STATE OF THE TROUT

By *Jack E. Williams*
Amy L. Haak
Kurt Fesenmyer
Daniel C. Dauwalter
Helen M. Neville
Matt Barney and
Matt Mayfield

+ ROBERT J. BEHNKE (1929 – 2013)

THIS REPORT IS DEDICATED TO THE MEMORY OF "DR. TROUT" WHO WAS THE RECOGNIZED EXPERT ON NATIVE TROUT DIVERSITY IN NORTH AMERICA AND AMONG THEIR GREATEST CHAMPIONS

TROUT UNLIMITED

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COVER PHOTO BY MARISA CHAPPELL

Foreword

By the next generation, Trout Unlimited will ensure that robust populations of native and wild coldwater fish once again thrive within their North American range, so that our children can enjoy healthy fisheries in their home waters.

—Trout Unlimited vision statement

Native trout in the United States are in trouble. As this report describes, of the nation's 28 native trout species and subspecies, three are already extinct. Thirteen of the remaining 25 occupy less than 25 percent of their historic habitat. All native trout face threats from water diversion, water quality degradation, non-native species, energy development, and climate change.

People who fish for trout are a strange lot. What else explains this passion for willingly—joyfully—standing in cold water for hours on end, often in freezing temperatures casting combinations of wire, plastic, rubber, feathers or fur at river ghosts? Other than the 155,000 members of Trout Unlimited, our state and federal agency partners, and others who love to fish, who should be concerned about the fate of native trout?

All of us.

If you care about clean drinkable water, you should care about trout as they persist in only the highest quality water.

If you are concerned about climate change, trout are the proverbial canary-in-the-coal-mine for the effects of a changing climate.

If you want your children to be able to play in rivers and streams without becoming sick, read the report as trout require the cleanest water to survive.

People who fish are also eternal optimists. Even the most cynical among us on the last cast of the day are confident we will catch the biggest fish of the day, or even our lives. That optimism and hope for the future breathes through this report. Consider:

- In Maggie Creek near Elko, Nevada, the BLM, mining companies, local ranchers and the state have worked for two decades to restore 82 miles of stream, 2,000 acres of riparian habitat and 40,000 acres of upland habitat. Trout Unlimited and the National Fish and Wildlife Foundation, then partnered to reconnect tributaries to the mainstem and now Lahontan cutthroat trout have returned to 23 miles of interconnected and restored streams.
- In the Bear River which flows through Utah, Wyoming and Idaho, Trout Unlimited worked with the Forest Service, BLM, state agency partners, the National Fish and Wildlife Foundation and others to remove nearly 50 barriers—reconnecting over 150 miles of habitat—that for 60 years kept migratory Bonneville cutthroat trout from spawning in headwater tributaries.
- In the Driftless Area of Wisconsin, Minnesota, Iowa and Illinois, the Natural Resources Conservation Service, state agencies, Trout Unlimited and dozens of other agencies have worked to restore over 75 miles of trout habitat. Pre-restoration fish counts indicated 200-300 fish per mile of stream. Post restoration? Over 2,000 fish per mile.
- In Maine, Trout Unlimited worked with a collation of conservation groups, state and federal agencies, tribes and utility companies to come to an agreement that led to the removal of three dams and restoration that will re-open over 1,200 miles of habitat to imperiled Atlantic salmon, and other species such as shad, herring and striped bass.
- In Idaho, Colorado, New Mexico, North Carolina, Pennsylvania and other states, sportsmen and women have engaged state and federal agency partners to protect millions of acres of important habitat on public and private lands for wild and native trout.

Two basic lessons emerge from these, and dozens of other examples where sportsmen and women have found common-cause with state and federal agencies, private industry and individual supporters.

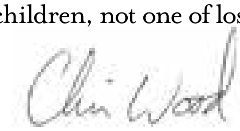
First, partnerships are imperative to restoring the legacy of wild and native trout in the United States. The author and nature philosopher Barry Lopez writes:

"Restoration work is not fixing beautiful machinery, replacing stolen parts, adding fresh lubricants, cobbling and welding and rewiring. It is accepting an abandoned responsibility. It is a humble and often joyful mending of biological ties, with a hope clearly recognized, that working from this foundation we might, too, begin to mend human society."

Every time we work in partnership to replant streamside areas; protect headwater habitats; repair irrigation diversions to reconnect river systems; and restore watershed health, we do more than recover trout and make fishing better; we build community in an otherwise fractured society. In many cases, the relationships—friendships—that emerge from previously competing interests are as important to the well-being of the country as the restoration work itself.

Second, every example of recovery and restoration cited above, and in this report, originated with one person, or a small group of people. So much of our lives today are dominated by fear: fear that our children will not do as well as us; fear of losing a job; fear of war or terrorism. Nature needs passionate leaders. Recovering the habitats that wild and native fish depend on demonstrates the unbridled optimism and confidence that makes America great, and proves that a few dedicated and committed people can make a difference and in their own way, change the world.

Native trout are in trouble in the United States. But we are making a difference, and with your help, involvement and action can promise a future of recovery for our children, not one of loss.



Chris Wood
President and CEO of Trout Unlimited

Executive Summary

Fishing for trout is a passion shared by countless anglers across the country. The challenge of catching a monster Lahontan cutthroat trout from Nevada's Pyramid Lake or a salter brook trout from a coastal stream in Massachusetts can be rewarding and frustrating all at the same time. As fly-fishing author John Gierach described it, «If people don't occasionally walk away from you shaking their heads, you're doing something wrong.»

The beauty and diversity of trout attracts the artist and photographer as well as the angler. Not only are the fish themselves works of art, but they occur in some of the most beautiful settings the country has to offer, from small gurgling country streams to high-mountain lakes to sweeping western rivers.

Unfortunately, neither the status of native trout nor their habitat is secure. During the past century, trout have declined as a result of land development, overfishing, water pollution, poor timber and livestock grazing practices and the introduction of non-native fishes and other aquatic invasive species. Stocking of hatchery trout has swamped the genes of the native trout through hybridization and competition.

Trout now face an evolution of these threats. Human population expansion has increased the demand for clean water, with more water diverted for municipal, agricultural and energy development. As our population expands, so does the demand for energy with new facilities invading prime trout country and the proliferation of hydraulic fracturing techniques that require 2 to 8 million gallons of water per well. Add to these the growing threat of climate change, which not only is warming the coldwater habitats trout depend on, but also compounds many of the traditional problems trout face. With climate change, our wildfire season is longer and fires are larger and more intense; droughts and flooding are more severe. Non-native species, including warmwater fish like smallmouth bass and chubs, are spreading into what was prime trout habitat.

This report details the status and trends within 28 separate species and subspecies of trout and char that are native to the U.S. Trout naturally occur in 38 of the 50 United States. Not included in this report are grayling, whitefish or the ocean-going steelhead and salmon, which will be described in a future report. Alaska will also be treated in a later report.

Westslope cutthroat

Of 28 native trout species and subspecies, three are extinct and six are listed as Threatened or Endangered. Excluding the extinct trout, 52 percent (13 of 25) occupy less than 25 percent of their historical habitat and are at high risk from at least one major threat. All native trout face some level of risk.

We divide our analysis into 10 large ecoregions: Pacific Coast, Central Valley/Sierra Nevada, Interior Columbia Basin/Northern Rockies, Interior Basins, Southern Rockies/Colorado Plateau, Southwest, Great Lakes/Upper Mississippi, Northeast, Mid-Atlantic, and Southeast. Trout status, threats and success stories of how to deal with these threats are described within this regional context.

Unfortunately, neither the status of native trout nor their habitat is secure. During the past century, trout have declined as a result of land development, overfishing, water pollution, poor timber and livestock grazing practices and the introduction of non-native fishes and other aquatic invasive species.

Widespread populations, genetic diversity and flexibility in life history expression have maintained trout over the eons and helped them adapt to changing conditions. But now, the loss of diversity, including genetic, life history and geographic diversity, threatens the persistence of most native trout species and subspecies. Not surprisingly, most trout face multiple threats, with two of the most common and serious threats to native trout—non-native species and climate change—now acting in tandem to degrade trout habitat and open new avenues for the spread of non-native species.

If future generations of Americans are to continue to reap the recreational and economic benefits of abundant trout populations, we must chart a new path forward. As described in this report, we have the knowledge and tools to deal successfully with current and emerging threats and to restore robust populations of native trout. The question is not whether we can restore native trout but whether we choose to do so. Trout Unlimited is dedicated to helping society make the necessary changes to implement the following steps.

1. Work at watershed scales to protect remaining high-quality habitats, reconnect fragmented stream systems and restore degraded mainstream and valley bottom areas. This will not only help restore fish populations but also improve the storage and delivery of water supplies during times of drought and flood.

2. Train volunteer leaders and the next generation of conservation stewards so that our work to protect, reconnect, and restore wild and native trout populations will persist over time.

3. Work to rebuild large, interconnected populations of native trout, which would facilitate restoration of migratory lifestyles and create populations that are resilient to climate change. This approach not only offers some protection from climate extremes but provides opportunities to conserve entire communities of rare aquatic species.

4. Become smarter and more effective in our restoration efforts. Restoration should occur at large scales, accommodate local climate change impacts and must be monitored and sustained over time.

5. Control the introduction and spread of non-native plant and fish species and minimize or eliminate trout hatchery stocking programs in the vicinity of native trout populations.

6. Become more efficient in our use of energy resources and the water that is required and make sure that energy development does not impact high-value fishery resources.

7. Conserve water resources and more efficiently use the water that our agricultural practices, cities, and factories require so that we can build more sustainable communities.

8. Increase angler participation in habitat restoration, monitoring and policies that affect fishery resources.

Ultimately, the human condition is inextricably linked to the status of native and wild trout populations. We all depend on high-quality water in stable supply, not only for our cities and agriculture, but for our recreation and spiritual sustenance. Native trout are sensitive to pollution and degraded water quality, so their sustainable populations are good indicators of the health of our rivers and their watersheds – all the more reason to make sure we maintain vibrant, fishable trout populations for our current generation and those yet to come.

The values of sustainable fisheries to our lives are sometimes hard to quantify but are well described in the following passage by Robert Traver (aka. John Voelker).

"I fish because I love to; because I love the environs where trout are found, which are invariably beautiful, and hate the environs where crowds of people are found, which are invariably ugly; because of all the television commercials, cocktail parties and assorted social posturing I thus escape; because in a world where most men seem to spend their lives doing things they hate, my fishing is at once an endless source of delight and an act of small rebellion; because trout do not lie or cheat and cannot be brought or bribed or impressed by power, but respond only to quietude and humility and endless patience; because I suspect men are going along this way for the last time, and I for one don't want to waste the trip; because mercifully, there are no telephones on trout waters; because only in the woods can I find solitude without loneliness; because bourbon out of an old tin cup always tastes better out there; because maybe one day I will catch a mermaid; and finally, not because I regard fishing as being so terribly important, but because I suspect that so many of the other concerns of men are equally unimportant — and not nearly so much fun."

The Diversity and Value of Native Trout Across the United States

Native trout of one species or another historically occurred in 38 of the 50 United States stretching in the East from the southern tip of the Appalachian Mountains in northern Georgia to Maine, throughout the Great Lakes Region and in all western states except Hawaii. These trout are prized for their beauty, ecological role in the broader aquatic ecosystem, spiritual and recreational value, and the economic stimulus that anglers in search of trout bring to many rural and urban communities across the United States.

The economic value of recreational fishing for trout can be hard to separate from broader values for recreational fishing but it is substantial at both local and state levels. The Sport Fishing Institute estimated the value of recreational fishing in the state of Colorado, where trout are popular target species for anglers, at $1.3 billion for 2011. In the Driftless Area of southwest Wisconsin, southeast Minnesota, northwest Illinois and northeast Iowa, where fishing for native brook trout and introduced brown trout is a major component of local angling, there is a $1.1 billion economic input to local communities from recreational angling. Nationwide, according to the American Sportfishing Association, recreational angling contributes more than $114 billion to the national economy.

Rainbow, brook and brown trout have been introduced widely, including into many states where they were not native historically. These many introductions as we will describe later, have been both a blessing and a curse. On the one hand, many introduced trout have thrived, spreading through the interconnected network of streams and rivers and providing great sport to the angler. Some species such as the European or German brown trout have exceeded expectations and have proven to be so successful in occupying new habitats that they now threaten remaining native trout populations. Hatchery-produced trout are often highly domesticated and maintain poor survival abilities compared to native trout, yet repeated stockings can swamp out native populations.

The natural diversity of native trout is impressive. Cutthroat trout occurred from west Texas to coastal streams in the Pacific Northwest and include at least 12 distinct subspecies. All are notable in the presence of red to orange-colored cutthroat marks along their throats, but each possesses unique coloration and spotting patterns. Redband trout are native to small desert streams in southeastern Oregon and southwestern Idaho, but also occur throughout the Columbia River basin, where they are the freshwater stream version of the anadromous steelhead. In the Sierra Nevada of California, golden trout proliferate with at least three distinct subspecies recognized. There are bull trout, lake trout, brook trout, Arctic char and Dolly Varden. Also on the list are little known trout like the blueback char and Eagle Lake rainbow trout. All told, there are 28 species and subspecies of trout native to waters of the US, not including the closely related grayling and whitefishes.

Fishes of the family Salmonidae – including trout, salmon, whitefishes and grayling – are an old and very successful group of fish from an evolutionary perspective. Part of their success is owed to their diversity of genetics, life history and geography. Simply put, there are many kinds of trout and each one may have many different life styles that allow them to persist under changing environmental conditions. Within a single species, some populations may spend their entire lives in small streams, others may migrate between lakes and tributaries or between larger rivers and their tributaries and some others may move between oceans and mountain headwater streams. Redband trout (often called rainbow trout) are a good example. Even within one pairing of male and female, some offspring may stay in small headwater streams as resident trout, while others migrate to the ocean and become steelhead.

Native trout occur in habitats ranging from small ponds in Maine to the Great Lakes and our larger western lakes such as Yellowstone, Flathead and Tahoe. Trout also occur from our largest rivers to our smallest headwater streams. They occupy literally thousands of streams, many so small as to be nameless.

Native trout occur in habitats ranging from small ponds in Maine to the Great Lakes and our larger western lakes such as Yellowstone, Flathead and Tahoe. Trout also occur from our largest rivers to our smallest headwater streams. They occupy literally thousands of streams, many so small as to be nameless. Where there is a consistent supply of cold water, one is likely to find trout – either naturally occurring or introduced, or both. Our management of water supplies has eliminated many trout populations but also provided some new habitat in deep reservoirs and in tailwaters below large dams.

Monitoring the status of the trout resource in the United States is no small task. Fortunately, many state, federal and tribal agencies track the distribution and status of trout populations within their jurisdictions. Much of this information has been summarized in TU's Conservation Success Index, which provides a significant amount of the information included herein. Countless agency scientists spend their careers monitoring, restoring and reintroducing trout populations across the country. We are indeed fortunate to have the benefit of their collective knowledge.

Our understanding of the condition of trout resources is quite good, especially when compared to other fishes, mollusks, amphibians and the many other species dependent on aquatic environments. The wide distribution of native trout, their dependence on cold, clean water and our comparatively good knowledge of their status and distribution makes them excellent indicators of the condition of our aquatic habitats and water supplies.

The purpose of this State of the Trout report is to summarize the current condition of native trout and their habitats and the current drivers, or causes of declines. Wild trout, which we define as naturally-reproducing populations of introduced trout, are under many of the same threats as described for native trout. Introduced brown, rainbow and other wild trout fisheries also are important to recreation and local economies. In some places native and wild trout seem to co-exist with little impact, but in other places wild trout cause conflicts with efforts to restore native trout.

As you will learn, most native trout occupy only a small fraction of their historically occupied habitats. Two subspecies of cutthroat trout, the Yellowfin cutthroat trout in Colorado and the Alvord cutthroat trout in Nevada and Oregon are extinct. The silver trout, once known from some ponds and lakes in the Connecticut River drainage, has not been seen since 1930 and is also extinct. Others are listed as Threatened or Endangered species pursuant to the Endangered Species Act. The causes of these declines vary widely but there are also many problems in common to all trout that are dependent on cold, clean water. Current trends will be described on a regional basis as shown on the following map. The regions were chosen for a combination of factors, including not only their general similarities in geology, physiography and vegetation, but also because of hydrology and fish distribution and a common suite of threats. The historical distributions of most native trout are restricted to a single region although for some species, such as brook trout, their range extends across multiple regions.

Fortunately, there are a wealth of people concerned with improving the condition of trout and their habitat. This report will also describe those efforts, their successes and where such efforts have met with something less than success.

Map of US showing regional breakdown used throughout in this report.

Trout Taxa	Pacific Coast	Central Valley and Sierra Nevada	Interior Columbia/ Northern Rockies	Interior Basins	Colorado Plateau/ Southern Rockies	Southwest	Great Lakes/Upper Mississippi	Northeast	Mid-Atlantic	Southeast
Coastal Cutthroat	X									
Westslope Cutthroat			X							
Yellowstone Cutthroat			X							
Greenback Cutthroat					X					
Yellowfin Cutthroat					Extinct					
Colorado River Cutthroat					X					
Lahontan Cutthroat				X						
Humboldt Cutthroat				X						
Paiute Cutthroat				X						
Alvord Cutthroat				Extinct						
Bonneville Cutthroat				X						
Rio Grande Cutthroat						X				
Apache Trout						X				
Gila Trout						X				
Coastal Rainbow	X									
Eagle Lake Rainbow		X								
Kern River Rainbow		X								
California Golden Trout		X								
Little Kern Golden Trout		X								
Klamath Redband Trout	X									
Columbia River Redband Trout	X		X							
Sacramento Redband Trout		X								
Bull Trout	X	Extirpated	X							
Dolly Varden	X									
Brook Trout							X	X	X	X
Silver Trout								Extinct		
Sunapee Trout/Blueback Char								X		
Lake Trout			X				X	X		

Historical regional distribution of native trout species and subspecies in the lower 48 United States. This table shows only the native historical distribution and does not include introductions made into non-native regions. Refer to Miller et al. (1989) for further information regarding extinct trout.

Summary of Status in the United States

The history of human settlement in North America is replete with anecdotes and evidence of the importance of freshwater fisheries to the continent's early inhabitants as well as the European explorers who settled and industrialized the United States. Although the taxonomy of native fishes continues to be refined, it is currently believed that 28 unique species and subspecies of trout and char plied the cold waters of the lower 48 states when the Lewis and Clark Expedition embarked on their transcontinental journey at the beginning of the 19th Century. By the middle of the 20th Century this number had dropped to 25 with the loss of Alvord cutthroat trout from the Interior Basins, Yellowfin cutthroat trout from the Southern Rockies and silver trout from the Northeast. Entering the 21st Century all but two of the remaining species (coastal rainbow trout and Dolly Varden) are managed as sensitive species and six are formally protected under the Endangered Species Act (bull trout, Lahontan cutthroat trout, Paiute cutthroat trout, Little Kern golden trout, Gila trout and Apache trout). The era of abundance has come to an end.

The degradation and fragmentation of aquatic systems, the spread of non-native species and management strategies that isolate populations above barriers have resulted in significant range contractions with more than half of the native trout occupying less than 25 percent of their historical habitat. All native trout have at least one moderate risk factor. Of particular concern are the 13 species and subspecies (52 percent) that occupy less than 25 percent of their historical habitat and are also at high risk to at least one of the four primary threats.

Most of the native trout have lost substantial genetic, life history and geographic diversity. Conservation portfolios of native trout have shifted away from large, interconnected populations to smaller populations that are isolated in headwater streams (1,2). These changes reduce the ability of trout to migrate long distances and to find suitable habitats during these times of rapid environmental change.

Non-native species and climate change pose the most widespread threat to native trout with 72 percent of native trout at high risk from non-native species, 64 percent at high risk from climate change and 44 percent at high risk from both. This presents a challenging conundrum to managers who must balance the need to protect populations from invading non-natives with the risks posed by increasing environmental disturbances and warming water temperatures due to climate change. Energy development was the least widespread of the threats, with only Colorado River cutthroat trout and brook trout in the Mid-Atlantic region classified as high risk, while water demand also presents a high risk to Klamath redband trout, Lahontan cutthroat trout and Bonneville cutthroat trout.

Report Findings

- **Of 28 unique native trout, three are extinct and six are listed as threatened or endangered.**
- **Fifty-two percent of the remaining trout (13 of 25) occupy less than 25 percent of their historical habitat and are at high risk to at least one major threat.**
- **Loss of diversity—genetic, life history and geographic—threaten persistence of many native trout.**
- **All native trout have at least one moderate risk factor.**
- **Most trout have multiple threats, including water diversion, non-native species, energy development and climate change.**
- **Most serious threats are non-native species and climate change.**

TROUT ILLUSTRATIONS BY JOSEPH TOMERLLERI

Region	Trout Taxa	Climate Change	Energy	Non-native Species	Water Demand	Percent of Historical Habitat Occupied
Pacific Coast	Coastal Cutthroat	Yellow	Green	Green	Yellow	>50
	Coastal Rainbow Trout	Yellow	Green	Red	Yellow	>50
	Bull Trout*	Red	Green	Red	Green	60
	Dolly Varden	Red	Green	Yellow	Green	10 - 25
	Columbia River Redband Trout*	Red	Green	Red	Yellow	44
	Klamath Redband Trout	Red	Green	Red	Red	>50
Central Valley and Sierra Nevada	Sacramento Redband Trout	Red	Yellow	Yellow	Yellow	22
	Eagle Lake Rainbow Trout	Red	Green	Red	Green	38
	California Golden Trout	Red	Green	Red	Green	49
	Little Kern Golden Trout	Red	Green	Yellow	Green	100
	Kern River Rainbow Trout	Red	Green	Yellow	Green	15
	Bull Trout*	EXTINCT WITHIN THIS REGION				
Interior Columbia Basin—Northern Rockies	Westslope Cutthroat Trout	Yellow	Yellow	Red	Green	42
	Yellowstone Cutthroat Trout	Yellow	Green	Red	Green	41
	Bull Trout*	Red	Green	Red	Green	60
	Columbia River Redband Trout*	Red	Green	Red	Yellow	44
	Lake Trout*	Yellow	Green	Red	Green	10 - 25
Interior Basins	Lahontan Cutthroat Trout	Red	Green	Red	Red	4
	Humboldt Cutthroat Trout	Red	Yellow	Yellow	Yellow	<9
	Bonneville Cutthroat Trout	Yellow	Green	Red	Red	31
	Paiute Cutthroat Trout	Red	Green	Red	Green	0
	Alvord Cutthroat Trout	EXTINCT				
Colorado Plateau—Southern Rockies	Colorado River Cutthroat Trout	Yellow	Red	Red	Yellow	11
	Greenback Cutthroat Trout	Yellow	Green	Yellow	Green	<1
	Yellowfin Cutthroat Trout	EXTINCT				
Southwest	Rio Grande Cutthroat Trout	Red	Yellow	Red	Yellow	10
	Apache Trout	Red	Green	Red	Yellow	25
	Gila Trout	Red	Green	Red	Yellow	5
Great Lakes—Upper Mississippi	Brook Trout*	Yellow	Yellow	Red	Green	55
	Lake Trout*	Yellow	Green	Red	Green	10 - 25
Northeast	Brook Trout*	Yellow	Green	Yellow	Yellow	55
	Sunapee Trout/Blueback Char	Yellow	Green	Red	Green	<10
	Lake Trout*	Yellow	Green	Red	Green	10 - 25
	Silver Trout	EXTINCT				
Mid-Atlantic	Brook Trout*	Yellow	Red	Red	Yellow	55
Southeast	Brook Trout*	Red	Yellow	Red	Yellow	55
Rangewide	Brook Trout*	Yellow	Yellow	Red	Yellow	55

Table 2. Summary table of major risk factors for native trout. Risk factors are based on professional judgment and data within TU's Conservation Success Index. Risk factors are classified as high (red), moderate (yellow) or low (green).

* Indicates trout that spans multiple regions. The percentage of historical habitat currently occupied is based on the species' rangewide extent. The actual percentage within a given region may be more or less than the rangewide value shown here.

The Evolution of Threats to Native Trout in the United States

All native trout in the United States have experienced a significant reduction in their historical range. The beginning of their decline dates back to the industrial revolution of the 1800s when our growing nation looked to its waterways to support manufacturing, power, agriculture and the transportation of raw materials. The industrial revolution changed the lives of people and altered the landscapes of the United States and in so doing it also changed the trajectory of the vast and diverse populations of native trout which had evolved over thousands of years in the nation's clean, cold waters.

During the 1800s intensive livestock grazing, land conversion, logging, mining, dams, irrigation and an expanding transportation system began to unravel many of the nation's freshwater systems. In addition to the degradation and fragmentation of aquatic habitats, the nation's growing population and the often unsustainable harvest of native trout caused the once seemingly limitless bounty to dwindle. In the early 1870s the first National Fish Hatchery was established in California on the McCloud River. Millions of trout eggs were shipped east from the Baird Hatchery beginning the practice of introducing trout well beyond their native borders. Only a decade later, brown trout from Germany were introduced into Michigan. Such introductions would become increasingly common and spell trouble for native trout populations.

Fortunately, by the early 1900s the conservation movement in the United States was also gaining momentum and the concept of setting aside some of the nation's natural resources and wild lands for future generations began to take hold. Today about 350 million acres of land is protected in the United States, providing important high quality habitat for the nation's flora and fauna, including native trout. However, even within these protected areas populations of native trout may be displaced by non-native species. Outside of these protected areas 380,000 miles of forest system roads, 87,000 dams over 25 feet in height, 55 million acres of irrigated farmland and 250 million acres of public land livestock grazing continue to impact the nation's streams and the native species that depend on them.

Today the protection and restoration of native trout is a priority for state and federal wildlife agencies. While they may never be restored to their historical levels (pre-1800), a representation of the genetic, life history, and geographic diversity that has characterized native trout for 1000s of years should be secured within a portion of their historical range. Accomplishing this requires protection of existing populations and the restoration and reconnection of fragmented and degraded habitat to support population expansion and/or the reintroduction of new populations. Given enough time and resources, many of the current impacts to important native trout streams from roads, agriculture, livestock grazing and other traditional land use activities can be mitigated through strategic restoration actions. Although improving habitat is an essential component of native trout conservation, it does not address the threat of non-native fish.

Non-native fish displace native trout through direct predation and by competition for food and spawning and rearing habitat. Some introduced trout, such as non-native rainbow trout in native cutthroat trout habitat, also cause hybridization between the species and can swamp the genetics of the native fish with repeated introductions. Since the first introductions of rainbow and brown trout in the late 1800s, these species as well as lake trout, brook trout and cutthroat trout have been moved from one river basin to another throughout much of the country. Some of these transplants were done deliberately by state agencies to augment sport fisheries while others are the result of illegal introductions by individuals. Regardless of the source, the

Changing Threat Regimes

For the past two centuries, native trout have been subjected to a long list of threats. Sometimes while one problem is being addressed, the changes inadvertently cause a new set of problems to arise. Land use changes, dams and over-harvesting precipitated a decline in trout abundances by the middle of the 19th Century, encouraging hatchery development to mitigate the lost habitat. Large numbers of hatchery-produced trout brought diseases to wild populations and swamped the genetics of the better-adapted native forms.

With the increasing conservation ethic of the 20th Century came an appreciation for native species and the recognition that native trout not only mattered, but that they were in trouble. In order to protect remaining populations of native trout from the highly successful non-natives, artificial barriers were constructed in many small headwater streams. While this approach has been fairly successful in terms of maintaining the genetic purity of remaining populations, it has exacerbated yet another new threat to native trout: climate change. Because these populations are small and isolated in short stream segments, they are highly vulnerable to the increasing fires, floods and droughts resulting from climate change.

As our knowledge of fisheries conservation has improved, new threats have emerged that confound management and recovery plans. Now, trout face increasing competition for clean water from expanding human communities and energy development. As waters warm, new invasive species appear in mainstem rivers. Further upstream, headwater areas are under increasing threats as snowpacks decline, forests warm, and wildfires increase.

presence of these fishes poses a serious threat to the persistence of native trout and a management conundrum for the fish and wildlife agencies. Reconnecting habitats and populations increases the risk of exposure to non-natives while isolating native populations above barriers eliminates their ability to migrate, leaving them vulnerable to environmental disturbances. Given the challenges associated with the use of piscicides, such as rotenone, to treat larger drainages, the management emphasis for native trout conservation has typically been isolation in small headwater streams above barriers. While this strategy has worked in terms of maintaining genetically pure populations, it has eliminated much of the migratory life histories that characterized native trout and increasingly these small populations are being lost to disturbance events such as wildfire, drought and floods.

In the following sections we describe the regional trends of the past 5-10 years and the primary stressors now affecting native trout and their habitat. Specifically, we review the regional effects from four major drivers of environmental change – non-native species, water use, energy development and climate change – that are likely to determine whether or not native trout will be a part of the American landscape for future generations to enjoy.

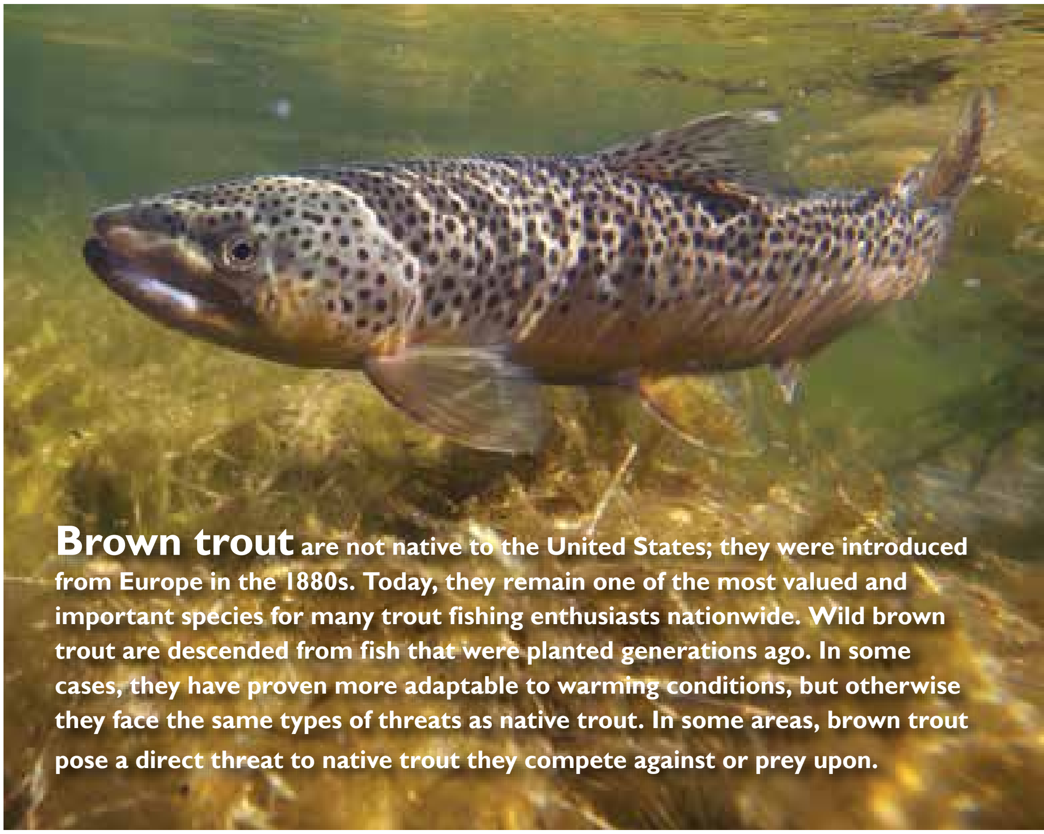
Non-native Species

One of the biggest drivers of change to native trout habitat has been the widespread introduction and invasion of non-native species. For native and wild trout, the problems of non-native species are three fold. The first problem is the introduction and establishment of non-native trout species. This includes establishment of brown trout and other species not native to North America as well as the widespread movement of native trout from one part of the country to another. For instance, brook trout, which are native to the East, have been widely introduced into western streams where they often overpopulate and compete with native trout for resources. The second problem is the invasion of native and wild trout waters by warmwater fishes. As streams and riparian areas are degraded, stream temperatures rise, which facilitates invasion by species such as smallmouth bass, carp and northern pike into trout habitat. The third problem is one of aquatic invasive species. This includes plant invaders such as yellow iris or purple loosestrife and invading mollusks such as New Zealand mud snail and quagga mussels. Another invasive species, Didymo, a diatom that forms nuisance algal blooms that can smother stream beds may actually be native to many river basins but often is considered to be a major aquatic invasive species problem. Aquatic invasive species can completely alter the ecology of trout streams. In Yellowstone National Park, for instance, the National Park Service tracks New Zealand mud snails, which despite their tiny size, were estimated to comprise 25 to 50 percent of the macroinvertebrate community in the Madison and Gibbon rivers (1).

Climate change can facilitate the invasion of native and wild trout habitat by undesirable species through the degradation of cold water systems (2). As air temperatures increase so do stream temperatures, facilitating invasion of trout waters by species more commonly associated with warm water habitats. Climate change may also contribute to non-native species problems by accelerating erosion and sedimentation through larger storm events and wildfire. These degraded streams may encourage the spread of the agents of whirling disease, Didymo and other aquatic invaders.

