

Final Report to the National Fish and Wildlife Foundation

NFWF Proposal #27139: "Identifying Upper Snake River Basin Native Fish Conservation Areas (ID, WY, NV, OR)"

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ABSTRACT:

Native Fish Conservation Areas (NFCAs) are watersheds where management emphasizes proactive conservation and restoration for long-term persistence of native fish assemblages while allowing for compatible uses. NFCAs are intended to complement traditional fisheries management that can be reactive to existing stressors and focused on single fish species conservation efforts rather than on entire communities. We identified potential NFCAs in the Upper Snake River basin above Hells Canyon Dam using a process that ranked all subwatersheds (Hydrologic Unit Code 12) using data on native trout distributions, abundance, and genetics (bull trout *Salvelinus confluentus*; redband trout *Oncorhynchus mykiss*; and Yellowstone cutthroat trout *O. clarkii*, including fine-spotted form); known occurrences and modeled potential distributions of native non-game fishes; drainage network connectivity; and land protection status. Clusters of high-ranking subwatersheds were identified as potential NFCAs that were then classified according to the presence of non-game fishes listed as Species of Greatest Conservation Need in state wildlife action plans. Last, we compare and contrast some of the potential NFCAs identified, and discuss the practical implementation of an NFCA in the Upper Snake River basin and how the concept relates to existing conservation partnerships.

INTRODUCTION

Despite substantial resources being allocated to conservation of freshwater ecosystems, freshwater fishes in North America are continuing to decline at a much faster rate than their terrestrial counterparts (Master et al. 2000; Jelks et al. 2008). Williams et al. (2011) discuss how current

conservation approaches, such as the National Wildlife Refuge system, have only been moderately successful at protecting riverine ecosystems because rivers are linear in nature and approaches based on terrestrial features and land ownership fail to consider watershed boundaries that are fundamental to aquatic conservation (e.g., Roux et al. 2008). While others have proposed protecting watershed-scale areas for aquatic conservation (Saunders et al. 2002; Suski and Cooke, 2007), Williams et al. (2011) proposed the concept of Native Fish Conservation Areas (NFCA) where entire watersheds are cooperatively managed for native fish communities. As a complement to existing conservation approaches (e.g., headwater isolation; Novinger and Rahel 2003), implementation of NFCAs would emphasize intact and persistent native fish communities and healthy and resilient ecosystems while simultaneously allowing for compatible commercial and recreational uses. Dauwalter et al. (2011) explored the NFCA concept and application in the Upper Colorado River Basin in Wyoming through a process that combined known and modeled species distributions, spatial prioritization analysis, and stakeholder discussions.

In this study, we further explored the utility of the NFCA concept by identification of potential NFCAs in the Upper Snake River basin above Hells Canyon Dam. The Snake River basin drains part of Wyoming, Idaho, Utah, Nevada, and Oregon, heads in Yellowstone National Park in Wyoming and flows southwest, then west, and then northwest before flowing north through Hells Canyon along the Idaho-Oregon border (Figure 1). The basin is divided by Shoshone Falls, a large waterfall near Twin Falls, ID that effectively separates the Snake River basin into upper and lower sections (Figure 1). The lower Snake River basin (Hells Canyon Dam to Shoshone Falls) supports 21 native fish species (Table 1), while the upper basin (Shoshone Falls to Wyoming headwaters) supports 14 native species. The impassability of Shoshone Falls, the unique geology, and past connections with historical Lake Bonneville during the Pleistocene have resulted in a unique species colonization history that has strongly influenced the biogeography of fishes in the Upper Snake basin; only seven extant species are native to both the upper and lower basin (Table 1; Wallace and Zaroban 2013).

Climate varies considerably across the Upper Snake River basin, with mean August temperatures ranging from 11 to 22C, with colder temperatures at higher elevations. Mean annual precipitation ranges from 22 cm in western deserts to over 200 cm in the highest elevations (e.g., Teton Range), and land cover ranges from sage-steppe in drier climates to montane forests. The basalt flows that form the Snake River Plain were extruded during the Pliocene to Holocene epochs; however, the youngest flows are no more than a few thousand years old while the oldest are about four million years old. Approximately 8,000 square miles of southern Idaho are covered by basalt flows. These flows and crustal uplift pushed the Snake River south and caused several basins to flow subsurface (the Lost Rivers and other sinks drainages) at their southern terminus, rendering them isolated from the rest of the basin (Kuntz et al. 1992).

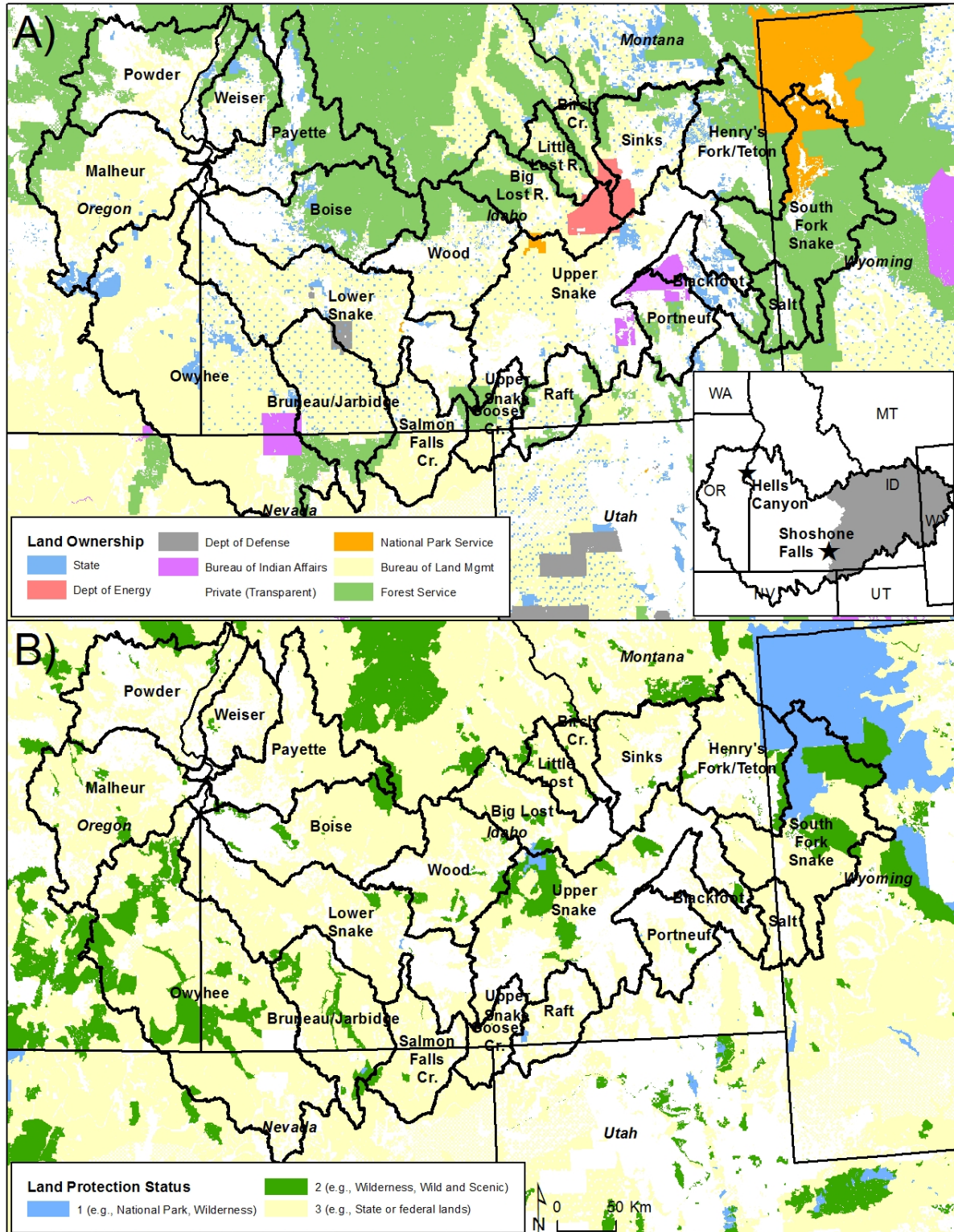


Figure 1. Land ownership (A) and land protection status (B) in the Upper Snake River basin above Hells Canyon. Inset shows upper and lower basin divided by Shoshone Falls.

Table 1. Fishes native to the Upper Snake River basin above Hells Canyon and their general distribution in the basin (upper or lower basin relative to Shoshone Falls), Species of Greatest Conservation Need status, Nature Serve rank, number of occurrences (and total sites) in survey data, and species weight used to rank subwatersheds.

