Redband Trout
Status Update Summary
2012

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Prepared by Bruce E. May[1], Benjamin Jason Writer and Shannon Albeke[2]

Introduction

This status update for redband trout (*Oncorhynchus mykiss spp.*) relies primarily on information derived during a number of workshops held in early 2012. At each workshop a number of biologists, with knowledge of redband trout, and database professionals entered redband trout information into a geo-referenced database. The database was structured to contain information pertinent to establishment of a historical perspective, along with information associated with the current distribution of redband trout and a delineation of conservation populations of redband trout within the context of the current distribution. It is anticipated that the database will be managed and maintained as a component of a larger redband trout interagency conservation effort. The impetuous for development of a geo-referenced perspective for redband trout was a result of a coordination meeting held in May, 2009. In attendance, at the meeting, were representatives from the fishery departments in Washington, Oregon, Idaho, Montana, California, and Nevada; also attending were representatives from the Fish and Wildlife Service, the Forest Service, and Bureau of Land Management. In addition, there were representatives from the Burns Paiute Tribe, the Pit River Tribe, Spokane Tribe, Colville Tribe, and the Shoshone-Paiute Tribes. There was consensus for completion of an updated status review and creation of the geo-referenced database. Leadership for the effort was assigned to Oregon Department of Fish and Wildlife.

It is important to note that redband trout exist as two very distinct "life forms", one life form is associated with redband trout that only occupy freshwater habitats. The other life form is associated with redband that occupy both fresh and saltwater habitats (anadromony) during their life cycle. This initial summary report covers only those watersheds that support redband trout without anadromny as a component of their life cycle.

As a preface to the information contained in this summary report, it is important to briefly discuss the taxonomic, geographical and environmental complexities associated with redband trout. As pointed out by Behnke (1992 and 2002), early efforts to classify the redband trout in certain portions of their range were often confused by associating them with cutthroat trout. This confusion was in part,due to coloration similarities between cutthroat and redband. Behnke also pointed out that as recently as 1980, the American Fisheries Society recognized redband trout as a separate species (no species name given) from coastal rainbow trout. More recently, genetic analysis leaves little doubt that coastal rainbow trout and redband trout are of the same species but represent different

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subspecies. The coastal rainbow trout on the westside of the Cascade Range and along the Pacific Coast being *Oncorhynchus mykiss irideus* and redband trout within the upper Columbia River Basin, the northern Great Basin and the Pitt and Klamath River Basins being *Oncorhynchus mykiss gairdneri* and other subspecies. The taxonomic picture for redband trout continues to present a challenge largely due to the uncertainty created by the almost universal introduction of hatchery coastal rainbow trout into redband trout habitats throughout their range and the potential genetic erosion that has occurred (Neville and Dunham 2011). The broad distributional maps provided by Behnke (2002) are illustrative of a number of complexities that can be associated with redband occupancy in habitats that range as far north as the Finlay River Drainage in northern British Columbia and as far south as the more arid regions of northeastern California and northern Nevada. Within this broad distributional area, habitats vary from higher elevation cold-water montane streams to lower elevation warmer desert-type streams that are often associated with periods of low stream flows and high water temperatures. It has long been conjectured that redband trout in these desert streams may have developed an adaptive tolerance to higher than normal temperatures. This tolerance to higher temperatures, however, was not evident in a recent laboratory study of redband trout tolerances to higher temperatures (Cassinelli 2007). Another possible environmental adaptation attributed to redband trout, particularly in the Klamath River drainage, is an apparent tolerance to infection from *Ceratomyxa shasta (C. shasta)* a myxosporean parasite that infects salmonid fishes. This parasite has been observed to occupy habitats in Idaho, Oregon, and Washington (Bartholomew 1998).

This summary contains information that updates and refines information in previous redband trout status assessments (Ashbrook et al, 2009; Thurow et al. 2007; Zoellick and Cade 2006; Behnke 1992 and 2002 and others). This summary is based on application of an updated version of a status protocol developed for and applied to several cutthroat trout subspecies[3]. The informational components of this updated status review for redband trout included a further refinement of what was believed to have been historically occupied (circa 1800), and a review and adjustment of the current distribution. The status review also identified "conservation populations" within the context of the current distribution.

This report is a relatively brief summary of certain components of the empirical information that was collected during the various workshops, and as such, the report should not be considered to be a comprehensive representation of all redband trout information contained in the database. It is anticipated that other reports and publications will emanate from the information contained in the database.