Water Use

Over 62 million acres of land was irrigated in the United States in 2010, accounting for about 38 percent of all freshwater withdrawals compared to 14 percent for public water supply. Thermoelectric power, which uses water to generate steam and for cooling in coal and nuclear power plants, is used primarily in the East, Northwest, California, and Texas and accounts for another 38 percent of total freshwater withdrawals. These three uses account for 90 percent of the freshwater (both surface and groundwater) used in the United States. The growing population in the United States continues to increase the demand for food, domestic water and energy while prolonged periods of drought due to climate change are contributing to water scarcities in some parts of the country. Fortunately, improved water efficiencies in irrigation systems and power plants as well as rising public awareness contributed to a 13 percent decrease in

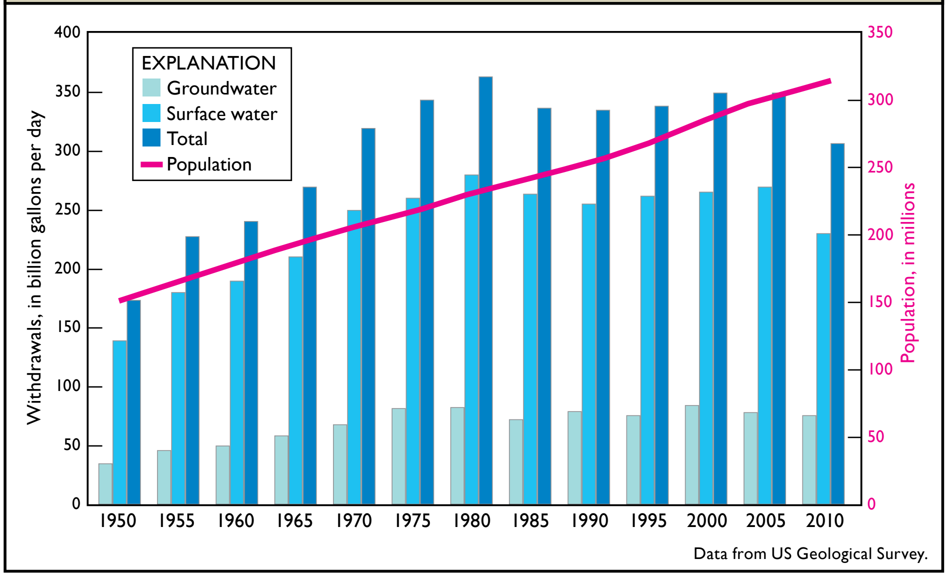


Brown trout are not native to the United States; they were introduced from Europe in the 1880s. Today, they remain one of the most valued and important species for many trout fishing enthusiasts nationwide. Wild brown trout are descended from fish that were planted generations ago. In some cases, they have proven more adaptable to warming conditions, but otherwise they face the same types of threats as native trout. In some areas, brown trout pose a direct threat to native trout they compete against or prey upon.

total freshwater withdrawals between 2005 and 2010 (3). While this trend is certainly encouraging, the geographic distribution of water demand relative to supply is cause for concern.

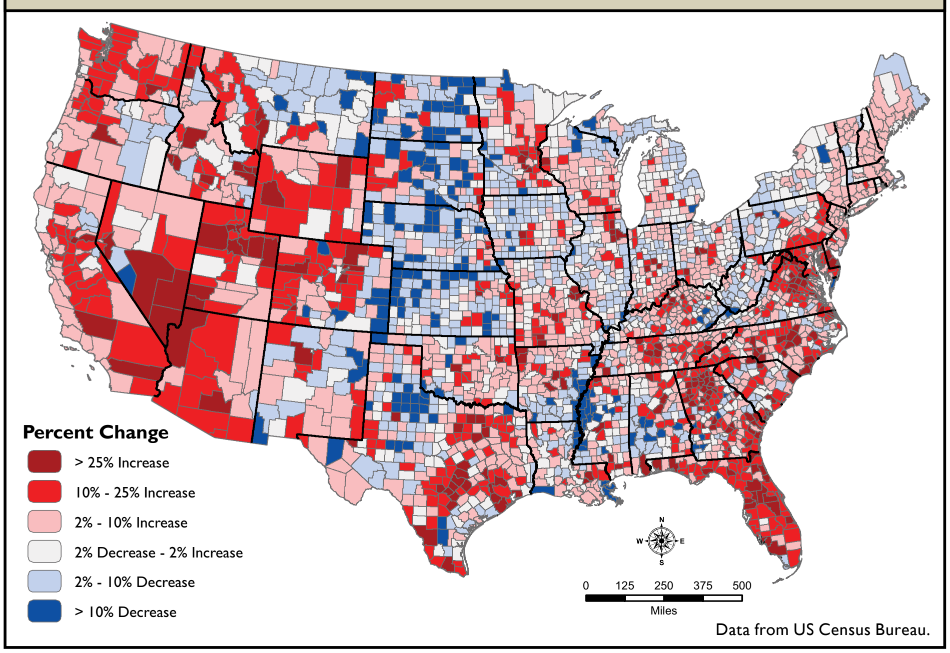
Much of the population growth in the United States over the past decade has occurred in the West and particularly in the arid and semi-arid regions of the Southwest and Texas. Between 2010 and 2014 the population in the United States increased by 3.3 percent while in California it rose by 4.2 percent, Nevada by 5.1 percent, Arizona by 5.3 percent, and Texas by 7.2 percent. The growing demand for increasingly strained water supplies may pit irrigation and municipal interests against the needs of aquatic ecosystems. California accounts for about 10 percent of the total freshwater withdrawals in the United States and is entering its fourth year of extreme drought conditions. Balancing human needs for freshwater with the needs of natural systems is an increasingly difficult task for water managers and may require some aggressive conservation measures if native trout are to persist.

Trends in Population and Freshwater Withdrawals by Source, 1950-2010



Total freshwater withdrawal in the United States is indicated by the dark blue bar while population increase is shown in the pink line. Improved water conservation measures have contributed to a decrease in freshwater withdrawals between 2005 and 2010 in spite of increasing population. Data from US Geological Survey.

Population Change, 2000-2010



Population growth across the United States by county between 2000 and 2010. The arid and semi-arid regions of the West have experienced some of the greatest population increase. Data from US Census Bureau.

Energy Development

For over a decade the development of domestic sources of oil and gas has been a high priority for the United States. Between 2000 and 2011, gross withdrawals of natural gas in the lower 48 States increased by about 47 percent, reaching historic highs in every year after 2006. During that same period, oil withdrawals increased by 11 percent, with much of that growth occurring after 2007. Although the development has been primarily concentrated in the Great Plains, Wyoming, Colorado, the Gulf Coast and Mid-Atlantic states, some type of energy development projects are being pursued in nearly every region in the country.

The primary step in the responsible development of energy resources is project siting. Some places such as the Rocky Mountain Front in Montana are deemed too important to fish, wildlife and water resources to be developed under any circumstances, while other places can support well designed projects. Of particular concern to stream conditions are increased sedimentation and pollution resulting from new roads, pipelines and well pads. Additional stream crossings and loss of riparian vegetation also may occur as sites are developed.

Hydraulic fracturing, or fracking, is one of the more controversial techniques for the extraction of fossil fuels because of its potential to have profound effects on both water quality and quantity in a watershed. The fracking process involves the high-pressure injection of a fluid comprised of chemicals and sand suspended in water into a wellbore in order to create cracks in deep shale formations that allow the natural gas and oil to flow more freely. The process requires large amounts of water which may be taken from surface or groundwater resources. Typically, 2 to 8 million gallons of water is needed for each fracking event and a single well can be fractured several times. A single well pad may host multiple wells thus placing significant pressure on local and regional water supplies and potentially altering the hydrologic regime of the surrounding watershed particularly during periods of low flow (4).

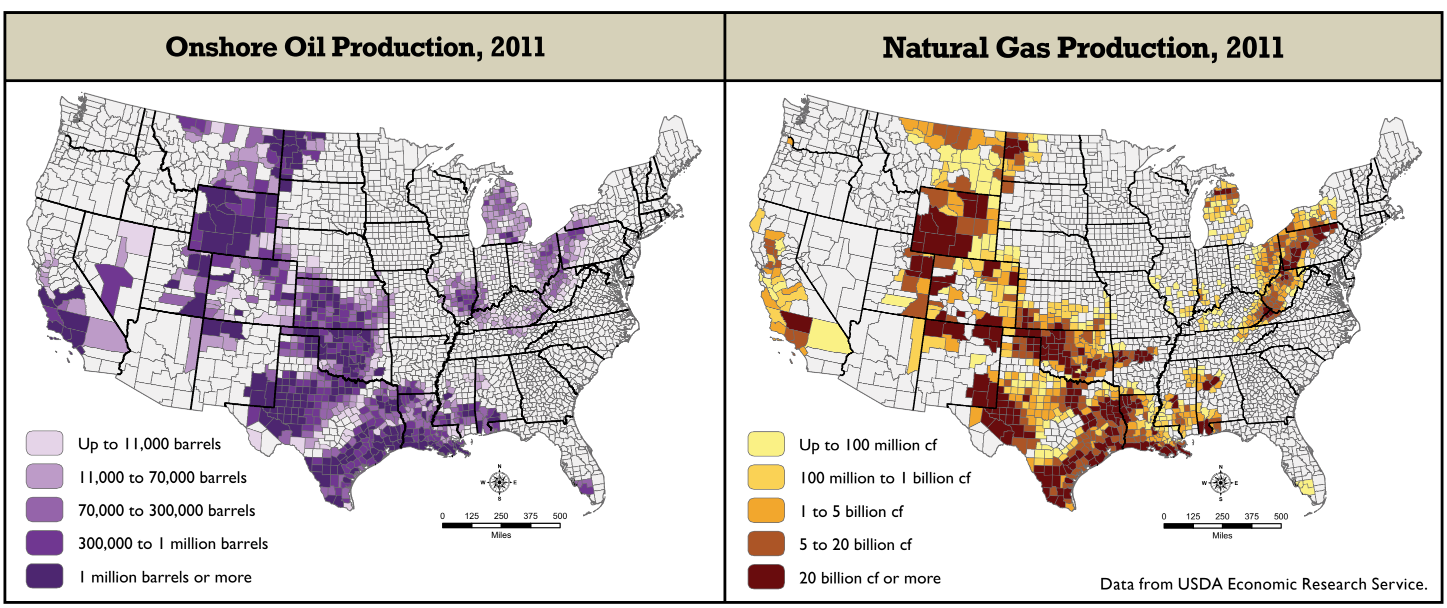
Oil and gas development may degrade water quality through both chemical waste and increased sedimentation. Although the chemical composition of the fluid mixture used in fracking may be proprietary information, the wastewater from the process is known to include high levels of total dissolved solids, metals and other toxic additives (5). Accidental spills of this liquid or direct discharge of treated waste waters back into streams can have detrimental effects on the health of the aquatic system. While more traditional drilling operations may not have the same risk of chemical contamination as fracking, all development projects have the potential to increase the sediment load in surrounding streams through the construction of well pads, roads and pipelines. Proper siting of infrastructure in a manner that protects the riparian corridor and minimizes the number of stream crossings is essential for minimizing aquatic impacts and maintaining healthy populations of trout over the life of the project.

Pipelines account for 90 percent of the total movement of crude oil and petroleum products across the United States. According to the American Petroleum Institute, between 2008 and 2013 the amount of crude oil delivered by pipeline increased nearly 20 percent while the mileage for liquid pipelines rose 9.3 percent for a total of 192,393 miles in 2013. Pipelines that cross stream channels either above or below the surface or pipelines that run next to a stream can damage aquatic systems. The siting of new pipelines should not only minimize removal of the riparian vegetation but should also take into account changing hydrologic conditions, particularly flood flows, due to climate change. Older pipelines are increasingly at risk of failure as erosion from uncharacteristically high flood flows has removed protective cover from along the banks and the stream bed, leaving the pipelines more susceptible to damage. Two such incidences have occurred recently on the nation's iconic Yellowstone River: one spill of 69,000 gallons of crude oil occurred in July 2011 while another happened in January 2015, spilling 42,000 gallons of crude oil into the river in eastern Montana and contaminating the drinking water of downstream communities. However, these two spills pale in comparison to the July 2010 spill on the Kalamazoo River in Michigan that dumped 840,000 gallons of crude oil into a tributary and closed 35 miles of the Kalamazoo River for a year. While renewable energy from solar, wind, geothermal, and hydroelectric sources provide energy without greenhouse gas emissions, their facilities, access roads, and transmission lines do have a physical footprint on the landscape and are thus subject to similar siting issues as oil and gas development. Hydroelectric dams are a major cause of habitat fragmentation and altered flow regimes.

Climate Change

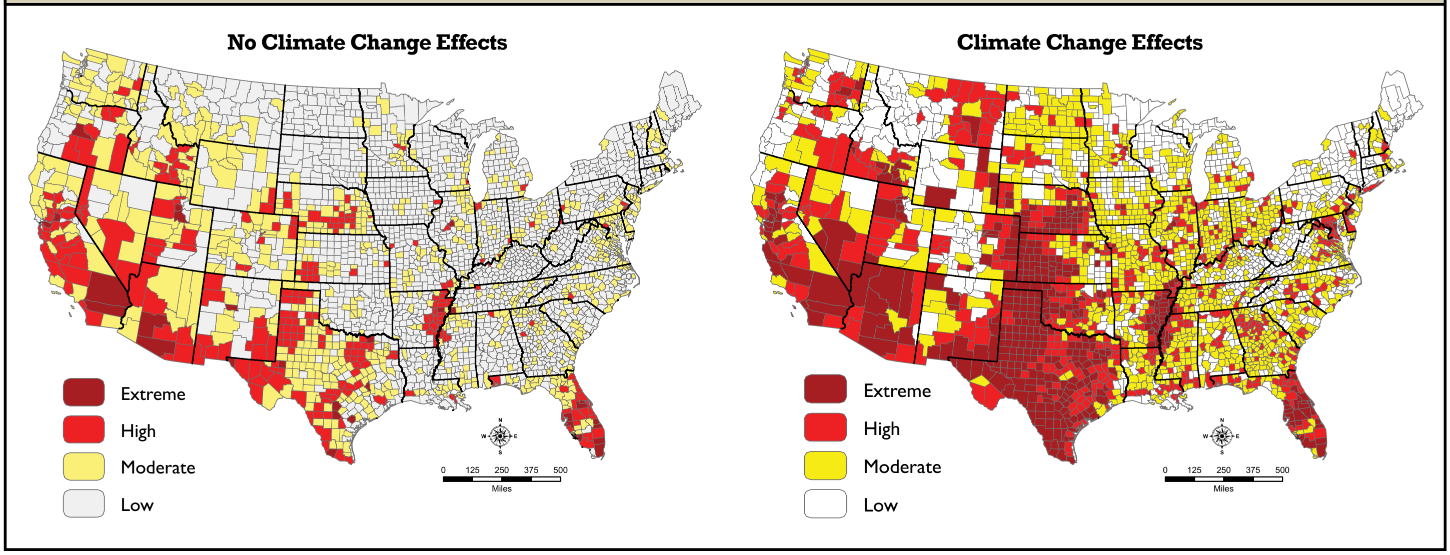
Global temperatures rose steadily during the 20th Century and they continue to do so as we enter the 21st Century with nine of the 10 warmest years on record having occurred since 2002. The rate and magnitude of this warming period has resulted in a series of environmental trends with significant implications for native trout. These changes not only directly impact coldwater habitats and the populations they support, but they also have the potential to exacerbate other stressors

The most obvious impact of these warming trends is increasing air temperatures resulting in long hot summers and earlier snow melt, particularly in the West. Early runoff and reduced spring and summer snowpack leads to a decrease in summer base flows leaving streams more susceptible to increasing air temperatures – a situation that is problematic for coldwater dependent species such as trout. A recent



Oil and gas production by county across the United States in 2011. Data from USDA Economic Research Service.

Water Supplies Projected to Decline



Projected risk of unsustainable water supply in 2015 by county across the United States. Even without climate change, areas of the Southwest are at high to extreme risk of experiencing a water supply shortfall and with climate change effects the risk expands significantly.(7)

study found that cutthroat trout may lose 58 percent of their currently occupied habitat by 2080 due to increased water temperatures that exceed their thermal tolerance (6). While these warmer waters may not be suitable for native trout, they often create a desirable environment for unwanted species such as smallmouth bass and other sunfishes, enabling them to encroach further into the domain of the native species.

Rising air temperatures also increase evaporative water losses further exacerbating drought conditions in arid climates such as the Southwest and California where the worst drought in decades continues to plague the region. Drought conditions are particularly problematic for populations of native trout isolated in small streams behind barriers that prevent them from accessing other tributaries as warming and drying conditions intensify over the summer. Long-term persistent droughts have profound implications on water supplies that are already stretched to their limit in many places and may not be able to support increasing demand even under normal climatic conditions.

Areas of the country experiencing earlier stream runoff and reduced mountain snowpack are also prime candidates for increasing wildfires. Although wildfire has always been a part of the landscape, the frequency and intensity of wildfires has increased dramatically over the past decade resulting in expansive fires that only cooler temperatures and rain are able to extinguish. Since the mid-1980s there has been a 60 percent increase in the frequency of large wildfires in the northern Rockies (8) and the three highest number of wildfire acres burned since wildfire statistics started being kept in 1960 occurred in 2006, 2007 and 2012.

Although native trout successfully evolved with wildfires, changes in watershed conditions and the isolation of populations have created a situation in which the direct and indirect effects of wildfires can be lethal. The increased severity of wildfires over the past decade, in combination with degraded or otherwise altered watershed conditions, can result in direct mortality on populations in the fire's path – particularly if a barrier prevents the fish from moving as the fire progresses. For those fish that survive the heat of the fire, they may still not survive the aftermath when heavy precipitation events on scorched soils can result in rapid runoff and scouring debris flows smother spawning habitats, invertebrate prey, and sometimes the fish themselves.

As with wildfire, floods are one of the natural processes that have shaped the American landscape. However, many of the floods experienced today are increasingly uncharacteristic of historical conditions due to the nature of the storm event as well as changes to the watershed and drainage network that have diminished the ability of the hydrologic system to absorb flood flows. These are typically associated with either extremely heavy precipitation events or mid-winter rain-on-snow events, when warm rains rapidly melt a snow pack. Between 1958 and 2007, the Northeast has experienced a 67 percent increase in the amount of precipitation that falls in the heaviest 1 percent of all rainfall events – in other words, significantly more of the region's annual rainfall is coming in major downpours. Channelization and the separation of a river from its floodplain further exacerbate the downstream impacts of a flood event. Scouring of the stream channel and the potential for debris such as road culverts to enter the stream course may also have detrimental effects on aquatic habitat.

In the West, the increased flooding events are more typically associated with an increase in the number of rain-on-snow events occurring at mid-elevations in mid-winter. These changes in the timing and magnitude of spring floods may result in a mismatch between the hydrologic regime and the timing of spawning. Depending on the local circumstances, this shift could favor one species over another and potentially provide another opportunity for non-native species to outcompete native trout.

Pacific Coast

Species Summaries

LISTING STATUS: red (ESA listed as Threatened or Endangered), yellow (not ESA listed but federal sensitive species or state species of concern (majority of states), green (not listed in majority of states)

CURRENT RANGE: red (10 percent or less), yellow (11-25 percent), green (>25 percent)

HISTORICAL RANGE: red (<1,000 miles), yellow (1,000-10,000 miles), green (>10,000 miles)

Coastal Cutthroat Trout

Category	Status	Explanation
Listing status	Yellow	Sensitive species (USFS) Species of Concern (WA) Species of Special Concern (CA)
Current range	Green	Data quality varies but most of historical range is believed to be currently occupied
Historical range	Green	Broadly distributed in coastal streams from Canadian border to Eel River in CA
Climate change	Yellow	Increasing drought and wildfires coupled with reduced snowpack negatively impact habitat
Energy development	Green	Impacts from energy development relatively minor
Non-native species	Green	Impacts from non-native species are minor
Water demand	Yellow	Impacts from diversions are uncertain but may be more substantial in southern part of this region
Data issues	Yellow	Populations are infrequently monitored

Coastal Rainbow Trout

Category	Status	Explanation
Listing status	Green	No special status for primary freshwater forms. Some steelhead ESUs are listed in the Pacific Coast region
Current range	Green	The degree of introgression from hatchery stocked rainbows is uncertain in many areas but most of historical range is believed to be currently occupied
Historical range	Green	Broadly distributed in coastal streams from Canadian border to Baja California
Climate change	Yellow	Increasing drought and wildfires coupled with reduced snowpack negatively impact habitat
Energy development	Green	Impacts from energy development relatively minor
Non-native species	Red	Potential widespread impacts, including hybridization, from hatchery-produced rainbows
Water demand	Yellow	Impacts from diversions are substantial in the southern part of this region
Data issues	Yellow	Better information is needed on degree of hatchery stocking influence on native genomes

Bull Trout

Category	Status	Explanation
Listing status		Listed as Threatened under ESA (Endangered Species Act)
Current range		Rangewide, approximately 60 percent of historical range is currently occupied but less in the Klamath Basin.
Historical range		Ranged broadly throughout Klamath, Upper Snake, Columbia, Coastal and McCloud River systems
Climate change		Very sensitive to rising water temperatures; wildfires a concern with reduced snowpack and forest drying
Energy development		Minimal impacts other than legacy hydroelectric developments
Non-native species		Lake trout, brook trout, brown trout and northern pike are particularly problematic
Water demand		Dams fragment habitat
Data issues		Status of many smaller populations is uncertain

Salvelinus malma

Dolly Varden

Category	Status	Explanation
Listing status		Not listed by WDFW or USFWS
Current range		Data are uncertain, but current populations appear to be restricted to smaller headwater streams
Historical range		Southern extent of range is northwest WA
Climate change		Very sensitive to temperature increases and changes in winter precipitation from snow to rain
Energy development		No known energy development concerns other than legacy hydroelectric power
Non-native species		Not believed to be a serious issue although potential competition with hatchery-produced salmonids
Water demand		Water divesions are minor issue
Data issues		Distribution uncertain; population data lacking for many stocks; distinction from bull trout not always certain

Columbia River Redband Trout

Category	Status	Explanation
Listing status		Sensitive species (USFS, BLM) Species of Special Concern (ID, MT, NV, OR)
Current range		Rangwide, 44 percent of stream habitat is currently occupied
Historical range		Historically occuped about 32,300 miles of stream habitat
Climate change		Snowpack is reduced; stream temperatures rising, wildfires increasing
Energy development		No known energy development projects
Non-native species		Major threat from hatchery-produced rainbow trout
Water demand		Drought-prone landscape and agricultural demands
Data issues		Have only tested genetics on 18 percent of occupied habitat and still a fairly high level of uncertainty on current distribution and abundance

Klamath Redband Trout

Category	Status	Explanation
Listing status		Listed as sensitive in OR
Current range		Although populations are reduced in some areas, most of the historical range is currently occupied within the Klamath Basin
Historical range		Broad historical range in the Klamath Basin
Climate change		Drought, stream warming and wildfires are major issues; the basin is currently in a prolonged drought
Energy development		No known energy conflicts other than legacy hydroelectric development
Non-native species		Introduced rainbow trout pose hybridization risk; yellow perch and other non-native fishes have become established in lakes and reservoirs
Water demand		Many streams have diversions; water demand is very high in the basin
Data issues		Interagency workgroup maintains good population data; flow data needs improving

Coastal Cutthroat Trout *(Oncorhynchus clarkii clarkii)*

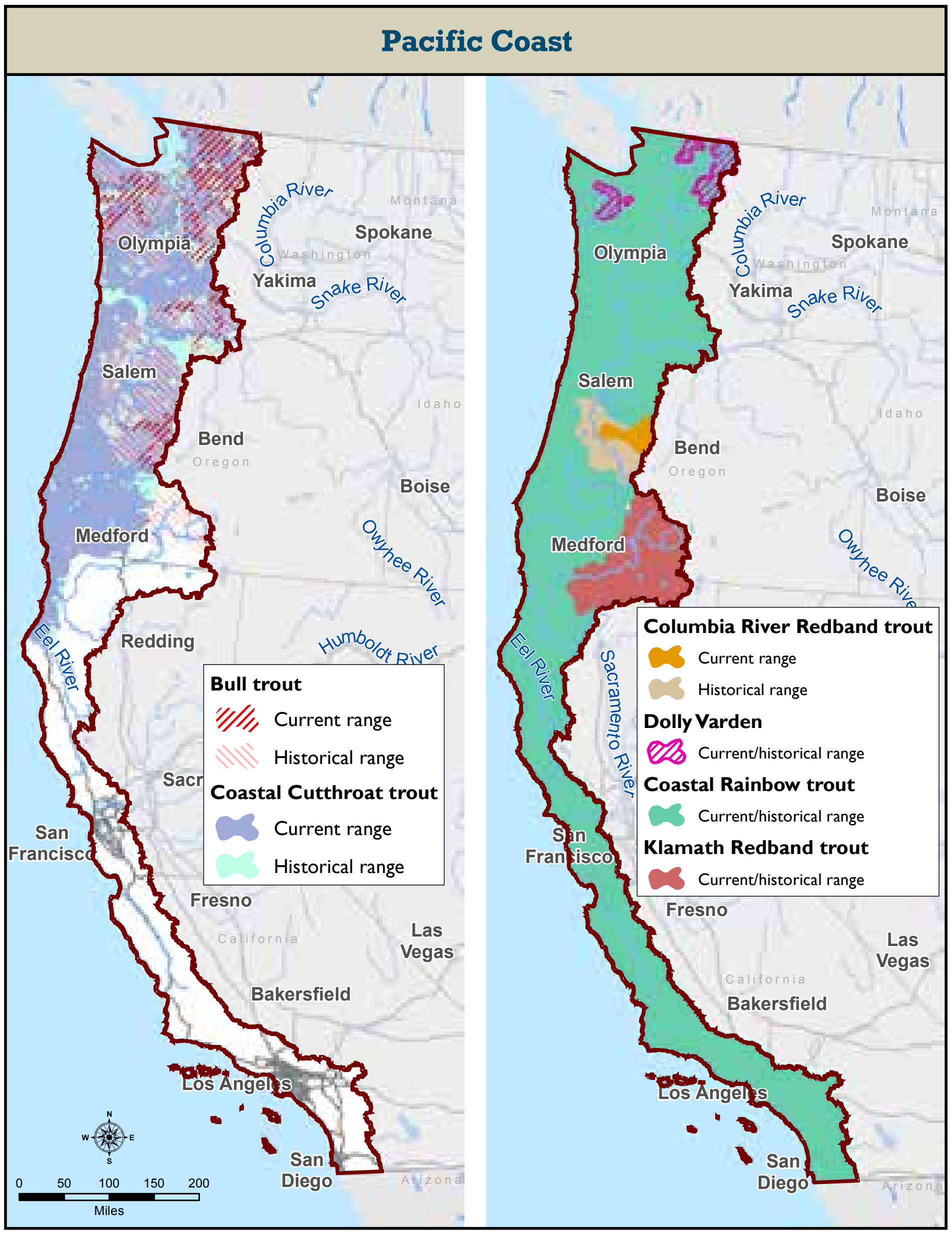
Coastal cutthroat trout are broadly distributed in watersheds draining the Coast Range from the Eel River in California northward into Canada and Alaska. Within the Pacific Coast region, they also occur as far inland as portions of the Willamette River drainage. The life history of these fish is highly variable and includes non-migratory resident freshwater forms, fluvial freshwater forms that migrate within the freshwater system, adfluvial forms that migrate between lakes and their tributary streams and sea-run or anadromous forms that move between freshwater and marine environments. The sea-run or anadromous forms do not have major oceanic migrations, but instead utilize estuaries and other near-shore environments for short periods of time before returning to freshwater; some individuals may take these migrations several times during their life.

Cutthroat trout tend to be more sensitive to warming water and disturbance than are rainbow or redband trout. Migratory fish, including the sea-run life history, are particularly sensitive to dams, poorly-designed culverts and other barriers to their free movement within stream networks. Other sources of degraded habitat for coastal cutthroat include poor forestry practices and poorly-designed or maintained roads that contribute sediment to stream systems, or land uses that degrade estuaries. Populations near or downstream of urban areas also may be impacted by polluted runoff and increasing pesticide loads.

In California, Dr. Peter Moyle from University of California-Davis estimates that the best remaining populations of coastal cutthroat occur in the Smith, Mad and lower Klamath rivers. In Oregon, the Department of Fish and Wildlife believes that virtually the entire historical habitat is currently occupied by coastal cutthroat trout and that all life histories are present. At times, some sea-run populations in Oregon and Washington have appeared to be at a higher risk but this generally reflected only sea-run fish and did not take into account the relative life history plasticity and the ability in single populations to express multiple migratory and resident forms. Nor did it focus on the extent of resident coastal cutthroat above barriers. Dams and other instream barriers have a greater impact on migratory forms. The larger, migratory fish may also be subjected to greater catch rates in the creel.

Coastal Rainbow Trout *(Oncorhynchus mykiss irideus)*

Coastal rainbow trout is the most abundant and widespread native salmonid in North America. In addition to a broad natural range throughout Pacific coastal areas, they have been widely cultured and introduced throughout much of the continent and beyond. As a result, there are now anadromous rainbow trout in the southern Pacific Ocean and northeastern Atlantic Ocean. Part of the success of this fish is due to its varied life history and ability to shift from one life style to another. Most anglers are familiar with two major life histories, an anadromous form known as steelhead and a resident form that spends its life in freshwater. But even within these two major groups there is variability such as with run timing of steelhead and separation between summer steelhead and winter steelhead. Environmental conditions, such as food availability, temperature, flows and habitat conditions, greatly influence whether an individual fish stays in freshwater or moves into the ocean to become a steelhead. In southern



Historical and current distributions of native trout and char in the Pacific Coast Region.

California, urbanization and dams now block many coastal drainages, effectively isolating the freshwater resident form. Generally speaking the distinction between these lifestyles is primarily environmental rather than genetic.

The federal government manages geographic distinctions in steelhead by grouping populations into ESUs – Evolutionarily Significant Units. Some steelhead ESUs are listed as Endangered or Threatened pursuant to the ESA. For example, the Southern California Coast Steelhead is listed as Endangered. The listing includes only anadromous steelhead naturally produced downstream of impassible barriers and not resident rainbow trout. Similarly, Central California Coast Steelhead are listed as Threatened and include only naturally-produced anadromous steelhead located downstream of dams and other impassible barriers. Other ESUs of steelhead also are listed northward through Puget Sound and to the Interior Columbia and Snake rivers.

Indiscriminate hatchery stockings and movement of populations across drainage boundaries have clouded the taxonomy and historical distinctions among many coastal rainbow populations. Substantial natural variation likely occurred among and within major drainage areas. Genetic techniques are available that can determine whether rainbow trout in a given stream system are genetically pure or whether they have been contaminated through introgression with stocked hatchery rainbows. A recent study completed by Trout Unlimited and NOAA-Fisheries staff examined rainbow trout from 27 streams in southern California and found only three streams that still contained predominantly pure native trout and many others that were some mix of hatchery and native genes (1). Such studies help focus recovery efforts where there is still a predominance of native fish.

Because threats to anadromous salmonids are more complex than freshwater resident forms and because federal agencies often manage steelhead separately from purely freshwater forms, we are treating steelhead and salmon in future State of the Salmon reports.

Bull Trout *(Salvelinus confluentus)*

In the Pacific Coast region, bull trout historically occurred in Washington coastal streams, Cascade-drainage streams in the Willamette River drainage in Oregon and in the upper Klamath River drainage. Bull trout are widely distributed within the Interior Columbia Basin/Northern Rockies region and were historically known to occur in the McCloud River in California, where they are now extinct. The species occupies a variety of large lakes, small headwater streams and larger river systems. In many areas, the species is highly migratory and maintenance of diverse life history expression is a primary recovery strategy. As such, habitat fragmentation caused by dams, poorly designed stream crossings and other factors is a major legacy threat to bull trout. Non-native species are another primary threat. Most large lake systems inhabited by bull trout are also habitat for introduced populations of brook trout, brown trout, lake trout and on occasion, northern pike. These species can prey on bull trout and are likely to compete for scarce resources. Many stream systems inhabited by bull trout also have large populations of brown and brook trout. The presence of brook trout is especially problematic because both brook and bull trout are fall spawners and readily hybridize, thereby reducing the diversity


Bull trout

and fitness of the bull trout population.

Preferred habitats of bull trout are characterized by the 4-Cs: cold, clean, connected and complex (2). Their habitat requirements are more specific than other native salmonids in the region. Bull trout require cold water, substrates that are clean of sediment and other pollutants, complex stream channels including deep pools and an interconnected stream network that facilitates spawning migrations and free movement up and down riverine corridors.

Climate change poses a dramatic risk for bull trout, especially warming of migratory and larger river habitats. The more southern portions of the range, including the Willamette and Klamath basin drainages in the Pacific Coast region may be particularly susceptible. In Idaho, warming stream temperatures are constricting the lower-elevation range of bull trout in many areas. Wildfires are another increasing risk associated with climate change. Like other parts of the bull trout range, changes in winter precipitation from snow to rain, earlier peak flows, forest drying and increased insect pests all favor increasing wildfires and subsequent stream sedimentation within the Pacific Coast region.

Bull trout populations along the Pacific Coast appear to be more robust in Washington streams and less robust in more fragmented habitat that becomes increasingly common as the distribution moves south in the region. In the Willamette River, for example, bull trout were known from the Clackamas, Middle Fork Willamette, McKenzie and Santiam. They were extirpated from all of these rivers except the McKenzie. Bull trout persist in the McKenzie River and the species has recently been reintroduced into the Clackamas River under experimental, non-essential provisions of the ESA. In the upper Klamath River system, bull trout occurred historically in the Wood, Williamson, Sprague, Sycan and some of the smaller streams draining from the Cascades into the Wood and Upper Klamath Lake systems. A reintroduced population persists in Sun Creek in Crater Lake National Park and downstream towards the Wood River. Small remnant populations still persist in the Upper Sycan and Sprague river systems.

Rangewide, the US Fish and Wildlife Service reports that the distribution of bull trout has changed little since the species was listed in 1999 (2). However the latest draft recovery plan of the USFWS also reports that more than 60 percent of known core areas have imminent threats that are rated as moderate or substantial. The status of bull trout in the Klamath Recovery Area is poor compared to other parts of the species range.

