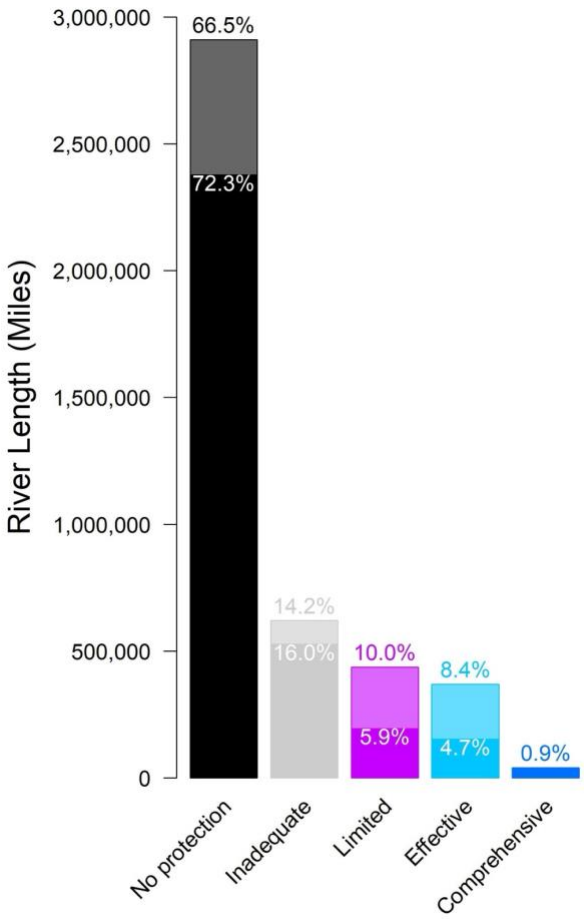

Figure 11. Total protected river miles in the U.S. according to the categories of the PRI reported separately for the contiguous U.S. and the entire U.S.

4.2.2. Spatial patterns in the PRI

Rivers located in Alaska and the northwestern and northeastern U.S. tend to display a greater degree of intended protection (Figures 12-14). Within watersheds, the degree of viable protection (Classes 1-3) varies between 0% and 100% of the river length, with an average of 16.1% (Figure 12). Only Alaska display more than 40% of rivers with a viable degree of protection, with an additional three states – Maine, New Jersey, and California – meeting the 30% threshold (Figure 13). Despite a high percentage of rivers being protected by at least one mechanism of protection in Massachusetts, Rhode Island, Idaho, and Oregon, these states display only between 19.2% and 24.8% of rivers with a viable degree of protection. Twenty-five states display less than 10% of viable protection, among which six – North Dakota, Indiana, Texas, South Dakota, Kansas, and Nebraska – display less than 5% of viable protection. Similar spatial patterns are observed at the regional level (Figure 14), with a clear divide between northwestern (including Alaska and Hawaii) and northeastern regions displaying a higher degree of viable protection (between 40.4% and 23.2% for the Northwest and Northeast regions, respectively) as compared to central regions of the country (less than 10% for the Great Lakes and less than 5.0% for the Central regions) (see *Regional Summary* reports).

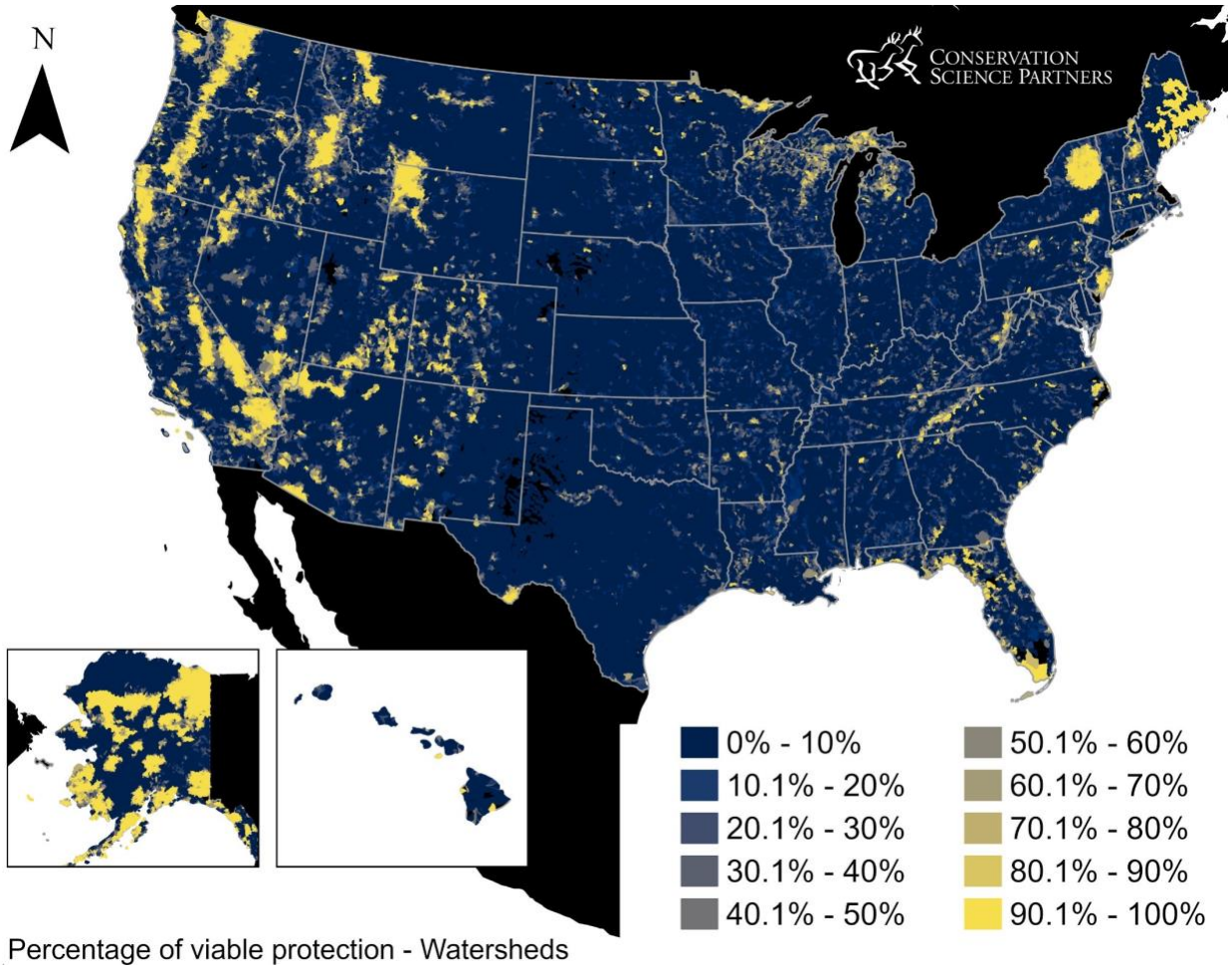

Figure 12. Percentage of rivers across watersheds in the U.S. displaying a viable degree of protection according to the PRI (categories Classes 1-3).

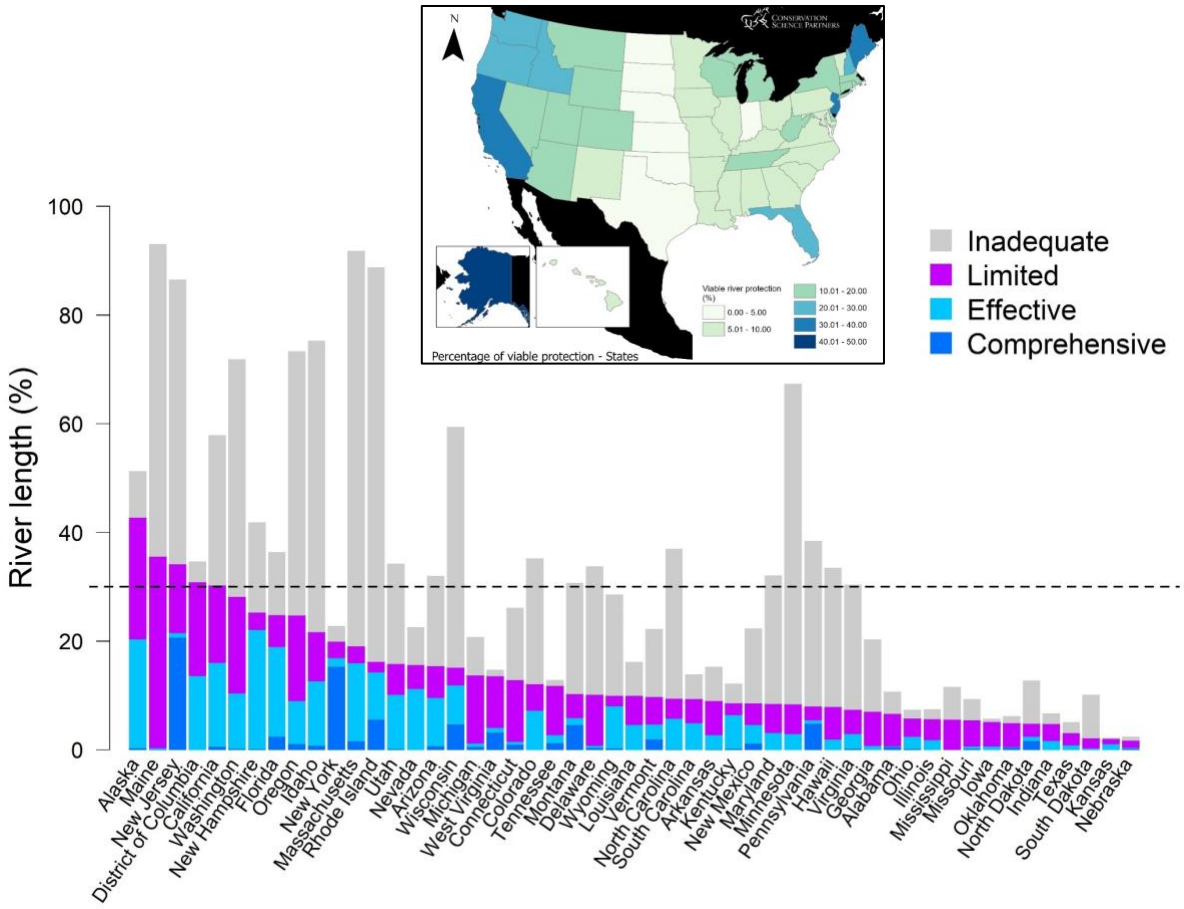

Figure 13. Percentage of rivers across states in the U.S. displaying a degree of protection classified as Comprehensive protection (Class 1), Effective protection (Class 2), Limited protection (Class 3) and Inadequate protection (Class 4) according to the PRI. To account for differences in the total river miles across states, protection is expressed in percentage of the total river miles for each state. The inset shows the percentage of rivers across states in the U.S. displaying a viable degree of protection (categories Classes 1-3) with a color scale varying from beige (less than 5% of rivers protected) to blue (more than 40% of rivers protected).

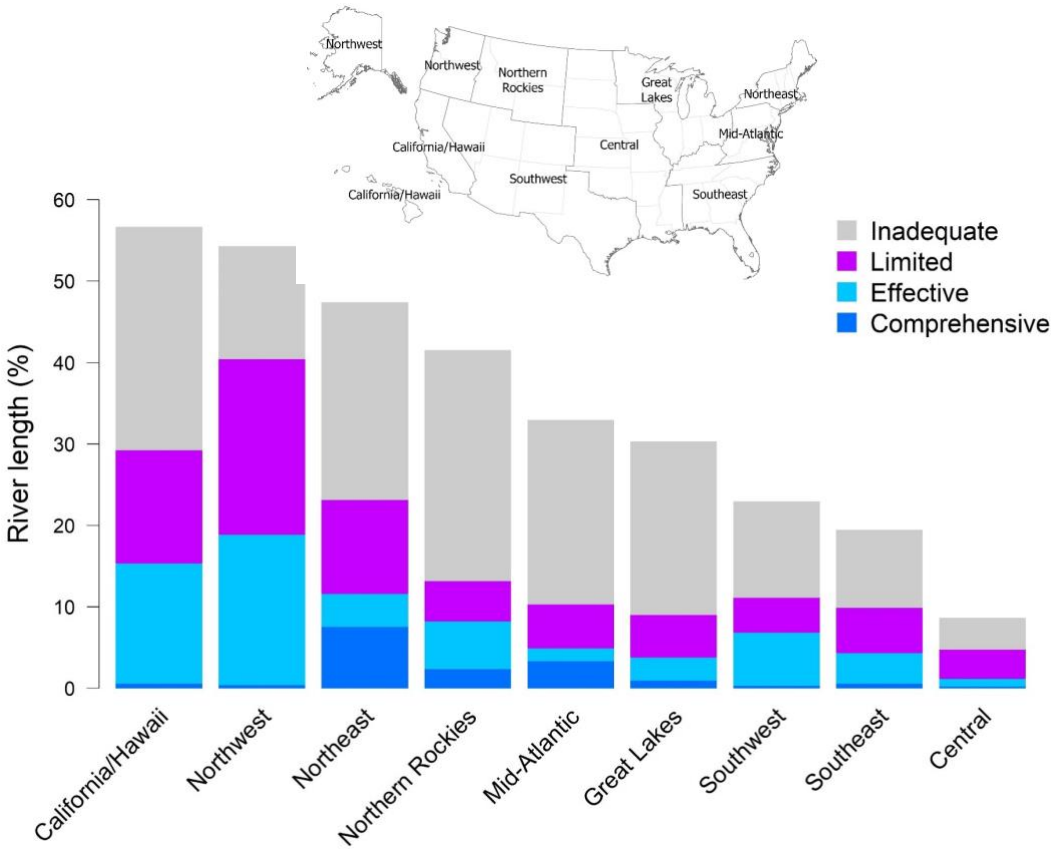

Figure 14. Percentage of rivers across regions in the U.S. displaying a degree of protection classified Comprehensive protection (Class 1), Effective protection (Class 2), Limited protection (Class 3) and Inadequate protection (Class 4) according to the PRI. To account for differences in the total river miles across regions, protection is expressed in percentage of the total river miles for each region. The inset illustrates the spatial distribution of the regions.