Methods

In total 13 workshops were held between January 9, 2012 and April 4, 2012. Biologists and ArcGIS (version 10) technical experts from several state, federal, and tribal agencies, along with representatives from private companies, combined their collective knowledge

3 The genesis and evolution of the status assessment protocol for cutthroat trout: A methods review. 2007. A white paper. Prepared by Bruce E. May and Bradley B. Shepard. 12pp.

and skills in an effort to input redband trout information into a common database developed to address the information identified in the redband trout status assessment protocol.

Analysis Area The analysis area included the likely historical range (circa 1800) of redband trout occurring in watersheds without anadromy in the United States (Figure 1).

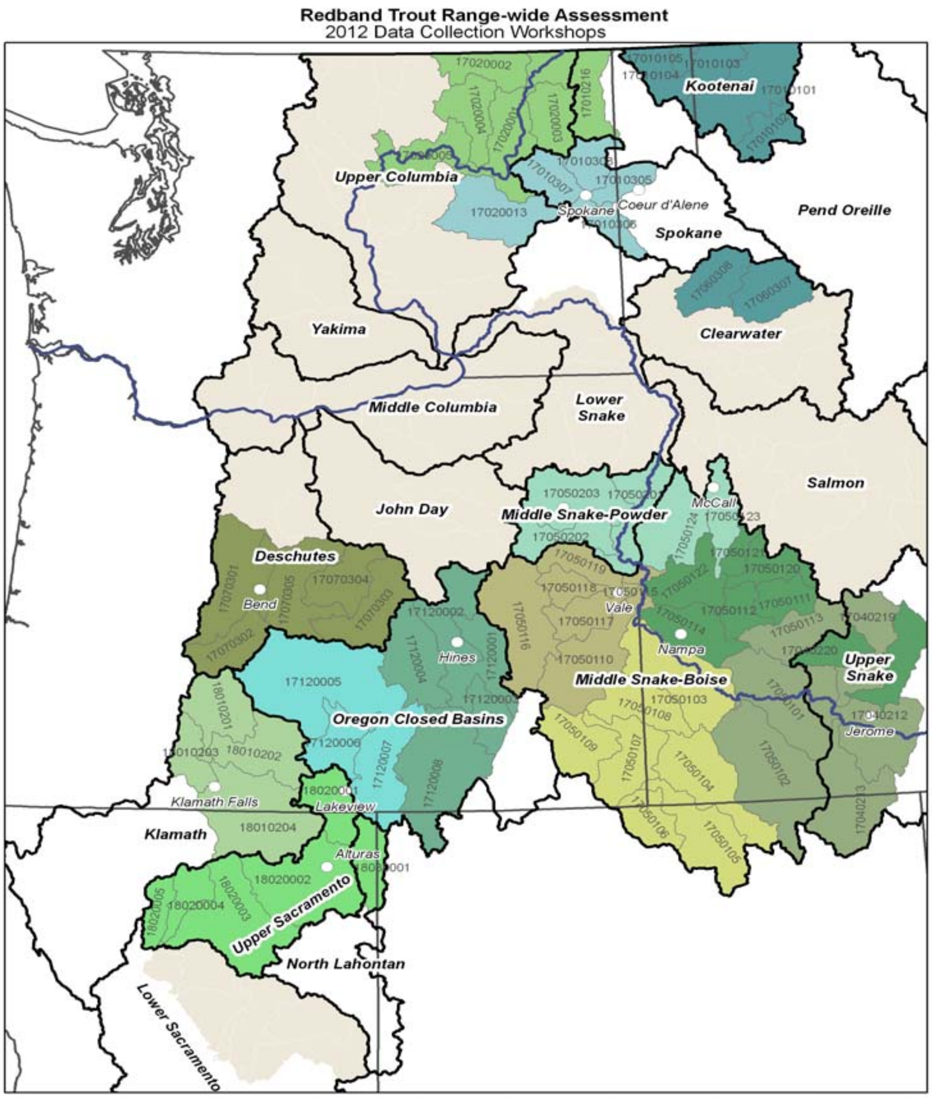

Figure 1 Map of 4th level hydrologic units (HUC's), with their identifier code number, believed to have been historically occupied by non-anadromous redband trout (aka steelhead trout). Note: This map does not include those redband watersheds that historically and/or currently support anadromous redband trout (aka steelhead trout).