Dolly Varden *(Salvelinus malma)*

Dolly Varden is a close relative to bull trout and it was not until 1978 that the two species were confirmed to be distinct. In the U.S., Dolly Varden naturally occur only in coastal drainages in northwestern Washington from the Canadian border south through Puget Sound and south on the Olympic Peninsula to the Quinault River. Morphologically, Dolly Varden are very similar to bull trout and there has been some confusion in distinguishing the species, especially in northwest Washington where both species coexist in the same or adjacent drainages. Adding to the confusion is the potential for hybridization between the two species, which has been recorded in British Columbia.

The Washington Department of Fish and Wildlife reported in 2000 that the two species occurred together in the Quinault and Nooksack rivers and perhaps the Elwha as well (3). Since that time it appears that Dolly Varden in Washington may be restricted to small headwater tributaries of coastal rivers. Email exchanges between Bill McMillan and colleagues around 2004 reveal a more restricted distribution with smaller, non-anadromous populations occurring in isolated headwater drainages. Bill and John McMillan report Dolly Varden present in the headwaters of the Sol Duc, Dungeness, Nooksack, Quinault, Skagit and Elwha, with few or no Dolly Varden present in larger mainstem river systems (4). Populations in Washington likely were always restricted to the headwater streams.

Dolly Varden exhibit various life histories, including anadromous, fluvial, adfluvial and resident stream forms. In a report that combined bull trout and Dolly Varden, the Washington Department of Fish and Wildlife reported that 5 of 29 stocks are classified as "healthy", none were classified as either "depressed" or "critical" but 24 were not classified due to incomplete data (3). At that time (2000), it was believed that most Dolly Varden populations were anadromous but more recent information indicates that most populations are restricted to headwater streams and exhibit freshwater resident life histories. Dolly Varden are readily caught and are susceptible to overfishing by anglers. They also appear very sensitive to pollutants and increases in stream temperature.

Oncorhynchus mykiss gairdneri

Columbia River Redband Trout *(Oncorhynchus mykiss gairdneri)*

For the purposes of this report, we follow the genetic relationships of redband trout as described by Ken Currens and co-authors in a 2009 report on the evolutionary ecology of redband trout (5). They report three distinct lines that appear to be worthy of subspecific description: the Columbia River redband trout, Klamath redband trout and Sacramento redband trout. A fourth line of redbands in isolated basins of southeastern Oregon also appear to be distinct but their taxonomy is not as clear. Many of these redband are known as "interior redband trout." State and federal agencies, Tribes and Trout Unlimited are all part of a rangewide conservation agreement dedicated to the conservation and restoration of interior redbands, including the Columbia River subspecies.

In the Pacific Coast region, the Columbia River redband trout is known from tributaries of the Willamette River, upstream of and including the Calapooia River, near Albany, Oregon (6). Hatchery rainbow trout have been broadly introduced within the Willamette drainage, which complicates distributional certainty. Currently, the most abundant and robust remaining population in the Willamette River drainage is in the McKenzie River. This fish also is known as the McKenzie redband, redside or rainbow and is a favorite of local anglers. Within the McKenzie River, stocking of hatchery rainbows is the largest threat posed to native redband trout. Habitat in the McKenzie River remains in relatively high quality with redbands distributed widely in the drainage. Minor areas of stream channelization and riparian habitat degradation exist in the lower sections of the river.

Columbia River redband currently occupy just 45 percent of their historical stream habitat in the Columbia River system. The degradation and fragmentation of aquatic systems from land conversion, roads and the development of natural resources has contributed to local extirpations of redband trout, particularly at the lower elevations where these activities are the most prevalent. Dams, irrigation diversions and road culverts often create passage barriers for redband trout, eliminating their ability to move among lake, river and stream habitats. Although non-native species such as brown trout and smallmouth bass have displaced redband trout through competition for resources and direct predation, the greatest threat is from the widespread introduction of hatchery rainbow trout and non-native cutthroat trout, which commonly hybridize with the native redbands. It is estimated that 55 percent of streams currently occupied by redband trout contain hybridized populations.

Klamath Redband Trout *(Oncorhynchus mykiss newberryi)*

Redband trout from the upper Klamath River headwaters, Agency and Upper Klamath lakes and streams draining the coastal Klamath Mountains comprise the Klamath redband trout. In the upper basin, redband trout occur in the Sprague, Sycan, Williamson, Wood and Lost rivers, Jenny Creek, in addition to lakes and reservoirs. The redband trout population in Upper Klamath Lake is the largest adfluvial trout population in Oregon. Generally, the Klamath redband are highly migratory and move between lake and riverine habitats to feed and spawn as seasons, flows and water conditions dictate. Hatchery rainbow trout have been widely introduced in this basin, including stocking into Upper Klamath Lake as early as 1928. However, the Klamath redband evolved in the hypereutrophic waters of Upper Klamath and Agency lakes and it is doubtful that hatchery rainbows could survive and reproduce in the system, thus maintaining the natural genetic stocks of redband trout in the upper basin. The extent to which hatchery rainbow stocking has influenced some of the other redband populations in the basin is unknown.

Drought, dams, water diversions and poor water quality are concerns throughout the Klamath Basin, especially in the upper basin in Oregon. Currently the basin is enduring a prolonged drought, which exacerbates problems of overallocation of water in the basin. Upper Klamath and Agency lakes are hypereutrophic with periodic blooms of blue-green algae and related poor water quality conditions. These conditions may extend downstream of the lakes into Copco and Iron Gate reservoirs near the California border. Although constructed with a fish ladder, J.C. Boyle Dam poses a migration barrier for redband as do the remaining dams on the mainstem Klamath that lack fish passage facilities. Drought conditions will cause further water quality declines and likely contribute to increased wildfire risk.

Historically, competition for water has been intense in the basin, often placing farmers and ranchers against Native American Tribes, fishermen and bird enthusiasts. Much of the upper basin is prime agricultural land but salmon, steelhead and trout in the basin also support major commercial and recreational fisheries. Water resources are thin and demand is very high. The continuing battles for water supply caused many disparate parties to come together in recent years to produce a Klamath Basin Restoration Agreement and Klamath Hydroelectric Settlement Agreement. The agreements were signed by 45 parties, including federal agencies, the states of Oregon and California, Tribes, counties, irrigators and conservation groups in 2010. If and when the agreements are funded and fully implemented, they would reallocate water among competing parties and improve water quality and fish passage in the basin by removing four major dams on the Klamath River, restoring the potential for anadromous fish to once again access the upper basin. The agreements remain contentious and dependent on federal funding.

Regional Trends

The following factors impact native trout in the Pacific Coast region: timber harvest and associated forestry practices, agriculture, urban development, overfishing, stocking of non-native fishes, dams and other instream barriers, estuary degradation and climate change. Impacts may not be consistent across the three-state coastal region. Urban areas containing large swathes of impenetrable surfaces, such as roads and buildings, speed runoff with earlier peak flows following storms and higher levels of polluted stormwater runoff, which can carry warm water, sediment, hydrocarbons and chemical pollutants into stream systems. Many rivers in the region contain dams and impassible culverts that limit movement of the highly migratory bull trout, Dolly Varden, Klamath redband trout and coastal cutthroat trout. Water temperature also may restrict fish migrations and hence their distribution within and across watersheds. The region also has experienced dam removal projects on the Sandy, Rogue and most recently, the Elwha River, which have restored access between headwater and downstream river networks.

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Estuary conditions are a concern for native trout that exhibit anadromous life histories. Unlike salmon and steelhead, the ocean migrations of coastal cutthroat trout, bull trout and Dolly Varden are short and may be limited to estuaries; occurring over the period of a few months rather than years for salmon. Although bull trout are also known to enter saltwater and to move between watersheds. In areas with poor estuary conditions or where dams or other

Glines Canyon Dam on the Elwha River: Removed 2012 – 2013

mainstem river problems are substantial, coastal cutthroat trout and Dolly Varden may be restricted to headwater streams and a freshwater resident life history. Generally, it is highly advantageous for these fishes to be able to move throughout stream networks to find suitable conditions and avoid acute disturbances associated with flood, drought, or wildfire.

The Pacific Coast region is timber country and there has been extensive timber harvest on public and private lands in the past that have left a legacy of problems. Often associated with timber harvest is the construction of a network of primitive roads to facilitate timber removal. Roads intercept hill-slope runoff and channelize flows into streams at a faster rate than would normally occur. At the time the Northwest Forest Plan was prepared, there was an estimated road density on Forest Service and BLM public lands in the region of 4.22 miles of road/sq. mile (7). This high road density coupled with steep lands and normally high rainfall in the Pacific Coast can greatly increase peak stream flows in addition to road failures and associated debris flows into streams that result in increased stream sedimentation (8).

Streamside riparian buffers were increased and harvest levels were reduced on federal lands in association with the Northwest Forest Plan. Watershed conditions improved in the 10-year period following plan implementation (9) yet a significant legacy of poorly maintained roads and stream crossings persist in the region. Culverts are susceptible to blow out, especially in areas where substantial logging debris may clog culvert entrances and where there are shallow soil mantles and high likelihood of rain-on-snow events.

As the Pacific Coast region warms from climate change, there has been a shift in higher elevation winter precipitation from snow to rain. This can cause earlier season peak flows and lower base flows in the fall (10). Also, winter stream scouring can occur, which adversely impacts fall-spawning bull trout and Dolly Varden. An extreme drought is occurring in the southern portion of the region. California is in the fourth year of one of the most severe droughts on record. Beyond the lack of precipitation for providing stream flow and recharging groundwater for storage later in the year, 2015's drought has been particularly consequential for all species that depend on water – humans and trout included – due to warmer than normal winter temperatures. Complicating the water supply situation in California has been rapidly expanding cultivation of water-thirsty marijuana plants. Each plant needs about 6 gallons per day. In Outlet Creek, which is a tributary of the Eel River, California Department of Fish and Wildlife estimates that there are 441 marijuana cultivation sites with 32,000 plants requiring 191,000 gallons of water per day. Legal and illegal diversions are drying these drought-stricken streams.

The year 2014 was the warmest on record for California, 4.1oF above the 20th Century average and 1.8oF above the highest previous record set in 1934. Following the warmest calendar year on record in California, December through February of 2015 were the warmest in the state's recorded history. The 2015 snowpack is also very low in Oregon and Washington with the Klamath Basin near 10 percent of its historical average.

SUCCESS STORY:

Restoring Habitat Diversity to an Oregon Coastal Stream: Niagara Creek Large Wood Project

BY ALAN MOORE, TROUT UNLIMITED

PHOTOS COURTESY US FOREST SERVICE – HEBO RANGER DISTRICT

Niagara Creek is a major spawning and rearing tributary to the Nestucca River for winter steelhead, coho and Chinook salmon and coastal cutthroat trout. Most of Niagara Creek and its tributaries run through an inventoried roadless area of the Siuslaw National Forest. Habitat conditions generally are good and it is considered to be a productive stream for salmonid fishes. However, there are sections of Niagara Creek that are devoid of large wood where spawning gravel has been scoured out and refuge areas needed by juvenile salmon and trout to survive are few and far between. "Stream cleaning" and other activities back in the last century removed a lot of the large wood that naturally occurs in streams like this that provides a catalyst for innumerable natural processes needed by rivers, fish and other species. One of the major strategies for restoring habitat function in streams like Niagara is putting some of that large wood back and setting the table for more of it to enter the stream naturally in the future.

What the operation looks like on the ground.

The Chinook preparing to place a large tree in Niagara Creek.

A twin-engine Boeing Chinook CH-47 heavy-lift airship, owned and operated by Columbia Helicopters. The Chinook is the only available helicopter capable of transporting the large size of trees (up to 160') needed for the project. Large trees, especially large complexes made up of multiple trees weighing each other down, will stay in the stream corridor during high water events without any cabling or other artificial anchoring. Using large trees not only keeps the wood relatively in place, it allows the wood to act more naturally with the dynamic forces of the stream, preventing unintended results like unnatural erosion and other problems associated with cabling wood in place. Also, using a large helicopter to place large trees allows for large areas of a stream to be treated in a relatively short time and, importantly, with minimal ground disturbance. For this operation, we were able to place 160 pieces of large wood in complexes over more than 3 miles of Niagara Creek and one of its tributaries, Beulah Creek, in a matter of hours.

The Niagara Creek project is a partnership with major contributions from Trout Unlimited, US Forest Service (Siuslaw NF Hebo Ranger District), Oregon Watershed Enhancement Board, National Fish and Wildlife Foundation, Nestucca-Neskowin Watershed Council, Columbia Helicopters and the Austin Family.

Central Valley and Sierra Nevada

Species Summaries

LISTING STATUS: red (ESA listed as Threatened or Endangered), yellow (not ESA listed but federal sensitive species or state species of concern (majority of states), green (not listed in majority of states)

CURRENT RANGE: red (10 percent or less), yellow (11-25 percent), green (>25 percent)

HISTORICAL RANGE: red (<1,000 miles), yellow (1,000-10,000 miles), green (>10,000 miles)

TROUT UNLIMITED

Sacramento Redband Trout

Category	Status	Explanation
Listing status		Sensitive species (USFS, BLM) Species of Special Concern (CA, OR)
Current range		22 percent of historical habitat currently occupied
Historical range		3,500 stream miles historically occupied + Goose, Abert Lakes
Climate change		Drought, loss of snowpack, and wildfires are major issues
Energy development		Range overlaps where renewable energy from the Northwest and gas from Wyoming access California's energy grid – pipelines and transmission of moderate concern
Non-native species		Introduced rainbow trout pose limited competition and hybridization risk; brown trout pose competition and predation risk; brook trout pose a competition risk; largemouth bass present in lower Chewaucan River
Water demand		Many streams have diversions in lower reaches
Data issues		Stream flow and temperature data need improving

Eagle Lake Rainbow Trout

Category	Status	Explanation
Listing status		Sensitive species (USFS), Species of Special Concern (CA), under evaluation as Threatened under Endangered Species Act
Current range		38 percent of historical habitat currently occupied
Historical range		Only 34 stream miles historically occupied + Eagle Lake
Climate change		Drought, loss of snowpack, and wildfires are major issues
Energy development		No known significant energy development issues
Non-native species		Introduced brook trout pose competition risk
Water demand		Diversions in headwaters and lake addressed in recent years
Data issues		Stream flow and temperature data need improving

Oncorhynchus mykiss aguabonita

California Golden Trout

Category	Status	Explanation
Listing status		Sensitive species (USFS) Species of Special Concern (CA)
Current range		49 percent of historical habitat currently occupied
Historical range		Historical distribution poorly understood, but range covered approximately 570,000 acres
Climate change		Drought, loss of snowpack, and wildfires are major issues
Energy development		No known significant energy development issues
Non-native species		Introduced rainbow trout pose competition and hybridization risk; brown trout pose competition and predation risk
Water demand		No known significant water demand issues
Data issues		Stream flow and temperature data need improving

Little Kern Golden Trout

Category	Status	Explanation
Listing status		ESA Threatened Species of Special Concern (CA)
Current range		100 percent of historical habitat currently occupied
Historical range		Only 100 stream miles historically occupied
Climate change		Drought, loss of snowpack, and wildfires are major issues
Energy development		No known significant energy development issues
Non-native species		Non-native species present downstream below natural barrier
Water demand		No known significant water demand issues
Data issues		Stream flow and temperature data need improving

Kern River Rainbow Trout

Category	Status	Explanation
Listing status		Sensitive species (USFS) Species of Special Concern (CA)
Current range		15 percent of historical habitat currently occupied
Historical range		Historical distribution poorly understood, but range covered approximately 560,000 acres
Climate change		Drought, loss of snowpack, and wildfires are major issues
Energy development		No known significant energy development issues
Non-native species		Introduced rainbow trout pose competition and hybridization risk; brown trout pose competition and predation risk; brook trout pose a competition risk
Water demand		No known significant water demand issues
Data issues		Poorly documented distribution and abundance; stream flow and temperature data need improving

Sacramento Redband Trout *(Oncorhynchus mykiss stonei)*
Sacramento redband trout is the collective name for redband trout in the Chewaucan, Goose Lake, Warner Valley and McCloud River basins. Although the trout in each of these basins is considered somewhat distinct, genetic analysis has confirmed a shared history within the headwaters of what is or once was the Sacramento River basin (1).

Chewaucan, Goose Lake and Warner Valley populations occur in the high desert of northwestern California and south-central Oregon. These redband are a hold-over from the cooler, wetter climates of the Pleistocene and became increasingly isolated as the regional climate grew warmer and drier. They are mainly confined to headwater streams, except in Goose Lake and the Warner Valley lakes, all shallow alkaline lakes which boast lake-dwelling populations. In extremely dry years – for example, during the Dust Bowl years and during California's current drought (2012 – 2015) - the lakes completely dry up during the summer dry season and must be recolonized during wet years from the headwaters populations.

The McCloud River populations persist in spring-fed streams that drain the southern slopes of Mount Shasta in northeastern California. Tributary streams north of the mainstem McCloud infiltrate into the area's porous volcanic geology and are typically disconnected from other surface waters. The mainstem McCloud and its southern, moderate-gradient tributaries are isolated from the larger Sacramento River basin by the Upper and Middle Falls.

Given the highly variable environmental conditions in the range of these populations, connectivity between populations is critical for allowing recolonization following local extinction events related to drought or disturbances like wildfire. Eliminating fish passage barriers in the basin remains the highest conservation priority for the subspecies. Threats for the Chewaucan, Goose Lake and Warner Valley populations include flow alteration associated with dams and diversions and sedimentation and channelization associated with livestock grazing and pasture irrigation.

For all populations and especially in the McCloud basin, the competition, exclusion and hybridization impacts of non-native trout introductions serve as an additional threat. Beginning in the early part of the 20th Century, stocked hatchery fish hybridized with redband in the McCloud. By the early 1970s, the distribution of non-introgressed, native fish was reduced to headwater tributaries, with the most distinct form limited to a 1.25-mile section of Sheephaven Creek. An impressive restoration effort since then has removed rainbow trout from many streams and transplanted the subspecies to historically fishless streams in the basin, but rainbow trout still persist in the mainstem McCloud River. As a result, redband in the McCloud are isolated in small, fragmented streams and vulnerable to chronic habitat stressors associated with grazing and logging and acute threats such as stream drying associated with prolonged drought.

Eagle Lake Rainbow Trout *(Oncorhynchus mykiss aquilarum)*
Eagle Lake rainbow trout are a lake-dwelling subspecies of rainbow trout found in Eagle Lake and its tributary streams on the east side of the Sierra Nevada in Lassen County, California. First described by J. O. Snyder in 1917, Eagle Lake rainbow trout were initially thought to be the hybrid offspring of Lahontan cutthroat and introduced rainbow trout. Recent genetic studies have shown the subspecies to be a distinct form of rainbow trout that colonized Eagle Lake through an ancient connection to the Feather River and the larger Sacramento River system.

Eagle Lake rainbow trout are uniquely adapted to the conditions in Eagle Lake, a 24,000 acre alkaline (pH 8 – 9) lake seasonally connected to its source tributaries only during the late spring snowmelt. Historically, long-lived and large adults – up to 11 years old and 24 inches long – ran up the largest tributaries to reproduce in the spring-fed headwater streams. By the 1950s, overfishing and habitat degradation from logging, grazing and road development caused population declines so severe that the California Department of Fish and Game (now Department of Fish and Wildlife) initiated a hatchery program from the few remaining fish. In 2012, the US Fish and Wildlife Service funded and built a fish ladder at the mouth of Pine Creek to allow for passage to historic spawning grounds. Combined with a trap-and-haul program by the California Department of Fish and Wildlife, after years of being completely sustained by the hatchery, young Eagle Lake rainbow trout have been recently discovered in the headwaters of Pine Creek, providing hope that natural populations can once again flourish. Nonetheless, the legacies of habitat degradation - loss of meadow habitats and altered hydrology exacerbated by declines in winter snowpack and drought - and the homogenization of the subspecies through hatchery fish still threaten the survival of Eagle Lake rainbow trout. Other threats include competition with introduced brook trout and natural factors that threaten any species with a limited distribution.

TROUT OF THE KERN PLATEAU –California Golden Trout *(Oncorhynchus mykiss aguabonita)*, **Little Kern Golden Trout** *(Oncorhynchus mykiss whitei)* **and Kern River Rainbow Trout** *(Oncorhynchus mykiss gilberti)*

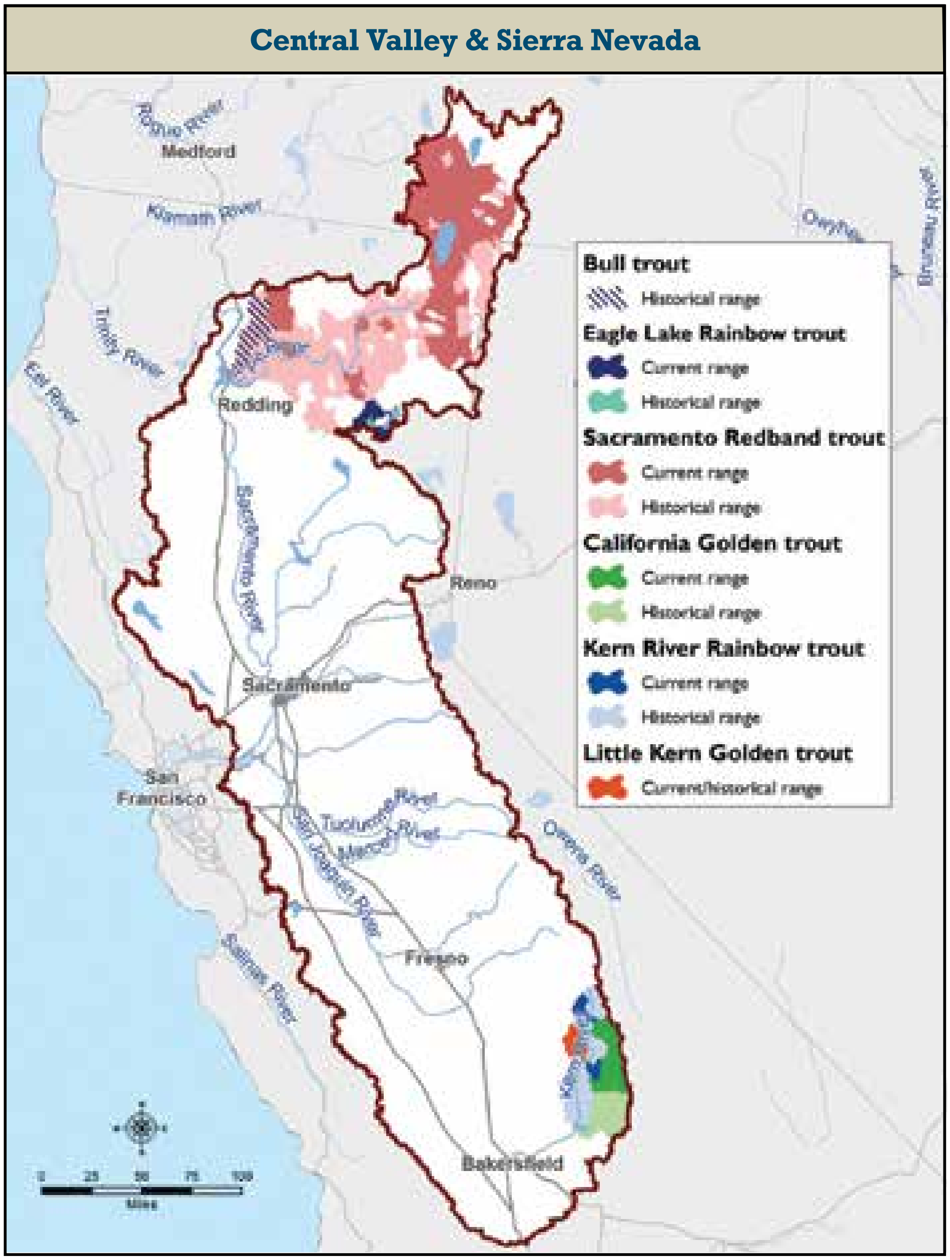
The Kern River basin drains the southern extent of the Sierra Nevada in California. The system was connected to the San Joaquin River and first occupied by ancestral rainbow trout around 10,000 years ago. As the connection to the San Joaquin River valley and Tule Lake dried up and natural barriers within the system developed, three distinct forms of trout developed through isolation: the Little Kern golden trout found in the Little Kern River, the California golden trout found in the South Fork Kern River and Golden Trout Creek basins and the Kern River rainbow trout found in the mainstem and tributaries of the Kern River.

Beginning in the late 1800s and continuing through the 1960s, rainbow and brown trout were widely introduced into the Kern River basin and the primary conservation issue for all three subspecies is hybridization with non-native species. Widespread restoration efforts – including construction of artificial barriers in the range of California golden trout and piscicide treatments of streams in the range of California golden trout and Little Kern golden trout – have eliminated non-native trout from portions of the basin, but the genetic legacy and loss of historical habitat remain major consequences of the introductions. Introgression was the primary motivation for the listing of Little Kern golden trout as Threatened under the Endangered Species Act in 1978.

The majority of the remaining distribution for the species is found in US Forest Service wilderness areas or Sequoia National Park and Monument such that very few development related stressors exist beyond the widespread legacy and ongoing effects of grazing meadows that the California golden trout depends upon have been particularly impacted. Climate change threats include drought, altered fire regimes, warmer summer stream temperatures and decreased snowpack and associated late summer stream flows.

Regional Trends

By virtue of time and the isolating effects of an active geology and climate, multiple



Historical and current distributions of native trout and char in the Central Valley/Sierras Region.

distinct trout species and subspecies have evolved in the Sierra Nevada region. All of these species persist in very limited footholds and in often harsh environments above the distributional limits of more widely occurring coastal rainbow trout (including steelhead). All these unique trout have a precarious existence in the face of increasing threats. The region has already witnessed the loss of bull trout.

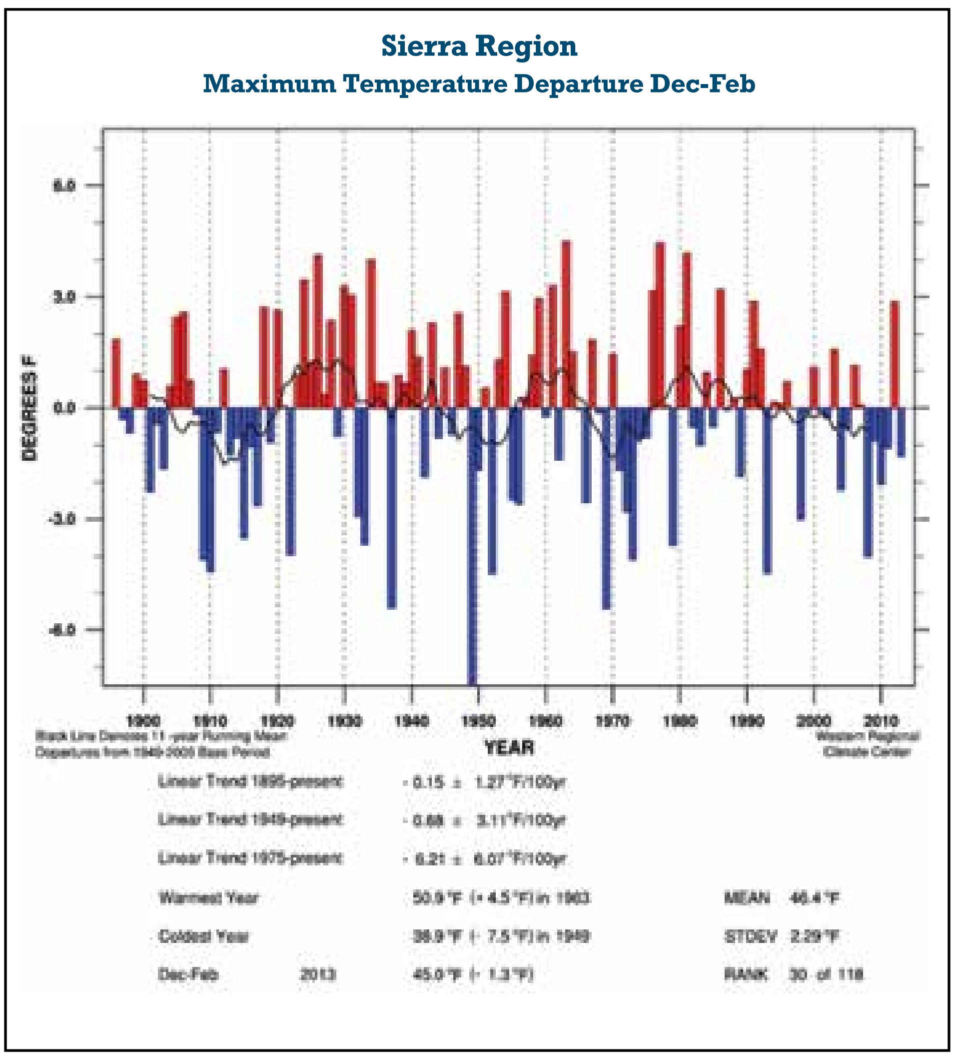
The native trout of the Sierra Nevada have some of the smallest ranges of any North American trout and populations within the wider ranges of the species are typically fragmented. The Sheephaven Creek population of Sacramento redband trout persists in a mere 1.25 miles of stream that starts at a spring and disappears in porous volcanic rock. Periods of drought can cause portions of the stream to dry up and the overall lack of habitat limits the populations' ability to recolonize or move if a disturbance like wildfire eliminates fish from some portion of the stream. Furthermore, most species exist as populations at the upper headwaters, where their ranges cannot shift upstream in response to warming climate (2).

When non-native trout are introduced into streams where native trout were once the only salmonid, they often out-compete, hybridize and prey on native trout. Since the native fish evolved under local conditions for long periods, the loss of their genetic legacy often means the loss of adaptations for long-term survival in extreme environments.

California is in the fourth year of one of the most severe droughts on record. Beyond the lack of precipitation for providing stream flow and recharging groundwater for storage later in the year, the continued drought in 2015 has been particularly consequential for all species that depend on water – humans and trout included – due to warmer than normal winter temperatures. Following the warmest calendar year on record in California, December 2014 through February 2015 were the warmest in the state's recorded history. These warm temperatures mean that what precipitation does fall in the Sierra Nevada largely falls as rain rather than snow. California's streams typically receive much of their flow from water stored in snowpacks in the highest elevations. Without that stored water and with decreasing annual precipitation, total stream flow will decrease, low flow periods will be longer and peak flows will shift earlier in the year (3).

Severe droughts are often associated with severe summer wildfire seasons that start earlier and end later than historical seasons. In 2013, the Rim Fire in the Stanislaus National Forest made history as the third largest recorded wildfire in California. The fire started in August and burned for over nine weeks into late October, scorching nearly 260,000 acres. A fire of that size within the remaining range of Eagle Lake rainbow trout, Little Kern golden trout, California golden trout, or Kern River rainbow trout would burn their entire distribution.

There are several restoration strategies that have been widely successful in recovering populations of native Sierra Nevada trout and more that show promise for the future. Manual or chemical removal of non-native trout above natural or artificial barriers has occurred in the range of Sacramento redband trout, Eagle Lake rainbow trout, Little Kern golden trout and California golden trout as a tool for limiting the impacts of non-native trout and is becoming a more widely accepted tool for such work by the California Department of Fish and Wildlife, which is a cultural shift from the past decade. Translocation of populations of Sacramento redband trout and California golden trout is a strategy for "spreading the risk" of extinction for the inherently vulnerable, small populations. Within the historical habitats of Sierra Nevada trout, meadow restoration is increasingly seen as a tool with promise for sustaining streamflows to benefit high mountain fish populations and downstream water users in cities and farms.



Over 100 years of record, the winter of 2015 is the warmest, nearly 6 degrees F warmer than average. Data from Western Regional Climate Center, Desert Research Institute

SUCCESS STORY:

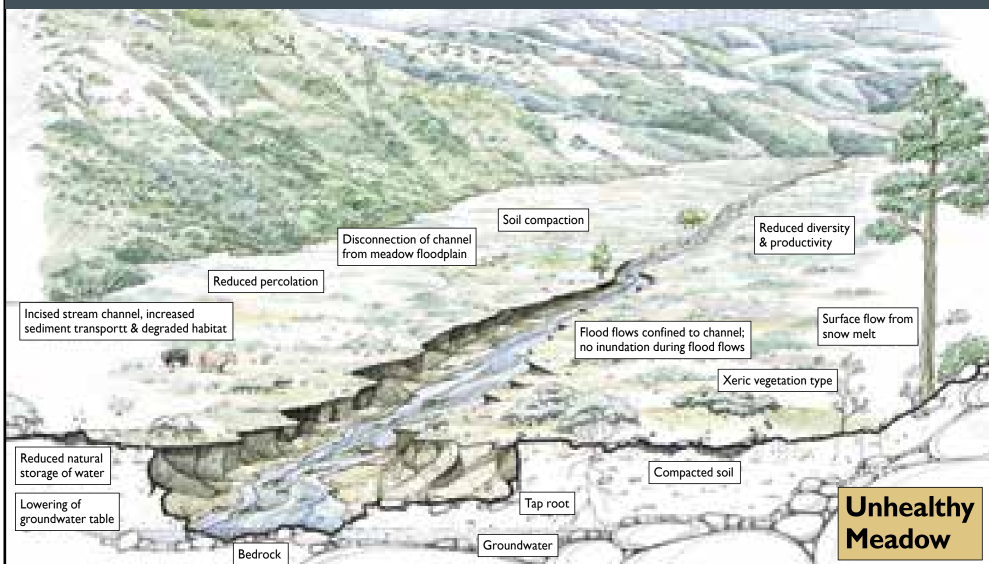
Meadow Restoration

Montane meadows can provide habitat for a diverse array of species, lower summer stream temperatures and serve as important groundwater recharge and storage zones (4). Because of this last aspect, the restoration of functioning mountain meadows is widely regarded as a win for both fish and people.