Abbreviation	Common name	Scientific name	Distribution in basin	Species of Greatest Conservation Need	Occurrences (Total sites)	Analysis weight
WST	White sturgeon	<i>Acipenser transmontanus</i>	Lower	ID, OR		
CSM	Chiselmouth	<i>Acrocheilus alutaceus</i>	Lower		88 (1452)	0.945
UTC	Utah chub	<i>Gila atraria</i>	Upper		23 (1280)	0.961
NLC	Northern leatherside chub	<i>Lepidomeda copei</i>	Upper	ID, WY	39 (1210)	0.977
PMT	Peamouth	<i>Mylocheilus caurinus</i>	Lower		No data	--
NPM	Northern pikeminnow	<i>Ptychocheilus oregonensis</i>	Lower		123 (1448)	0.250
RSS	Redside shiner	<i>Richardsonius balteatus</i>	Both		462 (3045)	0.371
LND	Longnose dace	<i>Rhinichthys cataractae</i>	Both		298 (3002)	0.676
SPD	Speckled dace	<i>Rhinichthys osculus</i>	Both		640 (3047)	0.001
KWD	Kendall Warm Springs dace	<i>Rhinichthys osculus thermalis</i>	Upper	WY	No data	--
LPD	Leopard dace	<i>Rhinichthys falcatus</i>	Lower	ID*	10 (660)	1.000
UMD	Umatilla dace	<i>Rhinichthys umatilla</i>	Lower	ID*	No data	--
UTS	Utah sucker	<i>Catostomus ardens</i>	Both		55 (1310)	0.938
BLS	Bridgelip sucker	<i>Catostomus columbianus</i>	Lower		290 (1609)	0.250
WBLS	Wood River bridgelip sucker	<i>Catostomus columbianus hubbsi</i>	Lower		No data	--
BHS	Bluehead sucker	<i>Catostomus discobolus</i>	Upper	ID*, UT, WY	46 (1296)	0.953
LSS	Largescale sucker	<i>Catostomus macrocheilus</i>	Lower		101 (1609)	0.250
MTS	Mountain sucker	<i>Catostomus platyrhynchus</i>	Upper		118 (2736)	0.820
YCT	Yellowstone cutthroat trout	<i>Oncorhynchus clarkii</i>	Upper	ID, NV, WY		0.991
	Fine spotted form		Upper	WY		0.736
RBT	Redband (rainbow) trout	<i>Oncorhynchus mykiss gairdneri</i>	Lower	ID, OR		0.923
BLT	Bull trout	<i>Salvelinus confluentus</i>	Lower	ID, NV, OR		1.025
MWF	Mountain whitefish	<i>Prosopium williamsoni</i>	Both	NV, WY	100 (1354)	0.558
MSC	Mottled sculpin	<i>Cottus bairdii</i>	Both		263 (2628)	0.461
PSC	Paiute sculpin	<i>Cottus beldingii</i>	Both		237 (2456)	0.340
SSC	Shorthead sculpin	<i>Cottus confusus</i>	Lower		239 (1609)	0.719
ShSC	Shoshone sculpin	<i>Cottus greenei</i>	Lower	ID	No data	--
WSC	Wood River sculpin	<i>Cottus leiopomus</i>	Lower	ID	44 (154)	0.922

*Species listed as SGCN but status not yet assessed.

Native Fish Conservation Areas provide a useful management approach for the Snake River Basin, which includes a diversity of land types, land ownerships and uses, as well as native salmonid and non-game fishes (Figure 1). NFCAs provide an opportunity to link the conservation of headwater trout populations with the medium-size streams that provide habitat for leopard dace *Rhinichthys falcatus*, bluehead sucker *Catostomus discobolus*, Northern leatherside chub *Lepidomeda copei*, and other native species. NFCAs would be managed to provide interconnected habitats that can increase population persistence by facilitating natural metapopulation processes (Dunham and Rieman 1999; Hilderbrand and Kershner 2000; Compton et al. 2008). At the same time, NFCAs can provide a discrete hydrologic unit in which native fish communities can be isolated, if needed, from non-native invaders downstream (Novinger and Rahel 2003; Fausch et al. 2006). Established NFCAs should be large enough to allow long-term persistence of populations yet be small enough to be substantively managed in order to address the needs of a full suite of native species with one set of management actions.

Management in the Upper Snake River basin has primarily emphasized trout species in the lower Snake River basin (reband trout and bull trout) and the upper Snake River basin (Yellowstone cutthroat trout and fine-spotted cutthroat trout) (Figure 2). All are Species of Greatest Conservation Need (SGCN) and are of special concern in Idaho, Wyoming, Nevada, or Oregon, while bull trout are listed as a threatened species under the Endangered Species Act. Nevertheless, eight other SGCN species occur in the lower Snake River basin (such as leopard dace, Umatilla dace *R. umatilla*, and the Shoshone sculpin *Cottus greenei*). Four non-salmonid SGCN species occur in the upper Snake River Basin, including bluehead sucker and Northern leatherside chub (Table 1), with only mountain whitefish *Prosopium williamsoni* occurring in both lower and upper basins. Identification of NFCAs that include both salmonids and non-game species, particularly those that are Species of Greatest Conservation Need, will link conservation and management actions within watersheds and across landscapes.

METHODS

Potential NFCAs were identified through a process that ranked all subwatersheds (Hydrological Unit Code [HUC] 12 watersheds) in the Upper Snake River basin based on native trout abundance and distribution, modeled occurrence probabilities for native non-game fishes, differential weighting of species based on their prevalence, drainage network connectivity, and land protection status. Rankings were intended to identify watershed-scale areas from the headwaters downstream where native trout overlap in distribution with, or occur in close proximity to, native non-game fishes. Our analysis did not focus on identifying unique habitats with endemic fishes (e.g., spring habitats with Shoshone sculpin) or genetically unique subpopulations or subspecies not currently recognized as a distinct species (Wood River bridgelip sucker or Big Lost Mountain Whitefish), nor did we focus on large river fishes (e.g., white sturgeon *Acipenser transmontanus*) or the mainstem Snake River because of the difficulty in managing large rivers to their headwaters per the NFCA concept. Clusters of high ranking subwatersheds (i.e., the top 25%) were aggregated and characterized based on the native fish

assemblage, land ownership and protected status, watershed size, habitat conditions, and future threats.

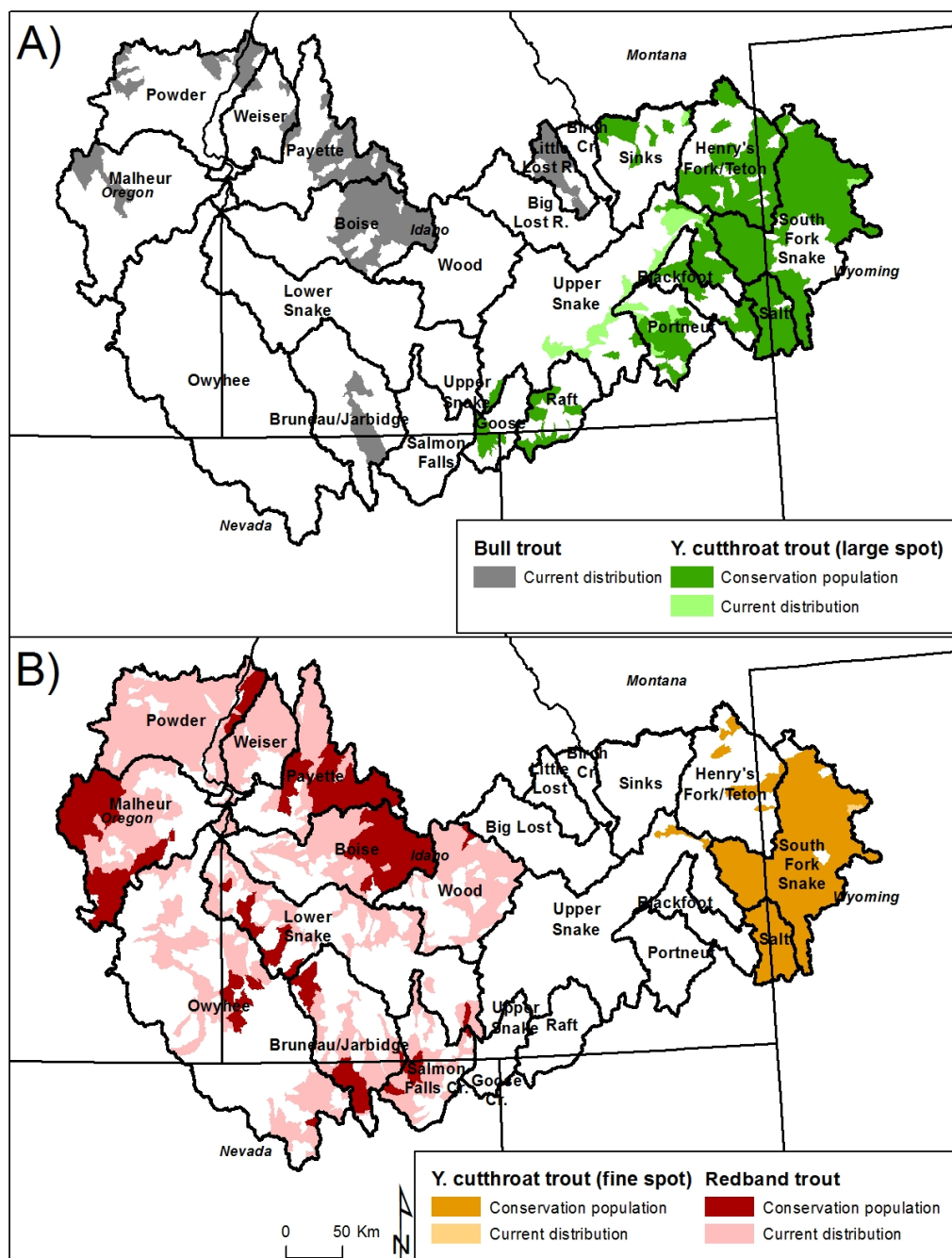


Figure 2. Conservation populations and current distributions of bull trout, large-spotted Yellowstone cutthroat trout (A), redband trout, and fine-spotted Yellowstone cutthroat trout (B) in the Upper Snake River basin.