The watersheds (HUC's) were grouped into geographical management units (GMU's) for the purpose of this status summary. It is anticipated that GMU's delineations will be further refined as organization of the redband trout conservation effort progresses. The analysis area included watersheds within the upper Columbia River basin, the Kootenai River drainage, the North Fork of the Clearwater drainage, portions of the Snake River drainage, the upper Deschutes River drainage, the upper Klamath and Sacramento River drainages, and drainages within the area referred to as the Oregon Closed Basins. With the exception of a very minor amount of habitat associated with streams that flowed from the United States into Canada and then back into the United States, the assessment did not include the Canadian portions of redband distribution. At some later date it might be beneficial to expand the conservation effort to include Canadian participation.

We chose to partition the information by 4th level HUCs and individual GMUs to accommodate accounting of the information at differing scales. Each individual HUC represented a separate, distinct portion of a larger drainage basin. The information was also partitioned by individual state. Each GMU represented a grouping of HUC's that form a logical unit for collection of redband information. One or more workshops were scheduled for each GMU. Specific individuals were identified as primary leaders for each workshop. These individuals assisted in organization of the respective workshops (i. e. notification of potential attendees, selection of workshop location, and identification of local accommodations, etc.). A total of 69 4th level (8-digit) watersheds were analyzed as part of the 2012 effort (Table 1). There were four additional watersheds that were initially included in the effort but dropped from consideration due to lack of information or other reasons.

Geographic Information System (GISGeographic Information System (GIS). Information was gathered and entered into a geographic information system using ArcGIS 10.0 (ESRI, Redlands, CA). Leveraging the ArcGIS Personal GeoDatabase format (MS Access), individual HUC8 databases were used to store both hydrography (streams/lakes) and attribute information. The GIS line work and associated redband trout attribute characterizations were completed in "real time" as biologists identified stream specific redband information as the data entry technicians entered the information for each watershed. Many different sources of information were used in the 2012 status effort. Consistency was maintained by having two individuals attend all workshops. One individual was there to answer questions regarding the protocol and the organization format of the workshops. The other individual provided oversight of data entry and resolved questions associated with ArcGIS and the associated databases. The 2012 redband status effort used the National Hydrography Dataset (NHD) at the 1:24,000 scale. Both stream and lake feature classes were used to define historic and currently occupied habitat. As a point of clarification, it should be noted that use of the NHD stream coverage required an adjustment that removed certain stream segments (e.g. intermittent and ephemeral stream channels, ditches and canals and other artificial stream paths), felt to be unsuitable for redband trout.

Table 1. Specific information for the workshop locations and watersheds analyzed in the 2012 redband status review.

Workshop Number	Workshop Location	River Basin	4th Field HUC Number	4th Field HUC Name
1	Baker City, OR	Middle Snake-Powder	17050201 17050202 17050203	Brownlee Reservoir Burnt Powder
2	McCall, ID	Middle Snake-Powder	17050123 17050124	NF Payette Weiser
3	Twin Falls, ID	Upper Snake	17040212 17040213 17040219 17040221 17040220 17050101 17050102 17050113	Upper Snake-Rock Salmon Falls Big Wood Little Wood Camas CJ Strike Reservoir Bruneau South Fork Boise
4	Klamath Falls, OR	Klamath	18010201 18010202 18010203 18010204	Williamson Sprague Upper Klamath Lake Lost River
5	Alturas, CA	Upper Sacramento North Lahontan	18020001 18020002 18020004 18080001	Goose Lake Upper Pit McCloud Surprise Valley
6	Lakeview, OR	Oregon Closed Basins	17120005 17120006 17120007	Summer Lake Lake Abert Warner Lakes
7	Bend, OR	Deschutes	17070301 17070302 17070303 17070304 17070305	Upper Deschutes Little Deschutes Beaver-South Fork Upper Crooked Little Crooked
8	Hines, OR	Oregon Closed Basins	17120001 17120002 17120003 17120004 17120008	Harney-Malheur Lakes Silvies Donner and Blitzen Silver Guano
9	Vale, OR	Middle Snake-Boise	17050110 17050115 17050116 17050117 17050118 17150119	Lower Owyhee Middle Snake-Payette Upper Malheur Lower Malheur Bully Willow
10	Spokane, WA	Upper Columbia Spokane	17020001 17020002 17020003 17020004 17020013 17010305 17010306 17010307 17010308	Franklin D Roosevelt Lake Kettle Colville Sanpoil Upper Crab Upper Spokane Hangman Lower Spokane Little Spokane
11	Coeur d" Alene, ID	Kootenai -Clearwater	17010101 17010102 17010103 17010104 17010105 17060307 17060308	Upper Kootenai Fisher Yaak Lower Kootenai Moyie Upper North Fork Clearwater Lower North Fork Clearwater
12	Nampa, ID	Middle Snake-Boise	17050111 17050112 17050114	North and Midddle Fork Boise Boise-Mores Lower Boise