4.2.2. Mechanisms of protection across PRI Classes

The PRI Classes are represented by different proportional contributions of the individual mechanisms of protection, reflecting the variability in the degree of intended protection for each individual mechanism (as defined using the weights attributed to the different key ecological attributes) as well as the overlap among several mechanisms of protection (which was considered to strengthen protection) (Figure 15). Comprehensive protection (Class 1) and Effective protection (Class 2) are mainly composed of individual mechanisms of protection belonging to the major categories of river-specific conservation system such as ONRW/OTRW and wild and scenic river programs, as well as terrestrial protected areas whose management objectives align explicitly with the conservation of freshwater resources ('strict'), such as wilderness areas and national parks. The Class Limited protection (Class 3) is mainly represented by other types of terrestrial protected areas ('other') such as national wildlife refuges and the Class Inadequate protection (Class 4) by riparian and floodplain protection mechanisms such as riparian buffers as well as multiple use landscapes/riverscapes (Gap status 3) such as national forests and grasslands or areas of critical environmental concern.

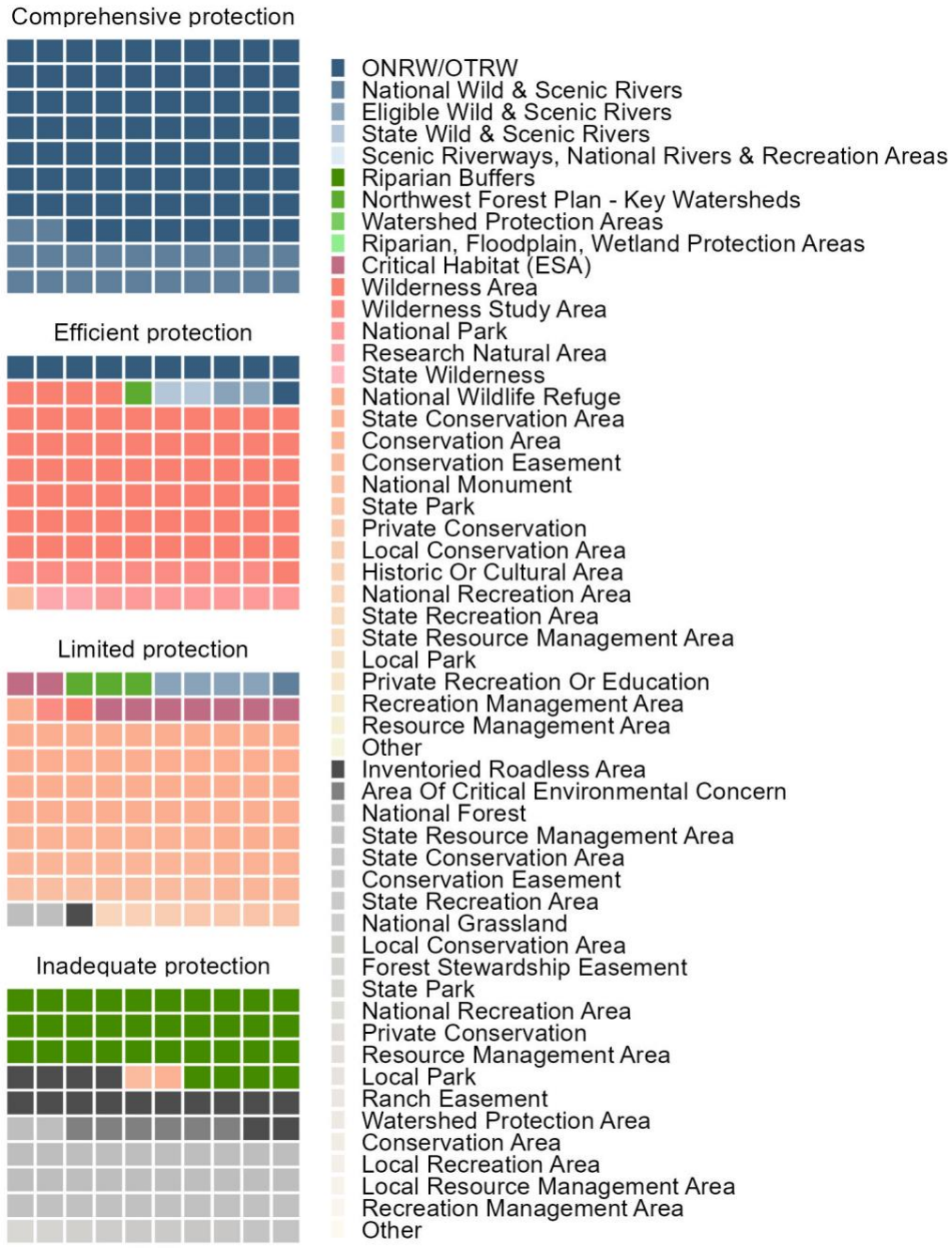

Figure 15. Proportional contribution of different protection mechanisms to the PRI Classes across the entire U.S. Each square represents 1% of the total cumulative river length protected by the protection mechanisms after removing the overlaps and classified as belonging to each PRI Class, with the color indicating individual protection mechanisms as represented by the associated legend (right).

5. Conclusions

The Protected Rivers Assessment of the United States reveals that many mechanisms of protection are being implemented in the U.S. but that the current level of protection is currently lagging behind the 30% conservation target set for 2030 in certain states and regions. Over the 4.4 million river miles analyzed across the nation, 33.5% (1,466,939 river miles) are intended to be protected by at least one mechanism. Over the 3.3 million miles in the contiguous U.S., 27.7% (910,709 river miles) are intended to be protected by at least one mechanism. Most of the protected rivers are managed through federal protection mechanisms, among which terrestrial protected areas (rivers flowing through protected areas primarily designed to preserve land against land use changes) represent the highest proportion, although less so for the contiguous U.S. (15.4% and 6.7% for the entire U.S. and contiguous U.S., respectively). In comparison, perhaps the strongest and most well-known river conservation system – the Wild and Scenic Rivers system – confers protection to 0.3% of rivers. The PRI intended to capture the extent to which key ecological attributes of rivers are being protected indicates that about 19.3% (846,372 river miles) of the nation's rivers and 11.7% (383,702 river miles) of rivers in the contiguous U.S. display a level of protection classified as viable, where at least one-quarter of 5 key freshwater ecological attributes are intended for protection. Further, these analyses capture clear inequalities in the degree of protection through space, with watersheds located in Alaska as well as the northwestern and northeastern states and regions displaying a consistently higher degree of protection than in the central parts of the country. These findings demonstrate successes of river protection in some areas of the U.S. and point to the need to dramatically scale permanent protection for rivers to better support biodiversity and equitable access to healthy rivers for all. The assessment highlights opportunities to enhance existing but insufficient protection, for example through regulatory changes to multiple land use designations to emphasize biodiversity protection over extractive uses or through enhanced protection via complementary mechanisms of protection targeting different key ecological attributes.

6. Acknowledgements

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Appendix A. Maps and data sources for individual mechanisms of protection

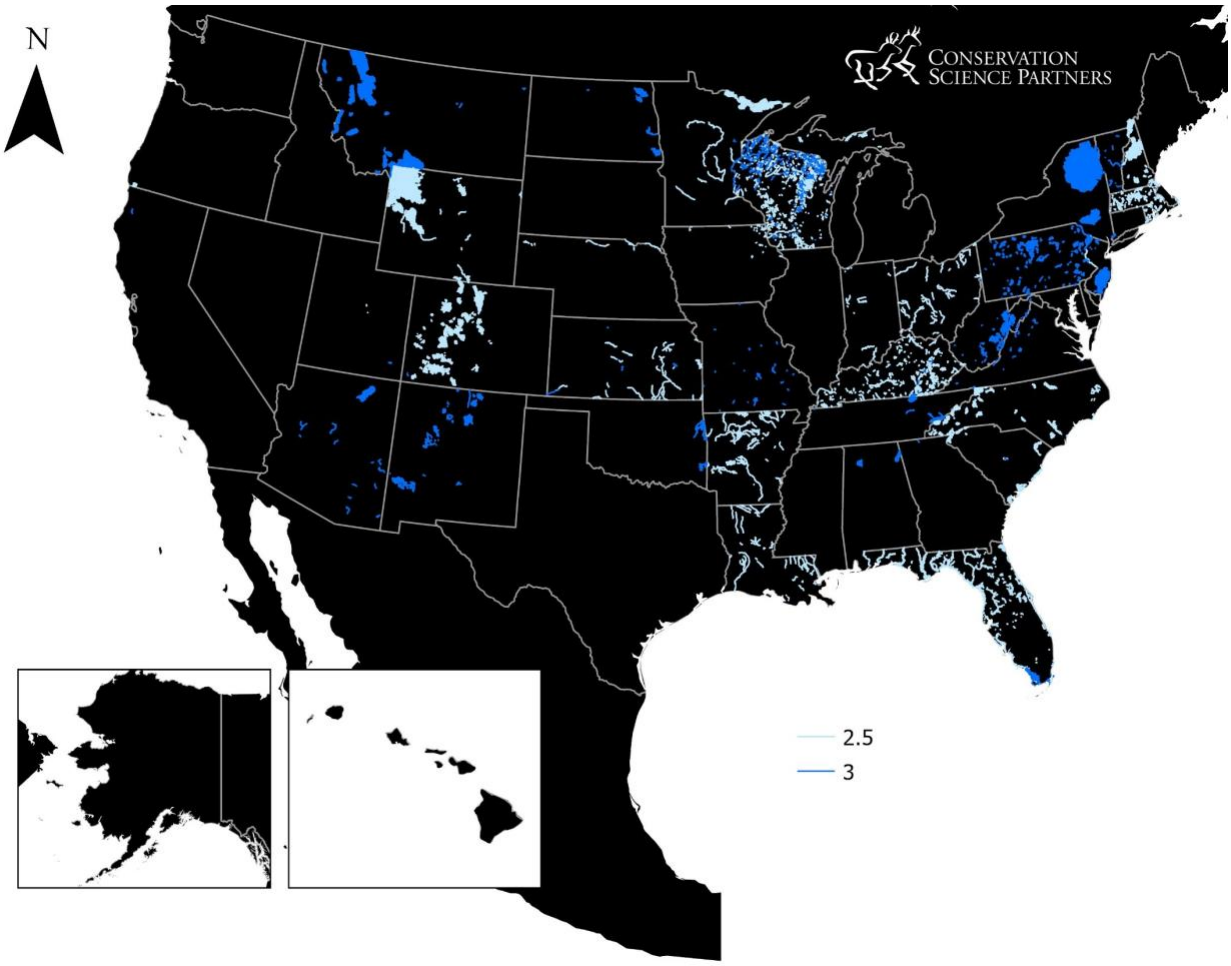

Figure S1. Map of Outstanding National, Tribal or State Resource Waters used in this assessment. River segments are colored according to their classification as Tier 3 or Tier 2.5 waters (note that it also includes Tier 2.75 waters). See Tables S2 and S3 for more details.

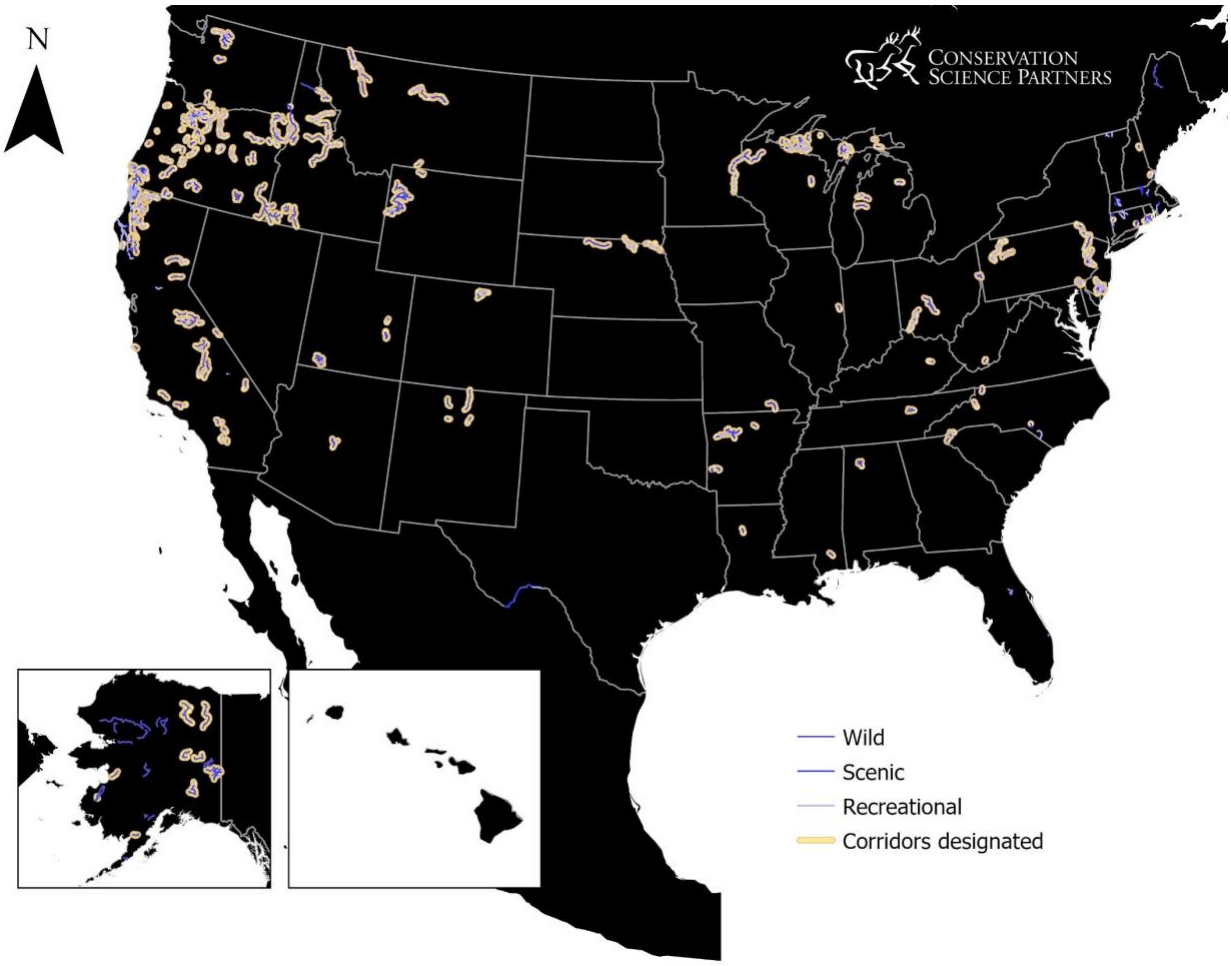

Figure S2. Map of designated national wild and scenic river segments. River segments are colored according to the designation type (wild, scenic or recreational river) and yellow polygons indicate river corridors.