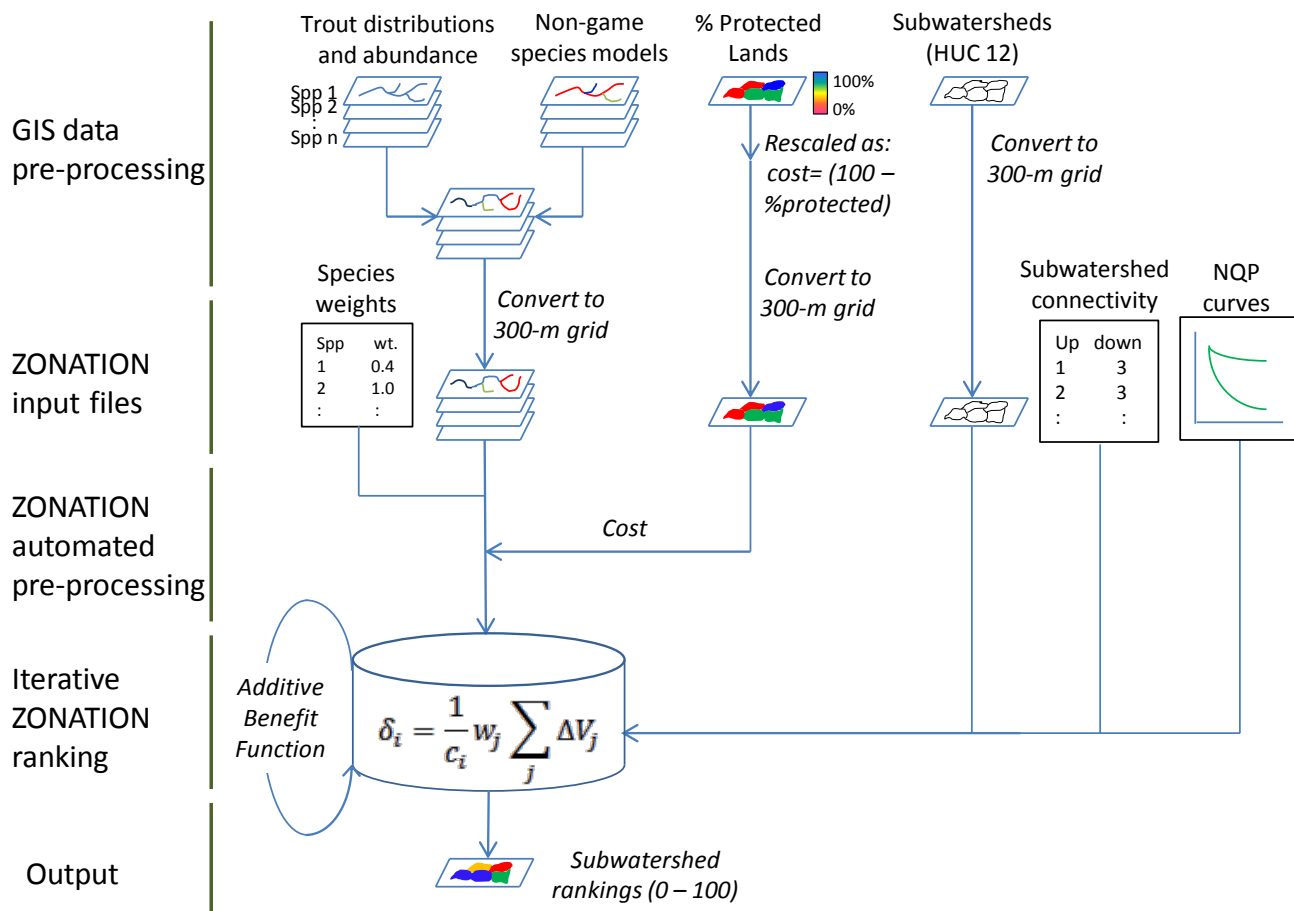


Figure 3. Conceptual model showing data integration for subwatershed ranking analysis.

Fish data

Many different data sources were used to define the distribution and abundance of native trout and the occurrence of native non-game fishes. Distribution and abundance data for native trouts were primarily derived from rangewide assessment databases. Yellowstone cutthroat trout data (including fine-spotted form) were based on the 2010 rangewide assessment database (an update of May et al. 2003), and redband trout data were based on the distribution of conservation populations from the 2012 rangewide assessment (May et al. 2012). For each database, only conservation populations were used to define distributions (Figure 2), and abundance was based on the midpoint of categorical population abundances in the database (e.g., 0 – 35, 35 – 100, 101 – 250, 251 – 625, 625 – 1250, >1250 fish per km). Conservation populations are defined as those populations that have <10% genetic

introgression or have unique genetic, ecological or behavioral attributes (e.g., adfluvial behavior) (UDWR 2000; Gresswell 2011; May et al. 2012). Bull trout distribution data were from Streamnet (StreamNet GIS Data 2011); bull trout abundance data were from Idaho Department of Fish and Game, Oregon Department of Fish and Wildlife, U.S. Geological Survey, U.S. Bureau of Reclamation, and U.S. Forest Service databases.

Native non-game fishes data were assembled from fish collections made across the Upper Snake River basin, and those data were used to develop species probability of occurrence models. Non-game fishes were sampled primarily by electrofishing but other methods were also used; for example, non-game species in Idaho were primarily sampled during Idaho Department of Fish and Game and Idaho Department of Environmental Quality electrofishing surveys (Meyer et al. 2012). But, both electrofishing and minnow traps were used in other datasets (Blakney 2012). In all, over 3047 fish collection records were used to determine species occurrences (see Acknowledgments for sources). From these collections, presence-absence data were used to develop species-specific models (aka, species distribution or niche models) where probabilities of occurrence were modeled as a function of multiple environmental variables. Specifically, random forest models (Breiman 2001) were fit as a function of mean annual streamflow from (cms), mean annual precipitation (mm), August air temperature (°C), stream segment slope (%), road density in watershed (km/km²), percent converted land (urban, agriculture, hay/pasture) in watershed, percent of 100-m buffer in watershed converted, cumulative reservoir storage in watershed (m³/km²), and canal density (km/km²) (DATA CITATIONS). To maximize model parsimony, all variables were evaluated for ability to explain species occurrence as determined using a model improvement ratio threshold that minimized mean squared error (Murphy et al. 2010). The models for all species, except leopard dace, showed good predictive ability with 10-fold cross-validated AUC values >0.75; the model for leopard dace – a species with only 10 occurrences - had the poorest predictive ability (AUC = 0.695). As an example, the model for northern leatherside chub predicted probability of occurrence as a function of mean annual streamflow; mean annual precipitation; August air temperature; road density; and percent of watershed converted from natural land cover. The model had a 10-fold cross-validated AUC of 0.925, suggesting excellent predictive ability (Figure 4). Species-specific models were then used to predict probability of occurrence for perennial stream segments with drainage areas greater than 159,100 km² in the National Hydrography Dataset (NHD) Plus (USEPA and USGS 2005); predictions were only made in sub-basins within the probable native range reported by Meyer et al. (2012) and Gamett (2003).

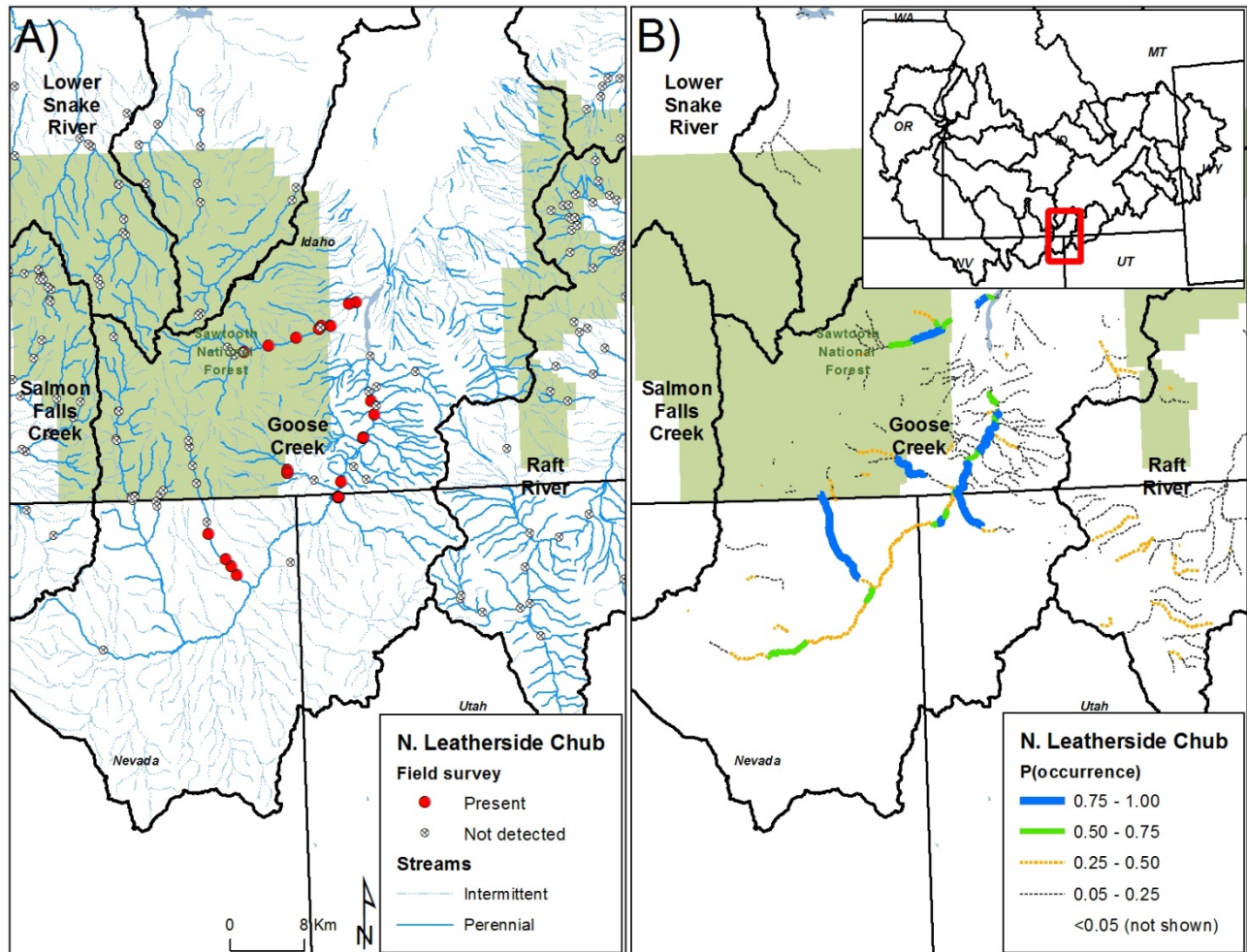


Figure 4. Sites where northern leatherside chub were present and not detected during recent field surveys (A), and predicted probability of occurrence in the Goose Creek and Raft River sub-basins of the Upper Snake River basin (B). Segments with probabilities of occurrence less than 0.05 are not shown.