			17050120 17050121 17050122	South Fork Payette Middle Fork Payette Payette
13	Nampa, ID	Middle Snake- Boise	17050103 17050104 17050105 17050106 17050107 17050108 17050109	Middle Snake-Succor Upper Owyhee South Fork Owyhee East Little Owyhee Middle Owyhee Jordan Crooked-Rattlesnake

<u>The Protocol for the Redband Assessment.</u> The protocol addressing the information to be collected for the assessment was based on the format developed for several cutthroat trout subspecies. The approach applied to redband trout allowed for collection of information at several scales or special layers[4]. Passage barriers were identified as specific point data on the NHD stream layer and attributed in a barrier database. Barriers of historical significance were coded differently from barriers identified as having influences on current distributions of redband. Historical barriers were primarily identified as waterfalls and high gradient cascade stream sections. Current barriers included barriers created by anthropogenic features such as culverts, dams, water diversions and other features that were judged as having a significant influence on redband trout movement.

Historical distribution of redband trout was primarily linked to the presence of geological features (e.g. waterfalls and high gradient cascade stream segments) that would have precluded fish occupancy above a specific barrier. In other instances habitat limitations were judged to have limited historical distribution due to small stream size, high stream gradients or general lack of stream flows. On occasion, historical determinations were linked to specific historical information (e.g. historical journals, diaries, natural historical reports or other historical documents). Historical distribution information was only represented as line work associated with the streams and lakes believed to be historically occupied.

Current distribution was based on site specific information and professional judgment related to the presence of redband trout The intent was to make the determination of current redband trout distribution as objective as possible. That being said, it was impossible, at times, to insure that only habitats known to support redband trout were included. Pre-existing current distribution coverages were available and these coverages were utilized to facilitate identification of current distribution in this effort. Some of these coverages were deemed to include over estimates of redband distribution while other coverages represented under estimates of known distribution. Use of these coverage's as references did prove to be highly beneficial because they did provide for increased efficiency at arriving at a current distribution determination based on consensus. Only those redband trout that were supported by natural reproduction were included in this assessment. These self-sustaining redband trout may be the residue of

[4] Redband trout status update entitled "Non-anadromous redband trout range-wide database initiation: Historical range, current status, conservation population identification, risk and health determinations and population restoration potential protocols" 2012. Prepared by Bruce E. May and Shannon Albeke. 37 pp.

aboriginal stocks or they could have been the result of population restoration. Streams determined to be currently occupied were either treated in total or subdivided into stream segments. Each stream or stream segment was attributed with a standard set of characterizations. Those characterizations included: information on "life forms" (either non-anadromous, anadromous or mixed), information on fish stocking, redband genetic status, population density, a determination of habitat quality, and, presence of non-native fishes. Each currently occupied lake was treated as a single independent habitat segment. Attributes associated with lakes included: "life form" (either non-anadromous, anadromous or mixed); information on fish stocking; redband genetic status; population abundance; and, presence of non-native fishes.

The protocol included a delineation of specific groupings of occupied habitat segments into discrete conservation populations. A primary determinant for these habitat groupings was linked to the capability of redband trout to be able to move, unimpeded by a blockage, within the occupied habitat. As such, there could be no complete passage barrier internal within the habitat grouping. Gene flow and re-colonization potential were the main considerations. These conservation populations were evaluated based on a set of additional attributes that included: 1. the degree of connectedness or complexity (number of streams occupied) of habitat, 2. identification of the specific qualifier or rationale for inclusion as a conservation population, and 3. identification of the specific life histories (i.e. fluvial, fluvial-adfluvial, lacustrine or allacustrine) represented within the population. In addition, any conservation actions that had been implemented and any human land uses were identified for each population. Conservation populations were also evaluated for risks associated with genetic contamination and significant diseases. A relative health evaluation was completed for those populations having completed information.

The information contained in the redband database was primarily empirical in nature based on sampled data and professional judgment. Information sources were identified and linked to general levels of reliability to better judge information quality (Table 2). Information associated with judgment calls and anecdotal sources, in general, were viewed as being less reliable and/or accurate than information developed as part of detailed surveys and studies that had undergone substantial analysis and review. Similar to other applications of this approach, this assessment relied upon existing information and, therefore, sampling was not random and in many cases not independent. As a result, there were undoubtedly biases associated with the information.