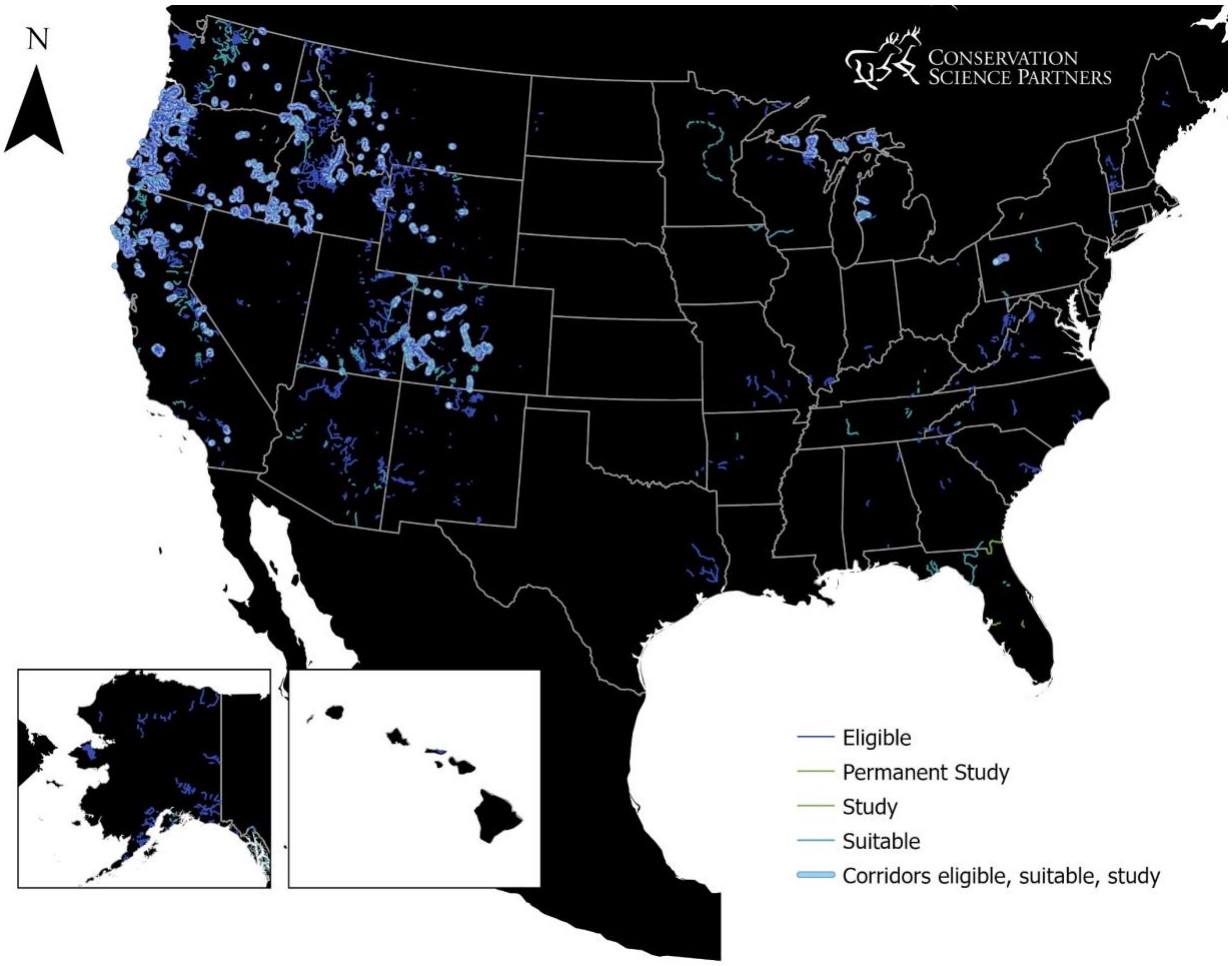

Figure S3. Map of eligible, suitable and study national wild and scenic river segments. River segments are colored according to the status (eligible, suitable or study river) and light blue polygons indicate river corridors.

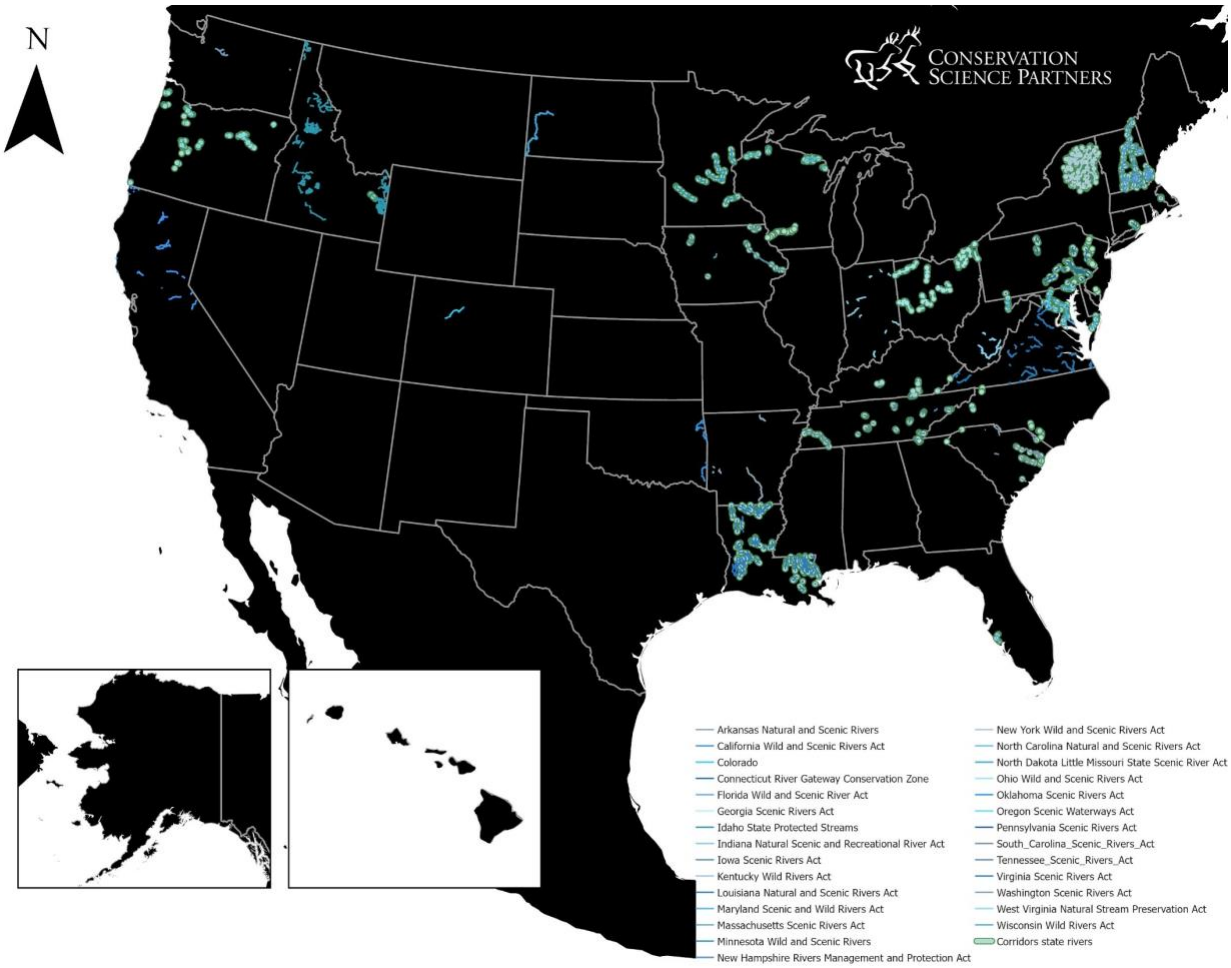

Figure S4. Map of state wild and scenic river segments. River segments are colored according to the state-specific wild and scenic programs (or equivalent) and light green polygons indicate river corridors. See Table S4 for more details and Figure S5 for the delineation of river corridors.

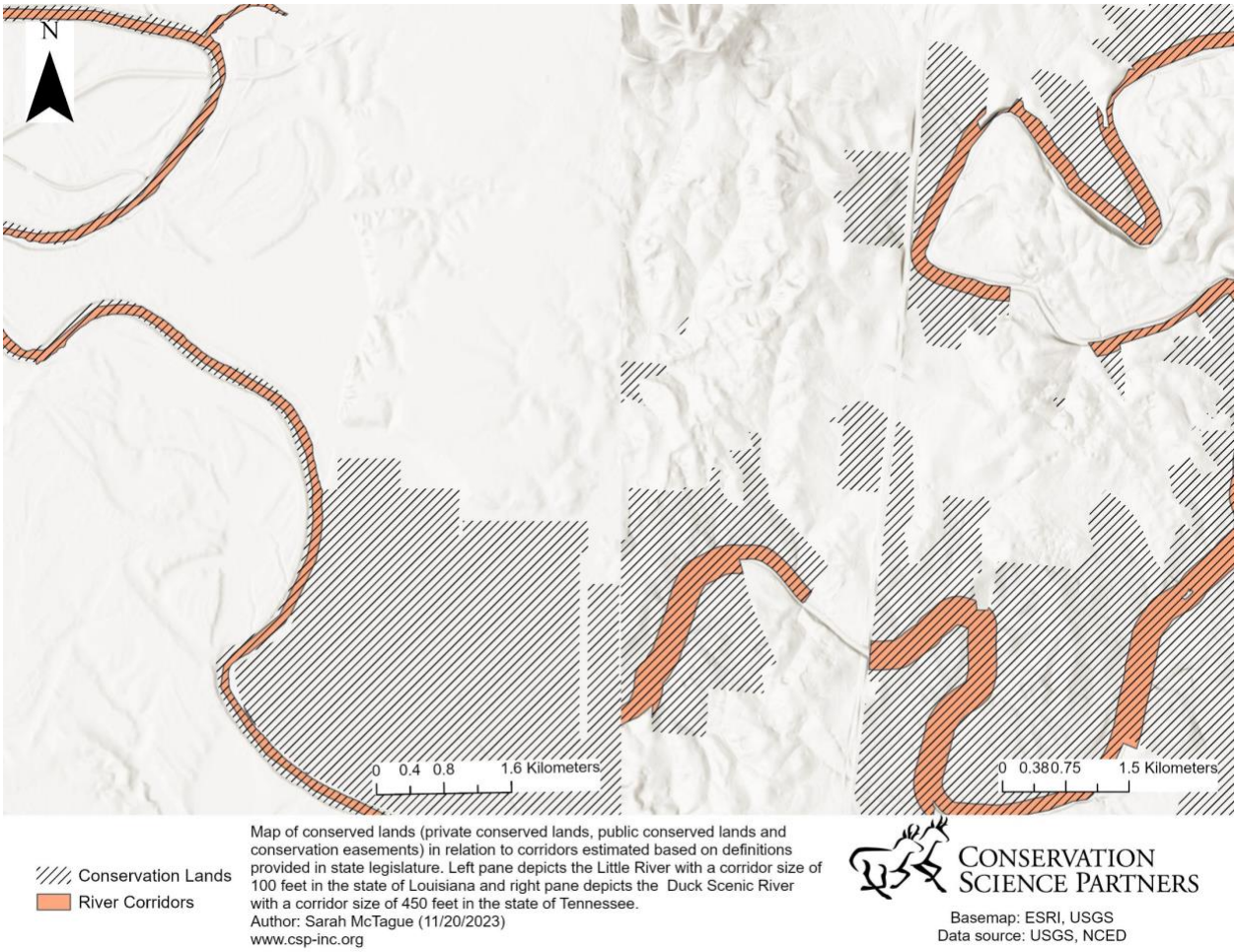

Figure S5. Examples of the delineation of river corridors for designated state wild and scenic rivers. See Table S4 for more details.

Figure S6. Map of river segments benefiting from protection through scenic riverways, national rivers and recreation areas and. River segments are colored according to their designation type.

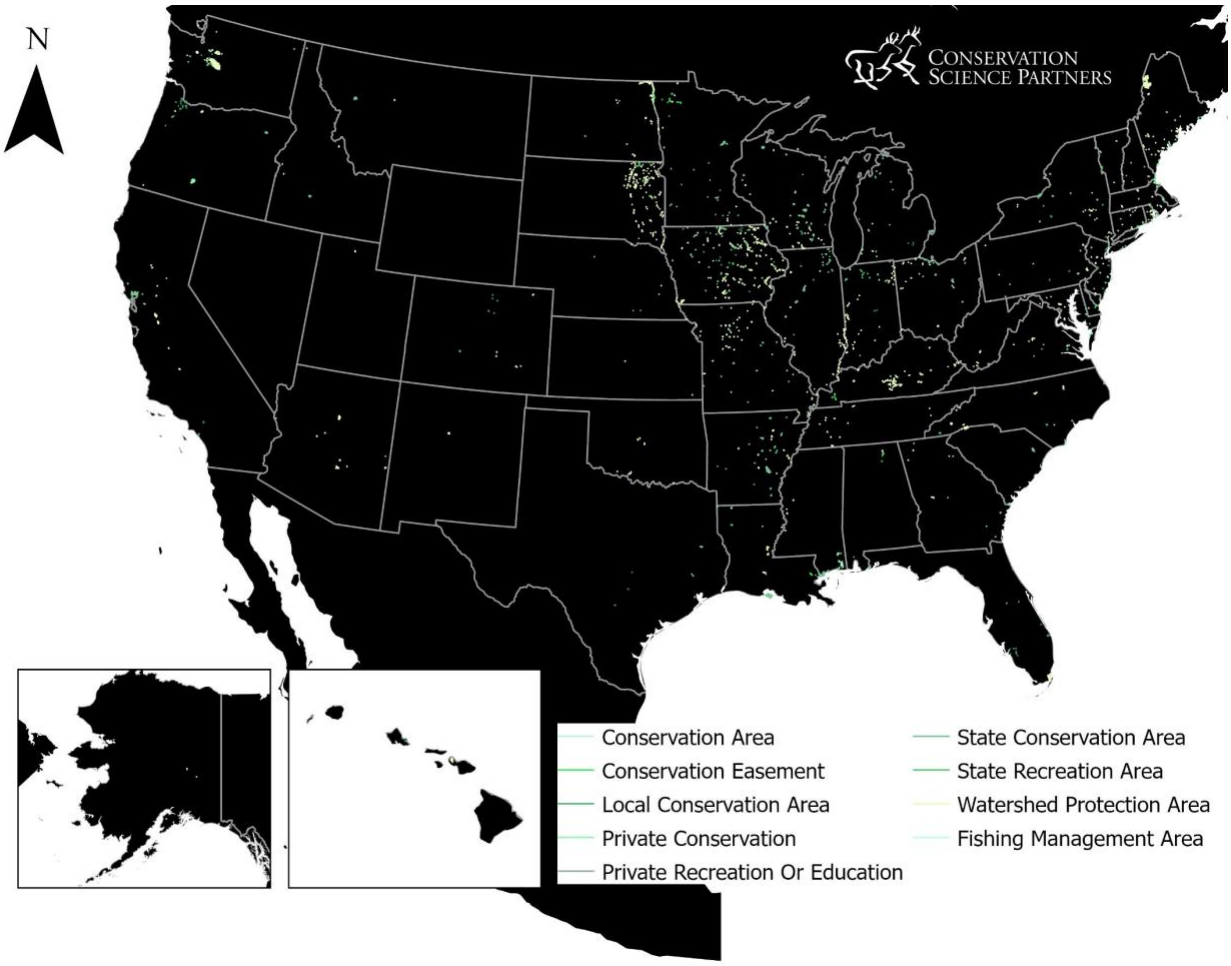

Figure S7. Map of river segments benefiting from protection through riparian, floodplain, wetland conservation areas, watershed protection areas and fishing Management areas. River segments are colored according to their designation type.