Watershed Rankings

To identify potential NFCAs, subwatersheds in the Upper Snake River basin were ranked based on native trout distribution and abundance data and non-game species probabilities of occurrence data, river network connectivity, and the percent of subwatershed encumbered in Gap Analysis Program Status 1 or 2 protected lands (e.g., designated wilderness, national park)(PADUS cite). Subwatershed rankings were done using the Additive Benefit Function in Zonation v3.0 conservation planning software (Moilanen 2007; Moilanen et al. 2011). Zonation produces a hierarchical ranking of all subwatersheds (scaled from 0 to 1) based on the minimum marginal loss across species-specific inputs:

$\delta_i = 1/c_i w_j \sum_j \Delta V_j$ where δ_i = the marginal loss across all j species for subwatershed i , c_i = 100 - % subwatershed protected, where % protected was based on protected lands identified as Gap Analysis Program (GAP) status 1 or 2 lands (e.g., designated wilderness, national park) (USGS 2011); w_j = the weight for species j based on professional judgment for native trouts or non-game species prevalence – one measure of rarity - defined by Meyer et al. (2012)(see Table 1); and ΔV_j = is the marginal loss of species j values between all remaining subwatersheds minus the value within subwatershed i (see Moilanen et al. 2011), where V = the midpoint of fish per km ranges reported for conservation populations of Yellowstone cutthroat trout and redband trout (see above), V = subwatershed fish per km average (from fish survey data) for the current distribution of bull trout (a value of 1 was used if no abundance data were available), and V = the probability of occurrence (range from 0 to 1) for all non-game species. Rankings were determined by computing the minimum marginal loss across all species for each subwatershed, and the subwatershed with lowest the marginal loss was removed. This process was repeated iteratively with all remaining subwatersheds until only one subwatershed remained, that is, the one with the highest marginal loss across all fish species. Trout data were represented by the spatial hydrography framework for each data source, and the probability of occurrence for non-game species was attributed on NHDPlus hydrography (1:100,000 scale hydrography). All data were then converted to a 300-m grid for the analysis.

River networks are a nested hierarchy of drainage systems that pose challenges to conservation of fishes that use riverine environments, which is why NFCAs are watersheds managed in their entirety for native aquatic communities. For this reason, river network connectivity was also used to impart a penalty on the marginal loss across species based on whether a neighboring subwatershed has already been removed during the ranking process (i.e., has a lower rank). The penalty specifically translates into a reduction in subwatershed value (δ_i) based on the proportion of subwatersheds that have been removed upstream or downstream of the focal subwatershed (Moilanen et al. 2011). The same penalties were used for all 21 species and were strong if upstream subwatersheds had already been removed but weak if downstream subwatersheds had been removed. It is important to note that connectivity was interrupted by large dams (i.e., those with reservoirs with ≥ 4 km² surface area) but not smaller dams or other barriers because the latter can be managed for fish passage.

POTENTIAL NFCAS

Clusters of subwatersheds representing independent drainage networks within the top 25% of the landscape (rank >75) were then aggregated into potential NFCAs. Selected attributes of potential NFCAs were then summarized: mean subwatershed rank; watershed size; documented native species occurrences; presence of non-game species of greatest conservation need as identified in state wildlife action plans; percent of watershed protected; percent of perennial stream corridor protected; habitat integrity of subwatershed; and, future security of subwatershed. Mean subwatershed rank was computed as an area-weighted mean from subwatershed ranking analysis. Documented species

occurrences were determined from rangewide assessment databases for native trouts and documented presence of native non-game species in fishery surveys. State Wildlife Action Plans were used to identify Species of Greatest Conservation Need by state. Land protection status was based on GAP Status 1 and 2 lands (cite). Subwatershed habitat integrity was based on Trout Unlimited's Conservation Success Index, which is a composite index ranging from 5 (low integrity) to 25 (high integrity) based on indicators of land protection, watershed connectivity, watershed condition, water quality, and flow regime scored each from 1 (low integrity) to 5 (high integrity)(Williams et al. 2007). Future security of subwatersheds was also based on Trout Unlimited's Conservation Success Index where future security is an index ranging from 5 (low security) to 25 (high security) based on individuals scores (1 to 5) for land conversion, resource extraction, energy development, climate change, and introduced species (Williams et al. 2007).

RESULTS

Watershed rankings from the Zonation analysis identified both entire subbasins consisting of large, clusters of high ranking subwatersheds as well as individual or small clusters of a few subwatersheds (Figure 5). Potential NFCA watersheds were primarily clustered in headwater areas, both with respect to individual river systems (e.g., Boise, Payette, Little Jacks, Little Lost, Goose), and to the Snake River as a whole (e.g., South Fork Snake, Salt, Blackfoot). The Payette, Boise, South Fork Snake, Portneuf, and Blackfoot river subbasins represented large clusters of subwatersheds with ranks greater than 75 (of a range from 0 to 100), or represented the top 25% of the entire Upper Snake River basin. Smaller aggregations were present in the Upper Malheur River, Upper Jarbidge River, Goose Creek, Little Lost River, and Fall River/Conant Creek (Henrys Fork watershed). Examples of individual drainages with one or a few high ranking subwatersheds were: Little Jacks Creek, Jack Creek (NV), Indian Creek, Cassia Creek, Upper Raft River, and Bitch Creek (Figure 5).

After the clusters of high ranking subwatersheds (top 25%) were aggregated, there were 44 watersheds ranging in size from 56 to 4,344 km² that were identified as potential NFCAs due to their high rank and native species assemblage (Table 2). All potential NFCAs had at least one native trout species, and all but three had documented occurrences of at least one native non-game species. Of those, 13 watersheds supported at least one non-game species of greatest state conservation need (Figure 7A).

Land status within watersheds ranged from 72% private land (Portneuf River) to nearly the entire watershed protected in public land and national parks (Upper Snake River; Cottonwood Creek; Fall River) (Table 2; Figure 6A). Stream corridors also ranged widely in level of protection (Figure 7B); however, land status was not a reliable predictor of habitat integrity or future security. Habitat integrity scores ranged from 12 to 25 (Table 2). Habitat integrity in the Upper Snake River basin was