The last century has witnessed widespread degradation of meadows in the Sierra Nevada, the consequence of road construction, over-grazing and development. Over the past 20 years a range of mountain stream and meadow restoration methods has been increasingly applied to bolster upper elevation water retention and slow runoff. One of the main symptoms of a degraded meadow are incised, widened and downcut channels, which limit the ability of peak flows to access the floodplain and provide limited habitat diversity for fish. Meadow restoration helps reconfigure the channel to allow flood waters to spread out over valley bottoms. Fish benefit from increased habitat complexity, increased cover and stream shading, and bolstered supplies of cool groundwater. Downstream water users benefit from prolonged stream flow in summer, when demand is high. Research suggests that restored meadows in the Sierra Nevada could store and release between 50,000 and 500,000 acre-feet of water annually, an amount equivalent to several proposed water storage reservoirs in California (5).

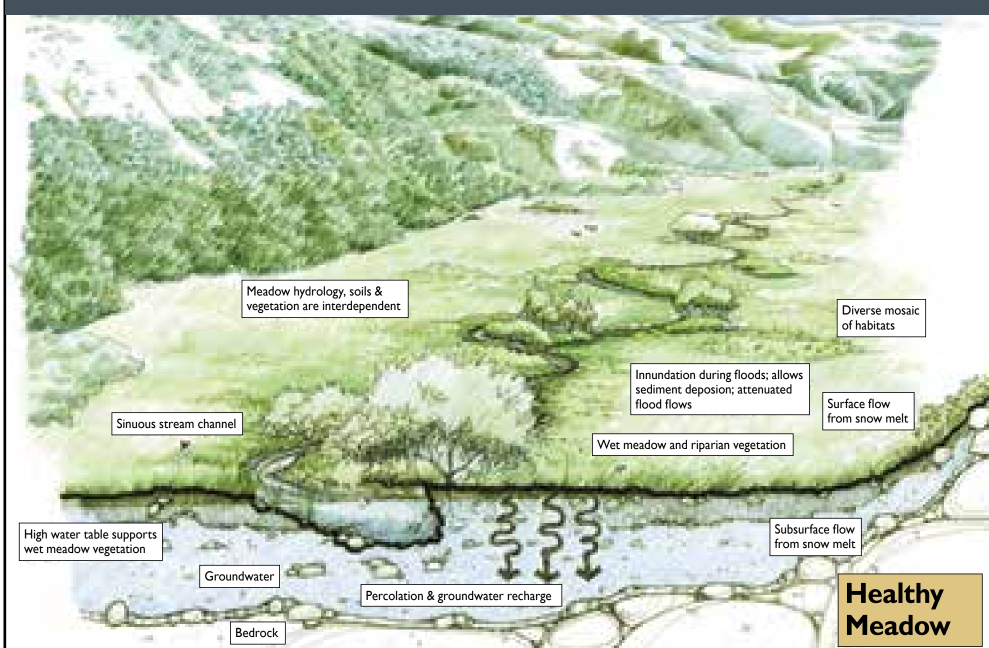
In Pine Creek in the headwaters of Eagle Lake, a partnership of stakeholders including Trout Unlimited is prioritizing the sequence of events necessary for successful meadow restoration to benefit Eagle Lake rainbow trout. The groups believe that cultivating and maintaining collaborative partnerships will serve as the foundation for the recovery and stewardship of Eagle Lake rainbow trout over the long-term and avert the listing of the subspecies as a Threatened or Endangered species under the Endangered Species Act through recovery of self-sustaining populations. Key proposed actions include the eradication of non-native brook trout, monitoring of key habitat variables and assessment of trends over time.

Degraded meadow system. Deeply eroded stream channel directs snowmelt quickly downstream, and drawing down meadow water tables resulting in drier community vegetation and more conifer encroachment. Little habitat exists for meadow-dependent species when there are streams with warm water and periods of lower or no flow.



AMERICAN RIVERS

Healthy meadow system. Naturally meandering creeks support native fish, riparian cover including willow and alder thickets, lush wetland vegetation, healthy soil and high levels of infiltration into groundwater which subsequently recharges streams during drier months and creates rich biological diversity for meadow-dependent species. Illustration by American Rivers.



AMERICAN RIVERS

Interior Columbia Basin and Northern Rockies

Species Summaries

LISTING STATUS: red (ESA listed as Threatened or Endangered), yellow (not ESA listed but federal sensitive species or state species of concern (majority of states), green (not listed in majority of states)

CURRENT RANGE: red (10 percent or less), yellow (11-25 percent), green (>25 percent)

HISTORICAL RANGE: red (<1,000 miles), yellow (1,000-10,000 miles), green (>10,000 miles)

TROUT UNLIMITED

Westslope Cutthroat Trout

Category	Status	Explanation
Listing status	Yellow	Sensitive species (USFS, BLM) Species of Special Concern (OR, MT, ID, WY);Threatened in Canada
Current range	Green	42 percent occupied by conservation populations in U.S.
Historical range	Green	Historically occupied over 58,000 miles of stream habitat and 450,000 acres of lacustrine habitat in U.S.
Climate change	Yellow	Wildfire risk compounded by forest health issues
Energy development	Yellow	Higher risk in British Columbia portion of range on the Columbia River
Non-native species	Red	Hybridization with rainbow trout and displaced by brook trout
Water demand	Green	Impacts from agricultural diversions exist in valley bottoms but water quantity issues are minor
Data issues	Yellow	Difficult to confirm abundance and genetics given expansive distribution and increasing pressure from non-native species.

Yellowstone Cutthroat Trout

Category	Status	Explanation
Listing status	Yellow	Sensitive species (USFS) Species of Special Concern (ID, MT, WY)
Current range	Green	41 percent occupied by conservation populations
Historical range	Green	Historically occupied over 17,000 miles of stream habitat and 125,000 acres of lacustrine habitat
Climate change	Yellow	Uncharacteristic wildfire, reduced snowpack and summer stream flow
Energy development	Green	Minimal impact currently
Non-native species	Red	Lake trout, brook trout, rainbow trout particularly problematic
Water demand	Green	Impacts from agricultural diversions exist in valley bottoms but water quantity issues are minor
Data issues	Yellow	Further genetic testing needed to monitor hybridization risk

Bull Trout

Category	Status	Explanation
Listing status		Listed as Threatened under the ESA; Sensitive Species (BLM, USFS) Species of Special Concern (CA, ID, MT, NV, OR, WA)
Current range		Occupy 22,400 miles of stream habitat; approximately 60 percent of historical range.
Historical range		Ranged broadly throughout Klamath, Upper Snake, Columbia, Coastal and McCloud River systems
Climate change		Very sensitive to rising water temperatures; wildfires a concern with reduced snowpack and forest drying
Energy development		Minimal impacts other than legacy hydroelectric developments
Non-native species		Lake trout, brook trout, brown trout and northern pike are particularly problematic
Water demand		Dams fragment habitat
Data issues		Status of many smaller populations is uncertain


Bull trout

Columbia River Redband Trout

Category	Status	Explanation
Listing status		Sensitive species (USFS, BLM), Species of Special Concern (ID, OR, WA)
Current range		44 percent of stream habitat currently occupied
Historical range		Historically occupied about 32,300 miles of stream habitat
Climate change		Wildfire, temperature and drought
Energy development		No known energy development projects
Non-native species		Introduced rainbow trout, brown trout, small-mouth bass
Water demand		Drought-prone landscape and agricultural demand
Data issues		Have only tested genetics on 18 percent of occupied habitat and still a fairly high level of uncertainty on current distribution and abundance

Lake Trout

Category	Status	Explanation
Listing status		Species of Special Concern (MT)
Current range		Remnant populations are reduced, but the species has been widely stocked for sportfishing
Historical range		Native to a few glacial refugia lakes in Montana, the Great Lakes Basin, and somewhat uncertain distribution in the northeast due to early, undocumented stockings.
Climate change		Warmer lake temperature may render some lakes unsuitable
Energy development		No known threats
Non-native species		Highly vulnerable to introduced salmonids
Water demand		No known issues
Data issues		Some native Montana populations lack adequate data

Westslope Cutthroat Trout *(Oncorhynchus clarkii lewisi)*

Westslope cutthroat trout were first discovered by the Lewis and Clark expedition in 1805, ironically on the east side of the Continental Divide at the Great Falls of the Missouri River. The original geographic expanse of westslope cutthroat trout was the greatest of all cutthroat trout subspecies extending east-west from the upper Missouri basin to the Columbia River basin and eastern slopes of the Cascade Mountains, and north-south from the Saskatchewan River in Canada to the John Day River in Oregon. The discontinuous nature of its distribution is a product of geologic events during the Pleistocene. Frequent bursts of the ice dam holding back glacial Lake Missoula on today's Clark Fork River likely spilled millions of westslope cutthroat trout across eastern Washington and Oregon, leaving behind remnant populations in the John Day basin of eastern Oregon, as well as portions of the Methow, Lake Chelan and Yakima basins of central Washington. Large waterfalls formed during this period such as Albeni Falls, Kootenay Falls and Spokane Falls are believed to have isolated populations of westslope cutthroat trout in the streams and lakes above the falls while large lakes such as Priest, Coeur d'Alene and Flathead lakes left behind by the last glacial retreat have provided important lacustrine habitat to migratory populations of westslope cutthroat trout.

Today, westslope cutthroat trout have been extirpated from more than half of their historical habitat. Traditional land uses such as logging, mining, livestock grazing and agriculture have contributed to the loss of habitat for westslope cutthroat trout, while introduced non-native species are displacing them throughout much of their range, even in protected areas. Lake McDonald, the largest lake in Glacier National Park, is dominated by non-native kokanee salmon, lake trout and lake whitefish that have largely displaced the native westslope cutthroat trout through competition for food and direct predation. In streams, brook and brown trout have also displaced westslope cutthroat trout through competition and predation, while introduced rainbow trout and other cutthroat trout undermine the genetic integrity of westslope cutthroat trout through hybridization. Today about 60 percent of the conservation populations are believed to be genetically pure but three-fourths of these populations are isolated in small stream habitats less than six miles in extent where they are vulnerable to wildfire and floods. However, remaining large migratory populations of genetically pure westslope cutthroat trout in the Flathead Basin in Glacier National Park as well as portions of the Priest River, Clearwater and Salmon basins in Idaho, and the John Day in Oregon serve as reminders of westslope cutthroat trout's once expansive presence on the landscape as well as hope for its long-term persistence in the West.

Oncorhynchus clarkii bouvieri

Yellowstone Cutthroat Trout *(Oncorhynchus clarkii bouvieri)*

Yellowstone cutthroat trout were originally named in honor of U.S. Army Captain Bouvier in 1883 but were subsequently combined with westslope cutthroat trout until the 1960s when biologists formally recognized them as two distinct subspecies of cutthroat trout. Like westslope cutthroat trout, Yellowstone cutthroat trout are also found on both sides of the Continental Divide. They originally became isolated in the headwaters of the Snake River after the creation of Shoshone Falls about 30,000-60,000 years ago. Retreat of the Pleistocene alpine glaciers from the Yellowstone Plateau facilitated the movement of Yellowstone cutthroat trout from the Snake River into the Yellowstone River at the site known today as Two Ocean Pass in Yellowstone National Park. From there, Yellowstone cutthroat trout spread downstream into Yellowstone Lake and the lower tributaries of the Yellowstone River, moving eastward as far as the Tongue River. Historically, one of the largest concentrations of cutthroat trout anywhere in the West was in Yellowstone Lake. From the early- to mid-1900s, Yellowstone Lake provided a hatchery operation which supported the distribution of Yellowstone cutthroat trout worldwide. On the west side of the Continental Divide, a finespotted form of Yellowstone cutthroat trout was once native to the large valley lakes in Grand Teton National Park from where they migrated into the mainstem of the Snake River. Today the finespotted form is found throughout much of the upper Snake River, frequently co-occurring with large-spotted Yellowstone cutthroat trout.

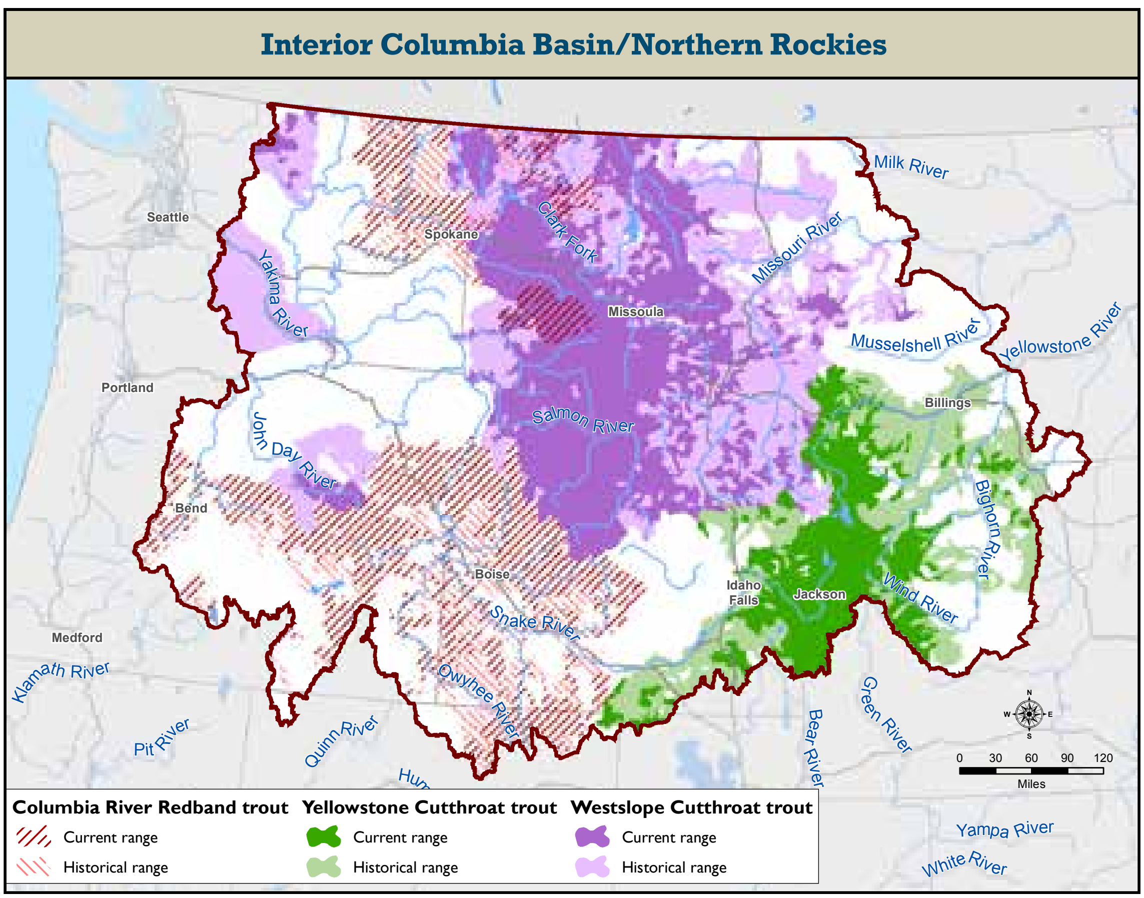
As with most of our native trout, the habitat quality for Yellowstone cutthroat trout has deteriorated since the early 1800s, particularly around the margins of the historical range where lower elevations and moderate terrain allowed for agricultural development, livestock grazing and logging. However, the rugged and remote landscape of the upper Snake and Yellowstone basins helped to preserve these watersheds so that today 28 percent of the streams currently occupied by Yellowstone cutthroat trout are found in National Parks or federally designated wilderness areas. Unfortunately, the spread of non-native species into these protected lands threatens remaining populations of Yellowstone cutthroat trout in some of the nation's otherwise most pristine landscapes. Building barriers to protect Yellowstone cutthroat trout from non-natives may fragment remaining migratory populations, increasing their risk to climate change, the effects of which are also permeating our protected lands. Fortunately, managing agencies, Trout Unlimited and many others are actively engaged in reducing the threat posed by non-native fish while striving to maintain Yellowstone cutthroat trout's inherent resilience to environmental change. (See the Yellowstone Lake success story at the end of this section for information on efforts to control non-native lake trout.)

Columbia River Redband Trout

(Oncorhynchus mykiss gairdneri)

The distribution of Columbia River redband trout in the Columbia Basin is a product of the landscape's dynamic past characterized by volcanism and continental glaciation interspersed with periods of major flooding. These dramatic events not only sculpted the land but also resulted in hydrologic shifts causing chance extinctions, recolonizations and long periods of isolation for the region's evolving fishes. While the Cascade Mountains are considered the dividing line between coastal rainbow trout (*O. m. irideus*) and Columbia River redband trout, recent genetic studies have also found significant distinctions between populations of Columbia River redband trout in the three major rivers that slice through the Cascade range from the interior to the ocean: Columbia, Klamath and Sacramento (1). Given this region's tumultuous geologic past, these large rivers and associated large lakes may have provided the only relatively stable aquatic environments for trout to evolve. So, as rainbow trout moved up these larger river systems to the interior they evolved in isolation from one another, creating what today is recognized as three distinct subspecies of interior redband trout, with the most broadly distributed of these being the Columbia River redband trout. Populations that are unable to migrate to the ocean due to a natural or man-made barrier are referred to as redband trout while those populations that are still able to migrate seaward are considered steelhead.

Although the landscape has been stable geologically for thousands of years, the distribution of Columbia River redband trout is changing once again as humans are now the dominant force. In the Columbia River basin, Columbia River redband trout



Historical and current distributions of native trout and char in the Interior Columbia Basin/Northern Rockies Region.

currently occupy just 44 percent of their historical stream habitat. The degradation and fragmentation of aquatic systems from land conversion, roads and the development of natural resources has contributed to local extirpations of Columbia River redband trout, particularly at the lower elevations where these activities are the most prevalent. Dams, irrigation diversions and road culverts often create passage barriers for Columbia River redband trout, eliminating their ability to move between lake, river and stream habitats. Although non-native species such as brown trout and smallmouth bass have displaced Columbia River redband trout through competition for resources and direct predation, the greatest threat is from the widespread introduction of hatchery rainbow trout and non-native cutthroat trout which hybridize with Columbia River redband trout – 54 percent of streams currently occupied by Columbia River redband trout are believed to contain hybridized populations. The impacts to Columbia River redband trout from degraded habitat and non-natives are further compounded by climate change. As the hot and dry landscape that supports Columbia River redband trout gets hotter and drier with climate change, the impact on coldwater habitat will become more profound. The loss of the cooling shade provided by a healthy riparian area or diminished stream flows from agricultural diversions may render some streams unsuitable for Columbia River redband trout while increasing their suitability for warmwater species such as smallmouth bass. Fortunately, Columbia River redband trout are now receiving some much needed attention as they have traditionally been overshadowed by their more charismatic relative, the steelhead. State and federal agencies, Tribes and Trout Unlimited are all part of a rangewide conservation agreement dedicated to the conservation and restoration of this hardy fish.

Salvelinus confluentus

Bull Trout *(Salvelinus confluentus)*

Bull trout are widely distributed within the Interior Columbia Basin/Northern Rockies region. The species occupies a variety of large lakes, small headwater streams and larger river systems. In many areas, the species is highly migratory and maintenance of diverse life history expression is a primary recovery strategy. As such, habitat fragmentation caused by dams, poorly designed road crossings and other factors is a major legacy threat to bull trout. Non-native species are another primary threat. Most large lake systems inhabited by bull trout are also habitat for introduced populations of brook trout, brown trout, lake trout and, on occasion, northern pike. These species can prey on bull trout and are likely to compete for scarce resources. Many stream systems inhabited by bull trout also have large populations of brown and brook trout. The presence of brook trout is especially problematic because both brook and bull trout are fall spawners and readily hybridize.

As described in the Pacific Coast account for bull trout, this species prefers habitats characterized by the 4-Cs: cold, clean, connected and complex. Their habitat requirements are more specific than other native salmonids in the region. Bull trout require cold water, substrates that are clean of sediment and other pollutants, complex stream channels including deep pools and an interconnected stream network that facilitates spawning migrations and free movement up and down riverine corridors.

Climate change poses a dramatic risk for bull trout, especially warming of migratory and larger river habitats. Warming stream temperatures are constricting the lower-elevation range of bull trout in many areas. Wildfires are another increasing risk associated with climate change. Changes in winter precipitation within the region from snow to rain, earlier peak flows, forest drying and increased insect pests all favor increasing wildfires and subsequent stream sedimentation within the region.

Bull trout populations in this region are somewhat robust, especially compared to places like the Klamath system where populations of bull trout are highly fragmented. The U.S. Fish and Wildlife Service reports that the distribution of bull trout has changed little since the species was listed in 1999. However the latest draft recovery plan of the USFWS also reports that more than 60 percent of known core areas have imminent threats that are rated as moderate or substantial. There is inadequate data to assess the status of about 50 percent of core population areas. In 2010, the USFWS modified designated critical habitat pursuant to the ESA to include 19,729 stream miles and 488,252 acres of bull trout habitat.

Lake Trout *(Salvelinus namaycush)*

Lake trout have a broad native range across northern environments, including northern Canada, Alaska, the Great Lakes and parts of the northeastern United States. The species inhabits large, coldwater lakes and is our largest native char, reaching weights over 50 pounds. Lake trout appear to be native to a small number of lakes in Montana. In addition, they have been broadly introduced into many larger western lakes. These introduced populations, such as in Yellowstone and Flathead lakes, can expand rapidly with lake trout preying on the native trout in the system.

Lake trout are slow-growing, long-lived fish that mature at 6 or 7 years of age. Unlike many native salmonids, they live and spawn in lakes during the fall without entering stream systems. The slow growth and late maturation make them vulnerable to overfishing. Pollution and the introduction of non-native fishes are other common problems for naturally-occurring populations.

According to Montana Department of Fish, Wildlife and Parks, the native populations in Montana are remnant populations that survived the last ice age. In western Montana, lake trout are native to Waterton, Glenns, Cosley and St. Mary lakes in Glacier National Park and nearby Lower St. Mary Lake. They are believed to be native to a few, scattered lakes (Twin Lakes and Elk Lake) in southwestern Montana. Other Montana populations have resulted from introductions. The status of these populations are not well known, however the habitats of many of the native populations in Montana are protected by their location in Glacier National Park.

Regional Trends

The Interior Columbia Basin/Northern Rockies region stretches from the upper

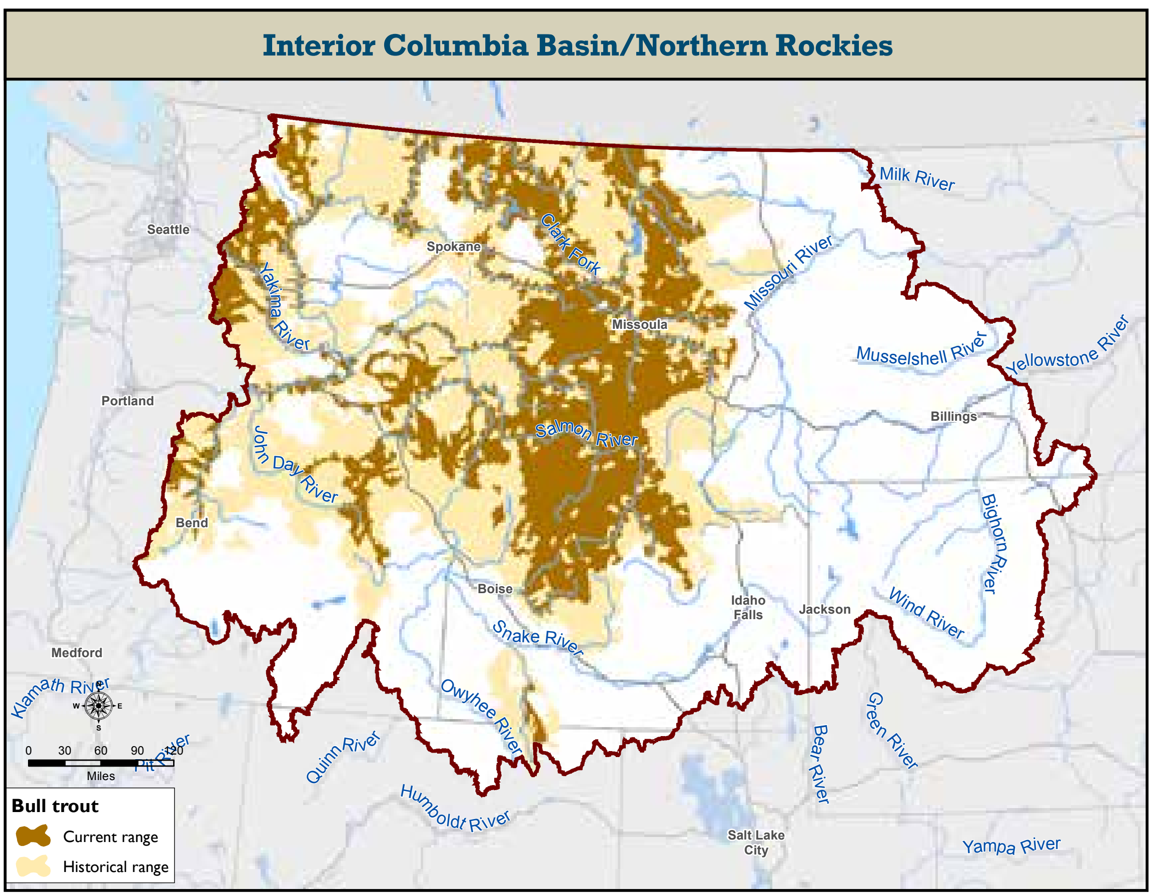
Missouri River basin on the east side of the Continental Divide to the crest of the Cascade Mountains in Washington and Oregon. The diverse landscapes range from the high peaks of the Continental Divide to the moist temperate forests of northern Idaho and the arid grasslands of eastern Oregon and Washington. The region is drained by some of the West's great rivers, including the Missouri, Yellowstone, Columbia, Snake and Salmon rivers. These rivers drain the high elevations, bringing water to the more arid lower elevations and providing the region's native trout with a well-connected network of lakes, large rivers and small streams capable of supporting large populations and a diversity of life histories.

Historically the region's four species/subspecies of native trout (i.e. westslope cutthroat trout, Yellowstone cutthroat trout, bull trout and redband trout) were broadly distributed across the region in a variety of habitats. Having evolved in a dynamic landscape, these fish have been able to adapt to environmental changes for thousands of years. Their ability to migrate long distances to support different life cycle stages (e.g. spawning, growing) and find suitable habitat as conditions change, has been an important part of their success in the region.

Although this region encompasses national parks and the largest wilderness complex in the lower 48 states, all four native trout have experienced significant range contractions. The fact that they all still occupy a large number of stream miles, particularly when compared to other native fish in the West, can be attributed to their expansive historical distribution rather than an indicator of their rangewide health today. Dams for hydropower, water storage and flood control block passage on many of the larger river systems, while agricultural development in the valley bottoms has contributed to degraded water quality with diversions that reduce flows and also impede movement between tributary streams and larger mainstem habitat. A history of intensive livestock grazing on the more arid rangelands and clearcut logging and the associated road network in the forested landscape have further contributed to degraded and fragmented aquatic systems in the region.

The central Idaho wilderness complex and the wildlands of and adjacent to Yellowstone and Glacier national parks provide high quality habitat for bull trout, westslope cutthroat trout and Yellowstone cutthroat trout and still allow for large migratory populations occupying several hundred miles of interconnected habitat. However, these well-connected networks also increase the exposure of native trout to invading non-native species such as lake, rainbow, brown and brook trout. All of these non-natives may displace the native trout through competition for food and cover, as well as the significant threat of hybridization. Brown trout can be aggressive predators on native trout and their higher tolerance of degraded water quality and warmer water temperatures leaves them well positioned to exploit the valley bottoms previously occupied by the native species. Predatory lake trout have contributed to the crash of Yellowstone cutthroat trout populations in the Yellowstone River although aggressive control measures over the past five years are coming to fruition as Yellowstone cutthroat trout populations begin to rebound (see Success Story). A similar situation exists in Flathead Lake where introduced lake trout threaten native bull trout, having also invaded a series of interconnected lakes between the Flathead and Glacier National Park. Unfortunately, control of non-natives in large interconnected stream and lake habitats is complex, leading managers in some situations to advocate for the construction of instream barriers to protect populations of native trout but at the expense of their migratory life history.

The ability to move has characterized the



Historical and current distributions of native trout and char in the Interior Columbia Basin/Northern Rockies Region.

evolutionary history of native trout in this region and although the area has been fairly stable geologically now for thousands of years, the ecological processes that shape the landscape continue to alter aquatic ecosystems. Although wildfire has been a force in this region for thousands of years, changing forest conditions over the past century, in conjunction with climate change, have altered the impact of wildfires on forests and the streams that run through them. Decades of fire suppression on western forests in the 1900s has contributed to a build-up of fuels and in some situations has also inhibited the growth of new trees as stands become more dense without the thinning effect of low-intensity wildfires. Clearcut logging practices, particularly from the end of the 19th Century into the mid-20th Century, led to the creation of large stands of even-aged trees. As these stands have aged they have become highly susceptible to disease, particularly bark beetle outbreaks. Since 1990 bark beetles have killed billions of trees across the West and although these infestations are a natural force in forested ecosystems, many of the outbreaks being experienced today are unprecedented. Add in longer and drier summers, reduced mountain snowpack and earlier snowmelt due to climate change and you have the perfect formula for uncharacteristically large wildfires.

The magnitude and intensity of wildfires has been increasing in the Rocky Mountains for the past several decades due to increased fuels and a longer fire season (2). While many of these fires may ultimately be beneficial to the forests through which they burn, high intensity fires can pose problems for the forest streams and the fish they support in the near term. In addition to direct mortality during the fire, watersheds that are completely burned may experience more rapid runoff during rainstorms that can lead to debris flows and other channel-altering events. This

SUCCESS STORY:

Yellowstone Lake

Yellowstone National Park 'Turning the Corner' on Native Cutthroat Trout Recovery

Historically, Yellowstone Lake provided habitat for what was likely the largest population of cutthroat trout anywhere in the world. The large population was not only a boon to anglers but also the ecosystem, as large spawning runs of Yellowstone cutthroat trout made their way to small headwater streams where everyone from grizzly bears to otters feasted on the bounty. All that changed when predatory lake trout were illegally introduced and their population exploded. The populations of Yellowstone cutthroat trout crashed in response.

For more than eight years, the National Park Service has conducted gill-netting operations and other efforts to reduce lake trout populations and give native Yellowstone cutthroat trout a chance to recover. Those efforts now are paying off as recent data indicate that culling efforts are working to suppress invasive lake trout and restore the native cutthroat trout fishery.

According to NPS staff, an analysis of data shows progress on several fronts:

- Annual monitoring suggests an increase in abundance of juvenile cutthroat trout within Yellowstone Lake over the last two years.
- Lake trout suppression efforts, especially in the larger-mesh gill nets, have significantly increased in recent years with approximately 300,000 lake trout caught annually.
- Beginning in 2013, the catch-per-unit-effort of lake trout has decreased despite increased effort, indicating a decrease in overall lake trout numbers.
- New analyses from Montana State University indicate that suppression efforts have put the lake trout population into a state of "negative

continued on next page

Lake trout netting effort in 2009. These fish were collected in large gill net sets by contractors of the National Park Service.

threat is compounded by the increasing risk of uncharacteristic winter flooding in the mid-elevations where rain on snow events are increasing due to warm winter storms characterized by the 'pineapple express' (3). When the drainage network is well connected and fish are able to move, they can vacate the burned watershed and find more suitable habitat elsewhere until the watershed recovers and they can then recolonize its streams. However, populations that are isolated behind a barrier and unable to leave have an increased risk of experiencing local extirpations.

The lower elevation arid rangelands occupied by Columbia River redband trout in southeast Oregon, southwest Idaho, and northern Nevada are also experiencing larger and more frequent fires due to climate change and the spread of highly flammable non-native annual grasses. Although range fires do not typically burn as hot as forest fires, they can still be problematic for trout. The loss of riparian vegetation can contribute to increasing water temperatures that may exceed the thermal tolerances of coldwater species and instead favor non-native fish such as brown trout and smallmouth bass that are more tolerant of the warmer waters and will prey on the native trout. The presence of beaver ponds or other wetlands can help reduce the fire effects in the riparian area and thus maintain the stream's cooling shade. Livestock grazing may also contribute to warming water temperatures for Columbia River redband trout through the removal of streamside vegetation and widening of the stream channel. Streams in the arid rangelands are more vulnerable to periods of drought than the forested watersheds due to typically low summer base flows and agricultural demand that frequently takes precedent over maintaining instream flows during dry years. Reduced flows during the warm summer months may also contribute to rising water temperatures and the displacement of native trout.

growth"—meaning that netting efforts are causing the population to decline.

After reviewing the data, the Yellowstone Science Review Panel recently concluded that the native cutthroat recovery campaign is making "significant progress," and that Yellowstone National Park should continue culling efforts at present levels.

At the same time, National Park Service and U.S. Geological Survey biologists are finding more sophisticated methods of controlling the lake trout population, such as using electricity to destroy lake trout eggs and larvae at spawning grounds—efforts that the independent science panel said show great promise.

"While we likely will never completely rid Yellowstone Lake of this invasive species, recent analyses suggest that, with a sustained effort, we can successfully manage the lake trout population and provide an environment where Yellowstone cutthroat trout can once again thrive in Yellowstone Lake, be a key component of a healthy ecosystem and a source of recreation for anglers and visitors," said Dave Hallac, chief of resources at the park.