Figure S8. Map of the river segments benefiting from protection through the key watersheds of the Northwest Forest Plan.

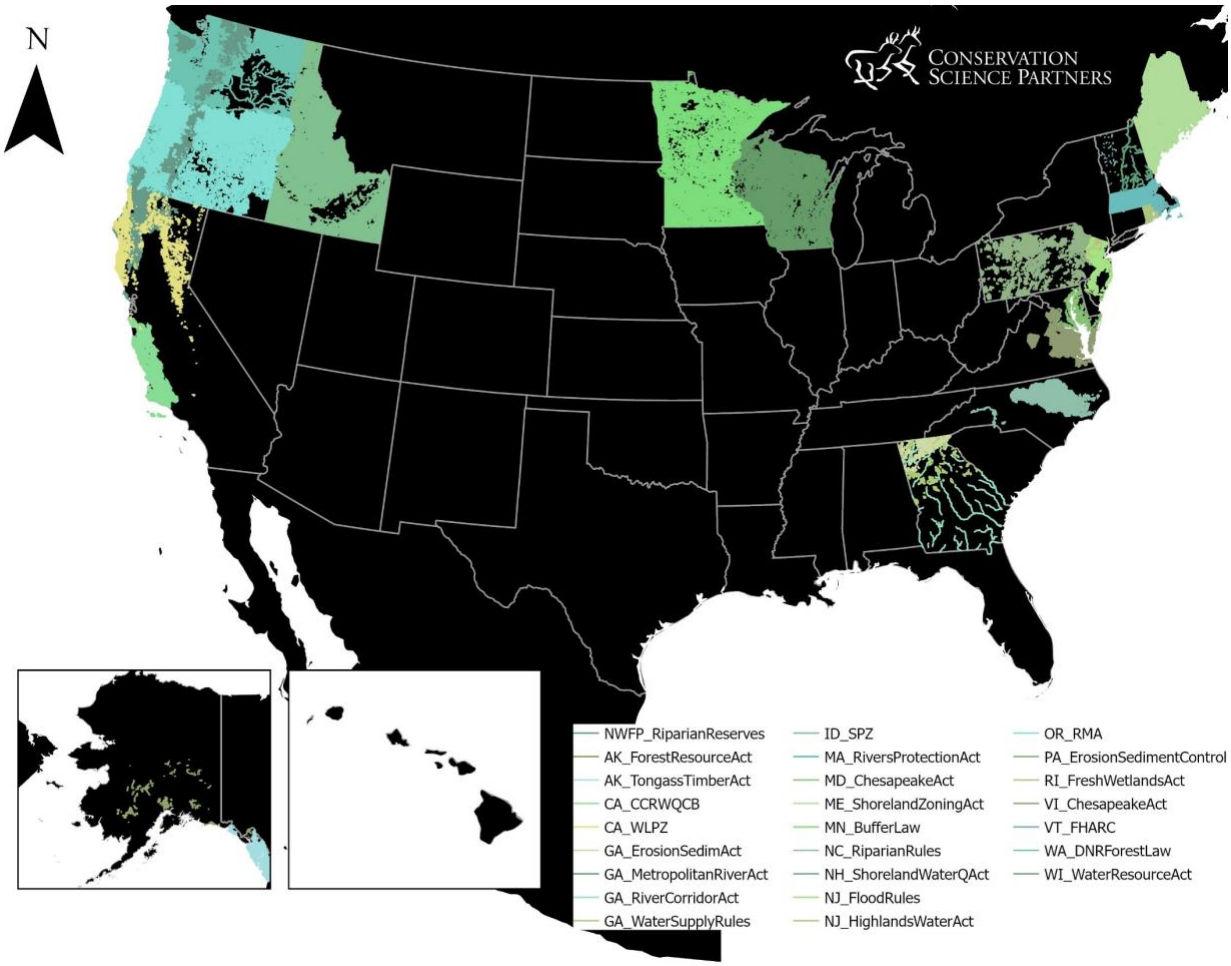

Figure S9. Map of the river segments benefiting from protection through riparian buffers. River segments are colored according to the regional (riparian reserves of the Northwest Forest Plan) or state-specific ordinances and administrative rules. See Table S5 for more details.

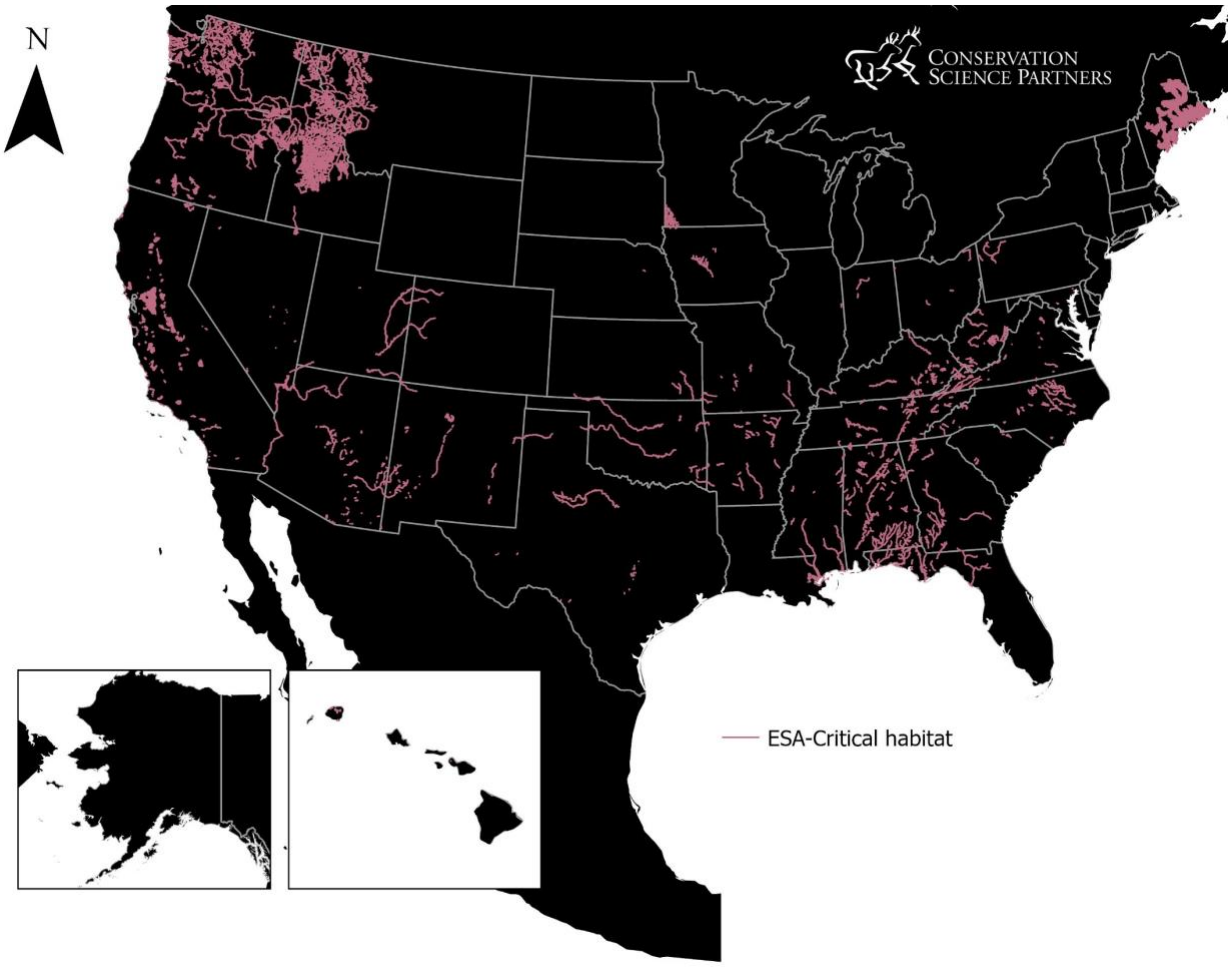

Figure S10. Map of the river segments benefiting from protection through critical habitat for ESA-listed endangered or threatened freshwater dependent species.

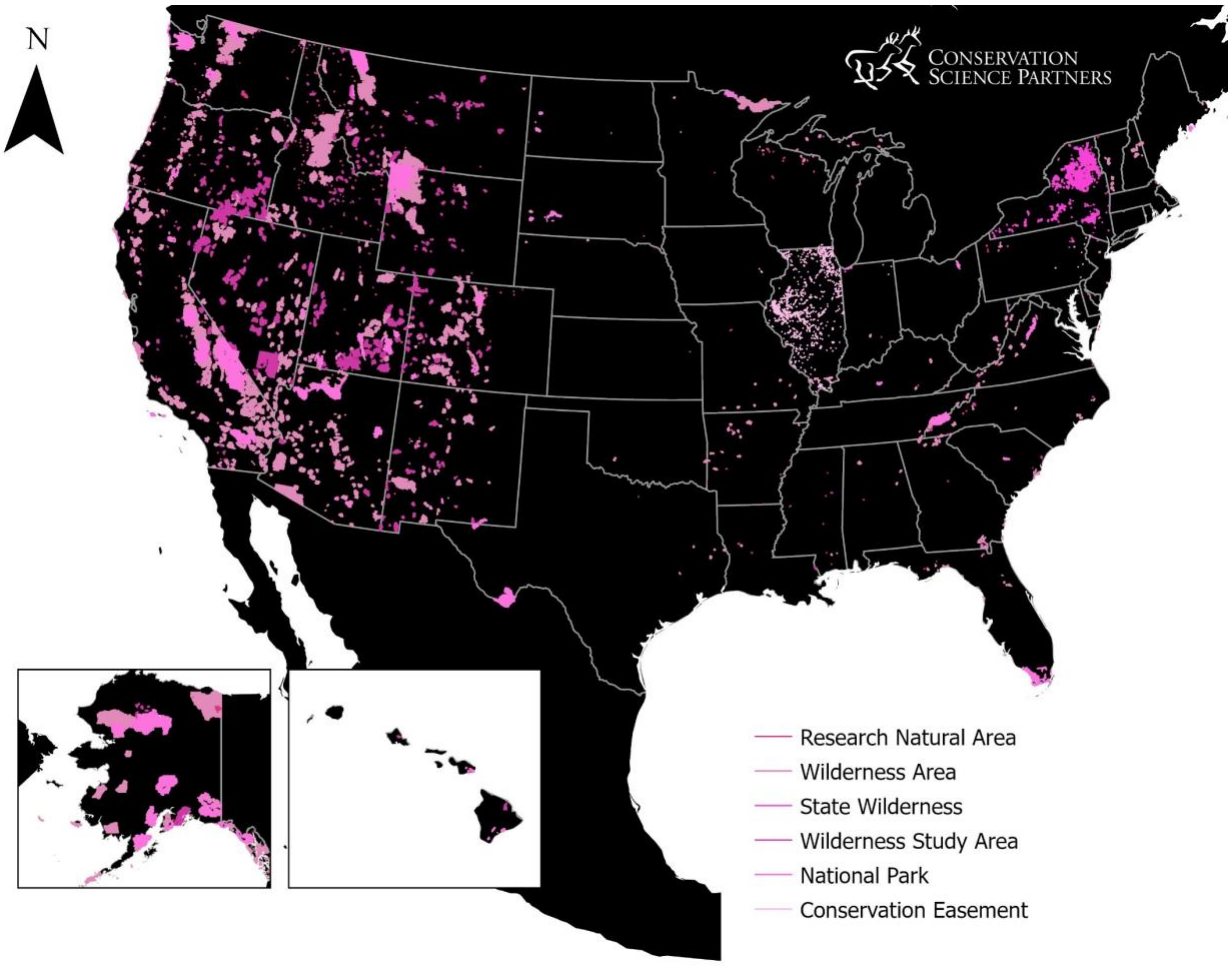

Figure S11. Map of the river segments benefiting from protection through terrestrial protected areas whose management objectives align explicitly ('strict': research natural areas, wilderness areas and national parks) with the conservation of freshwater resources) with the conservation of freshwater habitats. River segments are colored according to their designation type.