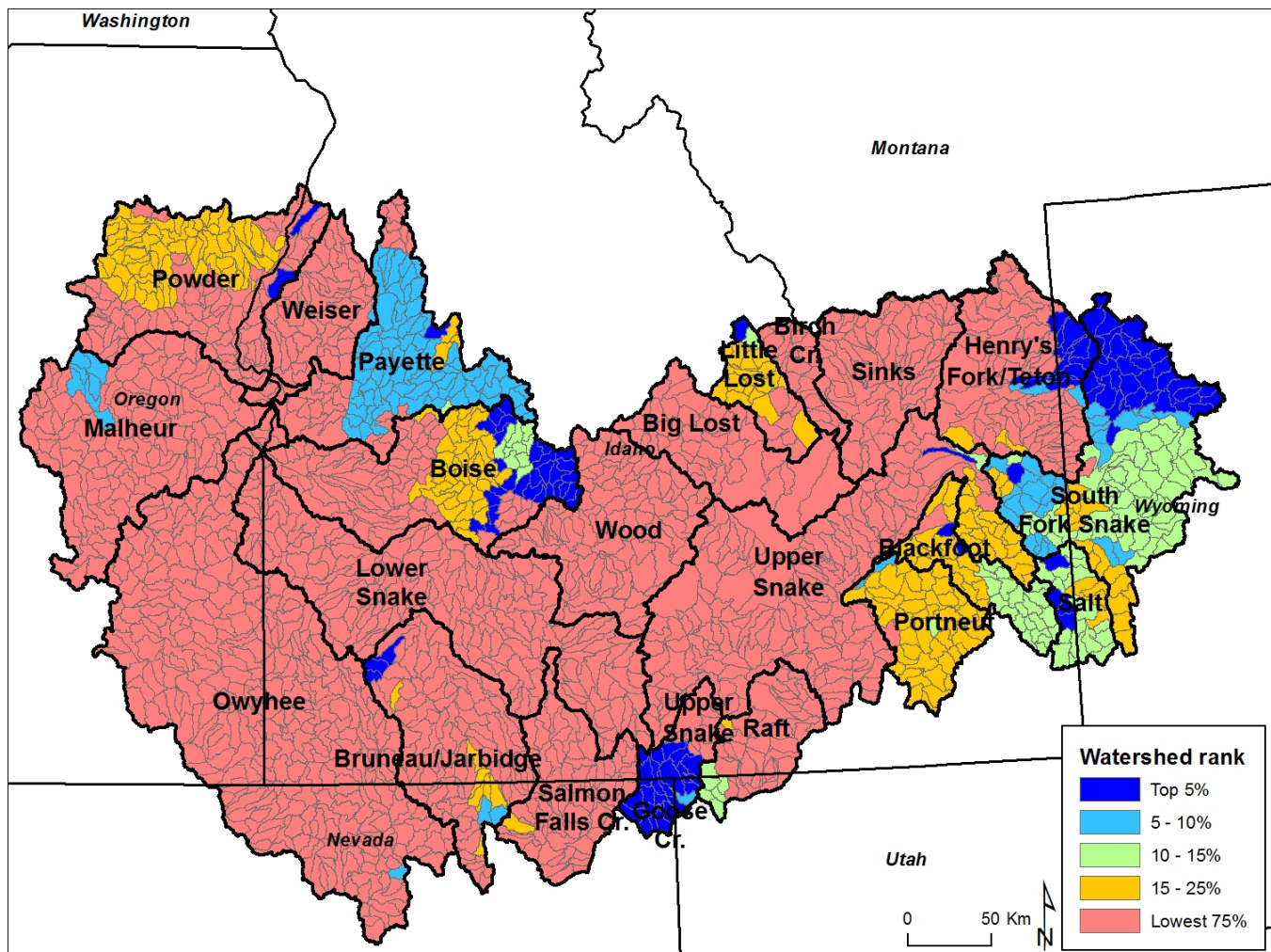


Figure 5. Subwatershed ranks in the Upper Snake River basin based on native trout distributions and abundance, native non-game species probability of occurrence, drainage network connectivity, and land protection status.

low in areas with high agricultural or urban land use, but was high in the high elevation mountainous regions (Figure 6A). Watersheds comprised largely of public land (>90%) exhibited habitat integrity scores ranging from the highest possible (25) to 12. In potential NFCAs, habitat integrity was high for Pacific Creek in Grand Teton National Park (score 25 out of 25) but was low for the Portneuf River and Conant Creeks (scores of 12 out of 25) due to low scores (1 out of 5) for each of the five individual indicators in at least one subwatershed, despite the watershed as a whole having species-rich fish assemblages (Table 2). While increased levels of private land ownership (within a watershed generally resulted in lower habitat integrity scores, of the eleven watersheds with >35% private land ownership, habitat integrity scores ranged from 12 in the Portneuf River and Conant Creek (Henry's Fork subbasin) and to 18 in the Upper Raft River, where 70% of the watershed is in private ownership.

Table 2. Characteristics of potential NFCAs in the Upper Snake River basin. Species of Greatest Conservation Need shown in bold.

Watershed (subbasin)	Mean Rank (0 – 100)	Watershed area (km ²)	Native species ^a	Protected (%) (stream corridor)	Public land (%)	Habitat Integrity ^b (5 – 25)	Future Security ^c (5 – 25)
Above Shoshone Falls							
Pacific Cr. (S. Fk. Snake)	98.8	431	YCT (both), NLC	95.4 (92.3)	97.3	25	21
Upper S. Fk. Snake R.	98.7	2,086	YCT (both), UTS, LND, SPD, RSS, MSC, PSC, UTC	99.9 (99.8)	92.2	24	21
Fall R. (Henrys Fork)	97.6	894	YCT (both), MTS, LND, SPD, RSS, MSC, PSC	93.4 (88.8)	97.9	23	16
Buffalo Fork (S. Fk. Snake)	95.8	959	YCT (both)	75.4 (80.2)	97.6	23	20
Goose Creek	95.3	1,842	YCT (lg.), BHS , BLS, MTS, UTS, LND, SPD, RSS, NLC , MSC, PSC, SSC, UTC	0.2 (0.1)	85.6	17	16
Conant Cr. (Henrys Fork)	95.0	312	YCT (both) BHS , MTS, LND, SPD, RSS, MSC, PSC	20.5 (8.8)	51.9	12	14
Cottonwood Cr. (S. Fk. Snake)	94.3	189	YCT (both), MWF	100 (100)	89.6	23	20
Spread Cr. (S. Fk. Snake)	90.6	344	YCT (both), PSC	15.3 (23.7)	90.7	19	19
Lower S. Fk. Snake R.	90.6	1,396	YCT (both), BHS , LSS, MTS, UTS, LND, SPD, RSS, MSC, PSC, MWF	0.7 (1.7)	74.7	16	13
McCoy Cr. (S. Fk. Snake)	89.5	282	YCT (both), MTS, UTS, LND, SPD, RSS, MSC, PSC	0.0 (0.0)	99.2	21	14
Ditch Cr. (S. Fk. Snake)	89.2	160	YCT (both), BHS	41.6 (10.6)	74.4	17	16
Gros Ventre R. (S. Fk. Snake)	88.7	1,617	YCT (both), PSC, MWF	36.4 (26.8)	97.6	20	18
Hoback R. (S. Fk. Snake)	87.9	1,469	YCT (fine), MTS, LND, MSC, MWF	19.3 (14.4)	94.1	21	14
Salt R. (S. Fk. Snake)	87.6	2,309	YCT (both), BHS , MTS, UTS, LND, SPD, RSS, NLC , MSC, PSC, MWF	0.7 (0.0)	71.3	15	15
Upper Raft R.	87.3	411	YCT (lg.), MTS, LND, SPD, RSS, MSC, PSC	4.9 (0.0)	30.2	18	16
Bear Cr. (S. Fk. Snake)	87.0	219	YCT (both), SPD, RSS, MSC, PSC	0.0 (0.0)	98.8	22	13
Upper Blackfoot R.	86.0	1,458	YCT (lg.), MTS, UTS, LND, SPD, RSS, MSC, PSC, UTC	0.4 (0.1)	56.0	16	15
Greys R. (S. Fk. Snake)	85.2	1,178	YCT (both), MTS, LND, MSC, PSC, MWF	0.3 (0.1)	99.7	19	16
Little Lost R.	84.3	1,528	BLT , MSC, SSC	10.7 (4.0)	94.7	17	21
Lower Blackfoot R.	83.3	1,832	YCT (lg.), MTS, UTS, LND, SPD, RSS, MSC, PSC, UTC	0.1 (0.4)	21.6	13	15
Big Elk Cr. (S. Fk. Snake)	81.6	160	YCT (both), SPD, MSC, PSC	0.0 (0.0)	97.6	24	14
Portneuf R.	80.0	4,344	YCT (lg.), BHS , MTS, UTS, LND, SPD, RSS, MSC, PSC, UTC	2.5 (0.1)	27.8	12	17
Willow Cr.	79.6	1,676	YCT (lg.), MTS, UTS, LND, SPD, RSS, MSC, PSC	19.0 (1.7)	36.9	15	17
Bitch Cr. (Henrys Fork)	78.7	245	YCT (lg.), MSC, PSC, MWF	77.2 (50.0)	78.6	22	14
Canyon Cr. (Henrys Fork)	77.4	215	YCT (lg.), LND, SPD, PSC, sculpin spp.	0.0 (0.0)	57.1	13	13
Cassia Cr. (Raft)	74.8	367	YCT (lg.), UTS, LND, RSS, MSC, PSC, UTC	0.4 (0.0)	74.8	15	17
Below Shoshone Falls							
Indian Cr. (Hells Canyon)	99.9	104	RBT , BLT	0.1 (0.0)	90.1	14	11
Little Jacks Cr. (Bruneau)	98.3	267	RBT , SPD, MSC, SSC	43.5 (59.2)	98.4	18	15
Brownlee Cr. (Hells Cyn.)	97.7	162	RBT , BLS, SSC, MWF	0.0 (0.0)	80.1	16	15
Squaw Cr. (Payette R.)	93.4	880	RBT , BLT , BLS, LSS, LND, SPD, RSS, NPM, MSC, SSC,	0.0 (0.0)	52.8	16	15
Lower N. Fk. Payette R.	93.1	810	RBT , LSS, SPD, RSS, NPM, MSC, SSC	0.0 (0.0)	50.3	15	12
Middle N. Fk. Payette R.	92.7	1,166	RBT , BLT , BLS, LSS, SPD, RSS, NPM, MSC	1.0 (0.4)	40.4	13	13
Middle Fk. Payette R.	92.3	878	RBT , BLT , CSM, LND, SPD, RSS, MSC, SSC, MWF	0.2 (0.3)	93.4	18	15
South Fk. Payette R.	90.0	1,918	RBT , BLT , LSS, CSM, LND, NPM, SSC	13.5 (10.7)	97.3	20	14
Upper Malheur R.	87.2	900	RBT , BLT , BLS, LSS, LND, SPD, RSS, NPM, MSC, MWF	18.8 (26.4)	76.3	15	18
South Fk. Boise R.	86.2	2,527	RBT , BLT , BLS, LSS, CSM, MTS, LND, SPD, RSS, NPM, MSC, SSC, MWF	0.0 (0.0)	88.4	17	16
Willow Cr. (Bruneau)	82.8	56	RBT	79.8 (80.5)	95.2	17	15
North/Middle Fk. Boise R.	79.7	3,156	RBT , BLT , BLS, LSS, LND, RSS, MSC, SSC, MWF	12.5 (12.3)	93.5	18	16
Jarbridge R. (Bruneau)	78.5	886	RBT , BLT , BLS, LSS, CSM, MTS, LND, SPD, RSS, NPM, MSC, SSC, MWF	47.7 (37.2)	89.6	18	16
Upper Little Weiser R.	78.4	205	RBT , BLT , LND, MSC, SSC	0.0 (0.0)	87.2	15	14
U. Deadwood R. (Payette)	77.5	283	RBT , BLT , SSC, MWF	0.0 (0.0)	95.5	21	15
Harrington Cr. (Owyhee)	69.2	151	RBT , SPD, PSC	0.0 (0.0)	61.0	16	16
Big Jacks (Bruneau)	65.3	632	RBT , BLS, LND, SPD, RSS, NPM	33.0 (66.1)	97.3	18	15
Cottonwood Cr. (Salmon Falls)	61.2	133	RBT , BLS, SPD, RSS, PSC	46.7 (42.5)	96.7	16	18

^a See Table 1 for species abbreviations.