That is a huge and historic win for conservation.

"The Yellowstone native cutthroats are as integral to Yellowstone's larger ecosystem as bison and grizzlies," said Jack Williams of Trout Unlimited. "And they're one of the most significant populations of native trout in the world. If we can't save them here, in our flagship national park, where can we save them?"

Lake trout collected from Yellowstone Lake with smaller cutthroat trout removed from their guts.

Interior Basins

Species Summaries

LISTING STATUS: red (ESA listed as Threatened or Endangered), yellow (not ESA listed but federal sensitive species or state species of concern (majority of states), green (not listed in majority of states)

CURRENT RANGE: red (10 percent or less), yellow (11-25 percent), green (>25 percent)

HISTORICAL RANGE: red (<1,000 miles), yellow (1,000-10,000 miles), green (>10,000 miles)

TROUT UNLIMITED

Lahontan Cutthroat Trout

Category	Status	Explanation
Listing status	Red	ESA Threatened Sensitive species (USFS, BLM) Species of Special Concern (CA, NV, OR)
Current range	Red	<1 percent of lake habitat currently occupied by self-sustained population; 4 percent stream habitat occupied
Historical range	Yellow	Moderate distribution historically, 59,500 acres of lake habitat
Climate change	Red	Drought from reduced snowpack and wildfires are major issues
Energy development	Green	Little impact in Sierra Nevada range
Non-native species	Red	Non-native trout and salmon pose continual threats
Water demand	Red	Agricultural uses threaten flows in this increasingly dry region
Data issues	Green	Agency protocols differ among states for data collection, but generally good data for this region

Humboldt Cutthroat Trout

Category	Status	Explanation
Listing status	Red	ESA Threatened Sensitive species (USFS, BLM) Species of Special Concern (CA, NV, OR)
Current range	Red	<9 percent of historical stream habitat
Historical range	Yellow	Moderate distribution historically, 6,800 stream miles
Climate change	Red	Drought, stream warming and wildfires are major issues
Energy development	Yellow	Gas pipeline borders several populations
Non-native species	Yellow	A relatively large # of un-hybridized populations, but brook trout and other non-native trout pose continual threats
Water demand	Yellow	Agricultural uses threaten flows in this increasingly dry region
Data issues	Yellow	Agency protocols differ among states for data collection, and many populations are sampled infrequently

Oncorhynchus clarkii henshawi

Bonneville Cutthroat Trout

Category	Status	Explanation
Listing status		Sensitive species (USFS,BLM) Species of Special Concern (ID, NV, UT, WY)
Current range		31 percent of historical habitat currently occupied
Historical range		Moderate distribution historically, 6,800 miles
Climate change		Drought and wildfires are issues, particularly for small populations
Energy development		Most of the energy development and identified reserves are outside of currently occupied watersheds
Non-native species		Introduced rainbow trout pose hybridization risk; brown trout invading many streams as temps warm
Water demand		Agricultural demand and large metropolitan area
Data issues		Interagency work group maintains good pop data; habitat conditions and barriers need improved monitoring

Paiute Cutthroat Trout

Category	Status	Explanation
Listing status		ESA Threatened Species of Special Concern (CA)
Current range		Historical distribution unoccupied, but current distribution occurs in comparable stream miles upstream
Historical range		Occurs in just 12.5 miles of habitat (9 miles historically)
Climate change		Drought, declining snowpack, and wildfires are major issues
Energy development		No known significant energy development issues
Non-native species		Introduced rainbow trout pose hybridization and competition risk
Water demand		No known significant water demand issues
Data issues		No known significant data issues

(the Tahoe/Truckee/Pyramid Lake system once supported a commercial fishery that supplied San Francisco and other cities) and throughout the range habitat fragmentation, degradation and non-native species continue to impact populations. It was one of the first species listed under the 1973 Endangered Species Act. Though non-native salmonids pose a threat throughout the range, fortunately most remaining populations have not been compromised with hybridization, leaving important genetic resources and opportunity for recovery of both the river and lake forms, with some unique twists. For instance, the U.S. Fish and Wildlife Service and Paiute Tribe are working to restore the genetic legacy of Pyramid Lake Lahontan cutthroat trout, using hatchery broodstock developed from a small stream in Utah where Lahontan cutthroat trout were transplanted prior to their extirpation in Pyramid Lake. Elsewhere in the range, management agencies, landowners and groups including TU are working to restore habitat, remove non-native trout and reconnect streams to recover the migratory life history in native populations.

Oncorhynchus clarkii utah

Lahontan Cutthroat Trout *(Oncorhynchus clarkii henshawi)* **and Humboldt Cutthroat Trout** *(O. c. humboldtensis)*

What is generally referred to, managed as and federally listed as the Lahontan cutthroat trout actually encompasses two described subspecies with distinct evolutionary histories (1). Together they represent one of the oldest lineages of cutthroat trout and have had ample time to respond to a dramatically changing landscape, having occupied the Lahontan basin at least several 100,000 years ago (2), if not even longer (3). The western form (*O. c. henshawi*) adapted to life in pluvial Lake Lahontan, which at its maximum (about 13,000 years ago) covered over 8,500 square miles. As this lake subsided, Lahontan cutthroat trout continued to persist in the relict desert terminal lake/river systems, where until recently it maintained large lake-river spawning runs and grew to enormous sizes as top predator. In fact, during his 1843 expedition Fremont referred to Lahontan cutthroat trout as "Salmon-trout" and a Lahontan cutthroat trout from Pyramid Lake set the world-record for a cutthroat trout at 41 pounds before the population here was lost in the 1940s. The genetic and morphological distinctions of the Humboldt cutthroat trout (*O. c. humboldtensis*) reflect its isolation and assumed adaptation to the river and stream environments of northern Nevada and southern Oregon.

Today, less than 9 percent of historic stream/river habitat is occupied and the Lahontan cutthroat trout has been lost from almost 99 percent of its historic lake habitat. Logging, dams and over-fishing were early threats in the west

Bonneville Cutthroat Trout *(Oncorhynchus clarkii utah)*

Bonneville cutthroat trout are native to the Bonneville basin of Utah, southeastern Idaho, southwestern Wyoming and eastern Nevada. Ancient Lake Bonneville was the largest of the Ice Age lakes of western North America covering about 20,000 square miles with a maximum depth of nearly 1,000 feet. Lake Bonneville formed over 30,000 years ago, but greatly enlarged when a lava intrusion along the Bear River diverted it southward from the Snake River into the Bonneville Basin, supplying the basin with additional water as well as the spotted fish that continued to evolve into today's Bonneville cutthroat trout. When the ancient lake breached its northern rim at Red Rock Pass about 14,500 years ago, it briefly overflowed back into the

Snake River via the Portneuf River. As the climate changed, the floor of the ancient lake gradually dried and turned into desert, leaving remnants such as the Great Salt Lake. The major tributaries surrounding the lake continued to flow and support populations of Bonneville cutthroat trout. In addition to the Bear River at the northern end of the basin, this also included the Weber and Jordan rivers to the east, the Sevier River to the south and small streams flowing from the Deep Creek Mountains to the west.

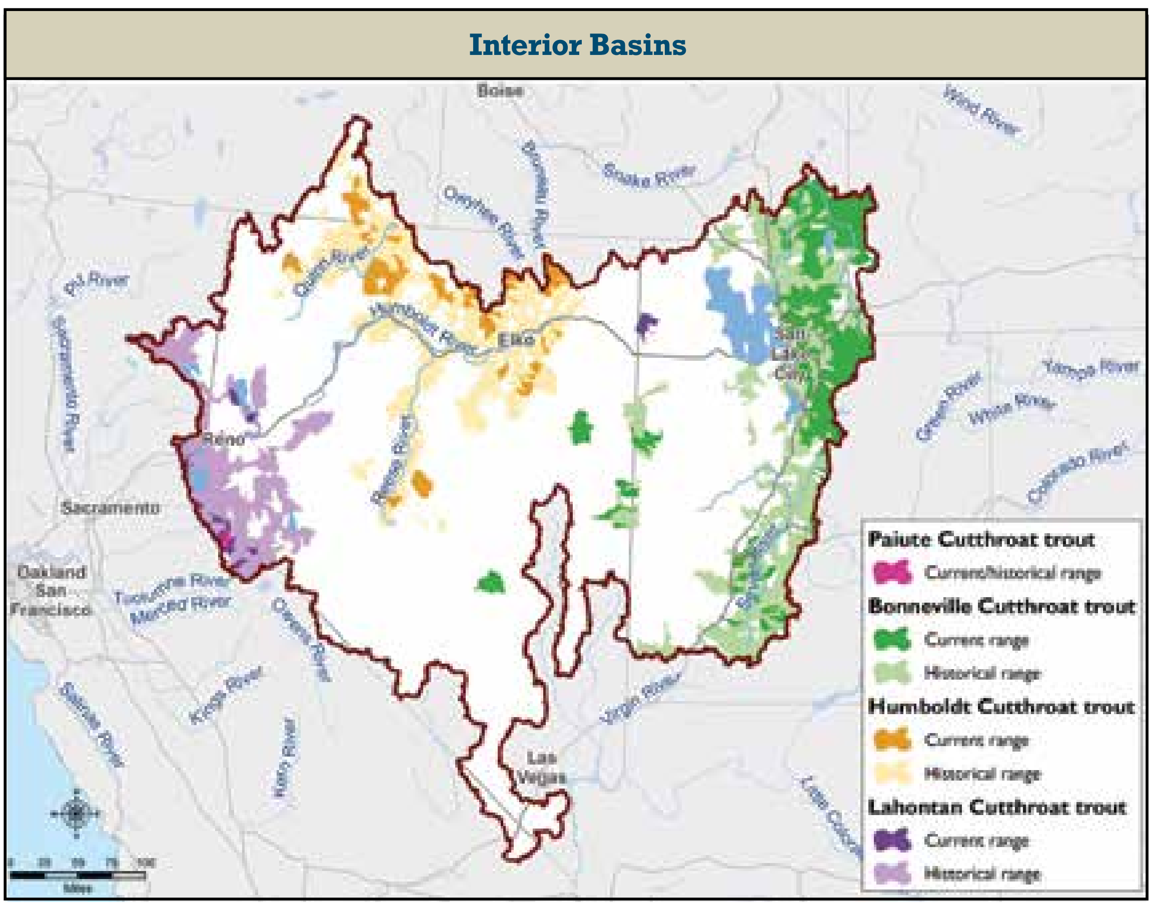
When the Bonneville basin was settled by Europeans many of these waters were overharvested. The once bountiful population in Utah Lake was harvested to extinction in the 1930s and has never returned. Today Bonneville cutthroat trout occupy about 30 percent of their historical stream habitat and over 50 percent of that is in the Bear River basin. The Bear River system still supports large migratory populations that move between the habitats in the mainstem and interconnected headwater tributaries for spawning. Bear Lake is the largest remaining occupied lake system. Some strongholds still persist in the Weber, Provo and Spanish Fork systems of northern Utah. The distribution of Bonneville cutthroat trout in the Sevier River system has also been severely reduced: small fragmented populations now occupy less than 10 percent of their historical range and the average population extent is only about 4 miles. These small populations in the Sevier basin and the equally small and isolated populations in the Deep Creek Mountains are highly vulnerable to environmental changes such as wildfire and drought although their isolation has protected them from non-natives and preserved their genetic integrity. The larger migratory populations in the Bear and Weber River systems are more resilient to climate change but they are under pressure from introduced rainbow and brown trout. Much of their mainstem habitat has also been degraded and fragmented by roads and urban and agricultural development. Bonneville cutthroat trout continue to be a popular sportfish where large individuals still exist.

Oncorhynchus clarkii seleniris

Paiute Cutthroat Trout *(Oncorhynchus clarkii seleniris)*

Paiute cutthroat trout historically occurred in just 9 miles of habitat on Silver King Creek, a tributary to the East Fork of the Carson River on the eastern side of the Sierra Nevada Mountains. This fish has one of the smallest historic ranges of any North American trout, as the entire distribution of Paiute cutthroat trout could fit inside the island of Manhattan. A steep, downstream canyon isolated Paiute cutthroat trout from its distant Lahontan cutthroat trout relative and a series of waterfalls prevented further colonization upstream until sheepherders fortuitously moved the species above the falls in the 1910s. Had this not occurred Paiute cutthroat trout may have been lost, as the subsequent introduction of other trout species eliminated Paiute cutthroat trout from its historical habitat below the falls.

Paiute cutthroat trout were listed as Threatened under the Endangered Species Act in 1973 and the fragmented distribution created by non-native trout species remains the major threat to species. The Silver King Creek basin is largely US Forest Service Wilderness Area and has little development. An intensive effort is underway to reintroduce the species to the downstream portion of Silver King Creek, to restore it to its historic range. As with the other native trout in the Interior basins, limited stream flows and increased severity of drought or wildfire



Historical and current distributions of native trout and char in the Interior Basins Region.

make Paiute cutthroat trout vulnerable to climate change.

Regional Trends

The Interior basins of the West are basically one giant hydrologic bowl where water flows inward and sinks into the desert, never reaching the ocean. It is an exceptionally beautiful landscape, characterized by extremes. To the west, for instance, the Truckee River originates in the high-elevations of the Sierra Nevada Mountains, flows through iconic Lake Tahoe (North America's largest alpine lake) and 120 miles downstream sinks in the desert at Pyramid Lake, a once world-famous Lahontan cutthroat trout fishery. Over to the east, Bonneville cutthroat trout used to roam throughout the Bear River, which begins in Utah's Uinta mountains and flows almost 500 miles north into Wyoming, west into Idaho and south back into Utah to drain into the Great Salt Lake not far from where it started. The central part of this region is "basin and range country," with literally hundreds of mountain ranges that seemingly pop out of the flat high-desert sagebrush. These ranges reach impressive heights: Wheeler Peak in Great Basin National Park hits over 13,000 feet and peaks of ranges like the Rubies and Toiyabes are 11,000 to almost 12,000 feet. Their cold alpine waters feed interior rivers such as the Humboldt, which meanders across most of northern Nevada, as well as smaller desert streams like Willow and Whitehorse creeks that sink into Oregon's Coyote basin.

In early March 2015 – normally about the time of peak flows – water levels in Lake Tahoe were so low the lake failed to connect to the outflowing Truckee River. Photo: Brian Hines

Though the range of Paiute cutthroat trout has always been limited, this rugged and contrasting landscape has enabled the Lahontan and Bonneville cutthroat trout to diversify into a range of life histories including stream-resident and river and lake migratory forms. Both of these native trout are able to handle relatively high temperatures and historically were found not only in cold mountain streams but also in the more turbid, warm waters of desert rivers and terminal lakes, the latter of which are generally too saline and alkaline for other trout species.

Still, despite this remarkable resiliency, the usual western human influences have threatened the existence of all the cutthroat trout in the interior basins. Starting in the early 1800s, fur trappers depleted even the largest river systems of beavers, 'ecosystem engineers' whose importance in maintaining water on this desert landscape we are only now beginning to understand. Grazing affects almost every cutthroat trout stream in the region and has caused widespread stream habitat degradation. In some of the larger systems, such as the Truckee, Bear and Weber rivers, major irrigation dams and diversions providing water to agriculture, metro areas and hydropower has greatly restricted flows and blocked migratory habitat and led to the loss of important populations like the Pyramid and Walker Lake Lahontan cutthroat trout. Perhaps less obvious but equally impactful are the hundreds of road culverts and smaller diversions that have riddled stream systems throughout the region with barriers and isolated trout in small headwater habitats where their persistence is tenuous. Further, as with the southwest trout, non-native species

TU field crew photos after the Holloway fire in Whitehorse Creek in 2012. Beaver ponds provided critical refuge for Lahontan cutthroat trout (right).

have been a major factor in native species decline here. Kokanee and lake trout – a voracious predator – hamper Lahontan cutthroat trout recovery in many of the larger alpine lakes and throughout the Interior basin brook, brown and rainbow trout occupy many systems and continue to contribute to native population losses.

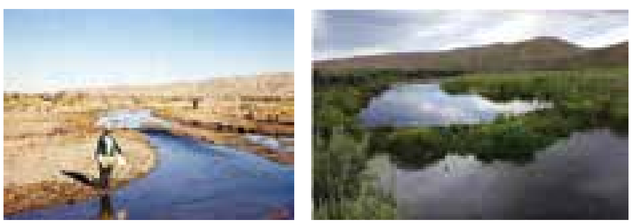
In contrast to other areas of the country, to date trout in this region have not been impacted significantly by energy development. However, several fracking wells have been installed in recent years and many leases are being proposed near trout streams, making this a potential threat in the future. A large below-ground natural gas pipeline extending from Wyoming to Oregon now closely circumvents several important Lahontan cutthroat trout recovery populations. Mining, a central component of the economy, continues to grow in the region; water needs and exploratory drilling for mine expansions have already had impacts on native trout populations (including one recent extirpation) and will continue to pose threats. At the same time, several large ranching properties encompassing Lahontan cutthroat trout streams are now mine-owned and these ranches are actively focused on improving riparian habitat through better grazing practices, which is greatly benefitting trout in these areas (see Success Story).

Wildfire is becoming an increasingly important threat. Fire has always been an important component of this region and is a disturbance these fish evolved with, but the landscape context has changed

SUCCESS STORY:

Recovering Trout Habitat in Desert Streams

Degradation of trout streams often is caused by many factors. In Nevada's Maggie Creek, decades of intensive grazing, combined with isolation of streams by road culverts and persistent drought, had taken a toll on native Lahontan cutthroat trout. But over the past few decades, a watershed approach to restoration, involving various strategies and a whole host of partners, has improved the resiliency of this important trout population.



BLM Elko District monitoring photos of Maggie Creek in 1980 (left) and 2014 (right). Courtesy of Carol Evans.

Cattle reign supreme in the West, valued by many as an iconic part of this landscape and an important thread of western social culture. But without proper management, cattle can cause problems for trout. When its hot, cows go to water and this has caused many western streams to become wider, shallower and warmer as stream-side vegetation is trampled.

In northern Nevada, grazing affects more than 95 percent of habitat occupied by Lahontan cutthroat trout conservation populations (those being managed for recovery under the Endangered Species Act) and the resulting habitat degradation is a major factor in this unique trout's decline. Invasive cheatgrass adds another dimension to the problem, by creating a fine fuel layer that encourages more wildfires.

This degradation, however, provides opportunity to make things better for trout. It takes a lot of work, but changing the length and timing of the cattle's stay on different pastures, along with a little fencing and seeding here and there, can be enough to give riparian vegetation a foothold. This is exactly what happened in Maggie Creek over the past few decades. In 1993, the BLM and local mining and ranching partners initiated the Maggie Creek Watershed Restoration Project to enhance 82 miles of stream and almost 2,000 acres of riparian habitat in the basin. Although the project comprised a number of components including riparian plantings and fencing, a conservation easement and water developments, the most important change was application of prescriptive livestock grazing practices to limit grazing during the hottest parts of the year.

The overall result of all of this work is dramatic. The restoration has created a more functional, hydrated floodplain and a healthy riparian zone. Beavers have also been part of the success story. As they moved back into improving riparian habitats, their dam building has expanded wet meadows and riparian areas that help hold water. These ponds are capturing sediment and providing critical wet refuge areas for fish and wildlife in times of unprecedented drought and wildfire.

Another problem facing Lahontan cutthroat trout in Maggie Creek was that poorly designed culverts had severed the connection between the mainstem creek and its tributaries, preventing the movement of trout within the drainage. Partners worked to replace the offending culverts with passage-friendly structures.

According to TU's long-term monitoring of trout responses, the restored habitat connectivity is now allowing Lahontan cutthroat trout to move to desirable habitat for growth and refuge from drought and other disturbances, which will help keep them secure in the future.

Culverts (above left) prevented fish from freely moving from Maggie Creek into Beaver Creek, a major tributary. In 2005 they were replaced with this fish-friendly structure (above) to connect the streams.

dramatically for trout over the last century: with habitat fragmentation, trout have lost their ability to deal with fire by moving to refuge habitats and so the consequences of fire are more severe. Additionally, the invasion of non-native Eurasian cheatgrass has altered the fire regime in the Interior Basins (4). Cheatgrass thrives particularly well in disturbed habitats and it not only invades after fires but, because it is highly flammable, it also contributes to fires. Areas with cheatgrass burn two to four times more frequently than areas with native vegetation. This cycle has led to the establishment of large cheatgrass monocultures, which are associated with some of the largest fires in the region. Over 2 million acres burned across the Interior basins in 2012 alone. Several fires that year impacted valuable native trout streams, such as the 400,000-plus-acre Holloway fire in Oregon, which ripped through one the few – and largest – interconnected stream systems remaining for Lahontan cutthroat trout.

Habitat degradation by grazing compounds the effects of fire in many trout streams. Drought and bark-beetle outbreaks are also increasing the magnitude of fires in higher elevation, forested areas.

An example from an Idaho stream, showing how grazing downstream of an exclusion fence has made this stream wider, shallower and likely warmer. Photo: Warren Colyer.

The size and frequency of fires are only expected to be exacerbated by climate change, which is already hitting the region hard. Average annual temperatures for the greater southwest region increased 3.4o F over the last century and in Utah and Nevada, average temperatures in 2001-2010 were warmer than for any other decade in the 20th Century (5). Paradoxically, while parts of the southwest have suffered declining precipitation over the long-term, precipitation actually seemed to increase over the 20th Century in many parts of the Interior basin (5). For the last several years, however, much of the region has been gripped in a persistent drought that is not predicted to let up. Much of the Interior basins have experienced less than 50 percent average precipitation this year; in April, the less than 5 percent average observed across the West prompted California to implement mandatory water restrictions for the first time.

The severity of drought is partly due to the fact that, with increasing temperatures, precipitation generally now comes more as rain rather than snow. Snow serves as an important 'release' valve for stored water, so less snowpack (and earlier snow melt) means less water is retained in streams and rivers throughout the year.

In Nevada's Walker River basin (flowing east from the Sierra Nevada mountains), unprecedented declines in water storage and associated unsustainable increases in groundwater pumping, recently prompted the Nevada state engineer to enact a 50 percent curtailment of supplemental irrigation rights. On the bright side, the Walker Basin Restoration Program is developing innovative tactics such as leasing or buying water rights from willing landowners and switching fields over to more water-friendly crops in this corner of Nevada. But if the drought continues as predicted, providing water and income security for the human population of the interior basin, while ensuring flows to protect and restore native trout, will require increasingly complex maneuvering.

Colorado Plateau and Southern Rockies

Species Summaries

LISTING STATUS: red (ESA listed as Threatened or Endangered), yellow (not ESA listed but federal sensitive species or state species of concern (majority of states), green (not listed in majority of states)

CURRENT RANGE: red (10 percent or less), yellow (11-25 percent), green (>25 percent)

HISTORICAL RANGE: red (<1,000 miles), yellow (1,000-10,000 miles), green (>10,000 miles)

Colorado River Cutthroat Trout

Category	Status	Explanation
Listing status		Sensitive species (USFS, BLM) Species of Special Concern (CO, WY, UT)
Current range		~11 percent of historical habitat currently occupied by populations of conservation value
Historical range		Upper Colorado River Basin
Climate change		Stream warming and desiccation of headwater streams
Energy development		Oil and gas development in CO, WY, and UT
Non-native species		Introduced brook and rainbow trout have been widely stocked and rainbows hybridize with cutthroats
Water demand		Localized water demand can influence flows
Data issues		Current rangewide database exists, but some uncertainty exists with regard to genetic lineages due to historical stocking

Greenback Cutthroat Trout

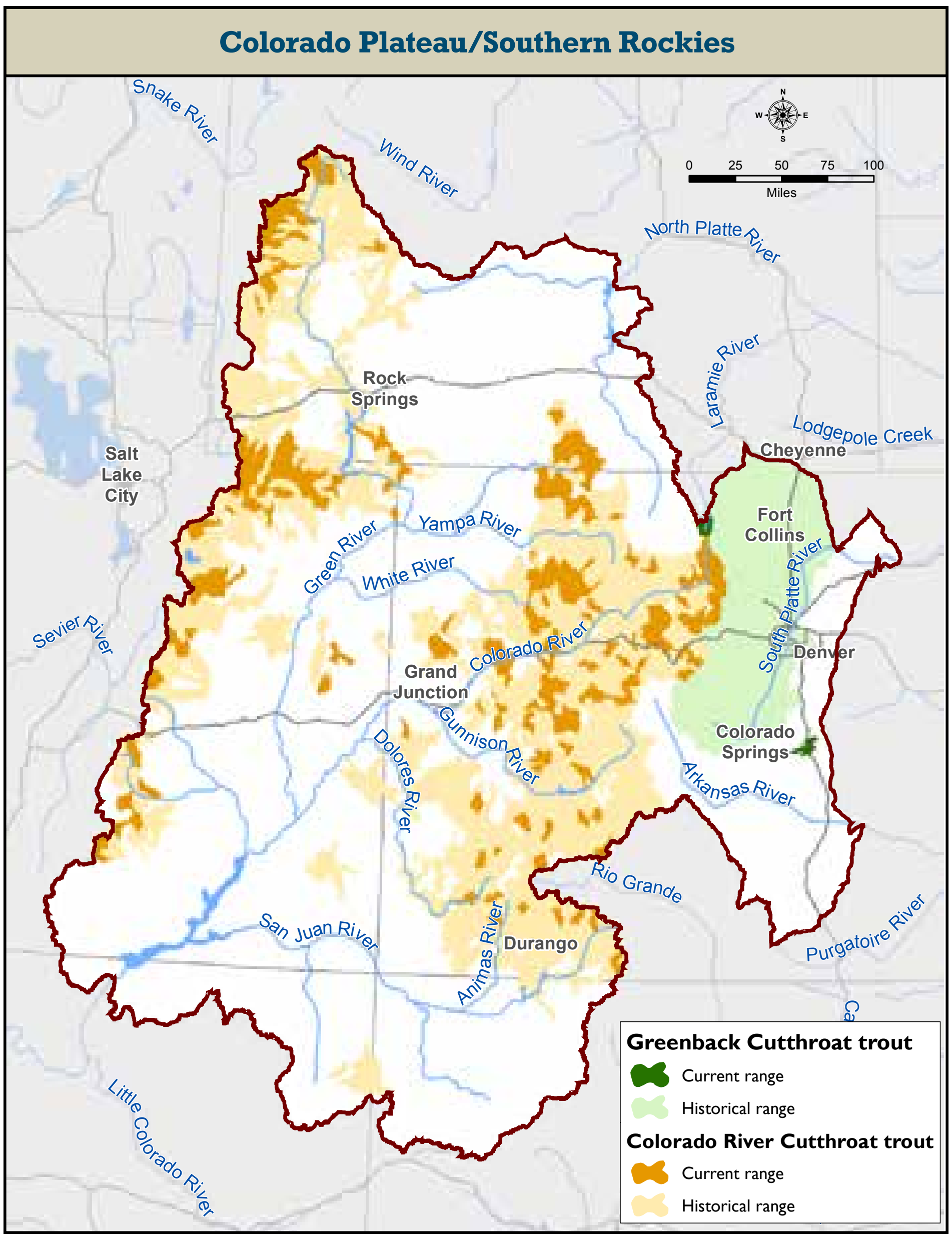
Category	Status	Explanation
Listing status		Listed as Threatened in ESA; Sensitive species (USFS, BLM), Species of Special Concern (CO, WY), currently under review by management agencies
Current range		Occupies only one stream, and recently reintroduced into one lake
Historical range		South Platte River basin
Climate change		Stream warming; reduced snowpack
Energy development		Populations currently protected
Non-native species		Introductions of non-native trout have greatly reduced the current range
Water demand		Populations currently protected
Data issues		The genetic identity of many cutthroat populations in Colorado has not been determined

Colorado River Cutthroat Trout

(Oncorhynchus clarkii pleuriticus)

The Colorado River cutthroat trout was first described by Edward Drinker Cope in 1872 from a specimen collected in the Green River near Fort Bridger, Wyoming. The subspecies' historical range is thought to be bound to the west by the Escalante River, to the south by the San Juan River, to the east by the Continental Divide and to the north by the Green River. Within this general historical range, the distribution of Colorado River cutthroat trout was thought to have been very discontinuous because of the sediment-rich, warm nature of larger rivers in the Colorado River Basin. The most recent 2010 status assessment listed 361 conservation populations occupying 2,115 miles of stream (1).

While populations of Colorado River cutthroat trout were historically fragmented among the major tributaries of the Colorado River, land and water uses, introduction of non-native trout, and isolation management have further truncated and disconnected populations. This has relegated most populations as residents of small headwaters streams, whereas historically large cutthroat up to 12 pounds could be caught west of the Continental Divide. Although the most recent status assessment from 2010 listed 361 populations of Colorado River cutts, the most recent genetic and meristic studies suggest that many more Colorado River cutthroat trout populations, once thought to be greenbacks, now reside in streams on the east side of the Continental Divide because of well-intentioned stocking efforts (2,3). Although there is the appearance of more extant Colorado River cutthroat populations than originally thought, recent genetic and meristic studies suggest within the existing populations there is also more genetic diversity than once thought. This genetic diversity has also been clouded by stocking efforts and future management of these diverse 'lineages' is not yet clear but will likely provide opportunities to conserve a suite of genetic diversity within the subspecies.



Historical and current distributions of native trout in the Colorado Plateau/Southern Rockies.

Oncorhynchus clarkii stomias

Greenback Cutthroat Trout *(Oncorhynchus clarkii stomias)*

Greenback cutthroat trout were considered to historically have occurred in the South Platte drainage and with some debate the Arkansas River drainage, on the east slope of the Continental Divide. Most of this historical distribution is in Colorado, save for some small tributaries of the South Platte in southeastern Wyoming. There is confusion as to where greenbacks were first collected by W. R. Hammond during an Army expedition in 1856 and the subspecies was described by Edward Drinker Cope but redefined by David Starr Jordan in 1891. Historically, greenbacks were mostly small trout, but widespread introductions of non-native trout, in addition to mining, irrigation and harvest by settlers, resulted in the rapid disappearance of greenbacks from the Front Range. They were even thought to be extinct by the mid-1930's. However, in the late 1960's a few populations were found above barrier falls in small headwater streams – the last remnants of the subspecies.

Greenbacks were listed as Endangered under the Endangered Species Act in 1973, but by 1978 its status was changed to Threatened due to establishment of some new populations. Much early restoration of greenbacks was done in Rocky Mountain

National Park using hatchery-raised fish from known remnant populations. As of 1998, the Greenback Cutthroat Trout Recovery Plan (4) listed 62 lakes (442 acres) and 102 miles of stream as occupied. Restored populations in some lakes were open to fishing. However, recent genetics studies of both existing populations and museum specimens have shown that stocked fish used in well-intentioned greenback restoration efforts were actually Colorado River cutthroat trout and the only greenback population currently in existence now resides in four miles of Bear Creek southwest of Colorado Springs above a natural barrier in a stretch of stream that was once fishless. Substantial effort has been made in the last year to replicate this population, including stocking into Zimmerman Lake in the South Platte River drainage.

Regional Trends

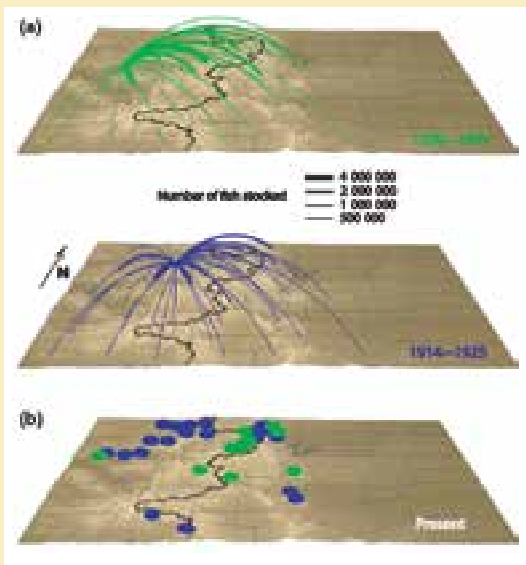
The Southern Rockies and Colorado Plateau includes the Upper Colorado River basin and basins east of the Continental Divide. The elevation change in this region is pronounced, ranging from the famous 14ers in Colorado to the deserts and canyons of the Colorado River and tributaries to Lake Powell. While the mainstem Colorado River and its larger tributaries become warm and filled with sediment as they leave the mountains, the clear and cold headwaters containing trout originate in the region's famed mountain ranges: Colorado Rockies, Wind Rivers, Wyoming Range, Uintas, Wasatch Range and high plateaus of eastern Utah. Historically, the Greenback and Colorado River cutthroat trouts thrived in these cold, clear streams.

Water use has and will continue to be an ongoing issue in the region. Most water within the Colorado River Basin is used for agriculture, municipal and industrial purposes; however, a substantial amount is diverted out of basin for use by cities such as Denver, Salt Lake City and Los Angeles. Rarely is water left in river for environmental purposes, such as sustaining fish and wildlife populations. Whoever coined the term "whiskey is for drinking; water is for fighting over" must have been thinking of the Colorado River. The appropriation of water to states through the Colorado River Compact was done in 1922 based on water yields computed during a wet climatic period. Since 2000, the climate of the basin has been hotter and dryer, resulting in less water and the river being over-appropriated. Not surprisingly, the water shortage has been a source of contention between states, Tribes and others in an arena where fish have no voice.