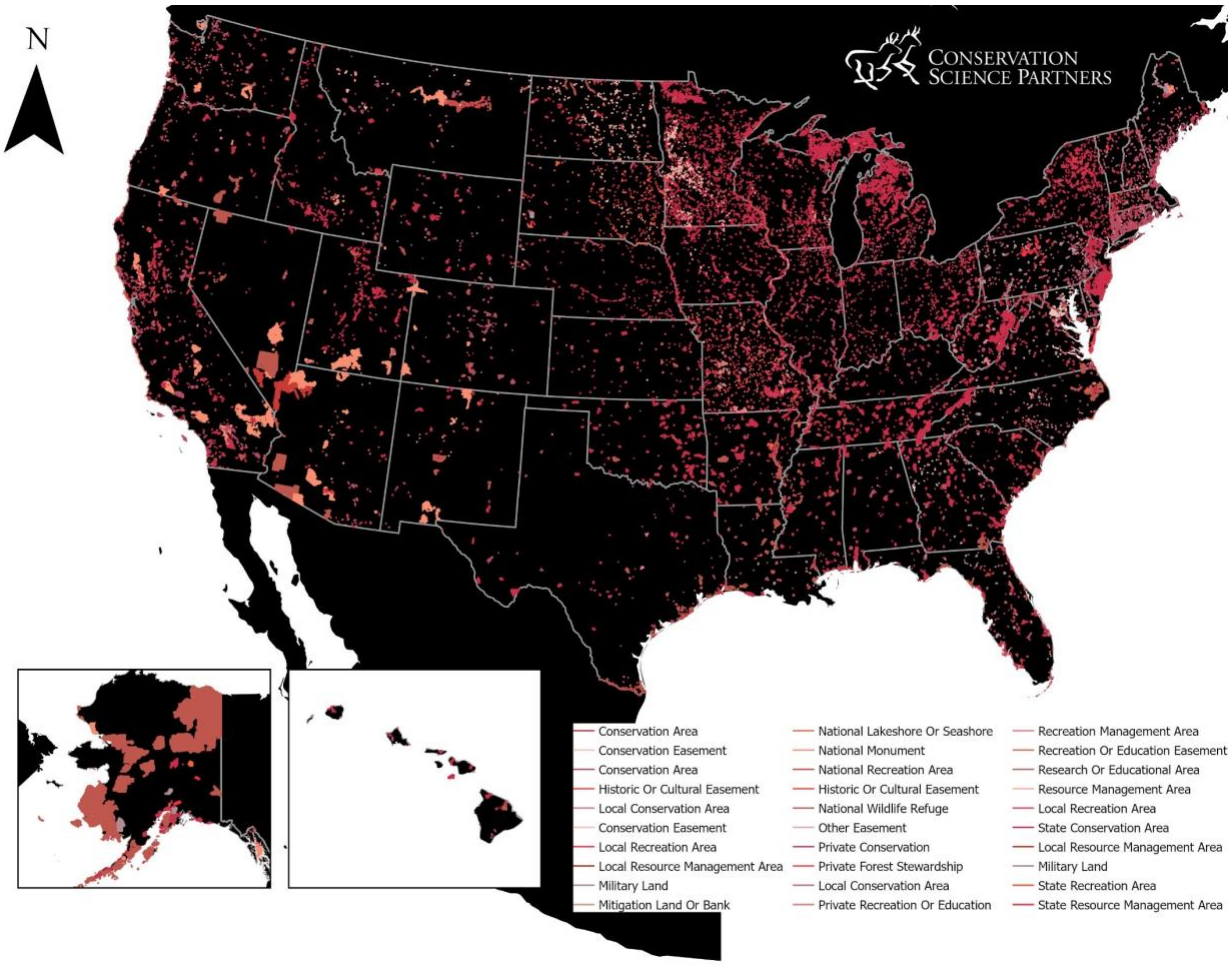

Figure S12. Map of the river segments benefiting from protection through terrestrial protected areas (other) whose management objectives usually align only incidentally with the conservation of freshwater resources. River segments are colored according to their designation type.

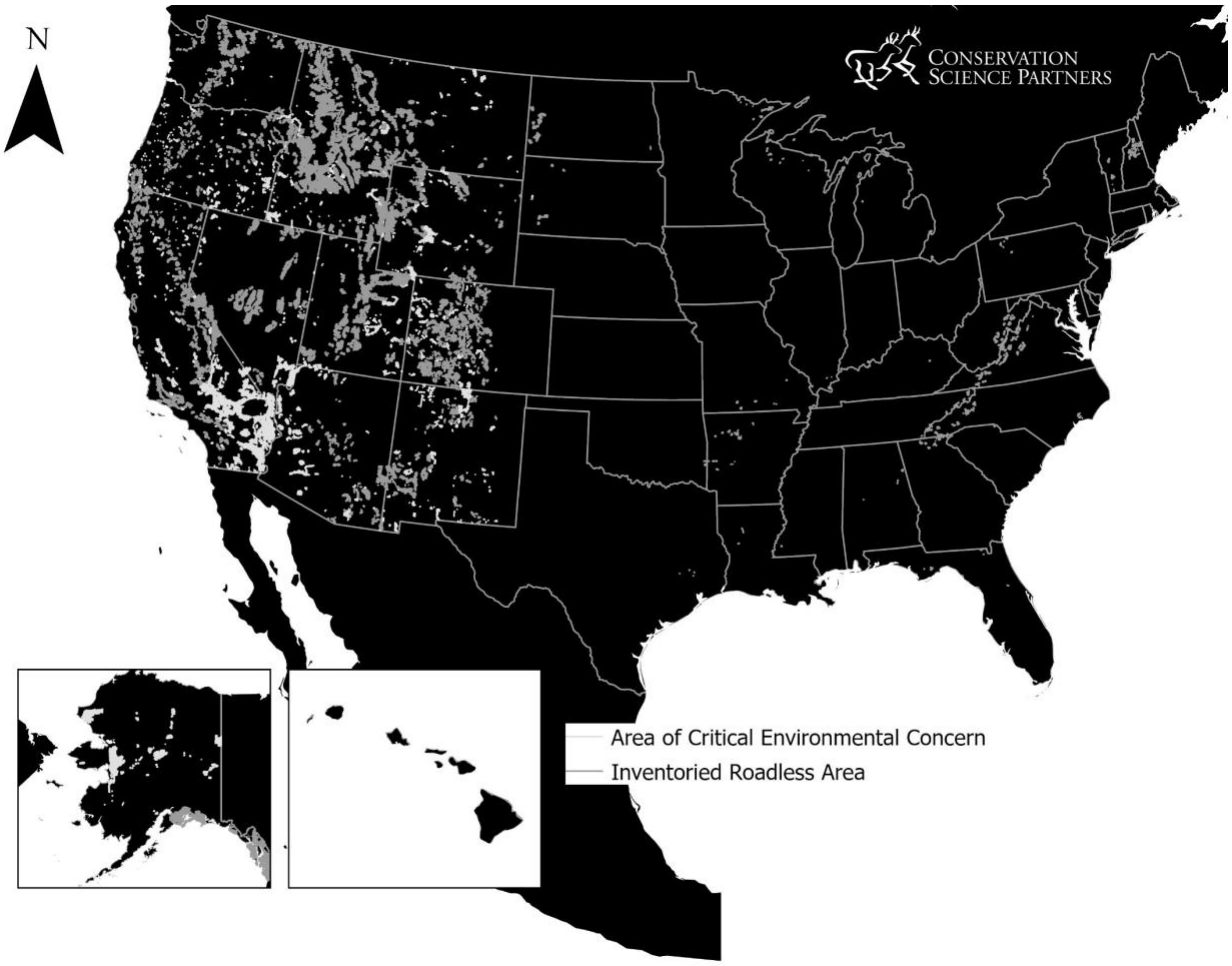

Figure S13. Map of the river segments benefiting from extended protection through multiple use landscapes/riverscapes with an emphasis on biodiversity conservation ('special management': areas of critical environmental concern and inventoried roadless areas). River segments are colored according to their designation type.

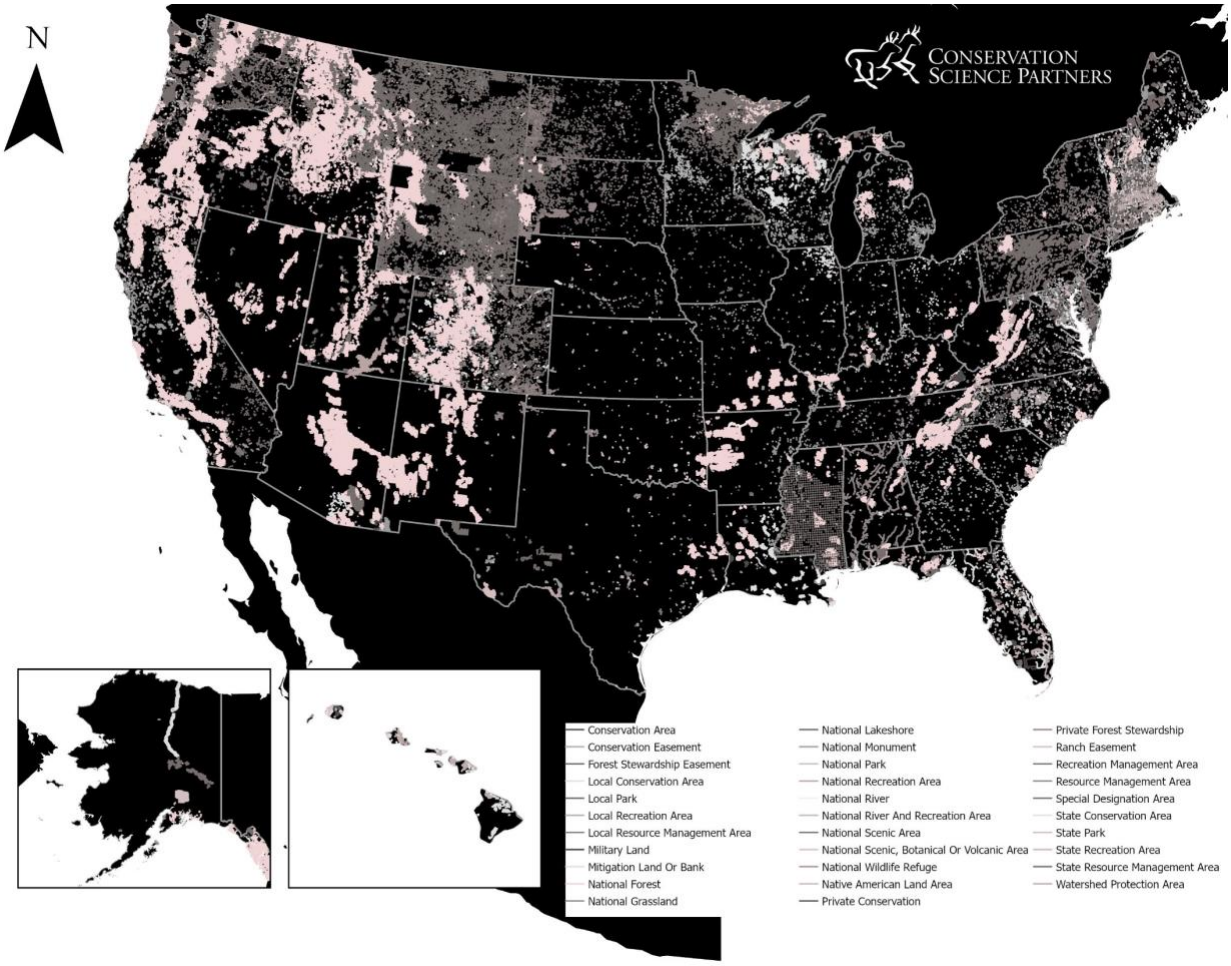

Figure S14. Map of the river segments benefiting from extended protection through other multiple use landscapes/riverscapes designation types, as well as areas with unassigned IUCN category. River segments are colored according to their designation type.

Table S1. Data sources used in this assessment. More details regarding ONRW/OTRW, state-level wild and scenic river and riparian buffers datasets can be found in Tables S2-S5.

Data type	Data source	Reference
Hydrographic network	NHDPlus v2.1	[1]
Hydrographic network	NHD Best Resolution - Alaska	[2]
Protected areas	PAD-US v3.0	[3]
Protected areas	NCED	[4]
Wild & Scenic Rivers - designated	National Wild and Scenic River Segments	[5]
Wild & Scenic Rivers - designated (corridors)	National Wild and Scenic Rivers	[6]
Wild & Scenic Rivers - designated (corridors)	Wild and Scenic River Boundaries	[7]
Wild & Scenic Rivers - designated (corridors)	BLM AK Wild and Scenic River Corridor	[8]
Wild & Scenic Rivers - designated (corridors)	BLM UT Designated Wild and Scenic River Corridors	[9]
Wild & Scenic Rivers - designated (corridors)	BLM CA Wild and Scenic River Corridors	[10]
Wild & Scenic Rivers - designated (corridors)	BLM OR Wild and Scenic Rivers Line Hub	[11]
Wild & Scenic Rivers - designated (corridors)	BLM NM Wild and Scenic Rivers Corridors	[12]
Wild & Scenic Rivers - eligible and suitable	National Wild and Scenic River Eligible and Suitable Lines	[13]
Wild & Scenic Rivers - study rivers	National Wild and Scenic River Active Study Rivers	[14]
ESA-Critical habitat	Critical Habitat - Linear Features	[15]
ESA-Critical habitat	Critical Habitat - Polygon Features	[16]
Northwest Forest Plan - Key Watersheds	Key Watersheds, 2002	[17]

[1] U.S. Geological Survey [USGS] (2019) USGS National Hydrography Dataset v2.1 (NHD) for Hydrologic Unit (HU) 4 - 2001 (published 02102019). Available at https://www.epa.gov/waterdata/get-nhdplus-national-hydrography-dataset-plus-data.

[2] U.S. Geological Survey [USGS] (2023) USGS National Hydrography Dataset Best Resolution (NHD) - Alaska (published 12272023). Available at https://www.sciencebase.gov/catalog/item/61f8b8ced34e622189c328f7.

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Table S2. Characteristics of the ONRW/OTRW datasets used in the assessment.