^b Habitat integrity from TU's Conservation Success Index. Subwatershed scores range from 5 (poor) to 25 (good). Habitat integrity based in indicators of riparian condition, watershed connectivity, watershed condition, water quality, and flow regime.

^c Future Security from TU's Conservation Success Index. Subwatershed scores range from 5 (not secure) to 25 (secure). Future security based in indicators of land conversion, resource extraction, energy development, climate change, and introduced species.

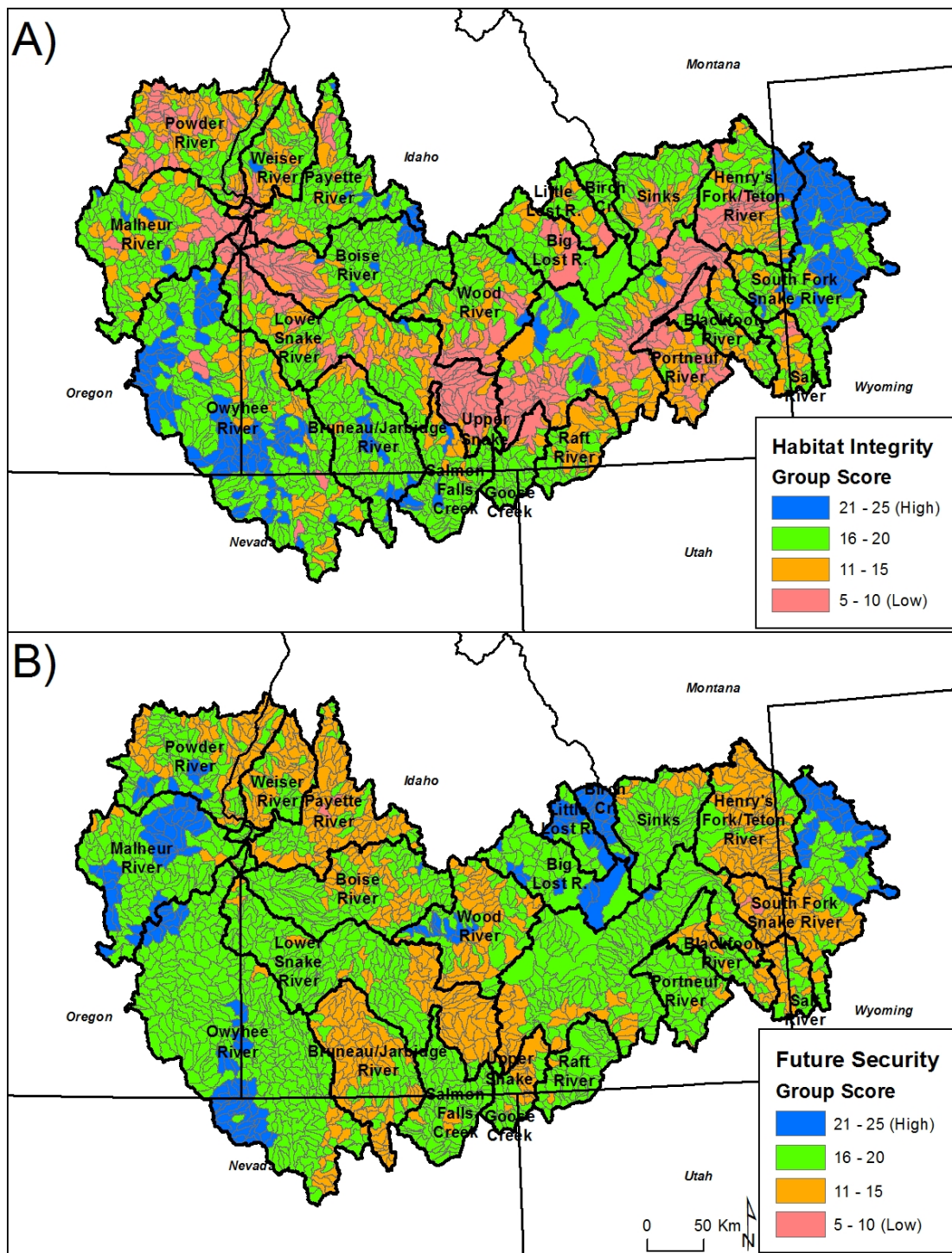


Figure 6. Spatial distribution of Habitat Integrity (A) and Future Security (B) scores for subwatersheds (HUC 12: n = 2079) in the Upper Snake River basin above Hells Canyon. Habitat Integrity and Future Security indicators were based on Trout Unlimited's Conservation Success Index (Williams et al. 2007).

Likewise, future security of habitats (and fishes) was variable across the basin (Figure 6B); it was high in protected areas and in areas with low development potential. Within potential NFCAs, future security of several watersheds within National Parks was high (scores 21 out of 25), whereas Indian Creek in Hells Canyon had low future security (scores 11 out of 25) because of threats to land conversion, resource extraction, and climate change (Table 2). Bear Creek in the South Fork Snake subbasin had a future security score of 13, in spite of being 99% public lands and a habitat integrity score of 22, while Canyon Creek in the Henry's Fork subbasin, the Lower South Fork Snake and several of the Payette River tributaries all had future security scores of 12 and 13 (Table 2).

Current distributions of bull trout and Yellowstone cutthroat trout (Figure 2A) show bull trout restricted to the lower Snake River basin (Hells Canyon to Shoshone Falls), except for occurrence in the Little Lost subbasin. It is uncertain whether bull trout occurrence in the Little Lost subbasin is a natural distribution (via headwater transfer from the Pahsimeroi River) or is a man-aided introduction. Yellowstone cutthroat trout occur in the upper Snake River basin above Shoshone Falls, primarily in the watersheds on the southern and eastern perimeter of the Snake River Plain. Conservation populations of Yellowstone cutthroat trout are shown in dark green and occur in numerous subbasins (IDFG 2007).

Redband trout are widely distributed across the lower Snake River basin with conservation populations located primarily in the headwater portions of watersheds and usually on public lands (Figure 2B). Fine-spotted cutthroat trout are a localized riverine form of Yellowstone cutthroat trout and occur primarily in the South Fork Snake and Salt River subbasins, and to a limited extent in the upper Henry's Fork subbasin. All four trout species are Species of Greatest Conservation Need (SGCN) with bull trout listed as threatened under the ESA. Their presence in a watershed, particularly bull trout, resulted in ranking the watershed higher in the analysis for potential NFCAs.

Identification of Potential NFCAs highlighted native trout distributions and abundance coupled with presence of native non-game species, particularly rare and sensitive species (i.e., Species of Greatest Conservation Need) (Figure 7). Potential NFCAs in the lower Snake River basin included assemblages of redband and bull trout and from one to eleven non-game species (except for Indian Creek which contained only redband and bull trout). Only one potential NFCA watershed in the lower Snake basin contained a non-game SGCN (mountain whitefish in the Jarbidge River); whereas approximately half of the potential NFCA watersheds in the upper Snake River basin contained non-game SGCN in addition to Yellowstone cutthroat trout (one or both forms). Non-game SGCN species (N=4) are disproportionately represented in potential NFCAs in the upper Snake basin, as compared to the lower Snake River basin, which contains six non-game SGCN species.

Land status of stream corridors (Figure 7B) in the potential NFCAs highlights the protection offered by public lands including national parks, wilderness areas, US Forest Service, and Bureau of Land

Management (BLM) lands. A comparison of the highest-ranking watersheds (Figure 5) with potential NFCAs (Figure 7A) and land status of the stream corridor (Figure 7B) shows striking similarities.