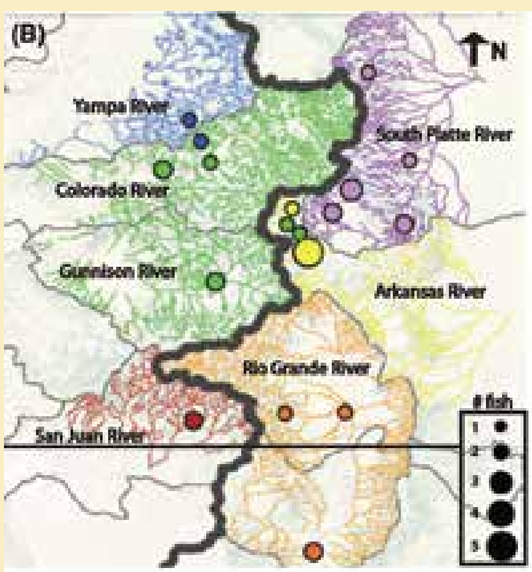
Increased population growth will continue to put pressure on native

Cutthroat Trout In Colorado: Genetics Reveals Multiple Lineages and Effects of Historical Stocking

Researchers at the University of Colorado-Boulder, along with other colleagues, recently revealed that well-intentioned, extensive stocking efforts of cutthroat trout in Colorado had led to Colorado River cutthroat trout being stocked across the Continental Divide into historical habitat of greenback cutthroat trout. A follow-up genetic study using both existing populations and museum samples showed that cutthroat trout in Colorado represented possibly six distinct lineages in Colorado, including Rio Grande cutthroats, the extinct yellowfin cutthroat and an undescribed lineage in the San Juan River. This study also revealed that greenbacks were now only found in a 4-mile stretch of Bear Creek, outside the subspecies' historical range and that the contemporary distribution of these lineages reflects extensive stocking efforts that began around 1900. Future management of these lineages is unclear. Will they simply be treated as separate lineages, or will they be elevated to the status of subspecies? Time will tell.



(Top) Effect of extensive stocking in Colorado on the present-day distribution of cutthroat trout from Trappers Lake and Grand Mesa.



(Bottom) Six different genetic lineages of cutthroat trout in Colorado, with points showing where stocking has moved those lineages across drainage boundaries. Figures from Metcalf et al (2,3).

cutthroat trout populations. For example, Colorado is the 5th fastest growing state in the U.S., particularly along the Front Range. Not only does this put added pressure on water resources of the Front Range, large metropolitan areas such as Denver receive water from the Colorado River Basin, too. The City of Denver is always looking to lengthen and enlarge its straw to sip from water across the Continental Divide, so the Colorado River and its namesake native trout are impacted as well by population growth. In fact, Trout Unlimited has been a critical player in the fight to keep Colorado River water in the Colorado River basin. Other water infrastructure projects have been completed in anticipation of population growth but to the detriment of cutthroat trout populations. For example, several Colorado River cutthroat trout populations in the Little Snake River drainage were isolated by a water diversion structure on the west slope of the Sierra Madre Mountains in Wyoming that captures water for trans-basin diversions used to deliver water to Cheyenne, Wyoming.

The Upper Green River basin and Colorado Plateau have recently been the focus of extensive oil and gas exploration, development and extraction. In fact, Wyoming and Colorado are the leading states for coalbed methane production in the United States, although fluctuating prices have led to some uncertainty as to future development of less-profitable reserves. The primary concerns from oil and gas development are water use, variable water quality associated with produced water discharge and sedimentation from well pads, among other impacts. Many concerns are associated with hydraulic fracturing used to extract gas from impermeable shale layers. While most of the development has been at lower elevations in the realm of warm water streams, some native trout populations occupy lower elevation streams, such as those in Piceance Basin. With all the energy development potential on public and private lands, it is hard to predict where new development proposals might threaten native trout populations.

SUCCESS STORY:

Roan Plateau – A Model for Balance

BY COREY FISHER, TROUT UNLIMITED

The Roan Plateau supports a host of natural values including scenic canyons and waterfalls, outstanding deer and elk habitat, and headwater streams harboring populations of Colorado River cutthroat trout. For nearly two decades, TU's Grand Valley Anglers chapter in Grand Junction, Colorado has worked on projects to improve trout habitat on the Roan Plateau, work that was threatened when these public lands were leased for energy development by the Bureau of Land Management (BLM) in 2007. With the future of the Roan Plateau and TU's conservation investments on the line, Colorado TU joined other conservation-minded groups to legally challenge the leasing.

Riparian planting along Colorado River cutthroat trout habitat. Photo: C. Fisher

Over the next six years, a series of negotiations led to a settlement agreement in which a limited amount of development could occur within a portion of the plateau that is less environmentally sensitive, while leases that encompass cutthroat trout drainages would be canceled. In short, all parties agreed to certainty for both conservation and development without conceding either one. Currently, the BLM is developing a new management plan for the Roan Plateau and TU is working to ensure that this plan reflects key components of the settlement agreement to ensure trout streams on the Roan Plateau are protected long into the future.

Throughout the course of the legal battle, Colorado Trout Unlimited and the Grand Valley Anglers continued on-the-ground restoration work, improving stream crossing, fencing riparian areas and planting vegetation. Much of the work is scheduled to culminate in the summer of 2015 with the reintroduction of Colorado cutthroat trout into the East Fork of Parachute Creek, a stream on the Roan that is the focus of an extensive, multi-year native trout restoration project.

Colorado River cutthroat trout from Roan Creek. Photo: C. Fisher

The Roan Plateau is an example of TU's restoration and protection work coming together to not only save a place, but to make it better. It also showcases the power of TU's grassroots to make a difference – without the time, sweat and money invested over the years by TU volunteers, the future of Roan Plateau would look much different and it might not include cutthroat trout.

Southwest

Species Summaries

LISTING STATUS: red (ESA listed as Threatened or Endangered), yellow (not ESA listed but federal sensitive species or state species of concern (majority of states), green (not listed in majority of states)

CURRENT RANGE: red (10 percent or less), yellow (11-25 percent), green (>25 percent)

HISTORICAL RANGE: red (<1,000 miles), yellow (1,000-10,000 miles), green (>10,000 miles)

TROUT UNLIMITED

Rio Grande Cutthroat Trout

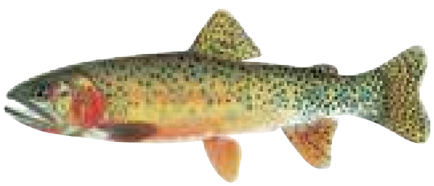
Category	Status	Explanation
Listing status		Sensitive species (USFS, BLM) Species of Special Concern (CO, NM)
Current range		10 percent of historical habitat currently occupied
Historical range		Moderate distribution historically, 6,650 miles
Climate change		Drought, stream warming and wildfires are major issues, most streams with <1 cfs baseflow
Energy development		Some overlap with oil/gas leases and potential solar
Non-native species		Introduced rainbow trout pose hybridization risk; brown trout invading many streams as temperatures warm
Water demand		Many streams have diversions in lower reaches
Data issues		Interagency workgroup maintains good population data; flow data needs improving

Apache Trout

Category	Status	Explanation
Listing status		ESA Threatened Species of Special Concern (AZ)
Current range		25 percent of historical habitat currently occupied
Historical range		Limited distribution historically, 680 miles
Climate change		Drought, stream warming and wildfires are major issues
Energy development		No known significant energy development issues
Non-native species		Introduced rainbow trout pose hybridization risk; brown trout invading many streams as temperatures warm
Water demand		Many streams are small and susceptible to diversions in lower reaches
Data issues		Recovery Team maintains good population data; habitat conditions and barriers need improved monitoring

Gila Trout

Category	Status	Explanation
Listing status		ESA Threatened Species of Special Concern (NM, AZ)
Current range		5 percent of historical habitat currently occupied
Historical range		Limited distribution historically, 600 miles
Climate change		Drought, stream warming and wildfires are major issues
Energy development		No significant energy development issues
Non-native species		Introduced rainbow trout pose hybridization risk; brown trout and smallmouth bass invading streams as water warms
Water demand		Many streams are very small and susceptible to any diversions
Data issues		Recovery Team maintains good population data; habitat monitoring often lacking; tracking needed for non-native species



Oncorhynchus clarkii virginalis

Rio Grande Cutthroat Trout *(Oncorhynchus clarkii virginalis)*

Rio Grande cutthroat trout were first discovered in 1541 by Francisco Coronado's expedition in the upper Pecos River although they were not formally described until 1856. They represent the southern extent of the cutthroat trout species, historically ranging from the mountainous headwaters of the Rio Grande, Pecos and Canadian rivers in Colorado and New Mexico to small streams in the Guadalupe and Davis Mountains of Texas. Today 121 populations of Rio Grande cutthroat trout occupy less than 10 percent (about 680 miles) of their historical stream habitat in Colorado and New Mexico and they have long since been extirpated from west Texas. Remaining populations primarily occur in small high elevation tributaries, disconnected from the larger rivers they once occupied.

Fragmentation of habitat from man-made structures such as diversions, dams and culverts and a management strategy of isolation above barriers for protection from non-native species have separated historically migratory populations of Rio Grande cutthroat trout from their feeding and growing habitats in larger rivers. Although 75 percent of Rio Grande cutthroat trout populations are genetically pure, none of the populations support a migratory life history. The average extent of occupied stream habitat is less than 6 miles, leaving them highly vulnerable to environmental disturbances such as wildfire and drought.

Oncorhynchus gilae apache

Apache Trout *(Oncorhynchus gilae apache)*

Apache trout are found only in the White Mountains of east-central Arizona where they historically occupied about 680 miles of stream habitat in the headwaters of the Little Colorado and Salt rivers. In the late 1800s, early settlers reportedly caught hundreds of the 'yellow bellies' in a single outing. However, by the mid-1900s habitat degradation from timber harvest, livestock grazing, road construction, water diversions, dams and the introduction of non-native trout had taken its toll on Apache trout, reducing the occupied habitat to less than 30 miles. Consequently, in 1969 Apache trout became one of the first species to be federally listed as Endangered.

In 1975 successful recovery efforts, including habitat restoration as well as stocking from hatcheries and protection from non-natives, led to the reclassification of Apache trout from Endangered to Threatened and some areas were re-opened to limited fishing. By 2010 there were 30 populations occupying nearly 180 miles of stream habitat, many of which were protected from invading rainbow and brown trout by stream barriers. However, their isolation in small fragmented streams left these populations vulnerable to rapid environmental changes such as the 2011 Wallow Fire that burned more than 490,000 acres, impacting seven populations in the Black and Little Colorado River watersheds. Although the fire was a setback to recovery efforts, it also provided some new restoration opportunities by eliminating non-native trout from many of the burned tributaries. Currently there are approximately 28 populations of Apache trout in 170 miles of habitat with plans to reestablish populations in 30-40 miles of unoccupied stream habitat, including the restoration of a metapopulation in the West Fork Black River.

Oncorhynchus gilae gilae

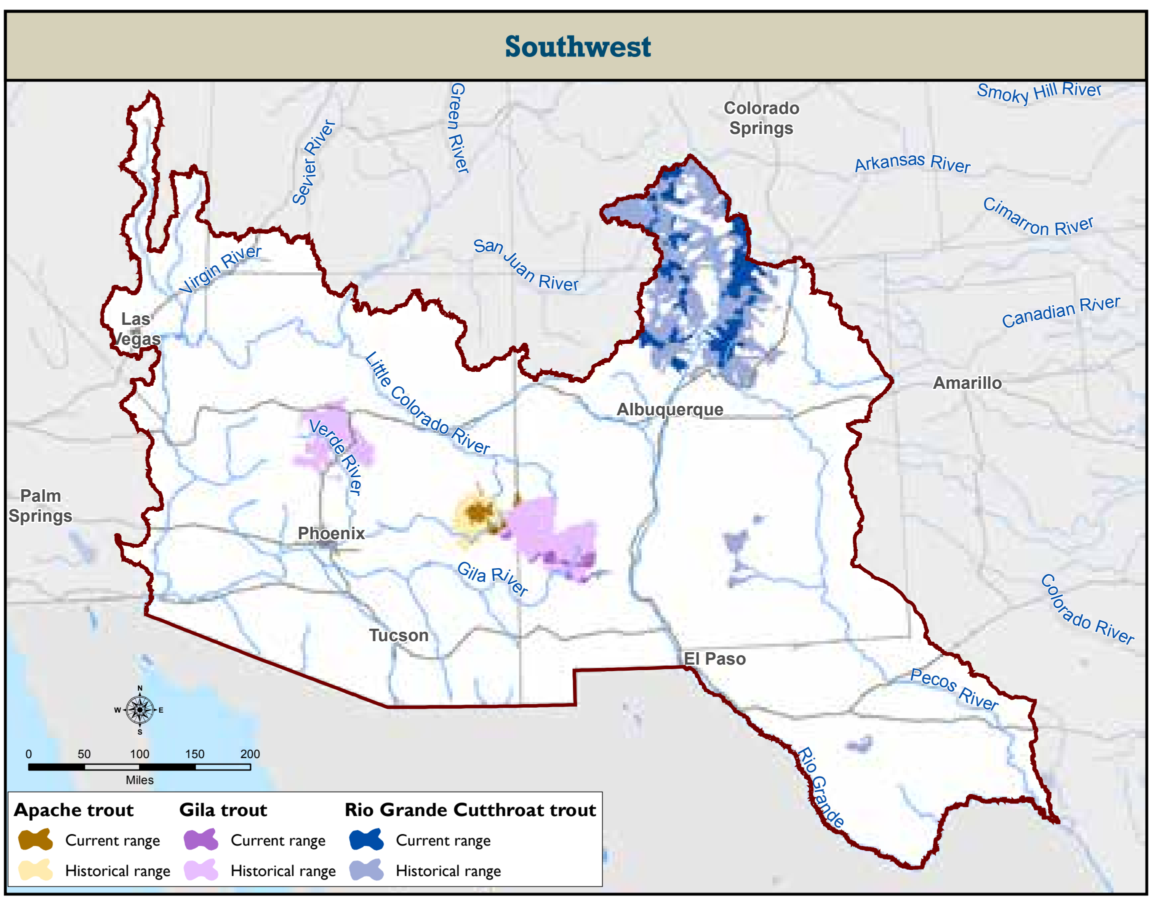
Gila Trout *(Oncorhynchus gilae gilae)*
The historical distribution of Gila trout included nearly 620 miles of small stream habitat within two separate population centers: one in the upper portion of the Gila River basin in western New Mexico, including the Blue and San Francisco rivers, and the other in the headwaters of the Verde River in central Arizona. Early reports of the 'speckled' trout in the Gila River drainage date back to the late 1800s, but Gila trout was not described as a separate species until 1950 when its distribution had already been dramatically reduced. This population decline led to an "Endangered" classification by the U.S. Fish and Wildlife Service in 1966. By 1975 only five relict populations of the species remained representing five ancestral lineages - two of which (Iron and McKenna creek populations) were later found to be hybridized with rainbow trout and were no longer included in recovery efforts. A sixth genetically pure relict population was discovered in Whiskey Creek in 1992. Despite its precarious status, in 2006 the U.S. Fish and Wildlife Service reclassified Gila trout from Endangered to Threatened.

The protection of remnant populations of Gila trout in small mountain streams is challenging given their vulnerability to wildfire, floods and drought. These vulnerabilities are compounded by the presence of non-native species such as rainbow trout, even in the remote rugged landscape of New Mexico's Gila Wilderness Area. In 2010, fifteen populations of Gila trout occupied about 80 miles of stream habitat primarily in the upper Gila River drainage. Ten of these populations were in the Gila Wilderness Area. In 2012 the Whitewater Baldy fire burned more than 300,000 acres through the core of remaining Gila trout strongholds within the wilderness area. In 2014 there were eight populations remaining in about 30 miles of habitat while the post-fire status of another three populations in 15 miles of habitat remains unknown. As with Apache trout, the wildfire may have created some opportunities for reestablishing populations within the burned area where non-native trout have been eliminated.

Regional Trends

The Southwest includes the lower Colorado River basin and the Rio Grande basin, including major tributaries such as the Gila and Pecos rivers. The diverse landscapes of the Southwest range from the 13,458-foot Canby Mountain in the San Juans of Colorado to the desert scrublands along the US-Mexico border in southwest Texas. Although the southern extent of this region is characterized by arid landscapes including the Mojave, Sonoran and Chihuahan deserts, the Rio Grande, Little Colorado, Pecos and Gila rivers emerge from high elevation forests and mountain meadows that receive more than 30 inches of precipitation a year. These cold mountain waters are the lifeblood of the region's three native trout: Rio Grande cutthroat, Gila and Apache.

These native trout of the Southwest have survived for thousands of years, adapting to many environmental changes along the way. Gila and Apache trout in particular evolved in small high elevation islands of clean, cold water rising above the surrounding arid landscape. Over the past century-and-a-half, as the region has been developed, these hardy fish have faced a series of increasing challenges and are now at a critical juncture. Logging and the associated roads and culverts, as well as dams and diversions to support agriculture, have contributed to the fragmentation and degradation of aquatic ecosystems in the region. However, of all of the historic alterations to coldwater habitats in



Historical and current distributions of native trout in the Southwest Region.

Rio Grande Cutthroat Trout: The Pros and Cons of Life in Small Headwater Streams

A recent study by the U.S. Geological Survey of temperature and baseflow discharge throughout the range of Rio Grande cutthroat trout underscores the vulnerability of remaining populations to increasing summer temperatures and persistent drought (3). The study involved a network of 108 monitoring sites across the current distribution of Rio Grande cutthroat trout. Data was collected between May 2010 and October 2011 to assess the suitability of occupied habitat from a thermal and flow perspective - two environmental variables strongly influenced by climate change in the region.

The study found that although temperatures in several streams supporting Rio Grande cutthroat trout approached thresholds considered to be harmful to cutthroat trout, the high elevation of most occupied streams maintained water temperatures well below critical limits. However, the study also found that over 70 percent of these streams had baseflows of less than 1.0 cubic feet per second in both 2010 and 2011. The isolation of remaining populations in small headwater streams behind barriers protects them from non-native species but limits their ability to move to more suitable habitat when their environment changes. The sensitivity of these small streams to persistent drought should be a consideration for the long-term conservation of Rio Grande cutthroat trout.

Monitoring site on North Fork Carnero Creek: measured baseflow discharge of 0.07 cfs on 9/20/2010 (3). Photo from U.S.G.S.

the region, perhaps the most pernicious has been the introduction of non-native trout to the streams and rivers historically occupied by the Southwest's native fish. These non-natives have displaced the native trout through hybridization, competition and predation, and the native trout now find themselves in the more isolated headwater streams, often upstream of constructed barriers designed to separate the native trout from invasive non-native fish from further downstream. These shrinking island habitats within their historically limited distribution further constrain their innate ability to adapt to changing conditions. Now, these problems are compounded by rapid population growth and climate change.

The Southwest is one of the fastest growing regions in the United States with population growth of 75 percent in Arizona, 125 percent in Nevada and 35 percent in New Mexico since 1990. Much of the growth has occurred in the Phoenix and Las Vegas metropolitan areas, where average annual rainfall totals are less than 10 inches and surface water is scarce. This amount of growth in an arid region obviously results in an inordinate amount of pressure on scarce water resources. Rivers such as the Salt, Verde, Colorado and Rio Grande that have supported native trout in their headwaters are also important to municipal water supplies downstream while aquifers underlying the surrounding watersheds are pumped to help meet the growing demand.

Agriculture is of even greater significance to the Southwest's water supply. The region supports a robust agricultural economy dependent on the availability of water for irrigation which comes from both groundwater pumping as well as elaborate delivery systems such as the Central Arizona Project (CAP). The Central Arizona Project uses more than 336 miles of aqueducts and pipelines to bring water from the Colorado River to central Arizona for agriculture. Although agriculture is a historical land use in the Southwest, projects such as the CAP have allowed for a shift from smaller farms to large industrial complexes dependent on the availability of an abundant water supply. However, climate change and associated record high temperatures and persistent drought in the region have contributed to water shortages throughout the Southwest, placing additional stress on the region's hydrologic system.

The Southwest has been in a drought for nearly a decade with the effects of reduced precipitation being exacerbated by increased evaporative losses due to rising temperatures. The decade 2001 – 2010 had regional temperatures almost 2° F higher than historic averages with longer and hotter summer heat waves and fewer wintertime cold air outbreaks. When rain occurs, it often falls in large storm events. During this same time period average streamflow totals in the region were up to 37 percent lower than the 20th Century average flows due to reduced winter snowpack and increased evaporative losses (1). This trend continued as the summer of 2014 found that almost all of New Mexico and Arizona were considered under moderate to extreme drought with warmer-than-average temperatures. Recent studies project that the 21st Century may bring unprecedented mega droughts to the region, surpassing the driest centuries of the Medieval period as well as the more recent drought conditions associated with the dust bowl of the 1920s (2).

Prolonged drought has severe implications on the region's native fish and wildlife, especially as populations are already threatened by a variety of activities and invasive species. The isolation of remaining populations of native trout in small stream habitats above barriers leaves them particularly vulnerable to drought conditions since they are unable to access the larger river systems downstream. Warming temperatures may also alter the thermal regime of the hydrologic system and create conditions that favor the invasion of non-native fish such as brown trout and smallmouth bass into previously coldwater habitats.

In addition to the direct effects of stream drying, the drought conditions have also contributed to an increase in wildfires throughout the region. Although the Southwest's native trout evolved in a fire-prone landscape, the intensity and severity of the wildfires today are much greater than under historical conditions and the isolation of populations leaves them unable to escape when a wildfire or post-fire debris flow moves through. Between 2009 and 2013, more than 2 million acres burned within the historical ranges of Rio Grande cutthroat, Gila and Apache trout, resulting in local extirpations. Many of these wildfires burned at high intensities over large landscapes. The Wallow Fire of 2011 became the largest blaze in Arizona history, burning nearly 470,000 acres, while the Whitewater-Baldy Fire became the largest wildfire in New Mexico history in just the following year.

SUCCESS STORY:

Rio Costilla Watershed Restoration Project

For over 10 years the Truchas Chapter of Trout Unlimited has been engaged in a collaborative effort with the U.S. Fish and Wildlife Service, New Mexico Department of Game and Fish, Carson National Forest, the Rio Costilla Cooperative Livestock Association, private landowners, the Quivera Coalition and numerous nonprofit organizations in an ambitious effort to restore Rio Grande cutthroat trout to 125 miles of stream habitat and 25 lakes within the Rio Costilla watershed of northern New Mexico. Where suitable habitat exists, the Rio Grande sucker, Rio Grande chub and longnose dace will also be restored, creating a self-sustaining native fish community free of non-native fishes.

Reconnecting the isolated populations that currently occupy the watershed and establishing a large genetically pure migratory population will provide some much needed resilience to climate change for Rio Grande cutthroat trout. As wildfire and drought continue to impact the region, the availability of high quality diverse habitats in a well-connected system allows fish to move when temperatures become too warm or a wildfire renders their current habitat unsuitable. Migratory populations are able to recolonize the disturbed habitat once it has recovered.

A restoration project of this magnitude requires a long-term vision and commitment that can't be replicated in every watershed. However, where possible the restoration of other migratory populations of Rio Grande cutthroat trout in well-connected habitat free of non-natives should be a conservation priority.

Bank stabilization work on Comanche Creek. Photo by Bill Schudlich.

Brook Trout (*Salvelinus fontinalis*)

The native distribution of fall-spawning brook trout (*Salvelinus fontinalis*) includes northeastern North America from the Canadian Maritimes to Hudson Bay and extends south through the Driftless region of Minnesota, Iowa, Wisconsin, and Illinois and the Great Lakes region and down the Appalachian Mountains to northern Georgia, spanning four regions in the State of the Trout report. Brook trout populations can often be comprised of resident individuals that have relatively small home ranges or reside in a single stream or lake because connectivity to suitable habitat in nearby streams is absent. However, some populations that occupy large interconnected habitats can exhibit seasonal movements from streams into larger rivers and lakes for feeding, from lakes to streams for spawning, or to estuaries. Additional details on the variety of life histories and an overview of specific threats are provided in the regional sections.

The rangewide status of brook trout is summarized below but each region where brook trout occur also have status classifications that are specific to each region. Relative to many other native salmonids, brook trout status is better off as they have a widespread historical distribution and currently occupy at least half of that distribution in most regions, with some exception such as in the southern Appalachians where their distribution is more restricted. The early and widespread culture and stocking of brook trout has aided in their current status, with some uncertainty as to whether existing populations represent native genetic lineages or those of a few populations comprising hatchery strains. Threats also vary regionally, but on the average are moderate compared to other native trouts.

Brook Trout (Rangewide)

Category	Status	Explanation
Listing status		Species of Special Concern (IA, MD, NJ, OH, SC, TN)
Current range		~50 – 90 percent of historical habitat currently occupied; widely stocked outside of historical habitat
Historical range		Broad historical range from Georgia, Maine, and west through Lake Superior and Upper Mississippi
Climate change		Higher frequency of larger floods and warming temperatures, particularly in the Southeast
Energy development		Shale gas development in Mid-Atlantic, and mining of frack sands for hydraulic fracturing in Midwest
Non-native species		Introduced salmonids pose threats across range that vary by region
Water demand		Localized water demand can influence flows
Data issues		Species databases exist but exclude Midwest populations and genetics data. State databases also exist

Great Lakes – Upper Mississippi

Species Summaries

LISTING STATUS: red (ESA listed as Threatened or Endangered), yellow (not ESA listed but federal sensitive species or state species of concern (majority of states), green (not listed in majority of states)

CURRENT RANGE: red (10 percent or less), yellow (11-25 percent), green (>25 percent)

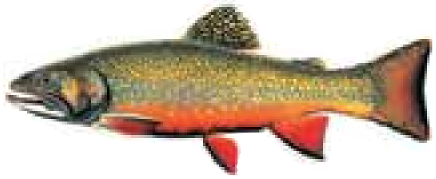
HISTORICAL RANGE: red (<1,000 miles), yellow (1,000-10,000 miles), green (>10,000 miles)

Brook Trout (Great Lakes/Upper Mississippi)

Category	Status	Explanation
Listing status		Species of Special Concern (IA)
Current range		~50 percent of historical habitat currently occupied; but widely stocked outside of historical habitat
Historical range		Widely distributed historically in the region, over 77 million acres
Climate change		Stream warming and higher frequency of larger floods
Energy development		Mining of frack sands for hydraulic fracturing is a threat in some areas
Non-native species		Introduced rainbow and brown trout pose competition and predation risks; Great Lakes salmon and steelhead pose competitive risk to coaster brook trout
Water demand		Localized water demand can influence flows
Data issues		No consistent rangewide database, but state databases exist

Lake Trout

Category	Status	Explanation
Listing status		Species of Concern (IN, OH)
Current range		Populations in the Great Lakes are reduced, but the species has been widely stocked for sportfishing
Historical range		Great Lakes Basin, and somewhat uncertain distribution in the northeast due to early, undocumented stockings. Native to a few glacial refugia lakes in Montana
Climate change		Warmer lake temperature may render some lakes unsuitable
Energy development		No known threats
Non-native species		Pacific salmon and steelhead, sea lamprey, and invasive mussels
Water demand		No known issues
Data issues		Most populations have good monitoring data



Salvelinus fontinalis

Brook Trout *(Salvelinus fontinalis)*

The brook trout (*Salvelinus fontinalis*) is native to the Great Lakes and Upper Mississippi River basins, where its historical distribution includes Lake Superior and northern Lake Michigan and Lake Huron and tributaries, as well as the Upper Mississippi River Basin south to the Driftless Area of Wisconsin, Minnesota, Iowa and Illinois. The exact native range of brook trout in the Great Lakes is uncertain. For example, some notable trout experts suggest brook trout were native to the northern-most portion of Michigan's Lower Peninsula. However, others have suggested that brook trout did not invade the Lower Peninsula until Arctic grayling began to decline there around the mid-1800s. Regardless, some experts even think that brook trout did not naturally occur as far south as the Manistee and Muskegon rivers (now two of Michigan's most famous trout streams), or even the Au Sable River on the banks of which Trout Unlimited was founded. Why brook trout never inhabited these southern tributaries of Lake Michigan and Lake Huron is not clear, however. The most notable brook trout in the Great Lakes is the coaster. Coaster brook trout can exhibit an adfluvial life history whereby individuals reside in the Great Lakes but then migrate into tributaries to spawn in the fall. Around Isle Royale in Lake Superior, coaster brook trout are completely lacustrine where they reside in near-shore areas and spawn along gravel shorelines.

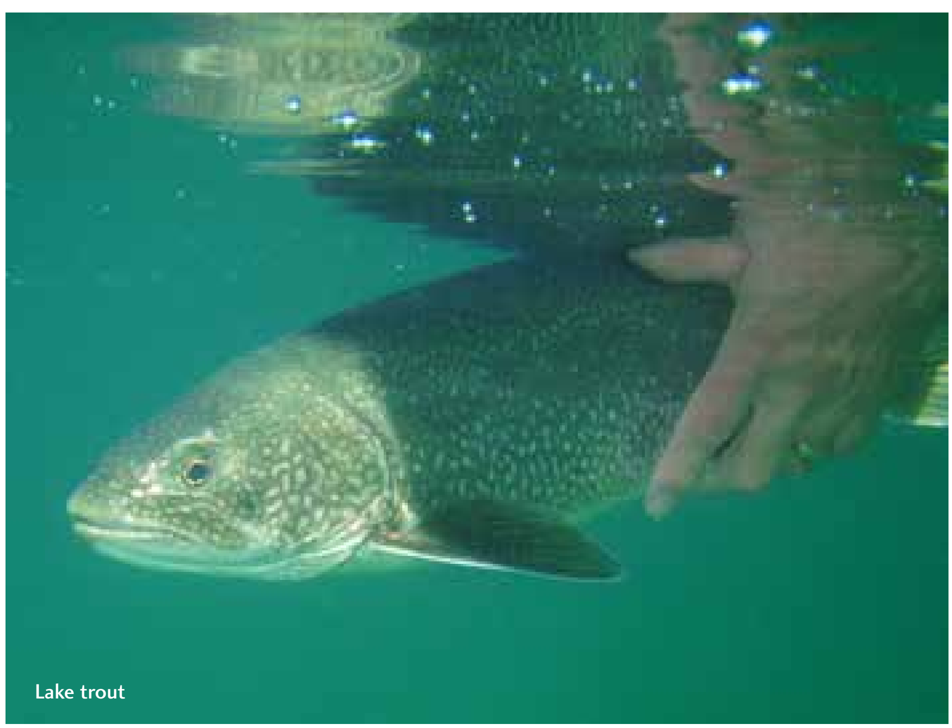
Great Lakes brook trout were impacted by historical logging practices, mining and impassible road crossings and dams. In the Driftless Area, high rates of soil erosion from certain agricultural practices degraded brook trout habitat. Across both regions, brook trout now occur in approximately 50 percent of their historical habitat. However, they have been widely cultured and stocked and therefore now occur in many streams not previously occupied, such as those in Michigan's Lower Peninsula. While some range reduction has occurred, the coaster life history has taken the biggest hit due to overharvest, habitat impacts and impassible barriers on tributary streams, and interactions with non-native salmon, steelhead and other sport fisheries in the Great Lakes. Coaster brook now occupy only about 13 percent of historical watersheds. Much effort has been put towards coaster brook trout recovery, including documenting and prioritizing fish passage projects, stream rehabilitation and reintroduction efforts with the goal of having populations in as many historical habitats as possible (1). In the Driftless Area, wide implementation of conservation farming practices and large-scale, multi-partner restoration programs – such as TUDARE – have led to restoration of many Driftless Area streams to the benefit of trout.

Salvelinus namaycush

Lake Trout *(Salvelinus namaycush)*

The lake trout is native to the Great Lakes basin, occupies cold, deep lakes and historically occupied all five of the Great Lakes. Because lake trout can attain large sizes (lake trout close to 50 inches long and over 100 pounds have been recorded), they are an important sport fish that have been cultured and stocked in many places. While lake trout can attain large sizes, they are often slow-growing because their cold, deep lake habitat is not very productive. This results in populations with an age distribution shifted towards older individuals when compared to most fish populations. Because early lake trout stockings were not well documented, the exact historical distribution of lake trout is not known.