	ONRW policy	Abbreviation	Tier	Designation	Regulation	Data source
Alabama	yes	ONRW	3	Outstanding National Resource Waters	335-6-11-Water Use Classifications	Accessed from: https://adem.alabama.gov/programs/water/constructionstormwater.cnt
Alaska	no (draft)	ONRW	3	Outstanding National Resource Waters	18 AAC 70.015(a)(3)] regulations	
Arizona	yes	OAW	3	Outstanding Arizona water	R18-11-112(G) OAWs - Tier 3	Provided by Pima County Information Technology Department
Arkansas	yes	ERW	2.5	Extraordinary Resource Waters	Reg. 2.203 Extraordinary Resource Waters	Accessed from: https://gis.arkansas.gov/product/extraordinary-resource-waters-segments-line/
California	yes (but no designation for rivers)	ONRW	3	Outstanding National Resource Water	Resolution 68-16	
Colorado	yes	OW	2.5	Outstanding Waters	§25-8-209	Accessed from: https://cdphe.colorado.gov/clean-water-gis-maps
Connecticut	yes (but no designation yet)	ONRW		Outstanding National Resource Waters	§22a-426-1 (50)	
Delaware	yes	SRW; OBW	2.5/3	Significant Resource Waters; Outstanding Basin Waters	§3.10.3.A.2.a	Accessed from: https://www.nj.gov/drbc/basin/map/GIS.html
District of Columbia	yes	SWDC	2.5	Special waters of the District of Columbia	Rule 1102.4	Digitized from description: https://doee.dc.gov/service/surface-water-quality-standards
Florida	yes	OFW; ONRW	2.5/3	Outstanding Florida Waters; Outstanding National Resource Waters	62-4.242	Accessed from https://geodata.dep.state.fl.us/datasets/outstanding-florida-waters/explore (using watershed delineations)
Georgia	yes	ONRW	3	Outstanding National Resource Water	391-3-6-.03	Accessed from: https://opendata.atlantaregional.com/dat

						asets/GARC::rivers-streams-georgia/explore based on information from text: https://epd.georgia.gov/watershed-protection-branch/watershed-planning-and-monitoring-program/georgia-water-quality
Hawaii	no (draft)	ONRW	3	Outstanding National Resource Water	HAR 11-54-1.1	
Idaho	yes (but no designation yet)	ONRW	3	Outstanding National Resource Water	§39-3620	
Illinois	yes (but no designation yet)	ORW	3	Outstanding Resource Waters	35 Ill. Adm. Code 303.205, 35 Ill. Adm. Code 303.206	
Indiana	yes (but no designation for ONRW)	OSRW; ONRW	2.9/3	Outstanding State Resource Waters; Outstanding National Resource Water	327 IAC 2-1-9, 327 IAC 2-1-10	Accessed from: https://maps.indiana.edu/previewMaps/Hydrology/Water_Bodies_Rivers_Outstanding.html
Iowa	yes (but no designation for ONRW)	OIW; ONRW	2.5/3	Outstanding Iowa Water; Outstanding National Resource Water	IAC 455B.105 and 455B.173	Accessed from: https://www.arcgis.com/home/item.html?id=6b58f0fa2c334c56a50d4da817d34df9
Kansas	yes	ESW; ONRW	2.5/3	Exceptional State Waters; Outstanding National Resource Waters	K.A.R. 28-16-28c(a)	Accessed from: https://hub.kansasgis.org/datasets/84b695d9afaa446795b381257bd369e6_1/explore?location=38.483310%2C-98.301350%2C8.38
Kentucky	yes	OSRW; ONRW	2.5/3	Outstanding State Resource Waters; Outstanding National Resource Water	401 Ky. Admin. Regs. 10:030	Accessed from: https://ky.app.box.com/v/energy-environment/file/850634358218
Louisiana	yes	ONRW	2.5	Outstanding Natural Resource Water	LAC 33:IX.1109.A.3.	Digitized from description: https://deq.louisiana.gov/assets/docs/Permits/SCC3-G.pdf using: https://mygeodata.cloud/data/download/osm/rivers/united-states-of-america--

						louisiana
Maine	yes	ONRW	3	Outstanding National Resource Water	MRS Title 38, §464	Accessed from: https://gis.maine.gov/arcgis/rest/services/dep/Maine_DEP_Outstanding_National_Resource_Waters/MapServer
Maryland	yes (but no designation yet)	ONRW	3	Outstanding National Resource Water	26.08.02.04-3	
Massachusetts	yes	ORW	2.5	Outstanding Resource Water	314 CMR 4.00	Accessed from: https://www.mass.gov/info-details/massgis-data-outstanding-resource-waters#downloads-
Michigan	yes	OSRW	2.5	Outstanding State Resource Water	R 323.1098	Digitized from: https://casetext.com/regulation/michigan-administrative-code/department-environmental-quality/water-resources-division/water-resources-protection/part-4-water-quality-standards/section-r-3231098-antidegradation using https://data-usfs.hub.arcgis.com/datasets/national-wild-and-scenic-river-segments-feature-layer/explore?location=42.733790%2C-82.487628%2C6.82 & https://gis-egle.hub.arcgis.com/datasets/7fc78cd7dc7d414dbfc839e2e95306f3_1/explore?location=44.262656%2C-84.863036%2C7.30
Minnesota	yes	ORVW	2.5	Outstanding Resource Value Water	Minn. R. 7050.0335	Accessed from: https://files.pca.state.mn.us/pub/file_requests/datasets/Water/
Mississippi	yes (but no designation)	ONRW	3	Outstanding National Resource Water	Miss. Code Ann. §§ 49-2-9, 49-17-17, 49-2-1, et seq. and 49-17-1	
Missouri	yes	OSRW	3	Outstanding State	10 CSR 20-	Accessed from: https://data-

				Resource Water	7.031(2)(C)	msdis.opendata.arcgis.com/datasets/MSDIS::mo-2013-outstanding-resource-waters-rivers-streams/explore?location=38.416019%2C-92.175212%2C7.67
Montana	yes	ORW	3	Outstanding Resource Water	§75-5-316(3)	Digitized based on information from: https://leg.mt.gov/bills/mca/title_0750/chapter_0050/part_0030/section_0160/0750-0050-0030-0160.html using https://www.sciencebase.gov/catalog/item/622262ded34ee0c6b38b6bd3
Nebraska	yes	OSRW; ONRW	2.5/3	Outstanding State Resource Water; Outstanding National Resource Water	Neb. Rev. Stat. §§ 81-1501(1) and 81-1505(1)(2)	Digitized based on information from: https://www.nebraska.gov/nesos/rules-and-regs/regtrack/proposals/00000000000001431.pdf using https://www.nebraskamap.gov/datasets/nebraska::major-streams/explore?location=43.670596%2C-102.781556%2C7.00 & https://www.nebraskamap.gov/datasets/nebraska::streams-title-117/explore?location=42.226900%2C-97.987205%2C9.76
Nevada	no (draft)	EAW		Ecological and Aesthetic Water		
New Hampshire	yes	ORW	2.5	Outstanding Resource Water	Env-Wq 1702.35	Accessed from https://www.nhgeodata.unh.edu/datasets/db1906ba00e547599d79054875fe0005/explore?location=44.108907%2C-71.351072%2C10.75 using https://www.nhgeodata.unh.edu/datasets/NHDES::outstanding-resource-water-watersheds-2/explore
New Jersey	yes	ONRW	3	Outstanding National Resource Water	N.J.A.C. 7:9B-1.5(d), N.J.A.C. 7:9B	Accessed from: https://gisdata-njdep.opendata.arcgis.com/datasets/njdep::surface-water-quality-classification-of-

						new-jersey/explore?location=40.426381%2C-74.319255%2C8.89
New Mexico	yes	ONRW	3	Outstanding National Resource Water	Rule 20.6.4.9 of NMAC	Provided by New Mexico Environment Department
New York	no (but alternative system)	Class AA-S; Class N; Forever wild	consistent with Tier 3	Class AA-Special; Class N	6 NYCRR 701.2;	Accessed from: https://data.gis.ny.gov/maps/258fe1be90ff48f385a546cdfd998e24/about
North Carolina	yes	ORW	2.5	Outstanding Resource Water	15A N.C. Admin. Code 2B.0216	Accessed from: https://data-ncdenr.opendata.arcgis.com/datasets/ncdenr::dwr-orw-hqw-management-areas-polygons/about
North Dakota	yes	OSRW	3	Outstanding State Resource Waters	rule 33-16-02.1-02, Appendix IV	Digitized based on information from: https://deq.nd.gov/publications/WQ/3_WM/AssessmentMethodology/Final_ND_AssessmentMethodology_20180223.pdf using: https://gishubdata-ndgov.hub.arcgis.com/datasets/ndgishub-streams-and-rivers-100k/explore?location=47.493660%2C-100.749355%2C12.00&showTable=true
Ohio	yes (but no ONRW designation yet)	OSW; ONRW	2.5/3	Outstanding State Water; Outstanding National Resource Water	OAC 3745-1-05	Accessed from: https://data-oepa.opendata.arcgis.com/datasets/antidegredation-tiers-surface-water-beneficial-use
Oklahoma	yes	ORW	3	Outstanding Resource Water	OAC 785:45-3-2(a)	Accessed from: https://www.oklahoma.gov/owrb/maps-and-data/gis-data.html
Oregon	yes	ORW	2.5	Outstanding Resource Water	ORS 468B	Digitized based on information from: https://www.oregon.gov/deq/wq/pages/wq-standards-policies.aspx using https://spatialdata.oregonexplorer.info/geoportal/search;q=*river*
Pennsylvania	yes	EV	3	Exceptional Value Water	25 Pa. Code § 93.9	Accessed from: https://www.pasda.psu.edu/uci/DataSummary.aspx?dataset=1098

Rhode Island	yes (but no ONRW designation yet)	SRPW; ONRW	2.5/3	Special Resource Protection Water; Outstanding National Resource Water	250-150-05 R.I. Code R. § 1.20	Accessed from: https://www.rigis.org/datasets/edc::rivers-and-streams-ri-integrated-water-quality-monitoring-assessment-2012/explore?showTable=true based on information from: https://www.epa.gov/sites/default/files/2014-12/documents/riwqs.pdf
South Carolina	yes	ORW; ONRW	2.5/3	Outstanding Resource Water; Outstanding National Resource Water	S.C. Code Sections 48-1-10 et seq.	Provided by South Carolina Department of Health and Environmental Control
South Dakota	yes (but no designation yet)	OSRW	3	Outstanding State Resource Water	Rule 74:51:01:39, Rule 340.041.0004	
Tennessee	yes (no data available for ETW yet so only ONRW were included)	ETW; ONRW	2.5/3	Exceptional Tennessee Waters; Outstanding National Resource Water	Chapter 0400-40-03, 0400-40-03-06	Digitized based on information from: https://dataviewers.tdec.tn.gov/dataviewers/f?p=2005:34304:12897918527595 using https://tdec-division-of-water-tdec.hub.arcgis.com/datasets/90a4028db6054a0c9885d76a2628e127_6/explore?location=35.260576%2C-86.229484%2C6.00
Texas	yes (but no designation yet)	ONRW	3	Outstanding National Resource Water	307.5(b)(3)	
Utah	yes	Category 1	2.5	Category 1 Waters	UAC R317-2-3	Accessed from: https://gis.utah.gov/data/water/lakes-rivers-dams/ using boundaries in https://documents.deq.utah.gov/legacy/programs/water-quality/standards-technical-services/docs/2011/11Nov/Category1and2waters.kmz
Vermont	yes	ORW	3	Outstanding Resource Waters	V.S.A., Title 10, section 1422	Accessed from: https://vermont-dcdev.hub.arcgis.com/datasets/e17704bd929b4798a693af287ea476cb/explore

Virginia	yes	ESW	3	Exceptional State Waters	9 VAC 25-260-30.A.3	Digitized based on information from: https://19january2017snapshot.epa.gov/sites/production/files/2014-12/documents/vawqs.pdf using: https://geohub-vadeq.hub.arcgis.com/datasets/b6db84dbec894e3ea1dcab802c34cc8a_236/explore?location=37.904732%2C-79.571900%2C7.86
Washington	yes (but no designation yet)	ORW	3	Outstanding State Water	WAC Chapter 173-201AWAC 173-201A-330	
West Virginia	yes	ONRW	3	Outstanding National Resource Water	WVCSR 46-l-4.1.g	Accessed from: https://dep.wv.gov/WWE/Programs/wqs/Pages/default.aspx
Wisconsin	yes	ERW; ORW	2.5/3	Exceptional Resource Water; Outstanding Resource Water	NR207	Accessed from: https://data-wi-dnr.opendata.arcgis.com/maps/wi-dnr::outstanding-and-exceptional-rivers-and-streams/about
Wyoming	yes	Class 1	2.5	Class 1, Outstanding Waters	020-1 Wyo. Code R. § 1-4	Accessed from: https://deq.wyoming.gov/water-quality/watershed-protection/surface-water-quality-standards/ (Class-1-Shapefiles.zip)

Table S3. Characteristics of the OTRW datasets used in the assessment.

Tribe	ONRW policy	Abbreviation	Tier	Designation	Data
Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation (MT)	yes (but no designation yet)	ONRW		Outstanding National Resource Water	
Bad River Band of Lake Superior Chippewa (WI)	yes (but data not available)	ORW; OTRW	2.5/3	Outstanding Resource Water; Outstanding Tribal Resource Water	https://www.arcgis.com/apps/View/index.html?appid=6f44c371217e4ee8b5f1c2c705c7c7c5
Big Pine Paiute Tribe of the Owens Valley (CA)	yes (but no designation yet)	ONRW		Outstanding National Resource Water	
Bishop Paiute Tribe (CA)	yes (but no designation yet)	ONRW		Outstanding National Resource Water	
Blackfeet Tribe (MT)	yes (but no designation yet)	OTRW		Outstanding Tribal Resource Waters	
Cabazon Band of Mission Indians (CA)	None at this time				
Chemehuevi Tribe of the Chemehuevi Reservation (CA)	None at this time				
Coeur D'Alene Tribe (ID)	yes (but no designation yet)	OTRW; ONRW		Outstanding Tribal Resource Waters; Outstanding National Resource Waters	
Confederated Salish and Kootenai Tribes of the Flathead Reservation (MT)	yes	ONRW	3	Outstanding National Resource Waters	Provided by TNC [all waters located within Tribally designated primitive or wilderness areas]
Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians (OR)	None at this time				
Confederated Tribes of the Chehalis Reservation (WA)	yes (but no designation yet)	ONRW		Outstanding National Resource Waters	

Confederated Tribes of the Colville Reservation (WA)	yes (but no designation yet)	ONRW; ORRW		Outstanding National Resource Waters; Outstanding Reservation Resource Waters	
Confederated Tribes of the Goshute Reservation (NV, UT)	None at this time				
Confederated Tribes of the Umatilla Indian Reservation (OR)	yes (but no designation yet)	OTW		Outstanding Tribal Waters	
Confederated Tribes of the Warm Springs Reservation (OR)	yes (but no designation yet)	ORW		Outstanding Resource Waters of the Reservation	
Dry Creek Rancheria Band of Pomo Indians (CA)	None at this time				
Eastern Band of Cherokee Indians (NC)	yes (but TRW only, ORRW not available)	TRW; ORRW	2.5/3	Tribal Resource Waters; Outstanding Reservation Resource Waters	Digitized [All waters within the reservation are TRW]
Fond du Lac Band of Minnesota Chippewa (MN)	yes (but no designations for rivers)	ORRW	3	Outstanding Reservation Resource Waters	Waters designated Outstanding Reservation Resource Waters include Perch Lake, Rice Portage Lake, Dead Fish Lake, Jaskari Lake, and Wild Rice Lake
Gila River Indian Community (AZ)	None at this time				
Grand Portage Band of Minnesota Chippewa (MN)	yes (but only OTRW-restricted; OTRW-Prohibited designations are for Lake Superior)	OTRW-Prohibited; OTRW-Restricted	3/2.5	Outstanding Tribal Resource Water – Prohibited	Digitized [OTRW-Prohibited: portion of Lake Superior north of latitude 47 degrees, 57 minutes, 13 seconds, east of Hat Point, south of the Minnesota-Ontario boundary, and west of the Minnesota-Michigan boundary; OTRW-Restricted: All waters of the Reservation, except those portions designated as OTRW-Prohibited]
Havasupai Tribe (AZ)	None at this time				
Hoopa Valley Tribe (CA)	yes (incomplete as only W&S rivers were included as	ORW	3	Outstanding Resource Waters	Digitized [only portion of the W&S Trinity River are included]