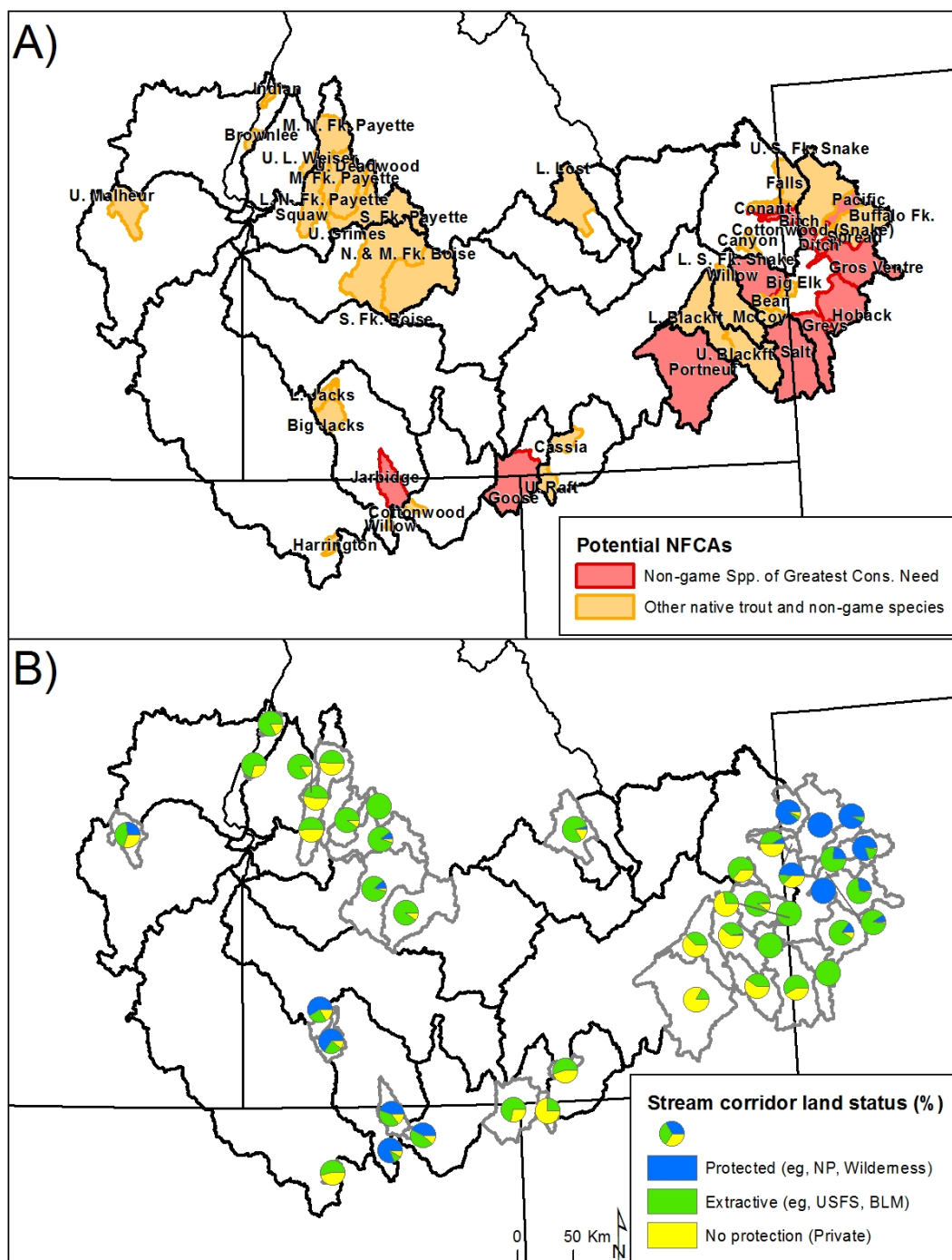


Figure 7. Potential NFCAs in the Upper Snake River Basin with the presence of non-game Species of Greatest Conservation Need (A) and pie charts show the land status of perennial stream corridors (B). Details of each watershed can be found in Table 2.

To illustrate the how the characteristics of potential NFCAs differed, we contrasted the characteristics of three watersheds: Jarbidge River, Goose Creek, and Upper Blackfoot River (Figure 8). The Jarbidge River has two native trouts, redband trout and bull trout, whereas the others have only Yellowstone cutthroat trout. The watersheds ranged in size from 878 to 1,842 km², but only two –Goose Creek and Upper Blackfoot River - have a natural downstream extents defined by dams impounding reservoirs. The Jarbidge River has no definitive downstream boundary and is connected to downstream rivers. The amount of public land in the watersheds ranges from 56 to 90%, with Forest Service lands in the headwaters and a mix of Bureau of Land Management and state lands at lower elevations. The perennial stream corridors were 72 to 87% public land except for the Upper Blackfoot where only 41% of stream kilometers were on public land; however, the mainstems of all streams and rivers were largely on private land. Little of the perennial streams had formal land protections, except in the Jarbidge River where 37% of perennial stream kilometers have formal protections in wilderness or wild and scenic river designation. Habitat integrity and future security for these three watersheds were moderate to high, in contrast for example to the future security of the South Fork Snake River and tributaries, which are lower and threatened by introduced species (e.g., rainbow trout), climate change (high drought risk), and energy development (potential hydropower development).

DISCUSSION

Our initial analysis identified many small subwatersheds as potential NFCA watersheds; however, many of the subwatersheds were surrounded by other candidate NFCAs within the context of larger watersheds, or subbasins (Figure 9). Therefore we aggregated many of these smaller subwatersheds into larger watersheds or subbasins where management considerations and actions were unlikely to differ among them. The aggregation of subwatersheds into larger watershed is seem most clearly in the Payette, Goose, Teton, South Fork Snake, and Blackfoot subbasins (comparing figure 7A Potential NFCAs to Figure 9B Tiers). For the NFCA approach to function and assist both public interest and management agencies long-term planning efforts, it is important that the NFCAs be practical and manageable. Aggregating the smaller subwatersheds with common species assemblages and management concerns into larger management units (as potential NFCAs) makes the NFCA designation more attractive and powerful as a management tool.

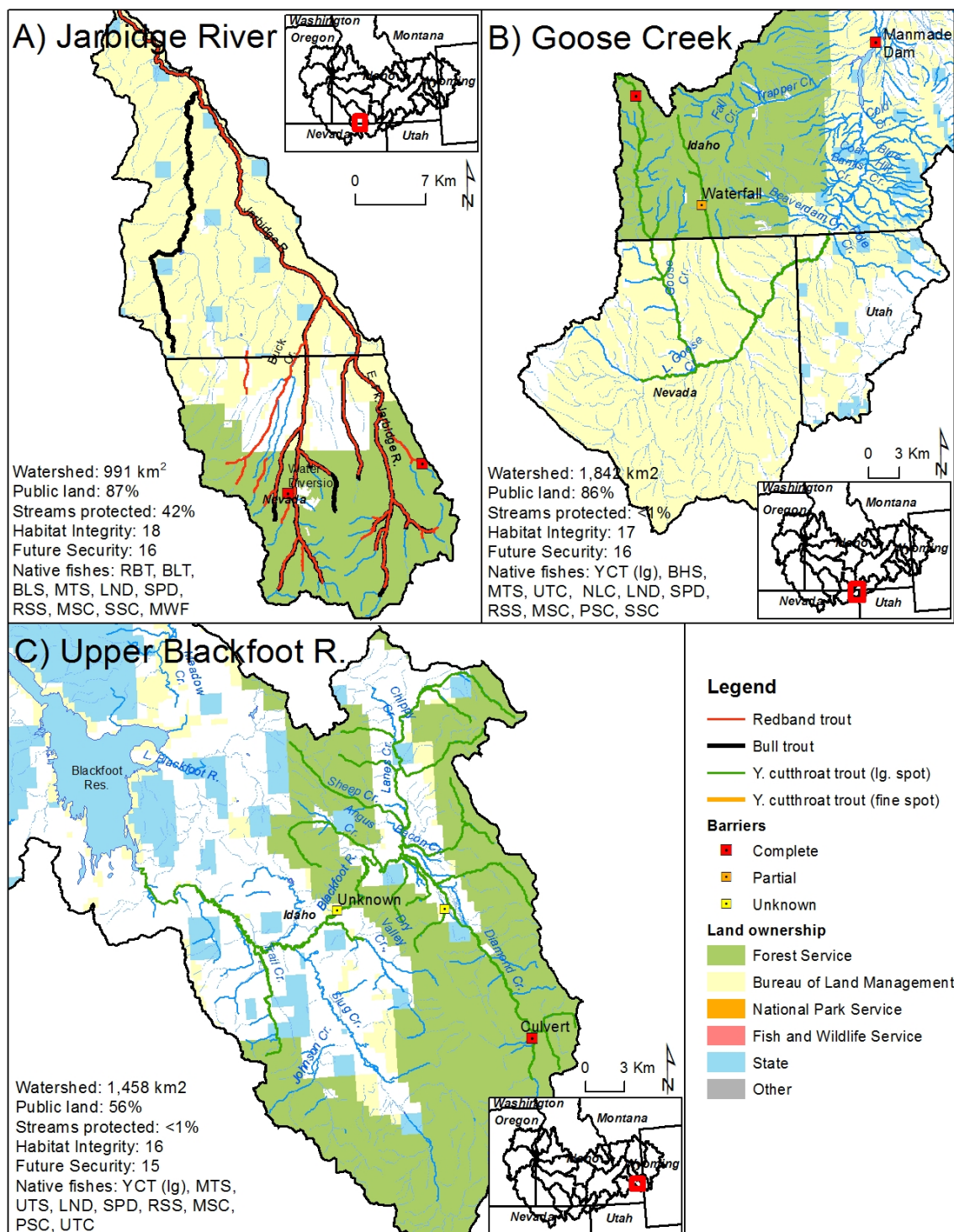


Figure 8. Land ownership and native trout distributions in the Jarbidge River (A), Goose Creek (B), and Upper Blackfoot River watersheds.