Commercial fishing, pollution and nutrient enrichment, and introduced species have impacted lake trout populations in the Great Lakes. Commercial fishing exploited over 20 million pounds of lake trout as early as the early 1900s, especially in the upper lakes: Huron, Michigan and Superior. Since lake trout are often in unproductive lakes and have an older age distribution they are very susceptible to overfishing. Because many U.S. cities are located on the shores of the Great Lakes (Chicago, Cleveland, Detroit), many pollutants have been discharged into the Great Lakes (2). This has resulted in nutrient enrichment that has been detrimental to lake trout. For example, Lake Erie is



Lake trout

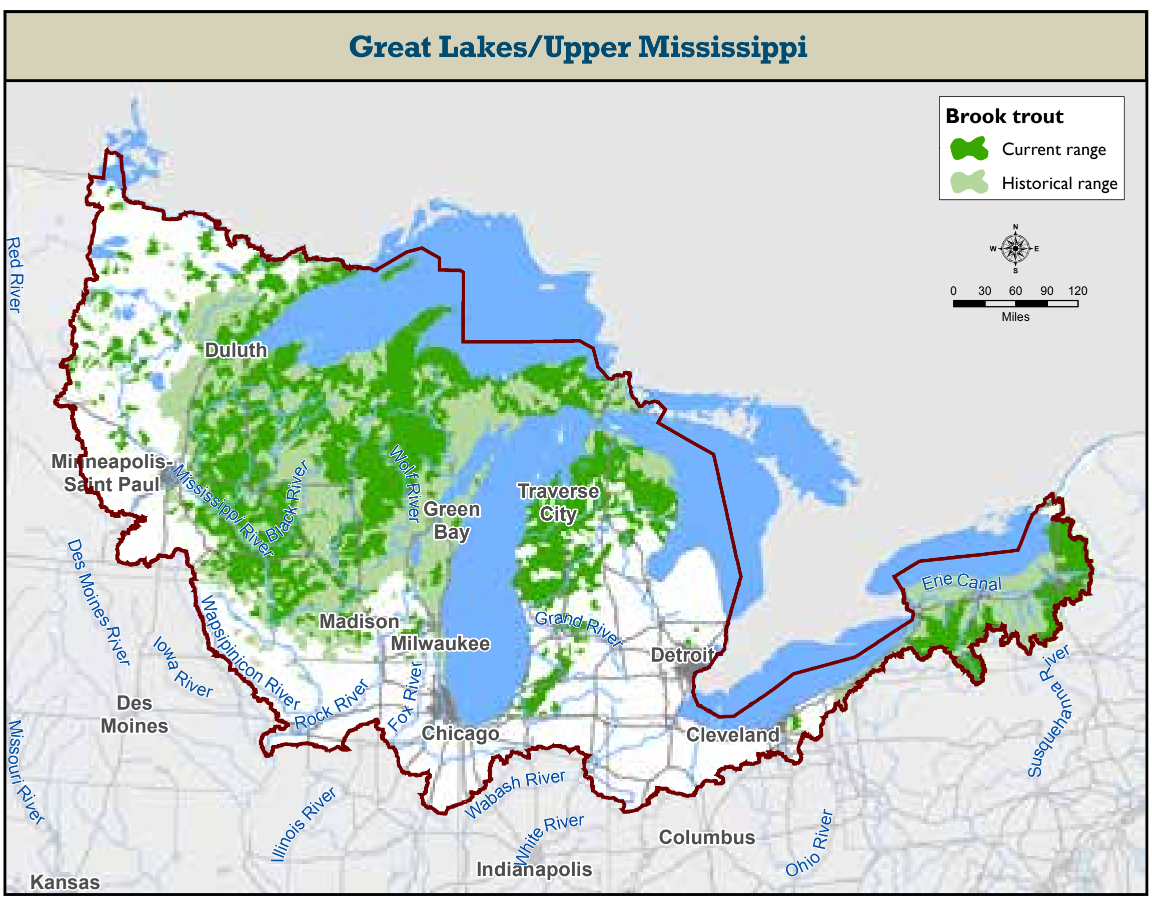
the shallowest of the Great Lakes and nutrient enrichment has resulted in excess algae blooms. When these algae blooms die off they sink to the bottom and are decomposed by bacteria. These bacteria consume oxygen and often deplete oxygen (hypoxia) in the deeper parts of lakes where lake trout reside. Because lake trout require well-oxygenated water, much of their habitat is no longer suitable. One of the largest impacts on lake trout has been the introduction of non-native species, particularly the sea lamprey. While the sea lamprey was native to Lake Ontario, it was restricted to below Niagara Falls, at least until construction of the Welland Canal. Sea lampreys attach themselves to lake trout and ingest bodily fluids. Lake trout were extirpated from Lake Ontario, Lake Erie and Lake Michigan and only remnant populations were left in Lake Huron; Lake Superior was the only lake to maintain offshore populations buffered from the sea lamprey. Pacific salmon and steelhead were introduced to take the place of lake trout at the top of the food chain in the Great Lakes and their naturalization there has inhibited lake trout conservation and recovery efforts.

Regional Trends

In the Great Lakes region, as in most places, a warming climate poses threats to trout that live in cold water. In fact, Wisconsin scientists predict that brook trout habitat will decrease by nearly 50 percent even under limited climate warming (3). Climate warming will trigger changes to precipitation regimes and in the upper Midwest climate warming is predicted to increase the intensity and severity of rainfall events, which will in turn lead to increased flooding – something that has been observed already in the last decade. Historic floods have ravaged trout streams over the last five years and streamflow trends have reflected an increase in peak flows and flooding in southern Wisconsin (4). Warming stream temperatures also have indirect effects on trout, such as increased prevalence of diseases and parasites. In fact, gill lice, a louse that attaches to the gills of brook trout and impedes their respiratory ability, have been observed to increase in some streams and scientists think that warmer temperatures may be part of the reason (5).

People don't often think of the upper Midwest when they think of energy development. However, energy development elsewhere causes impacts in the Midwest. Hydraulic fracturing used to extract oil and gas from some geologic formations with low permeability uses water to fracture the formation and 'frack sand' to keep the fractures open and permeable. Frack sands are high quality silica sand with durable, round grains and one oil or gas well can require several tons of this material. The increasing use of hydraulic fracturing has led to a high demand for frack sand -- most of which comes from the Midwest. Wisconsin, for example, which has numerous trout streams across the state, is a leading producer of frack sands. Like other types of mining, frack sand mining can contribute fine sediments to streams, use water, and expel used water with poor quality into streams and rivers.

While historical agriculture and silviculture may be mostly to blame for reductions in the historical abundance and distribution of brook trout in the upper Midwest, there is no doubt that the introduction of non-native salmonids has led to negative interactions with the region's native brook trout (6). Brown trout and rainbow trout have been widely stocked in streams and rivers to diversify sportfishing opportunities. However, the increased value placed on native trout species, whether due to petitions to list them under the Endangered Species Act or simply the recognition that they were here prior to European settlement, has led to more interest in preserving them



Historical and current distributions of native brook trout in the Great Lakes/Upper Mississippi Region.

in, or restoring them to, the coldwater habitats they once inhabited. For example, brown trout were widely stocked because they are known to be more tolerant of degraded stream conditions. However, stream restoration efforts have increased the habitat amenable to the fickle brook trout, and the removal of brown trout for the benefit of brook trout has been evaluated in some Driftless Area streams. Likewise, salmon and steelhead have been introduced into the Great Lakes and interactions with these Pacific Northwest fishes have been cited as one reason for the decline of the famed coaster brook trout. Since most introduced trout and salmon have been in the Midwest for decades, resource managers today also must balance the preferences of anglers wishing to pursue these highly prized sport fish versus those of anglers wishing to pursue what they consider to be part of their natural heritage – a native brook trout.

While commercial fishing and pollution have played a role in reducing the abundance of lake trout populations in the Great Lakes region, non-natives have played a significant role as well. The opening of the Welland Canal allowed sea lamprey to colonize Lakes Erie, Huron, Michigan and Superior, where they attach themselves to lake trout. Round gobies and smelts are also considered harmful to lake trout because they prey on eggs and fry. Because of suppressed abundance or extirpation of lake trout in the Great Lakes, Pacific salmon and steelhead were stocked to fill the void left by lake trout as a top predator. Originally stocked to control unchecked populations of alewives, which also invaded through the Welland Canal, Pacific salmon and steelhead have now naturalized and provide popular sport fisheries, the presence of which inhibits lake trout restoration in some of the Great Lakes. While fish non-native to the Great Lakes have been naturalized for some time now, new invaders such as zebra and quagga mussels have only recently invaded and their expansion will continue to alter Great Lakes ecosystems. Some recent evidence suggests that invasive mussels are altering Great Lakes ecosystems in a way that is detrimental to non-native Pacific salmon and alewives but beneficial to lake trout and other natives like yellow perch and walleye.

Consider…

People don't often think of the upper Midwest when they think of energy development. However, energy development elsewhere causes impacts in the Midwest. Hydraulic fracturing used to extract oil and gas from some geologic formations with low permeability uses water to fracture the formation and 'frack sand' to keep the fractures open and permeable. Frack sands are high quality silica sand with durable, round grains and one oil or gas well can require several tons of this material. The increasing use of hydraulic fracturing has led to a high demand for frack sand—most of which comes from the Midwest. Wisconsin, for example, which has numerous trout streams across the state, is a leading producer of frack sands. Like other types of mining, frack sand mining can contribute fine sediments to streams, use water and expel used water with poor quality into streams and rivers.

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Wisconsin holds 75% of the frac sand market in the US. It is a relatively new industry with little oversight in Wisconsin.

SUCCESS STORY:

Stream Restoration in the Driftless Area

The Driftless Area – that area in Wisconsin, Minnesota, Iowa and Illinois missed by the most recent glaciation – is a bluff land region with numerous springs and over 4,000 miles of coldwater streams. Early land clearing and farming practices led to much erosion of upland soils that triggered a movement towards conservation farming in the 1930s. While stream conditions have improved substantially since then, many Driftless streams still have excess fine sediments that smother spawning habitat as well as the habitat for stream invertebrates that trout feed upon. Floodplains of Driftless Area streams also have accumulated as much as ten feet or more of new sediment derived from farm fields and gullies. Fire suppression and encroachment of shallow-rooted trees, when coupled with higher floodplains, has led to increased streambank erosion – a leading contributor of sediment to streams. Implementation of conservation farming practices has reduced soil erosion and benefited the 600 spring creeks in the Driftless Area; the region now hosts a fishing industry that contributes over $1 billion to the regional economy. In addition, local, state, federal agencies and conservation groups like Trout Unlimited – collectively known as the Driftless Area Restoration Effort (DARE) – have been working to restore Driftless streams by controlling streambank erosion, reconnecting streams with their floodplains and enhancing fish habitat. In the last 25 years, over 450 miles of stream have been restored in the Driftless Area and many projects completed on private land now have angler access easements. Thus, Driftless Area restoration is a boon for trout, as well as for anglers.

An angler coaxing trout in a restored reach of a Driftless stream. Photo: J. Hastings

Contour farming practices in the uplands of the Driftless Area.

SUCCESS STORY:

Protecting and Restoring Coldwater Fisheries in a Changing Climate

BY NICHOL DEMOL AND JEREMY GEIST, TROUT UNLIMITED

With more than twenty percent of the world's freshwater flowing through its rivers, streams and lakes, the Great Lakes basin provides an unparalleled coldwater resource. Because it is a veritable ark of coldwater fishes, perhaps nowhere else are the impacts of climate change more threatening to such a vast array of aquatic species. Climate warming is predicted to increase the intensity and severity of rainfall events, which could affect the ability of coldwater fishes in these rivers to thrive or even survive, thus impacting the livelihood of communities built around these water resources.

Volunteers planting native plants along the Rogue River to help slow down and infiltrate stormwater runoff before it enters the river. Photo by Nichol DeMol.

In the more urbanized Lower Peninsula of Michigan, Trout Unlimited is working with local governments in the Rogue River watershed to adopt policies that will protect coldwater resources from increased surface runoff. A Rogue River Stormwater Guidebook has been developed to educate and empower planning commissions on making wise land use decisions that protect natural resources. In addition, Trout Unlimited is working with homeowners, businesses and municipalities in the watershed to implement low impact development practices that manage stormwater close to its source and infiltrate runoff to protect water quality.

In northern Michigan, Trout Unlimited has started a new initiative that is addressing aquatic organism passage issues such as poorly designed road-stream crossings and dams. There are over 2,500 dams in Michigan and an unknown number of road culverts that act as barriers to fish migration, fragment coldwater habitat and disrupt stream processes. Trout Unlimited is currently identifying, prioritizing and implementing road-stream crossing improvements and habitat restoration in northwest Michigan that will improve watershed resiliency in the face of predicted climate change and sustain coldwater fisheries for the enjoyment of future generations of anglers.

Perched culvert in Northern MI.

Northeast

Species Summaries

LISTING STATUS: red (ESA listed as Threatened or Endangered), yellow (not ESA listed but federal sensitive species or state species of concern (majority of states), green (not listed in majority of states)

CURRENT RANGE: red (10 percent or less), yellow (11-25 percent), green (>25 percent)

HISTORICAL RANGE: red (<1,000 miles), yellow (1,000-10,000 miles), green (>10,000 miles)

Brook Trout (Northeast)

Category	Status	Explanation
Listing status		Species of Special Concern (NJ)
Current range		Northeast is stronghold of current distribution
Historical range		Widely distributed historically in the region, over 58 million acres
Climate change		Warmer temperatures and increased flooding in streams may influence populations
Energy development		Not much threat from proposed development
Non-native species		Naturalized populations are spreading and bait-bucket introductions continue to occur
Water demand		Hydropower and dams inhibit salter life history
Data issues		Some uncertainty due to many unsampled waters, and much uncertainty on salter brook trout distribution

Sunapee Trout\Blueback Char

Category	Status	Explanation
Listing status		Species of Concern (NH, VT, ME)
Current range		Occupies only about 14 lakes and ponds
Historical range		Historical distribution in US is small and sporadic
Climate change		Warmer lake temperatures may render some occupied lakes unsuitable
Energy development		Not much threat from proposed development
Non-native species		Non-native lake trout, Atlantic salmon, and smelt
Water demand		Not much of a threat
Data issues		Good information about limited distributions

Lake Trout

Category	Status	Explanation
Listing status		Not listed
Current range		Has been widely stocked in the northeast for sportfishing
Historical range		Great Lakes basin, and somewhat uncertain distribution in the northeast due to early, undocumented stockings. Native to a few glacial refugia lakes in Montana
Climate change		Warmer lake temperature may render some lakes unsuitable, in some cases due to temperature interactions with nutrients
Energy development		No known threats
Non-native species		Atlantic salmon, smelt and other introduced fishes
Water demand		Many lake trout lakes have water control structures
Data issues		Most populations have good monitoring data

Brook Trout *(Salvelinus fontinalis)*
The brook trout is a char native to northeastern North America from the Canadian Maritimes to northern Labrador and Quebec, including Ungava and Hudson Bays. In addition to the Great Lakes and Driftless Area, the native distribution of brook trout in the United States occurs from Maine south down the Appalachian Mountains to northern Georgia. Brook trout populations in the northeast most commonly inhabit streams and ponds. However, populations with access to the sea can exhibit anadromy whereby some individuals, often called "salters" or "sea-run" brook trout, migrate to estuaries (or open ocean) to feed during late-spring to early summer. During the 1800s, exclusive fishing clubs were established on famous salter streams. The Monument and Mashpee rivers in Massachusetts and the Carmans and Connetquot rivers in New York all hosted clubs whose members were among the nation's wealthiest and most influential people. The legendary "world record" brook trout was almost certainly an anadromous individual caught by the leading American statesman Daniel Webster in 1827 on Long Island's Carmans River.

Brook trout in the northeast generally are faring better than their brethren to the south, but they have still declined (1). Anthropogenic land uses have resulted in stream warming and deteriorated habitat, causing population declines. Population fragmentation due to road culverts and other barriers has likely caused local extirpations (2). Given the need to move between fresh and salt water, the construction of dams, road crossings and other impassable anthropogenic structures likely had a disproportionate effect on the decline of salter brook trout, where they are only known to occupy a fraction of their historical habitat (3). For example, in Maine the access to riverine habitat by river herring is only 20 percent of historical levels because of dams, many of which were built on coastal streams used also by salters. Competition with and predation by non-native fishes have also been cited as reasons for declines. Lastly, because brook trout can obtain larger sizes due to the prey resources in saltwater environments, anadromous brook trout have been harvested for both subsistence and sport since European colonization.

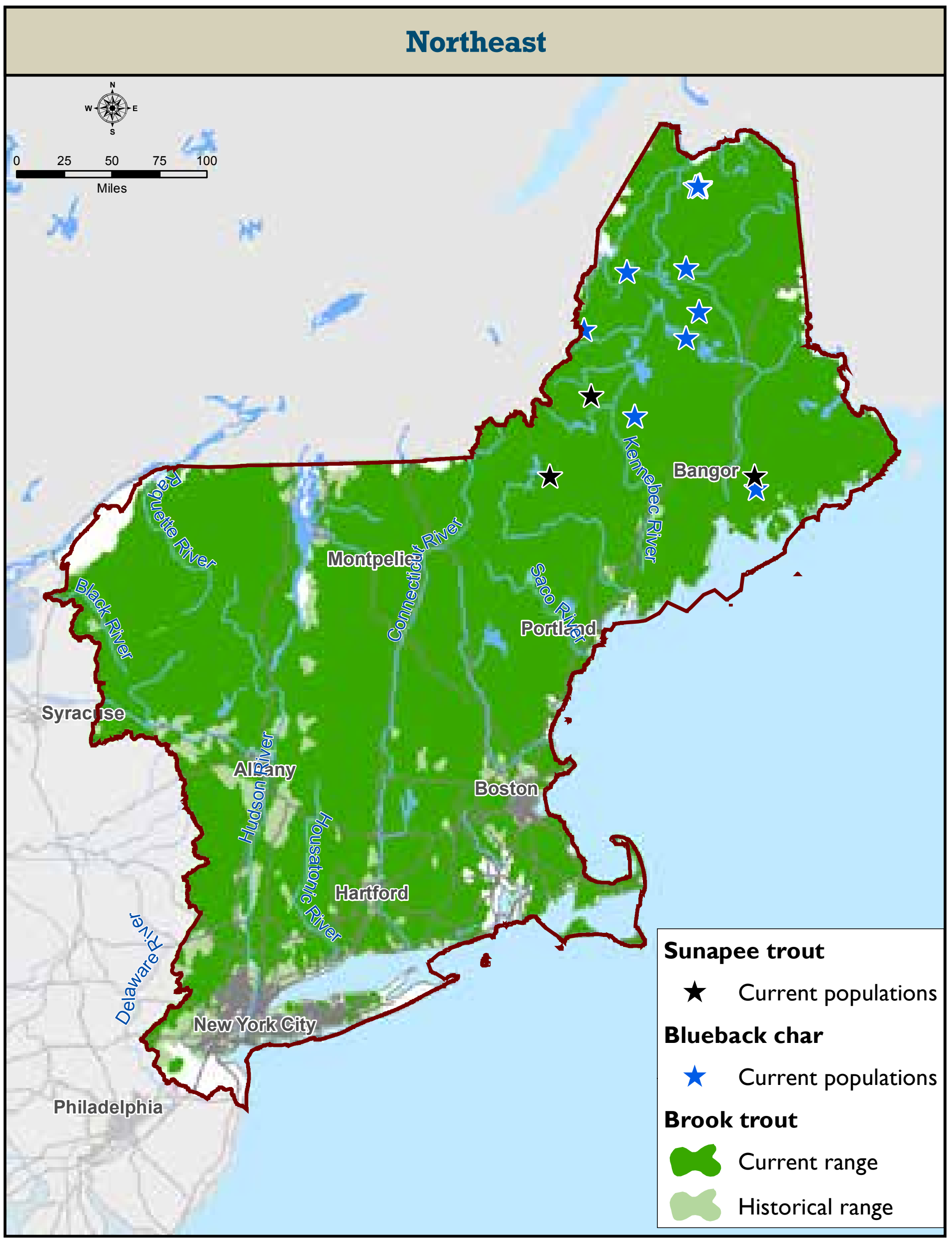
Sunapee Trout/Blueback Char *(Salvelinus alpinus oquassa)*
The Sunapee trout (sometimes called silver char) and blueback char (often called blueback trout) are two forms of the same subspecies of Arctic char that historically occurred in Maine, Vermont and New Hampshire. They were once thought to be two separate subspecies. The Sunapee trout has been extirpated from Vermont and New Hampshire, including from Sunapee Lake – its namesake. The blueback char now occurs in about 10 lakes in Maine (4). Blueback char were a main prey species of brook trout in the Rangeley Lakes (headwaters of the Androscoggin River), comprising a unique predator-prey relationship between those two salmonids. However, bluebacks were extirpated from the Rangeley Lakes in the early 1900s. Like most Arctic char, the Sunapee trout and blueback char primarily occupy deep cold lakes and ponds and have been occasionally reported from saltwater. Maine contains the southern-most distribution of this Arctic char subspecies, but it has been stocked outside its native waters, including in Idaho (5).

The Sunapee trout and blueback char in the northeastern US have been most impacted by non-native species introductions. The Sunapee trout was extirpated from Sunapee Lake in the early 1950s after lake trout were introduced, leading to hybridization. The blueback char was extirpated from the Rangeley Lakes (around 1900) after landlocked Atlantic salmon and rainbow smelt were introduced. Because the subspecies requires cold water in deep lakes, pollution of some lakes led to oxygen depletion and extirpations there. Overfishing was also a problem in some lakes after fishing techniques became more efficient (e.g., use of gill nets). Recent efforts have been made in Maine to re-establish populations of Sunapee trout and blueback char, where non-native lake trout and smelt have been eradicated.

Lake Trout *(Salvelinus namaycush)*
While primarily restricted to the Great Lakes basin (but also Montana), lake trout are native to some parts of New England as well (~100 lakes in Maine)(6). Because they are an excellent food fish and attain large sizes, lake trout have always been a popular sport fish. They have been cultured and introduced widely where suitable habitat (cold, deep lakes) exists. Many earlier introductions around the turn of the 19th Century went undocumented and so native distribution of the species in the Northeast is not known precisely (6). Protection of spawning areas, fishing regulations and control of illegal introductions of fishes are a primary management strategy used to preserve known native stocks of lake trout in the Northeast.

Regional Trends

Relative to other regions in the United States, the Northeast is blessed with water. But some populations and species of coldwater fishes are nonetheless threatened.



Historical and current distributions of native trout and char in the Northeast Region.

One of the biggest threats to native trout in the Northeast is the introduction and spread of non-native species. Historical fisheries management was often focused on diversifying fishing opportunities for anglers, resulting in the introduction of various species from other regions in the United States and across the world.

One of the biggest threats to native trout in the Northeast is the introduction and spread of non-native species. Historical fisheries management was often focused on diversifying fishing opportunities for anglers, resulting in the introduction of various species from other regions in the United States and across the world. While some of these introductions were deliberate, other introductions have been unintentional. For example, the use of baitfish has led to the transfer of species across drainage basins, because bait fish that are collected from one drainage are often used by anglers in a different drainage; this becomes problematic when anglers dump their bait after fishing. In addition, baitfish have also been unintentionally introduced with stocking of other sportfishes (baitfish regulations are being implemented in some states to curb the further spread of non-natives). Still other introductions of non-native species have been by anglers intending to create their own fishery. By way of these mechanisms, non-native yellow and white perch, chain pickerel, northern pike, muskellunge, smallmouth bass, largemouth bass and brown trout populations now compete with or prey on native brook trout. Introductions of landlocked Atlantic salmon and rainbow smelt have led to the demise of some Sunapee and blueback populations. Even lake trout have been impacted by non-native species introductions. The presence of introduced species also prohibits reintroduction of natives like blueback char unless expensive chemical treatments (e.g., rotenone) are used to eliminate non-native fishes.

Human population growth will continue to threaten fishes in the Northeast. Species like brook trout have already been shown to be very unlikely to inhabit watersheds with greater than 20 percent urban land cover (7). The world population is expected to reach 9.6 billion by 2050 and the US population is expected to reach 400 million by this date. This population growth will lead to increased urbanization of watersheds to the detriment of coldwater fishes. While major strides have been made in improving water quality in urbanized watersheds, increased human development will still cause water quality issues in some places. For example, the Carmans River on Long Island has seen a continual rise in nitrate levels that now exceed water quality criteria. Similarly, in coldwater lakes pollutants can lead to anoxic conditions near lake bottoms – the haunts of many lake trout populations.

As in all other regions, climate change is expected to impact aquatic systems in the Northeast. Rising temperatures will shrink coldwater habitat occupied by stream-dwelling brook trout and warm some lakes and ponds rendering them unsuitable for brook trout, Sunapee trout, blueback char and lake trout. As habitat shrinks, populations will become fragmented. But climate change is also expected to bring more frequent, high-intensity precipitation that will lead to increased flooding (although precipitation projections are less certain than temperature projections). Increased flooding can lead to increased channel scour and sediment delivery into stream channels (8). These increased storm intensities have also influenced infrastructure such as road culverts that often are incapable of passing large floods. Luckily, flooding over the last five years caused by events such as Hurricane Irene have prompted municipalities to initiate programs to evaluate culverts and bridges for their capacity to pass large floods and to update or replace them. These efforts will improve fish passage and aquatic connectivity and should benefit native trout.

SUCCESS STORY:

Red Brook – A History of Salter Brook Trout Restoration

Streams and rivers on Cape Cod, Massachusetts, historically harbored anadromous brook trout fisheries upon which exclusive fishing clubs were established in the 1800s. However, by the mid-19th Century, industrialization had resulted in dammed and degraded streams and the decline of brook trout. This prompted the establishment of a fisheries commission (now MassWildlife) to address declines in anadromous fisheries, including the famed salter brook trout fisheries. Commissioner Theodore Lyman purchased land on Red Brook, where he proceeded to protect the stream and its anadromous brook trout. By the 1970s the Lyman family had acquired almost 640 acres along 75 percent of Red Brook proper.

In 1988, a Red Brook Trust was established that eventually deeded the Lyman properties to Trout Unlimited, who then began restoring Red Brook's habitat and salter brook trout. In 2001, an agreement signed by Trout Unlimited, The Trustees of Reservations and MassWildlife set up joint management of the former Lyman properties (now Theodore Lyman Reserve and Red Brook WMA) with a focus on salter brook trout restoration. To date, Red Brook restoration has included fish passage and dam removal projects, cranberry bog restoration, vegetation rehabilitation, instream habitat enhancements and streambank restoration. Research and monitoring has also helped to understand brook trout genetics and trout movements in Red Brook, including the documentation of anadromous behavior. Red Brook represents a proven, multifaceted approach to salter brook trout restoration that integrates land protection, restoration, research, monitoring and strong partnerships, an approach that should provide a useful template for salter brook trout restoration in coastal streams from Maine to Long Island, New York.

Ron Merly and a salter brooktrout. Photo: Nutmeg TU.

Red Brook restoration.

SUCCESS STORY:

Nash Stream – A Multi-Faceted, Watershed Scale Restoration Effort

BY JAMES MACCARTNEY, TROUT UNLIMITED

The Nash Stream Restoration Project is a collaborative, multi-year effort initiated in 2005 to restore river processes and improve habitat quality, habitat connectivity and ecosystem health to benefit native brook trout, Atlantic salmon, and other fishes. What triggered this restoration effort was a catastrophic dam failure that altered the stream channel and damaged fish habitat. To date, seven road culverts have been replaced with natural-bottom structures that span the stream channel. Three culverts have been removed entirely and their roads have been decommissioned. These culvert remediation projects reconnected tens of miles of previously inaccessible habitat for native fish species and other aquatic organisms. Over five miles of mainstem habitat on Nash Stream were also restored and large wood replenishment was conducted on two perennial tributaries to Nash Stream. This restoration project is one of the largest in the Northeast and Nash Stream was recently named one of the "Waters to Watch" by the National Fish Habitat Partnership.

Has all of this reconnection and restoration work improved fishing opportunities in Nash Stream? Fish survey data collected by New Hampshire Fish and Game Department indicate that the work in Nash Stream and its tributaries is having a dramatic and beneficial effect on the native fish community; both fish abundance and age class diversity are improved where restoration work has been completed. Emerson Brook, a tributary to Nash Stream, has been the focus of instream wood restoration and now has six times the number of brook trout compared to streams where no restoration has been done.

So, what's next? Over the next two years, the project will restore riverine processes and habitat on 2.4 additional miles of the Nash Stream mainstem. Wood will be added to nine tributaries and two problem culverts will be replaced. The project ultimately will restore over nine miles of mainstem and three miles of tributary habitat and reconnect over six miles of tributaries.

Long Mountain Brook culvert replacement. Photo: J. MacCartney

Nash Stream wood replenishment. Photo: J. MacCartney

Mid-Atlantic

Species Summaries

LISTING STATUS: red (ESA listed as Threatened or Endangered), yellow (not ESA listed but federal sensitive species or state species of concern (majority of states), green (not listed in majority of states)

CURRENT RANGE: red (10 percent or less), yellow (11-25 percent), green (>25 percent)

HISTORICAL RANGE: red (<1,000 miles), yellow (1,000-10,000 miles), green (>10,000 miles)

Brook Trout (Mid-Atlantic)

Category	Status	Explanation
Listing status	Green	Species of Special Concern (MD, TN)
Current range	Green	59 percent of historical stream habitat currently occupied
Historical range	Green	Widely distributed historically in the region, over 50 million acres
Climate change	Yellow	Stream warming and increasing variability of precipitation are issues
Energy development	Red	Epicenter of shale gas development in the east; ongoing and legacy issues with coal mining, conventional oil/gas wells
Non-native species	Red	Introduced brown and rainbow trout pose continual competitive and predatory threats
Water demand	Yellow	Water demand associated with energy development can cause acute stream flow issues
Data issues	Yellow	Species distribution, stream temperature, passage, and flow data are largely lacking

Brook Trout *(Salvelinus fontinalis)*
Brook trout in the mid-Atlantic region are found in streams that drain the highlands of the Allegheny Plateau in Pennsylvania, West Virginia and New York as well as the Blue Ridge and Valley and Ridge Provinces in Virginia, Maryland and New Jersey. Brook trout habitat is found within an hour's drive of most of the major cities in the region – Washington, D.C., Philadelphia, Baltimore, Pittsburgh – making them one of the most "accessible" trout species in the US.

Brook trout thrive in ecologically intact watersheds: over half of the remaining brook trout populations occur in watersheds with at least 80 percent forested lands (1). As the amount of forest cover decreases in watersheds and especially along streams, stream temperatures become too warm for brook trout and reduces their ability compete with non-native species like brown trout (2, 3). Declines in brook trout populations in the region have been linked to land conversion and the associated degradation of instream habitat, especially sedimentation related to agricultural land use, displacement by introduced rainbow and brown trout through competition and predation, and habitat fragmentation caused by dams, culverts, or impaired water quality.

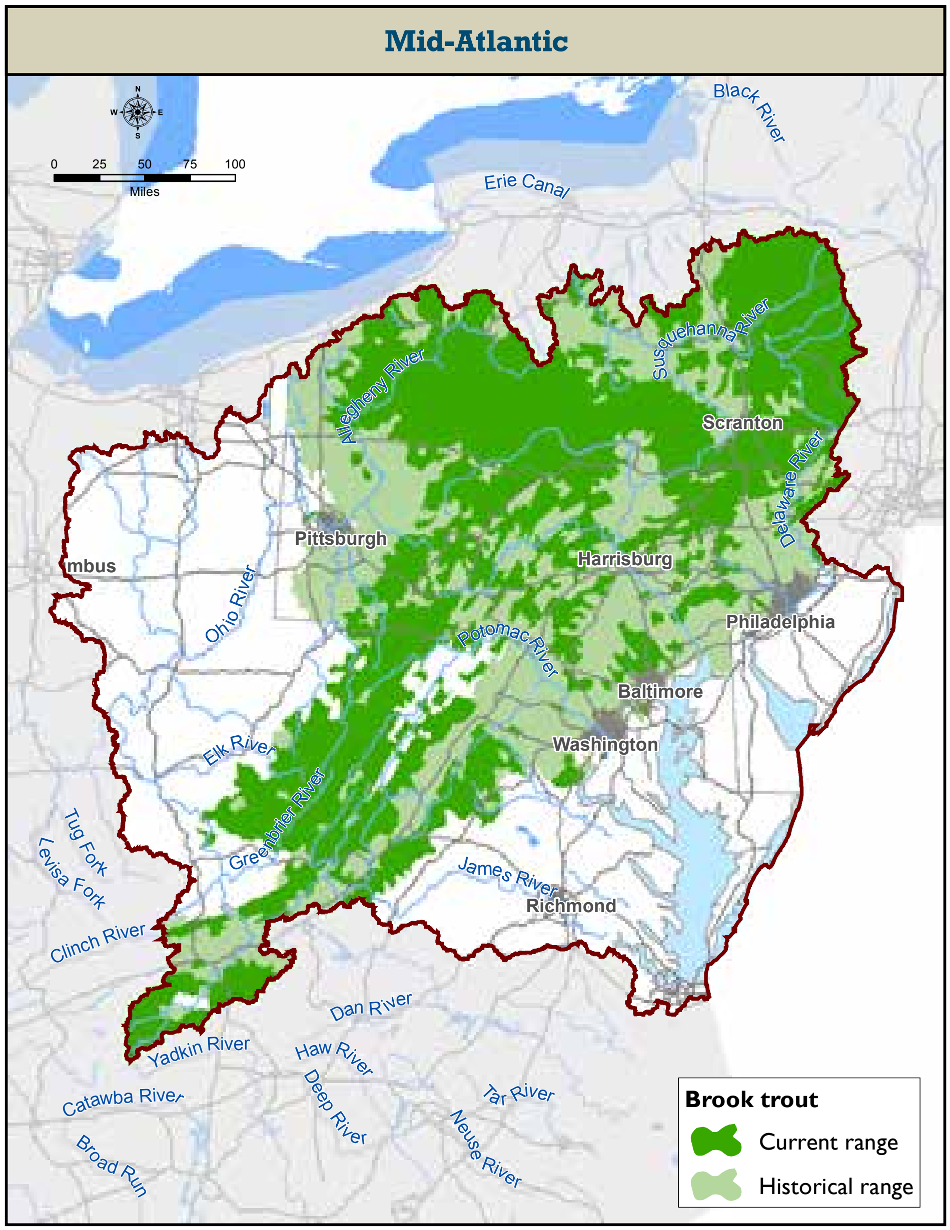
Regional Trends

Brook trout require cold, clean water and the highlands of the mid-Atlantic region provide a large concentration of this habitat. The margins of the core habitat will be vulnerable to loss of brook trout with a warming climate. One of the key conservation strategies in coming decades will be identification and protection or restoration of those habitats with qualities that make them resistant to climate change effects. Streams that are highly dependent on springs and groundwater will be less susceptible to increases in temperature or decreases in precipitation.

The core of brook trout distribution in the mid-Atlantic region overlaps with the epicenter of the shale gas boom in the East. Pennsylvania saw the first wave of development in the Marcellus and Utica Shale formations and, since the early 2000s, nearly 8,000 unconventional gas wells have been drilled across the Allegheny Plateau. Development has expanded in recent years to West Virginia, Ohio and Maryland. The unconventional wells in the region typically use hydraulic fracturing, or fracking, techniques in which a pressurized mix of water, sand and chemicals are sent down deep wells to release natural gas within the buried rock formations. Shale gas development is associated with impacts to aquatic resources such as sedimentation from road construction, flow impairments from water withdrawals, and water quality issues related to transportation and disposal of hydraulic fracturing chemicals and effluents (4). Shale gas resources are also present in New York, but hydraulic fracturing techniques were prohibited in that state in 2014. Even outside the footprint of the shale gas resource, aquatic habitats can be threatened by poorly planned pipeline placement as natural gas is transported to customers along the eastern seaboard. TU staff and volunteers have been monitoring water quality in the region of shale gas development and working with industry and state agencies to ensure that development of the resource, where it does occur, does not impair native trout fisheries.