	ORW designations not available)				
Hopi Tribe (AZ)	yes	UW	3	Unique Waters	Provided by TNC [In the Moencopi Wash watershed, from Blue Canyon Springs to the confluence of Begashibito Wash]
Hualapai Indian Tribe (AZ)	yes (but no data available)	OTRW	3	Outstanding Tribal Resource Waters	Segments assigned as Tier 3: Spencer; Meriwhitica; Willow Spring; Upper Milkweed Spring; Bridge Canyon; Travertine Spring; Travertine Falls; Diamond Creek; Diamond Creek Spring; Blue Mountain; Metuck; Peach Springs Spring; Westwater; Clay Tank; Hocky Puck; Pocamote Spring; Mohawk Spring; Granite Spring; Three Spring; Warm Spring; Honga Spring; National Canyon Spring; National Canyon; Moss Spring.
Jamestown S'Klallam Tribe (WA)	None at this time				
Kalispel Tribe of Indians (WA)	yes (but no designation yet)	ORW		Outstanding Resource Waters of the Reservation	
Karuk Tribe (CA)	None at this time				
Keweenaw Bay Indian Community (MI)	None at this time				
Kletsel Dehe Wintun Nation (CA) (formerly the Cortina Indian Rancheria)	yes (but no designation yet)	OTRW		Outstanding Tribal Resource Water	
La Jolla Band of Luiseño Indians (CA)	None at this time				
La Posta Band of Diegueno Mission Indians of the La Posta Indian Reservation (CA)	None at this time				
Lac du Flambeau Band of Lake Superior Chippewa (WI)	yes (but no designations for rivers)	ETRW; OTRW	2.5/3	Exceptional Tribal Resource Water; Outstanding Tribal Resource Water	

Leech Lake Band of Ojibwe (MN)	None at this time				
Lummi Tribe (WA)	yes (but no designation yet)	ORW		Outstanding Resource Waters	
Makah Indian Tribe (WA)	yes (but no designation yet)	ORW		Outstanding Resource Waters	
Miccosukee Tribe (FL)	yes (OMW but no ONRW at this time)	OMW; ONRW	2.75/3	Outstanding Miccosukee Waters; Outstanding Natural Resource Waters	Digitized [OMW: waters of its Federal Reservation which are contained within Water Conservation Area 3A (North Grass, South Grass, Gap) and Miccosukee Reserved Area; no ONRW]
Morongo Band of Mission Indians (CA)	None at this time				
Navajo Nation (AZ, NM, UT)	yes (but no designation yet)	EWNN		Exceptional Waters of the Navajo Nation	
Northern Cheyenne (MT)	yes (but no designation yet)	OTRW		Outstanding Tribal Resource Waters	
Ohkay Owingeh (NM) (formerly the Pueblo of San Juan)	yes (but no designation yet)				
Pala Band of Mission Indians (CA)	None at this time				
Pawnee Nation (OK)	None at this time				
Port Gamble S'Klallam Tribe (WA)	yes (but no designation yet)	ORW		Outstanding Resource Waters	
Pueblo of Acoma (NM)	yes (but no designation yet)				
Pueblo of Isleta (NM)	yes (but no designation yet)	ONRW		Outstanding National Resource Waterbody	
Pueblo of Laguna (NM)	yes	OTRW	3	Outstanding Tribal Resource Waters	Provided by TNC [Mountain Streams & Springs; Rio Paguate Above the Jack Pile Mine; Water Canyon Creek; Encinal Creek]
Pueblo of Nambe (NM)	yes (but no designation yet)				

Pueblo of Picuris (NM)	yes (but no designation yet)	OSRW; ONRW		Outstanding State Resource Waterbody; Outstanding National Resource Waterbody	
Pueblo of Pojoaque (NM)	yes (but no designation yet)				
Pueblo of San Felipe (NM)	None at this time				
Pueblo of Sandia (NM)	yes (but no designation yet)				
Pueblo of Santa Ana (NM)	yes (but no designation yet)	OTRW		Outstanding Tribal Resource Waters	
Pueblo of Santa Clara (NM)	yes (but no designation yet)	ORW		Outstanding Resource Waters	
Pueblo of Taos (NM)	yes	OTRW	3	Outstanding Tribal Resource Waters	Provided by TNC [Mountain Streams and Springs; Mountain Lakes]
Pueblo of Tesuque (NM)	yes (but no designation yet)				
Puyallup Tribe (WA)	yes (but no designation yet)				
Pyramid Lake Paiute Tribe (NV)	yes (but no designation yet)				
Quartz Valley Indian Community (CA)	None at this time				
Quinault Indian Nation (WA)	None at this time				
Red Lake Band of Chippewa (MN)	None at this time				
Resighini Rancheria (CA)	None at this time				
Rincon Band of Luiseño Mission Indians (CA)	None at this time				
Sac and Fox Tribe of the Mississippi in Iowa (Meskwaki) (IA)	None at this time				
Saint Regis Mohawk Tribe (NY)	yes (but no designation yet)	ORW		Outstanding Resource Waters	

Salt River Pima-Maricopa Indian Community (AZ)	None at this time				
San Carlos Apache Tribe (AZ)	None at this time				
Seminole Tribe (FL)	yes (but no designation yet)				
Seneca Nation of Indians (NY)	None at this time				
Shoshone-Bannock Tribes of the Fort Hall Reservation (ID)	None at this time				
Shoshone-Paiute Tribes of the Duck Valley Reservation (NV)	None at this time				
Sokaogan Chippewa Community (formerly Mole Lake Band) (WI)	yes	EHQW; OTRW	2.9/3	Exceptional High Quality Water; Outstanding National Resource Waters	Provided by TNC [all tribal waters]
Southern Ute Indian Tribe (CO)	yes (but data kept confidential, upon request)	OTRW	3	Outstanding Tribal Resource Water	
Spokane Tribe (WA)	yes (but no designation yet)				
Squaxin Island Tribe (WA)	None at this time				
Summit Lake Paiute Tribe (NV)	None at this time				
Swinomish Indian Tribal Community (WA)	yes (but no designation yet)	OTRW		Outstanding Tribal Resource Waters	
Table Mountain Rancheria (CA)	None at this time				
Tulalip Tribes (WA)	None at this time				
Twenty-Nine Palms Band of Mission Indians (CA)	yes (but no designation yet)	OTRW		Outstanding Tribal Resource Waters	
Ute Mountain Ute Tribe (CO)	yes	OTRW	3	Outstanding Tribal Resource Waters	Provided by TNC [1. Ute Spring and unnamed creek from Ute Spring downstream within Section 12, TWP35N R18W (Colorado). 2. Allen Canyon Creek, Sections 17, 20, 29, 30, 31, TWP 35S, R21E (Utah) 3. “Lopez” Spring and unnamed creek tributary to and downstream from

					the spring, within Section 35, TWP 34N, R18W]
Walker River Paiute Tribe (NV)	None at this time				
White Mountain Apache Tribe (AZ)	yes	OTRW	3	Outstanding Tribal Resource Waters	Provided by TNC [East Fork While River, in Wilderness area; Pumpkin Lake]
Winnebago Tribe of Nebraska (NE)	None at this time				
Yerington Paiute Tribe (NV)	None at this time				

Table S4. Characteristics of the state wild and scenic river datasets used in the assessment.

State	Name of the Program	Regulation #	Data source	Associated corridor
Arkansas	Arkansas and Scenic Rivers Act	AR Code § 15-23-301 (2018)	Accessed from: https://gis.arkansas.gov/product/high-resolution-national-hydrography-dataset-flowline-feature-line/ based on information from text: https://law.justia.com/codes/arkansas/2018/title-15/subtitle-2/chapter-23/subchapter-3/	No mention in the Act
California	California Wild and Scenic Rivers Act	PRC § 5093.50	Accessed from: https://csp-inc.maps.arcgis.com/home/item.html?id=708e420c300b4f9793af993a2612dbd4	No mention in the Act
Colorado	Upper Colorado River Wild & Scenic River Management Alternative	Colo. Rev. Stat. § 37-60-122.3	Digitized from map: https://www.northernwater.org/getmedia/14d44e10-aed7-4bed-bb73-367bca018053/Wild-Scenic-Rivers-Alternative-Management-Map	No mention in the Act
Connecticut	Connecticut River Gateway Conservation Zone	P.A. 73-349, S. 1, 11	Accessed from: https://rivercog.maps.arcgis.com/apps/webappviewer/index.html?id=c874276f8cad4f2b85d5eb337908825d	Provided by the Connecticut River Gateway Commission
Florida	Florida Wild and Scenic River Act	258.501	https://geodata.dep.state.fl.us/datasets/573b52eee1024a13869dd4cf5b71c255_4/explore based on information from text: http://www.leg.state.fl.us/statutes/index.cfm?App_mode=Display_Statute&URL=0200-0299/0258/Sections/0258.501.html	Digitized as 220 feet corridor on each river bank based on information from the Act: ““Wild and scenic protection zone” means an area which extends 220 feet landward from the river area”
Georgia	Georgia Scenic Rivers Act	GA Code § 12-5-350 (2020)	Accessed from: https://opendata.atlantaregional.com/dat	In Georgia, stream corridor protection is mandated by several additional laws: the Erosion and

			asets/GARC::rivers-streams-georgia/about based on information from text: https://law.justia.com/codes/georgia/2022/title-12/chapter-5/article-5/part-2/	Sedimentation Act, the Georgia Planning Act, the Mountain and River Corridor Protection Act, and the Metropolitan River Protection Act. See riparian buffers.
Idaho	Comprehensive State Water Plan - Protected Rivers	Idaho Code 42-173A(1)	Accessed from: https://data-idwr.hub.arcgis.com/datasets/IDWR::state-protected-streams/about	No mention in the Act
Indiana	Indiana Natural, Scenic and Recreational River Act	IC 14-29-6	Accessed from https://www.indianamap.org/datasets/natural-and-scenic-rivers/explore?location=40.105114%2C-86.235466%2C6.61	No mention in the Act
Iowa	Iowa Scenic Rivers Act	567D53.1(455B)	Accessed from: https://www.arcgis.com/home/item.html?id=7bc6a9f93aad4969a371be30cceeaf25	Digitized as 50 feet corridor on each river bank based on information from text: "voluntary protection zone [..] is a minimum of 50 feet adjacent to the river and the natural, historical, and/or archaeological areas, and other areas where visual degradation would adversely impact the scenic qualities of the river route"
Kentucky	Kentucky Wild Rivers Act	15 Ky.R. 693	Accessed from: https://kygisserver.ky.gov/arcgis/rest/services/WGS84WM_Services/Ky_KNP_Wild_River_Corridors_WGS84WM/MapServer	Digitized as 2,000 feet corridor on each river bank based on information from the Act: "Each wild river is actually a linear corridor encompassing all visible land on each side of the river up to a distance of 2,000 feet."
Louisiana	Louisiana Natural and Scenic Rivers Act	LS R.S. 56:1840-1856	Accessed from: https://databasin.org/datasets/ab841affbdf54d95980d1e98c9d5c14b/	Digitized as 100 feet corridor on each river bank based on information from best management practices for Scenic Rivers: "Maintain vegetated buffers, a minimum of 100 feet in width, between land disturbance activities (e.g. construction of access and haul roads, wash plants, processing plants, maintenance and staging areas) and all intermittent and perennial streams that flow into Scenic Rivers."
Maine			Already included in National W&S	Already included in National W&S