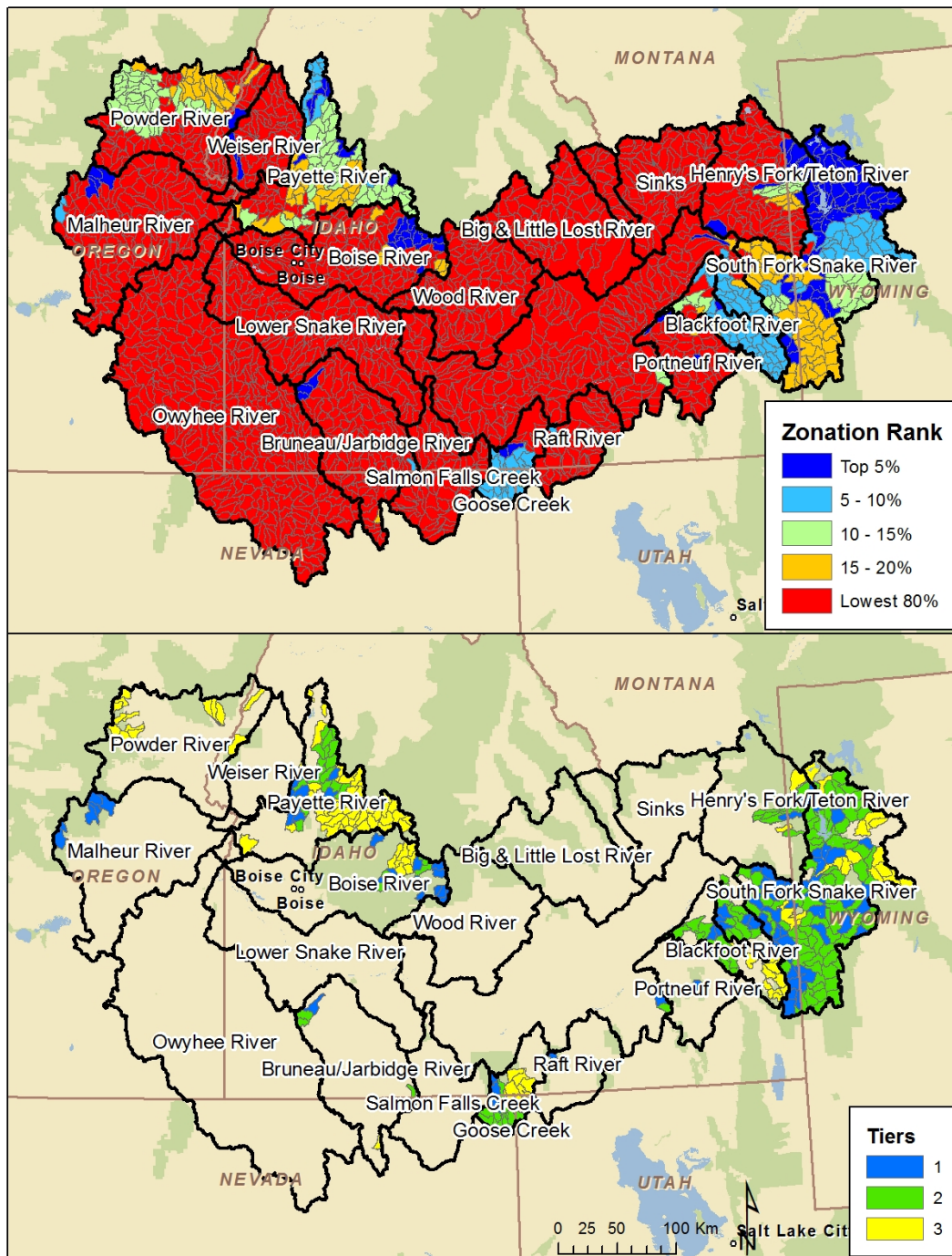


Figure 9. Subwatershed ranks (Top panel) and tiers (Bottom panel). Ranks are based on native trout distribution and abundance, native non-game species probability of occurrence, drainage network connectivity, and land protection status. Tier I watersheds are those with both native trout and native non-game species occurrences in the same subwatershed (HUC 12), and Tier II watersheds are those with both native trout and native non-game species occurrences in the same subwatershed (HUC 10).

Our analysis for potential NFCAs was conducted at the HUC 12 level of subwatershed (defined as ranging from 40 – 161 km²), while potential NFCAs (Table 2) identified in the Snake River basin occur primarily at the watershed level (HUC 10, which typically range from 161 – 1012 km² in size). Average size of potential NFCAs in the Snake River basin was 978 km², with those in the upper basin averaging slightly larger (1074 km²) than those in the lower basin (840 km²)(Table 2). These watershed scale NFCAs are compatible with management objectives and plans by state and federal natural resource management plans. For example, Idaho Department of Fish and Game's Management Plan for conservation of Yellowstone cutthroat trout defines 13 Geographic Management Units (GMUs) with respect to abundance, trends, genetics, and an evaluation of existing threats. Finally, IDFG's Plan presents management strategies and conservation actions based on habitat conditions, genetics, and population status that are compatible with the proposed management strategy for Native Fish Conservation Areas (Williams et al 2011).

NEXT STEPS

Final steps for the NFWF-funded (Proposal #27139) "Identifying Upper Snake River Basin Native Fish Conservation Areas (ID, WY, NV, OR)" will involve additional meetings with fisheries management agencies in Idaho and Wyoming to discuss our results and recommendations. We have presented this work (and project) in poster form at the 2013 National American Fisheries Society meetings, and were scheduled to present at the October 2013 Wild Trout XI Symposium, which was cancelled due to US Federal Government mandatory shutdown of services, including Yellowstone National Park where the Symposium was scheduled. We are planning (and have been accepted to present) the project at the re-scheduled Wild Trout XI Symposium in September 2014 in West Yellowstone.

Finally, we are preparing a condensed version of this report for submission to a peer-reviewed fisheries journal, most likely Fisheries, and AFS publication.

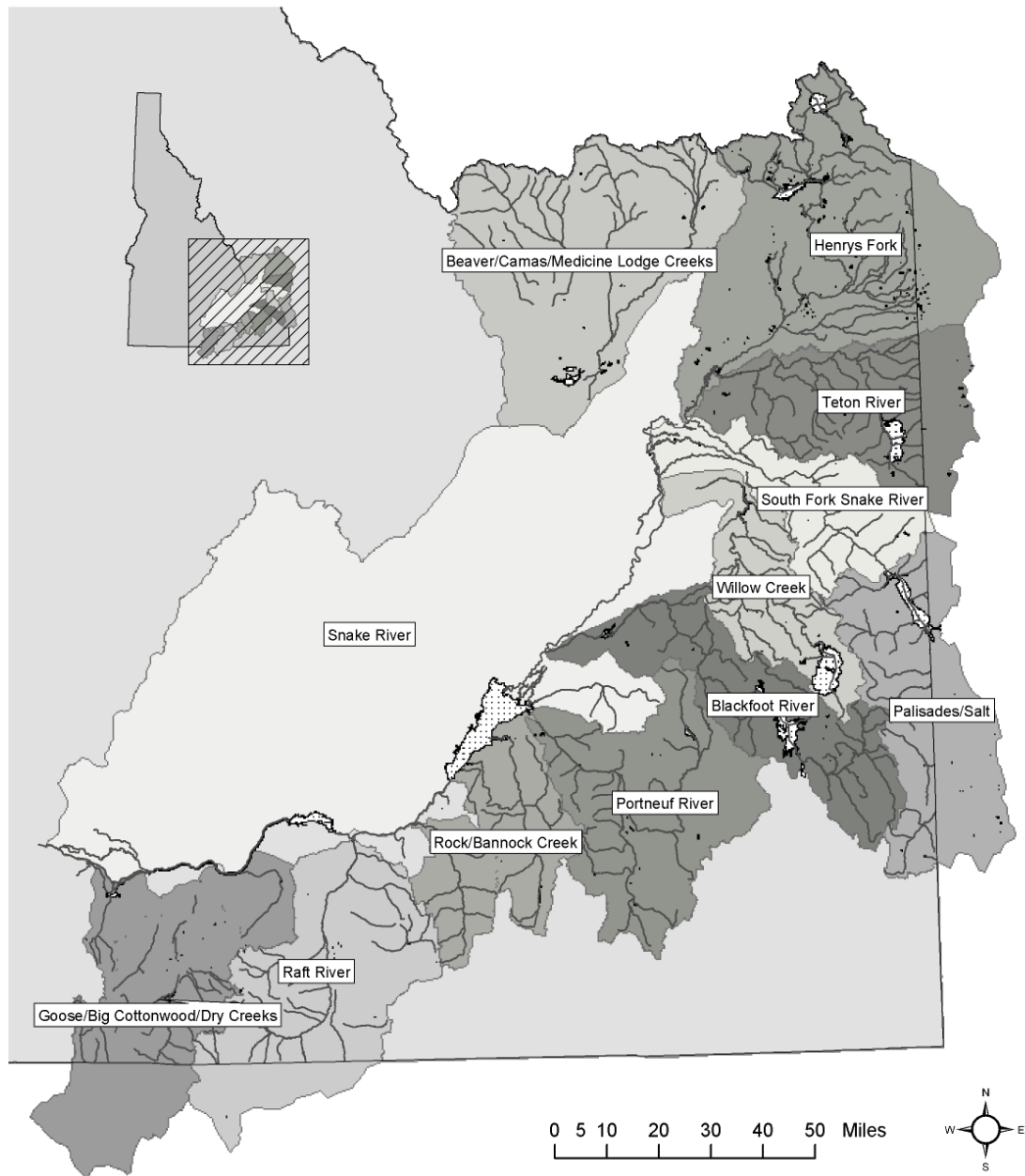


Figure 10. Location of YCT Geographic Management Units (GMUs) in Idaho from IDFG's (2007) Management plan for conservation of Yellowstone cutthroat trout in Idaho.

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