Swaths of brook trout habitat in the region have experienced several waves of natural resource development over the last 200 years, from widespread logging and conventional oil and gas development, to large and small scale coal mining. Acid deposition rates (primarily from the burning of fossil fuels) are also high along the Allegheny Plateau and have impaired many miles of streams (see Southeast region report). These legacies have left a mark on the brook trout landscape, none more prominent than the water quality issues created by acid mine drainage.

The demand for water for agricultural, municipal and industrial uses is high across the region, but mostly concentrated in the developed valley bottoms away from brook trout habitats in the headwaters. In the headwaters, one use of water with potential consequence for brook trout is withdrawals for hydraulic fracturing, which can alter flow regimes, especially at low flows and when withdrawals do not require minimum flow past the points of diversion (4,5). Climate change will be associated with some additional uncertainty for water supplies.



Historical and current distributions of native brook trout in the Mid-Atlantic Region.

SUCCESS STORY:

Recovering Trout Habitat in Acidified Streams

BY AMY WOLFE AND SHAWN RUMMEL, TROUT UNLIMITED

Throughout the central and southern Appalachian mountains, more than 13,000 miles of Eastern brook trout habitat have been impaired by pollution from unregulated, historical coal mining operations. Although abandoned mine drainage continues to be one of the top causes of impairment to coldwater streams in the region, restoration and reconnection of brook trout populations in these waters is possible and has been realized in many watersheds.

Coal mined from the central and southern Appalachian Mountains played an important role in shaping the social and economic fabric of this region and was a major factor in boosting the Industrial Revolution across America. However, prior to the federal Surface Mining Control and Reclamation Act of 1977, coal mining was largely unregulated. As a result, thousands of streams and rivers became polluted with abandoned mine drainage (AMD). Over 10,000 miles of stream are impaired by AMD in West Virginia and Pennsylvania alone.

Twomile Run AMD treatment project. Photo by Amy Wolfe

The Kettle Creek watershed, in north-central Pennsylvania, contains top-notch trout fishing, pristine mountain streams and large remote tracts of public land. However, this watershed has not escaped the pollution legacy of historical coal mining. Coal mining in the lower Kettle Creek watershed began in the late 1800s and larger-scale surface mining occurred through the early 1970s. During this period, mining was conducted with little to no requirement that miners restore the land and water when mining operations were completed. The historical mining in this area left behind over 1,000 acres of scarred mine lands and approximately 12 miles of Kettle Creek and its tributaries became acidic, with high concentrations of heavy metals such as iron and aluminum that are toxic to fish and other aquatic life.

Recovered Middle Branch below the AMD treatment system. Photo by Amy Wolfe

Since 1998, more than $3 million in grants from government, non-government and philanthropic programs has been spent to evaluate, plan and construct AMD projects in the Kettle Creek watershed. Over a dozen projects have been completed to date, including construction of AMD collection systems, drilling and installation of groundwater monitoring wells, mine pool stabilization, land reclamation and AMD passive treatment systems. In late 2013, construction began on a 100-acre land reclamation project, funded by a $12.2 million contract from the Pennsylvania Department of Environmental Protection. This project is a major first step for the last phase of AMD cleanup that will ultimately lead to the full recovery of the lower Kettle Creek watershed.

Collectively, these projects have led to improved water quality in the watershed. Water that once flowed from abandoned mines with a pH of 2.5 and iron and aluminum concentrations above 50 mg/L is now being treated to a pH of 7.0 and metal concentrations of less than 0.5 mg/L. These dramatic improvements in water quality have allowed benthic macroinvertebrate communities and native brook trout to naturally recolonize sections of stream that have long been devoid of life.

To date, nearly seven miles of coldwater streams have been restored and reconnected in the Twomile Run subwatershed in lower Kettle Creek. After the construction of nine treatment systems, brook trout have returned and are now thriving in previously dead sections of streams. The mainstem of Kettle Creek is also on the brink of full recovery, only needing a final boost of water quality improvement to benefit the low numbers of various fish species already living there.

Southeast

Species Summaries

LISTING STATUS: red (ESA listed as Threatened or Endangered), yellow (not ESA listed but federal sensitive species or state species of concern (majority of states), green (not listed in majority of states)

CURRENT RANGE: red (10 percent or less), yellow (11-25 percent), green (>25 percent)

HISTORICAL RANGE: red (<1,000 miles), yellow (1,000-10,000 miles), green (>10,000 miles)

Brook Trout (Southeast)

Category	Status	Explanation
Listing status	yellow	Sensitive Species (USFS) Species of Special Concern (SC, TN)
Current range	green	55 percent of historical stream habitat currently occupied
Historical range	green	Over 10 million acres of historical distribution in the region
Climate change	red	Stream warming is major issue
Energy development	yellow	No local energy development, but downwind of coal-fired power plants which contribute to acid rain and acidify streams at high elevations
Non-native species	red	Introduced brown and rainbow trout, northern strains of brook trout
Water demand	yellow	Population growth in the region may increase water demand
Data issues	yellow	Stream temperature data lacking; genetics information for many populations needs clarification

Brook Trout *(Salvelinus fontinalis)*
The Southern Appalachian strain of brook trout is the only trout native to the Southeast. These colorful fish are fondly referred to as "specks," "speckled trout," "mountain trout," or "brookies." Historically, they thrived in streams draining the rich, temperate forests on the slopes of the Appalachian Mountains. Following agricultural development of the mountain valleys and especially as the region experienced widespread logging in the latter half of the 19th Century, Southern Appalachian brook trout habitats were degraded by sediments that ran off of denuded slopes or scoured when splash dams were used to float logs downstream.

As Southern Appalachian brook trout declined due to habitat loss, rainbow trout and brown trout were planted in streams to "replace" the resource. Through competition or predation, these species displaced native brookies in many streams, especially in relatively warm streams at lower elevations. In other cases, brook trout from northern hatcheries were planted to supplement the local stocks, effectively swamping the unique genes and associated adaptations to local conditions that Southern Appalachian brook trout had acquired over millennia. Genetic analysis has confirmed the unique nature of the historical brook trout strain of this region and there has been an increasing appreciation for those pure Southern Appalachian populations that remain for just how rare they are: in South Carolina, for example, just four populations of genetically unaltered Southern Appalachian brook trout persist. Through displacement or extirpation, brook trout of some form have been lost from 45 percent of their historical habitats across the Southeast. The presence of non-native species, habitat fragmentation caused by dams and impassable road culverts, and private lands development threaten those remaining populations.


Brook trout

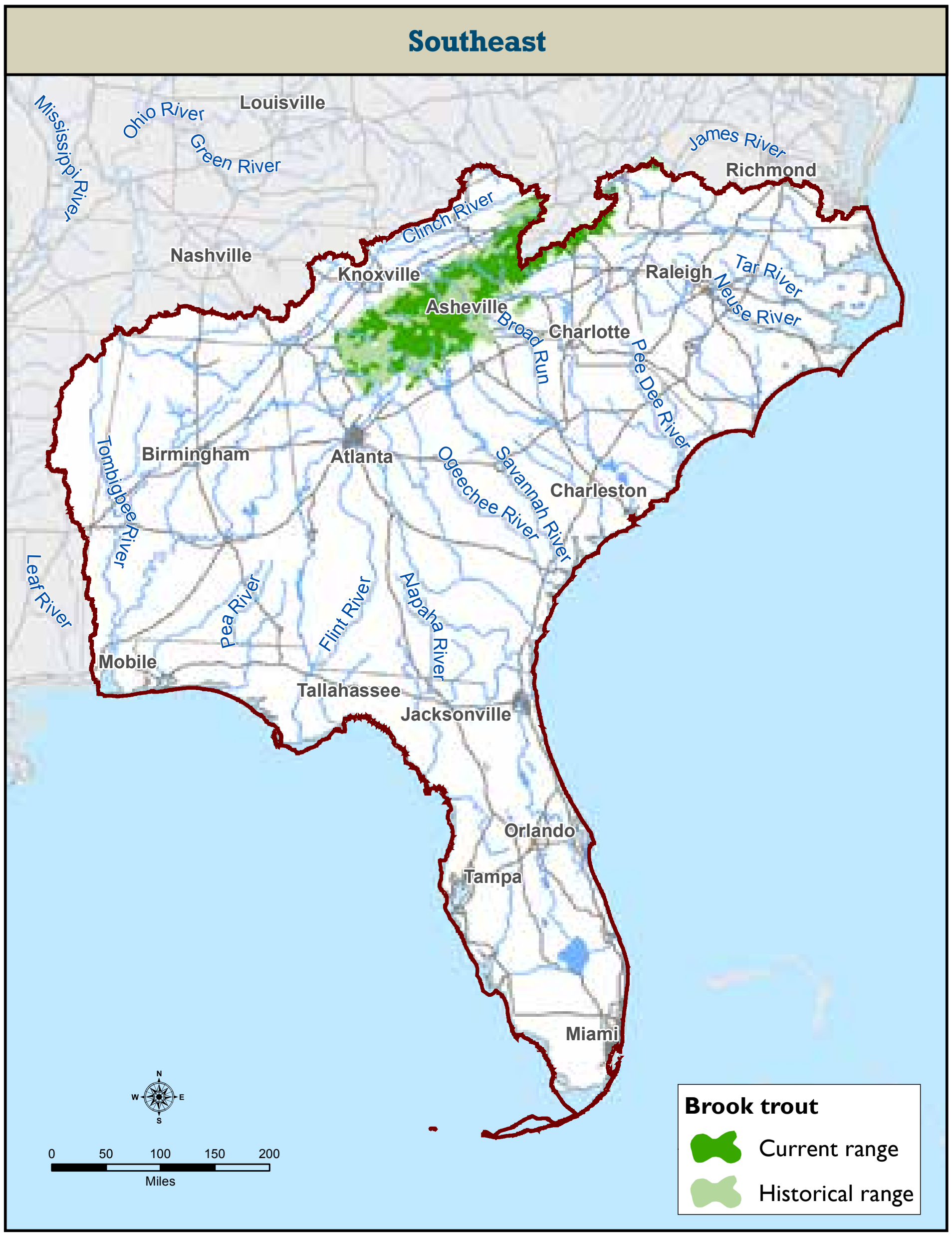
Regional Trends

The southern extent of the Appalachian Mountains provides a cool, moist, high-elevation refuge for Eastern brook trout. Yet hanging on at the southernmost margins of the species' range, Southern Appalachian brook trout will experience the brunt of warming effects anticipated with changing climate. Range constriction of the already highly fragmented populations will be most pronounced at lowest elevations, while populations relegated to headwater streams will have no ability to shift their distribution upstream. Long term stream temperature data reveal an average annual warming trend of approximately 0.36°F per decade since 1960 (1). According to projections, warming of annual temperatures by just 2.7°F from current conditions is expected to result in a 20 percent loss in trout habitat in Virginia, North Carolina, South Carolina, Tennessee, and Georgia, while a warming of 6.3°F is expected to result in a nearly 80 percent loss (2). Additional climate change threats include prolonged drought and an increase in the frequency of large floods (see Northeast section for more details on flooding).

While non-native rainbow and brown trout and strains of brook trout from outside the region have displaced Southern Appalachian brook trout, the non-native species threats aren't all aquatic. In the last decade, a small Asian bug called the hemlock wholly adelgid has caused a widespread die-off of hemlocks, the quintessential riparian tree of the southern mountains. Hemlocks along streams provide a dense canopy year-round and help to buffer stream temperatures from extremes of hot or cold. Studies have shown that brook trout are three times more abundant in streams draining hemlock-dominated watersheds than in streams flowing from hardwood stands (3). The deciduous trees or evergreen shrubs that replace hemlock along streams will determine how stream shading, water chemistry and forest water yields will be affected.

The Southern Appalachians have not experienced the same recent development of shale gas and wind resources as has the mid-Atlantic region and threats associated with new energy development are, for the time being, limited. Higher elevations are, however, affected by acid rain associated with nitrates and sulfates from automobile and coal-fired power plant emissions in the region. Acid rain not only alters the pH of streams but also causes toxic metals such as aluminum to leach from the uplands into streams. High elevations are associated with higher amounts of precipitation, subjecting them to more acid deposition – high elevation streams in Great Smoky Mountains National Park have chronically low pH (pH < 5) and even lower elevation streams can have pH spikes (decreases in pH of >0.7) episodically with rainfall, pushing the physiological limits of Southern Appalachian brook trout (4). Six populations have been lost in Great Smoky in the last 30 years. Conditions have improved over the last decade in response to new emissions scrubbing technology and more stringent clean air regulations, however improvements in some streams may take decades due to excessive nitrate stored in forest soils.

High elevations of the Southern Appalachians can receive over 6 feet of annual rainfall, enough to be considered a temperate rain forest. Yet the region is not immune to periods of drought, and climate change forecasts predict decreases in water availability (5). Population growth in urban areas of the region since 2000 has been among the highest in the country -- Charlotte has grown nearly 33 percent, Atlanta nearly 28 percent, and the drinking

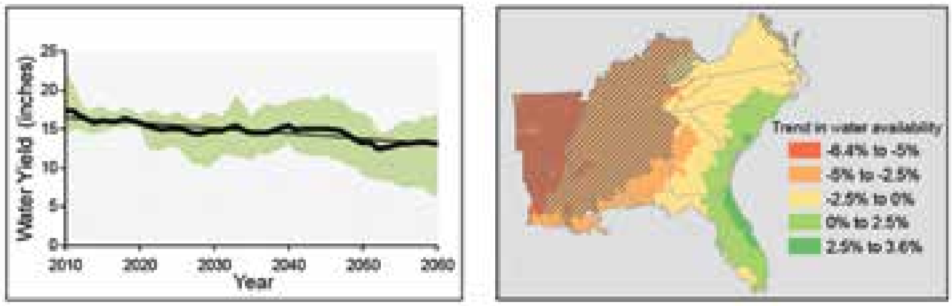


Historical and current distributions of native brook trout in the Southeast Region.

water for both cities originates in Southern Appalachian brook trout habitat. Water demand will only increase and with it the potential for conflict, as illustrated by Atlanta's water withdrawals from Lake Lanier and the Chattahoochee River during the drought of 2007.

An additional consequence of increasing population growth is the rate of land conversion. With only 50 percent of Southern Appalachian brook trout occurring on public lands in North Carolina, for example, an important conservation strategy for the Southern Appalachians is permanent conservation of unconverted private lands using conservation easements and other similar measures with willing landowners.

Trends in Water Availability



Left: Projected trend in Southeast-wide annual water yield (equivalent to water availability) due to climate change. The green area represents the range in predicted water yield from four climate model projections based on the A1B and B2 emissions scenarios. Right: Spatial pattern of change in water yield for 2010-2060 (decadal trend relative to 2010). The hatched areas are those where the predicted negative trend in water availability associated with the range of climate scenarios is statistically significant (with 95% confidence). As shown on the map, the western part of the Southeast region is expected to see the largest reductions in water availability. (Figure source: adapted from Sun et al. 20131).

SUCCESS STORY:

Southern Appalachian Brook Trout Recovery in Great Smoky Mountains National Park

Some of the coldest and clearest streams in the Southeast are found in Great Smoky Mountains National Park, the largest protected area with an explicit mandate for conservation within the range of Eastern brook trout. However, as a result of acid rain (described above) and historical land uses including logging -- which buried habitats for brook trout and other aquatic species in sediments -- and the stocking of rainbow, brown and northern strains of brook trout, Southern Appalachian brook trout aren't nearly as widespread in the park as they once were.

Beginning in the 1990s, the park and its partners, including local chapters of Trout Unlimited, set out to bring back the Southern Appalachian brook trout to some of those streams where it had been lost. Forty miles of habitat across 19 streams were identified as potential reintroduction sites based on a history of brook trout populations and presence above a natural barrier. To date, 27.6 miles of habitat across 11 streams have been treated to remove non-native trout and reintroduce Southern Appalachian brook trout and four other Threatened and Endangered fish species. These reintroduction efforts take time and countless hours of hard work – Lynn Camp Prong restoration took seven years – but as a testament to the strength of the recovery of brook trout in the park, in March 2015 all streams in the park were opened for angling for the first time since the park was established in 1934.

"The opening of all streams in the park to recreational fishing marks an incredible milestone for the park and speaks to the commitment and dedication of our biologists and partners in restoring fish populations in the Smokies." Cassius Cash, Superintendent, Great Smoky Mountains National Park.

Willow Rutter with a Southern Appalachian Brook Trout on Lynn Camp Prong. Willow had helped collect this very fish several seasons earlier from a nearby stream for its reintroduction into Lynn Camp Prong. Photo: Ian and Charity Rutter

The Path Forward

This report describes the many and varied threats facing native and wild trout in this country. Threats have evolved over time, from agriculture and mining practices of the past to a new suite of problems related to four primary issues: energy development, introduction of non-native species, increasing water use and demand, and climate change. Legacy problems remain in many areas and their impacts are compounded by these emerging challenges.

There is good news as well. The practice of restoration is becoming a mature science with more effort dedicated to stream restoration each year. At TU our efforts to protect, reconnect and restore the habitat of trout grows annually. In 2014, TU volunteer members donated more than 650,000 volunteer hours to more than 1,050 restoration projects and more than 1,550 environmental education projects. Altogether, more than $1 billion is spent on stream restoration each year in this country. This number increases significantly if recovery efforts for Threatened and Endangered species such as Lahontan cutthroat trout, Apache trout and bull trout are included.

As we describe in the report, there are major success stories in each region. State and federal agencies dedicate sustained effort towards monitoring and improving the status of native and wild trout. These agencies have developed and signed conservation agreements for the rarer native trout species and organized active workgroups to implement these efforts. In 2014, for example, the Interior Redband Trout Conservation Agreement – an agreement describing commitments for restoration of interior redband populations -- was signed by three federal agencies, six state fish and wildlife agencies (all states within the historical range of the subspecies), five tribal governments and Trout Unlimited. These same agencies will track implementation progress and modify the agreements as conditions change.

Despite this dedication from agencies and anglers alike, the current suite of problems affecting native and wild trout cannot be addressed adequately by strategies and actions of the past. An improved knowledge base must be brought to bear on the conservation challenge and new strategies, tactics, and capacity developed to implement an enhanced effort.

Anglers can be a potent force for trout conservation and their numbers represent a vast resource for conservation. Many anglers are close observers of on-the-ground conditions for trout, their habitats and emerging threats such as the spread of invasive species. Many anglers are becoming citizen scientists, adding their observations to the growing public participation in scientific observation and research. As anglers learn more about the streams they love, they become stronger advocates for improved resource management. TU takes a unique approach to this, dubbed Angler Science, and our programs have a particular ability to focus the passion of our angling members toward doing meaningful science in support of the fish and the landscapes that they love. Today's mobile and online technologies combine to provide new opportunities for citizen scientists to capture important data that can instantly be documented with photographs and GPS locations on-the-spot.

Energy Development

Over the past several decades the demand for energy resources has grown and has been accompanied by an unprecedented increase in oil and natural gas production as well as renewable energy development. More states are passing renewable energy portfolio standards requiring a greater use of renewable energy resources. Oil and gas development has pushed into new territory and the increased use of chemicals and water for hydraulic fracturing has resulted in higher water demand. Pipeline failures have damaged iconic rivers such as the Yellowstone. Renewable energy development is spreading on public and private lands with increased road networks and sedimentation of stream systems. Oil, gas, wind and solar development have moved onto large tracts of National Forest and BLM public lands.

Sportsmen and women have worked to discourage or prevent energy development on public lands containing high quality

streams and high priority trout restoration areas such as the Wyoming Range in Wyoming, the George Washington National Forest in Virginia, the Rocky Mountain Front in Montana and the Roan Plateau in Colorado. Trout Unlimited assists such efforts through public awareness campaigns and development of an ecological footprint assessment locating those areas with the greatest concentration of people and resource disturbances and encouraging energy development there as well as in areas with already compromised natural resource values rather than in higher quality natural areas.

On public lands in the West, such as the White River National Forest, we are actively working with energy companies to site energy development to minimize effects on trout. In parts of the East where shale gas is being developed with hydraulic fracturing technology, state agencies are teaming with angler-scientists to track potential water pollution problems in brook trout streams. With the expansion of hydraulic fracturing, which may require 2-8 million gallons of water per well, a better understanding of how energy development is likely to impact surface and groundwater resources is needed so that we can ensure adequate water remains instream for aquatic life and other human uses. Funding to mitigate impacts of energy development is needed and would be provided by the bipartisan Public Lands Renewable Energy Act now pending in Congress.

Non-native Species

The interconnected nature of most aquatic habitats renders them particularly vulnerable to the introduction and spread of non-native species. Once introduced, some non-natives can readily spread throughout entire river drainages. Historically, stocking of non-native trout has been one of the greatest threats to native trout as species such as brown trout and hatchery-produced rainbow trout compete with, prey on, or hybridize with native species. More recently, invasive aquatic invertebrate and plant species are a growing problem, with anglers, boaters and other recreationists unwittingly assisting with their spread as they and their equipment move from one drainage to the next. Also, as waters warm from climate change, species such as smallmouth bass, carp and catfish invade former trout habitat as temperatures increase. Programs urging or requiring recreationists to inspect, clean and dry waders and other angling equipment, as well as boats and their trailers, can help stop the spread of aquatic invasive species.

Traditionally, many agencies have sought to isolate native trout in small headwater streams by constructing instream barriers to prevent contact with downstream invasive species. Unfortunately, this strategy can restrict native trout to isolated areas where they are increasingly vulnerable to flood, drought, or wildfire. Better balanced trout management strategies should maintain larger, interconnected stream systems and large lakes as well as isolated headwater streams (1). That means we need new methods to better understand and track the presence of non-native species and better ways to control and eliminate them once they are found. Improving technology may help in this area. New tests for "environmental DNA," or "eDNA," can detect the presence of different species simply by identifying their DNA from samples of the water where they occur. In this way, brown trout could be detected in, or confirmed absent from, waters by tracking their shed skin, mucous, or secreted feces, without ever seeing a fish.

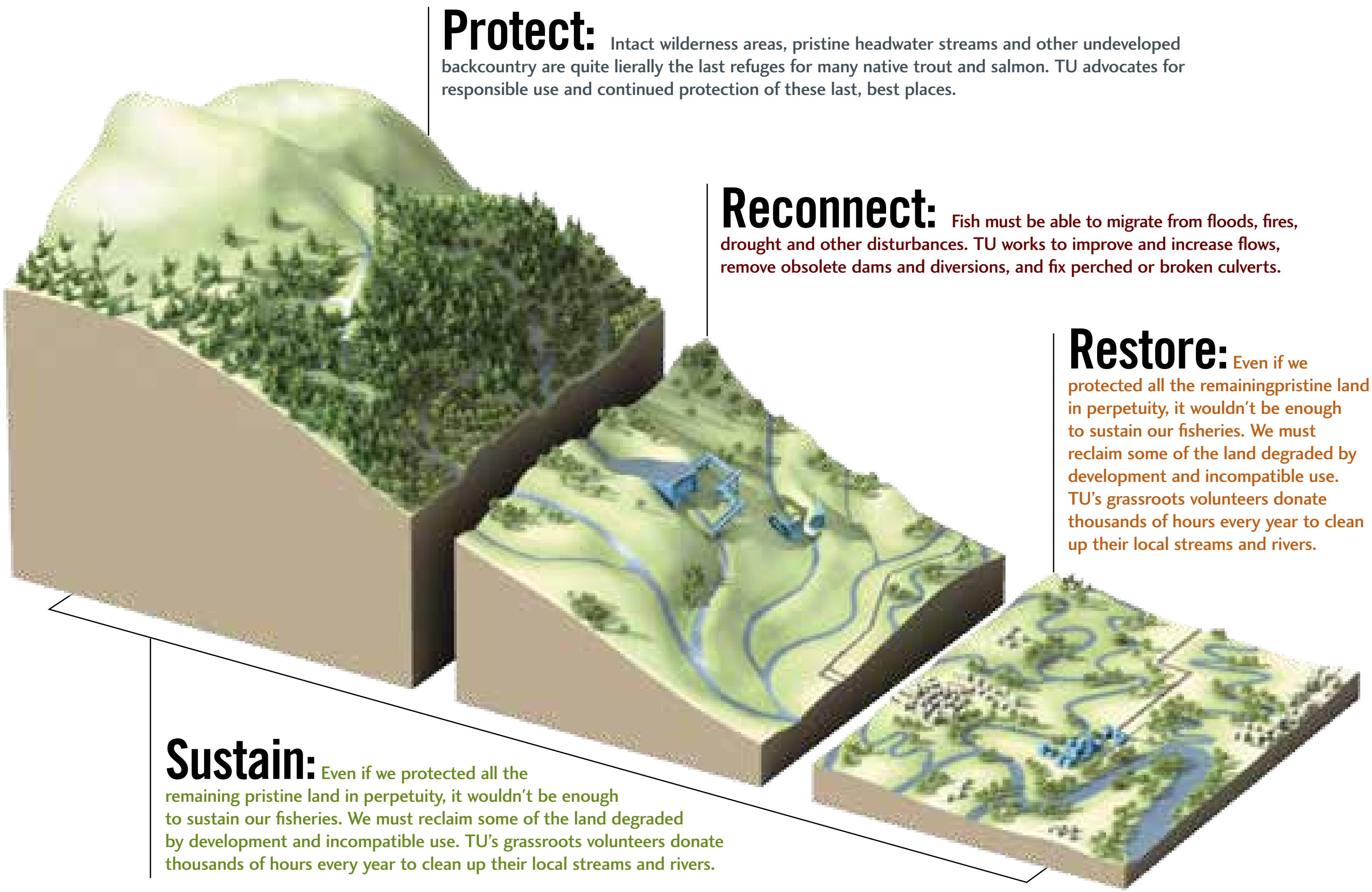
We are finally gaining the upper hand in the battle to control non-native lake trout in Yellowstone Lake and other parts of the West where they have been introduced to the detriment of native trout populations. The National Park Service, aided by U.S. Geological Survey, Trout Unlimited and others, have netted hundreds of thousands of lake trout annually in recent years and the population of this non-native predator in Yellowstone Lake appears to be in decline. In addition to netting programs, biologists now track lake trout to spawning areas where eggs can be targeted by electrofishing or sonic pulses. Controlling lake trout in western lakes is no easy task but progress in places as large as Yellowstone Lake gives us hope elsewhere.

We also may be able to control some non-native species by restoring more natural streamflow regimes, including high spring flows and improving riparian and channel conditions that can cool water and reduce the threat from warmwater fishes. Research and development of novel ways to control non-native species should be a high priority.

Controlling lake trout in western lakes is no easy task but progress in places as large as Yellowstone Lake gives us hope elsewhere.

Water Use and Demand

Demand for clean water is increasing as our human population continues to grow, especially in many parts of the West where water supplies are naturally scarce. Large western urban areas have tapped deeply into traditional sources of groundwater and over-allocated rivers. Some cities,



Trout Unlimited's watershed approach to coldwater fisheries management includes Protect, Reconnect, Restore and Sustain elements, providing an important approach to climate change adaptation and many other complex problems affecting stream systems. Illustration by Bryan Christie Design for TU.

like Las Vegas, are reaching as far away as the Utah-Nevada border for municipal water and affecting habitats for Bonneville cutthroat trout as traditional sources of water from Lake Mead and the Colorado River decline. According to a recent EPA study (2), the April snowpack has declined across three-fourths of the western states since 1955. Most of California and the Interior Basins are currently in a severe drought and much of the Southwest is predicted to see more severe droughts than any yet experienced in this region since humans began recording history (3). This dire forecast demands immediate action to protect our aquatic resources and native trout.

One way to improve stream flows is by working with the agricultural community and irrigation districts to improve irrigation efficiencies. Nationwide, water withdrawals for agriculture amount to about 40 percent of all water diversions (only thermoelectric power operations use more). Water supports agricultural production but gains in efficiencies can benefit natural systems while maintaining important food production. One recent example of success in this effort is in Washington's Methow Valley, which is home to both salmon and agriculture. Trout Unlimited and the Methow Valley Irrigation District recently reached agreement to leave 11 cfs in 3.5 miles of the Twisp River by eliminating the Twisp River Diversion and replacing it with a pump on the Methow River.

Restoration of natural watershed function – the capture, storing and slow release of precipitation – can maintain more water in headwaters and help recharge shallow groundwater aquifers. Natural watershed function will improve from restoration of wetlands, high elevation wet meadows, riparian areas and floodplains. These habitats are critical to capture precipitation, modulate runoff, replenish groundwater aquifers and slowly release water to improve late-season stream baseflows. Trout Unlimited and California Trout work closely with the National Fish and Wildlife Foundation on an innovative program designed to restore wet meadows in California's drought-stricken Sierra Nevada.

Water conservation is the third leg of our approach to water demand. Not only must we become more efficient in our use of water but we need to use less, especially in areas where valuable natural resources such as threatened trout populations are at risk. The biggest potential for water conservation is in agricultural operations, which can use less water simply by switching irrigation methods, from flood-irrigation to drip lines, for instance. Each of us can help reduce water use in our daily lives, as well.

Climate Change

Climate change is likely the greatest threat faced by native and wild trout, yet it is difficult to isolate and define because many problems already facing trout are compounded by the effects of climate change. For example, as winter snowpack decreases and forest moisture levels decline, the severity, extent and intensity of western wildfires are increasing (4). As storms in the Northeast U.S. become more severe (5), the impacts of floods and stream sedimentation increase. Increasing summer temperatures are, of course, a particularly significant problem for coldwater-dependent trout. Available trout habitat decreases while invasion by more warmwater species increases.

The problems associated with climate change must be approached on several levels. The good news is that many traditional approaches to stream and riparian area restoration also help alleviate impacts associated with climate change and make

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fishing better. Protecting headwater sources of cold clean water is crucial. Reconnecting streams to floodplains and widening riparian reserves and increasing shading by trees will diminish flood damage and help keep streams cool, respectively. The problems are so severe that effective restoration needs to occur at larger watershed scales to be most effective in reducing climate change impacts (6). Similarly, as described for Maggie Creek in the heart of Nevada, progress can be made in securing water supplies and making stream systems resilient to increasing disturbances despite drought conditions. The current degraded status of many of our streams leaves opportunity for widespread gains through restoration that will offset climate change impacts.

Perhaps most importantly, we must slow the rate of climate change by reducing our fossil fuel consumption and greenhouse gas production. Energy policies should encourage reduced energy consumption with a preference to renewable forms of energy.

As policy decisions and shifts to more renewable forms of energy move forward, fisheries managers must continue to adapt to increasing impacts of climate change. If we're smart, we make communities safer from wildfires and floods, while simultaneously improving habitat conditions for wild and native trout. Stream restoration projects must integrate local climate-related effects to the scope and implementation of their projects. Projects to reduce flood, drought and wildfire damage should rely more on holistic solutions that benefit rather than degrade natural systems. Culverts of greater capacity can be designed for increased flooding and rivers reconnected to their floodplains where high flows can naturally dissipate their energy by spreading out across the land.

Improved monitoring of stream temperatures and flow are critical if we are to fully understand the scope of the problems and potential solutions. Existing water monitoring programs of the U.S. Geological Survey should be expanded. Anglers and other citizen scientists can play an important role in monitoring changing stream conditions and filling in gaps in agency monitoring programs (7). The U.S. Forest Service has demonstrated the importance of landscape scale monitoring of stream temperatures through their development of the NorWeST project, which collects, displays and analyzes stream temperature data from across the Northwest and Interior Basins. Recently, these data have been used to predict specific stream systems that are likely to maintain their cold water through the 21st Century (8). These areas form a "climate shield" where efforts to conserve cutthroat and bull trout are most likely to succeed. TU is partnering to expand this work to areas with a critical need for stream temperature information, like the Lahontan and Bonneville regions of the Great Basin. Large temperature databases are also being assembled for the Northeast as part of the NorEaST project.

Individual anglers can make a difference as well by changing their angling practices and lifestyles. Catch and release practices can be improved by minimizing handling stress and minimizing the time that fish are held out of water. Where stream temperatures are stressing trout, angling should be avoided. Anglers can change their personal habits to increase water conservation and decrease energy use. Finally, anglers can leverage their collective passion and know-how by joining organizations such as Trout Unlimited that are working toward a more positive future for trout.

Ultimately, the human condition is inextricably linked to the status of native and wild trout populations. We all depend on high quality water in stable supply, not only for our cities and agriculture, but for our recreation and spiritual sustenance. Native and wild trout are sensitive to pollution and degraded water quality, so their sustainable populations are good indicators of the health of our rivers and watersheds. All the more reason to make sure we maintain vibrant, fishable trout populations for our current generation and those yet to come.

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Primary Authors:

Jack E. Williams, Senior Scientist, Trout Unlimited, Medford, Oregon

Amy L. Haak, Resource Information Director, Trout Unlimited, Boise, Idaho

Kurt Fesenmyer, Terrestrial and Aquatic Scientist, Trout Unlimited, Boise, Idaho

Daniel C. Dauwalter, Research Fisheries Biologist, Trout Unlimited, Boise, Idaho

Helen M. Neville, Research Geneticist, Trout Unlimited, Boise, Idaho

Matt Barney, Senior Programmer, Trout Unlimited, Boise, Idaho

Matt Mayfield, GIS Specialist, Trout Unlimited, Boise, Idaho

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