	Allagash Wilderness Waterway	Title 12 M.R.S.A. Section 1803(6)(C)		
Maryland	Maryland Scenic and Wild Rivers Act	Maryland Code, Natural Resources § 8-401	Accessed from https://data.imap.maryland.gov/datasets/3b97cf1fb8494e3799f27ee6c718e972_0/explore?location=39.377367%2C-78.099118%2C9.51 based on information from map https://dnr.maryland.gov/land/Pages/Stewardship/Scenic-and-Wild-Rivers-Map.aspx	Digitized as 2,000/1,000 feet corridor on each river bank based on information from the Youghiogheny river management plan (see also Act): "To maintain the integrity of this river, protection boundaries were established in buffers of the "wild" and "scenic" sections. In the "wild" section (from Millers Run to the southern limit of Friendsville), the protection boundary is called a "scenic corridor" and generally includes the buffer area visible from the river or adjacent shore. DNR manages this "scenic corridor" and is trying to acquire properties within this boundary from willing landowners. In the section not considered "wild" (the remaining portion of the river within Maryland) but still designated as "scenic," the protection boundary is called the "study area." This "study area" is a 1000-foot setback from the stream center and is managed by the County. "
Massachusetts	Massachusetts Scenic Rivers Act	Section 11C of MGL 21A	Digitized based on textual information: https://www.mass.gov/doc/302-cmr-3-scenic-and-recreational-rivers-orders/download	Digitized as 300 feet corridor on each river bank based on information from the Act: "River Corridor. Any river or stream and land up to 300 horizontal feet from the natural bank of the river or stream, which has been included in an Order. "
Michigan	Michigan Scenic Rivers Act	H.R.476	Already included in National W&S	Already included in National W&S
Minnesota	Minnesota Wild & Scenic Rivers Act	6105.0010 - 6105.0250	Accessed from https://gisdata.mn.gov/dataset/water-national-hydrography-data based on information from text: https://www.dnr.state.mn.us/waters/watermgmt_section/wild_scenic/index.html	Digitized as 0.25 mile corridor on each river bank based on information from the Act: ""Land use district" means those lands designated by the commissioner as the protected land corridor along those rivers or river segments which the commissioner has designated as components of the Minnesota wild and scenic rivers system. The boundaries of such land use district shall include

				not more than 320 acres per each mile of river on both sides (not each side) of the river. ”
New Hampshire	New Hampshire Rivers Management and Protection Act	RSA 483	Accessed from: https://www.nhgeodata.unh.edu/datasets/NHGRANIT::nh-designated-rivers-24k/explore	Digitized as 1,320 feet corridor on each river bank based on information from the Act: “The river corridor includes the river and the land area located within 1,320 feet of the normal high water mark or to the landward extent of the 100-year floodplain as designated by the Federal Emergency Management Agency, whichever distance is larger. ”
New Jersey	New Jersey Wild and Scenic Rivers Act	NJ Rev Stat § 13:8-48 (2019)	Provided from the Delaware River Basin Commission	Digitized as 100-year floodplain on each river bank based on information from the Act: “"Designated adjacent area of land" means those lands immediately adjacent to rivers or sections of rivers included in the system which have been delineated by the department as a floodway, flood fringe area or flood hazard area, as determined by the department, pursuant to the provisions of P.L. 1962, c. 19 (C. 58:16A-50 et seq.), as amended by P.L. 1972, c. 185, as well as any additional lands to which the department acquires a fee simple interest or scenic easement in accordance with the provisions of this act.”
New York	New York Wild and Scenic Rivers Act	(ENV) CHAPTER 43-B, ARTICLE 15	Accessed from: https://apa.ny.gov/gis/ApaData.html * **only data from the Adirondack Park are available, which represent most of the state Wild and Scenic Rivers system*	Digitized as 0.5 mile corridor on each river bank based on information from the Act: “"River" means a flowing body of water or a section, portion or tributary thereof, including rivers, streams, creeks, runs, kills, rills, branches, or lakes. "River area" means the term river and the land area in its immediate environs as established by the commissioner or the agency, but not exceeding a width of one-half mile from each bank thereof.”
North Carolina	North Carolina Natural and Scenic Rivers Act	NC § 113A-30	Accessed from: https://data-ncdenr.opendata.arcgis.com/datasets/surface-water-classifications/explore	Digitized as 250 feet- for the Lumber River and 20 feet-corridor elsewhere on each river bank based on information from the Act: “Boundaries of the system shall be the visual horizon or such distance

				from each shoreline as may be determined to be necessary by the Secretary, but shall not be less than 20 feet." We note that for the Lumber River, the Master Plan sets a goal for vegetative buffers of at least 250 feet from each shoreline, with a preferred width of 400 feet.
North Dakota	Little Missouri State Scenic River Act	MO 61-29-01	Digitized based on textual information: https://www.ndlegis.gov/cencode/t61c29.pdf	No mention in the Act
Ohio	Ohio Wild and Scenic Rivers Act	OH Section 1547.81	Accessed from: https://data-oepa.opendata.arcgis.com/datasets/antidegredation-tiers-surface-water-beneficial-use based on information from text: https://osra.clubexpress.com/	Digitized as 1,000 feet corridor on each river bank based on information from the Act: "The area shall include lands adjacent to the watercourse in sufficient width to preserve, protect, and develop the natural character of the watercourse, but shall not include any lands more than one thousand feet from the normal waterlines of the watercourse unless an additional width is necessary to preserve water conservation, scenic, fish, wildlife, historic, or outdoor recreation values. Scenic River Lands are defined as property owned by the Ohio Department of Natural Resources along state-designated wild, scenic and recreational rivers. These rules do not apply to privately owned property."
Oklahoma	Oklahoma Scenic Rivers Act	82 OK Stat § 82-1452 (2015)	Accessed from https://www.owrb.ok.gov/maps/PMG/owrbdata_SW.html based on information from text: https://law.justia.com/codes/oklahoma/2015/title-82/section-82-1452	The Act mentions "adjacent and contiguous lands" but not defined in quantitative terms
Oregon	Oregon Scenic Waterways Act	ORS 390.805-390.925	Accessed from https://maps.prd.state.or.us/arcgis/rest/services/Admin_boundaries/AD_SCENIC_WATERWAYS/MapServer/0	Digitized as 0.25 mile corridor on each river bank based on information from the Act: ""Related adjacent land" means all land within one-fourth of one mile of the bank on the side of Waldo Lake, or a river or segment of river within a scenic waterway, except land that, in the State Parks and Recreation Department's judgment, does not

				affect the view from the waters within a scenic waterway."
Pennsylvania	Pennsylvania Scenic Rivers Act	71 P. S. § 510-20	Accessed from https://csp-inc.maps.arcgis.com/home/item.html?id=af81109919734c2e97e0824a6a7e7d85	Accessed from: https://mapservices.pasda.psu.edu/server/rest/services/pasda/PennsylvaniaStateUniversity/MapServer
South Carolina	South Carolina Scenic Rivers Act	SC Code § 49-29-10 (2012)	Accessed from https://csp-inc.maps.arcgis.com/home/item.html?id=3db2b3e015a84d459fd24dc45023e1b0	Digitized as 300-500 feet corridor on each river bank based on information from the Act: "The width of the river corridor (measuring from the ordinary high water mark or the mean high water line on both sides of the river) is defined according to river classification: 300 to 500 feet for a natural river, 200 to 500 feet for a scenic river, and 100 to 500 feet for a recreational river."
Tennessee	Tennessee Scenic Rivers Act	TN Code § 11-13-101 (2015)	Accessed from https://csp-inc.maps.arcgis.com/home/item.html?id=37f5ef4a31534731a8cbfe6928b5e347	Digitized as 3,000/450 feet corridor on each river bank based on information from the Act: "For a Class I river (the gorge and swamp rivers), the boundary shall be established in such a way that it includes at least the entire scenic vista from the river and its banks. For gorge rivers, the boundaries shall be no more than three thousand feet (3,000') from the center of the river on each side. For swamp rivers, the boundaries shall be no more than one thousand feet (1,000') from the center of the river on each side; and For Class II or Class III river areas, the boundary shall include the vista from the river and shall be no more than four hundred fifty feet (450') from the usual banks of the river on each side."
Virginia	Virginia Scenic Rivers Act	1970, c. 468, § 10-168;	Accessed from https://vdcr.maps.arcgis.com/home/item.html?id=678e960ac9b247e8b82a0cc560d32e30	No corridor according to the Act: "All riparian land and water uses along or in the designated section of a river that are permitted by law shall not be restricted by this chapter"
Washington	Washington Scenic Rivers Act		Accessed from https://geo.wa.gov/datasets/waecy::hydr	Digitized as 0.25 mile corridor on each river bank based on information from the Act: ""River area"

		1977 ex.s. c 161 § 6. Formerly RCW 79.72.060	ography-major-streams/explore?location=47.524009%2C-121.347782%2C8.17 using information from text: https://app.leg.wa.gov/rcw/default.aspx?cite=79A.55.070	means a river and the land area in its immediate environs as established by the participating agencies not exceeding a width of one-quarter mile landward from the streamway on either side of the river."
West Virginia	West Virginia Natural Stream Preservation Act	WEST VIRGINIA CODE chapter 22	Digitized from information provided in: https://code.wvlegislature.gov/22-13-4/	No mention in the Act
Wisconsin	Wisconsin Wild Rivers Act	s. 30.26.	Accessed from https://data-wi-dnr.opendata.arcgis.com/maps/wi-dnr::outstanding-and-exceptional-rivers-and-streams/about	Digitized as 150 feet corridor on each river bank based on information from the DNR best practices: "On DNR lands, there is no vegetative control within 150 feet from the bank on either side of the river, walk-in access only, no motorized vehicles, no stream alterations, no maintained trails and few developed parking lots or canoe put-ins"

Table S5. Characteristics of the riparian buffer datasets used in the assessment.

State(s)	Protection	Level of protection	Regulation	Data source
California, Oregon, Washington	Northwest Forest Plan Riparian reserves	region		Data sent by U.S. Forest Service
Alaska	Tongass Timber Reform Act	national forest	PUBLIC LAW 101-626	Accessed from https://hub.arcgis.com/datasets/usfs::tongass-national-forest-riparian-management-area-buffers/about
Alaska	Alaska Forest Resources & Practices Act	state	AS 41.17.115(a), 11 AAC 95.185(a)	Digitized based on https://forestry.alaska.gov/forestpractices using https://gis.data.alaska.gov/datasets/63496ef73a4f4f2a954d6798860a5dae_0/explore?location=60.195263%2C30.025600%2C5.05; https://gis.data.alaska.gov/datasets/b450c10a8682451bb6571a43bdbfcf79/explore?appid=1f0eed6d786240de8484a078e5d4bcee&edit=true&location=61.747928%2C-149.588114%2C5.21; https://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm?ADFG=maps.dataFiles
California	CCRWQCB Riparian Setback Area	water region	Agricultural Order 4.0 [Order No. R3-2021-0040]	Digitized based on https://gispublic.waterboards.ca.gov/portal/home/item.html?id=b125e0e7321a481ab08b3a31113663ed; https://www.sciencebase.gov/catalog/item/5cf02bdae4b0b51330e22b85 [attribute information]
California	Watercourse and Lake Protection Zones	state	Cal. Code Regs. Tit. 14, § 916.4	Digitized based on https://www.waterboards.ca.gov/rwqcb6/water_issues/programs/waste_discharge_requirements/timber_harvest/docs/timber_waiver/attb_wbbz14.pdf; https://hub.arcgis.com/maps/e1b29a8583ed482daab77866332d92d5/about
Georgia	Metropolitan River Protection Act	state	O.C.G.A. 12-5-440 et seq.	Accessed from https://garc.maps.arcgis.com/apps/webappviewer/index.html?id=06786d2927824ae0b585608a49c8939c&extent=-9476931.7654%2C3965737.897%2C-9358072.1864%2C4033996.1632%2C102100

Georgia	Georgia Mountain and River Corridor Protection Act [Criteria for Water Supply Watersheds]	state	O.C.G.A. 12-2-8/Rule 391-3-16-.01	Digitized based on https://epd.georgia.gov/water-supply-watersheds#:~:text=Coastal%20Georgia%20Watershed,Map
Georgia	GA Mountain and River Corridor Protection Act	state	O.C.G.A. 12-2-8/391-3-16-.04	Accessed from https://georgia-dca.maps.arcgis.com/home/item.html?id=30fd9dc237ea43e5b0ecf4aa02780cc4
Georgia	Georgia Erosion and Sedimentation Act	state	OCGA 12-7-6	Accessed from https://hub.arcgis.com/maps/c019227530f545f1ad74d71ab3ff9144/about
Idaho	Stream Protection Zones	state	ID Forest Practices Act, Title 38, Ch 13, Idaho Code. (3-31-22) 02	Accessed from https://gis1.idl.idaho.gov/portal/apps/sites/#/gis/datasets/b65bd92c8e2c4cb9b0da75f7369e9df0/about?layer=0
Maine	Shoreland Zoning Act	state	Title 38, Chapter 3, §435-449	Digitized based on https://www.maine.gov/dep/land/slz/ip-shore.html
Maryland	Chesapeake Bay Critical Area Protection Act	state	Critical Area Act - Title 8, Subtitle 18	Accessed from https://data.imap.maryland.gov/datasets/maryland::maryland-critical-areas-critical-area-counties/explore?location=38.555086%2C-76.594510%2C8.84
Massachusetts	Rivers Protection Act	state	Chapter 258	Digitized based on https://www.mass.gov/doc/about-the-massachusetts-rivers-protection-act/download
Minnesota	Buffer Law	state	MN Statute 103F.48	Accessed from https://gisdata.mn.gov/dataset/env-buffer-protection-mn
New Hampshire	Shoreland Water Quality Protection Act	state	RSA 483-B	Digitized based on https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-01/consolidated-list.pdf; https://nhdes.maps.arcgis.com/apps/webappviewer/index.html?id=d3869f998e614d81925481ac71c3903e
New Jersey	Highlands Water Protection & Planning Act	state	N.J.A.C. 7:13-4	Accessed from https://highlands-data-njhighlands.opendata.arcgis.com/datasets/NJHighlands::open-water-protection-area

New Jersey	Flood hazard Area Control Act Rules		N.J.S.A. 13:20	Digitized based on https://gisdata-njdep.opendata.arcgis.com/datasets/njdep::surface-water-quality-classification-of-new-jersey/explore?location=40.359198%2C-75.308961%2C15.33
North Carolina	Riparian Buffer Protection Program/North Carolina Riparian Buffer Rules	watershed	15A N.C. Admin. Code 02B .0267	Digitized based on https://ncdenr.maps.arcgis.com/apps/webappviewer/index.html?id=5c3265f774284547a22cbd8f9ff681b4 (floodplains : https://www.nconemap.gov/maps/a178aae74ee347d786e853e5a442eea2/explore?location=35.145949%2C-79.918650%2C7.94 for Goose Creek watershed)
Oregon	Riparian Management Areas/Forest Practices Act	state	OAR 629-600-0100/629-635-0300	Digitized based on https://oregon-department-of-forestry-geo.hub.arcgis.com/datasets/geo::hydrography-flow-line/about
Pennsylvania	Erosion And Sediment Control And Stormwater Management	state	25 Pa. Code § 102.14. Riparian buffer requirements.	Digitized based on https://www.pasda.psu.edu/uci/DataSummary.aspx?dataset=1098
Rhode Island	Freshwater Wetlands Act	state	250-RICR-150-15-3	Accessed from https://ridemgis.maps.arcgis.com/apps/webappviewer/index.html?id=2d0393d182204c1d881dcd9df732804e
Vermont	Flood Hazard Area and River Corridor Rule	state	10 V.S.A, § 1428	Accessed from https://dec.vermont.gov/watershed/rivers/river-corridor-and-floodplain-protection/protection
Virginia	Chesapeake Bay Preservation Act	state	Section 9 VAC 10-20-80 B 5	Accessed from https://apps.deq.virginia.gov/arcgis/rest/services/public/EDMA/MapServer/33
Washington	Forests & Fish Law/Western WA riparian management zones	state	WAC 222-30-021-23	Accessed from https://geo.wa.gov/datasets/wadnr::dnr-hydrography-watercourses-forest-practices-regulation/explore?location=47.248140%2C-120.754300%2C8.46
Wisconsin	Water Resources Act	state	NR 115, Wis. Admin. Code	Digitized based on https://www3.uwsp.edu/cnr-ap/UWEXLakes/Documents/ecology/shoreland/nr115/WT54200.pdf