Table 2 Example look-up table for data sources with a relative index values for information reliability and accuracy.

Information 'Source	Relative Degree of Reliability
Anecdotal Information	Low 1
Letter	Low 1
Professional judgment	Moderate 2
Cursory reconnaissance	Moderate 2
Information derived from minor sampling; contained in agency databases, reports and summaries (generally, non-peer reviewed)	High 3
Information derived from major sampling; generally contained in agency databases, a thesis or dissertation or a published paper (peer reviewed).	Highest 4

Assessment Teams A total of 93 fisheries professionals representing a number of state, federal, and tribal agencies, along with a few private firms and organizations provided the information that was included in the 2012 redband status update. Each fishery professional was asked to specify their affiliation, position title, educational achievement and years of experience, both total experience and experience with redband trout. These individuals formed a number of assessment teams that met in 13 workshops. In addition there were at least 15 GIS/database specialists that also participated in the effort.

Results and Discussion

Not all information contained in the 2012 redband trout database will be reported in this summary. In total, the 2012 redband trout database contains 108,957 GIS records and 94,697 attribute records. That amount of information is far too large to include in a single summary report. It is recommended that a more complete review of the information in the database be detailed in additional documents and published reports. The intent of this report is to provide a summary of pertinent information associated with the historical and current redband trout distribution along with a summary of information associated populations identified as having conservation significance.

As a point of clarification, it should be noted that use of the NHD stream coverage required an initial adjustment that removed certain stream segments (e.g. intermittent and ephemeral stream channel, ditches and canals and other artificial stream paths) that were considered to be unsuitable for redband trout. The total stream length contained in the

NHD stream coverage, prior to the adjustment, was 398,096 kilometers (247,365 miles). The adjusted NHD stream coverage, used in this assessment, was 152,861 kilometers (94,983 miles).

Historic Distribution

In 2012, a total of 60,295 kilometers (37,465 miles) of stream habitat were estimated as being historically (circa 1800) occupied by resident redband trout. The estimated amount of historical range in each state was 21,556 kilometers (13,395 miles) in Idaho (36%), 19,839 kilometers (12,327 miles) in Oregon (33%), 10,598 kilometers (6,585 miles) in Washington (18%), almost 4,606 kilometers (2862 miles) in California (7%), 2,606 kilometers (1,620 miles) in Nevada, 1,067 kilometers (663 miles) in Montana and a very minor amount (less than 1%) in Canada (approximately 14 miles). This small amount of stream habitat in Canada was included to maintain continuity of a single stream. In total there were 152 lakes identified as being historically occupied by redband trout. The amount of surface area associated with these lakes was 53,251 hectares (131,584 acres). The lake surface area estimates are inflated to a small degree due to the way that standing bodies of water were portrayed in the NHD lake layer. In some instances it was obvious that wetlands, marshes, and sloughs were included within certain lake basins. There were 69 4th level (8 digit) hydrologic units (watersheds) identified as being historically occupied (Table 3).

There were 286 historical barriers identified in the assessment. Nearly all historical barriers were associated with either waterfalls or high gradient cascades that would have limited historical upstream movement. In some instances, these blockages precluded redband movement into otherwise suitable habitats.

Current Distribution

Redband trout were estimated to currently occupy 25,417 kilometers (15,793 miles) or 42% of the 60,295 kilometers (37,465 miles) of historically occupied stream habitats. Redband trout were reported to occupy 11,016 kilometers in Oregon (43% of current), 8,928 kilometers in Idaho (35% of current), 2,828 kilometers in Washington (11% of current), 1,301 kilometers in Nevada (5% of current), 788 kilometers in Montana (3% of current), 535 kilometers in California (2% of current) and a very small amount (22 kilometers, less than 1% of current) in Canada (Figure 2.). A total of 3,288 stream habitat segments were associated with the 25,417 kilometers of occupied stream habitat. A tally of the total number of streams analyzed was not made. In total, there were 124 lakes and/or reservoirs identified as being currently occupied by redband trout throughout the analysis area. Each lake environment was treated as a discrete habitat segment. The amount of lake and reservoir habitats that are currently occupied totals 184,504 hectares (455,919 acres). All 69 hydrologic units identified as being historically occupied also supported current distributions of redband trout. The currently occupied stream and lake habitats associated with the hydrologic units are presented in Table 4.

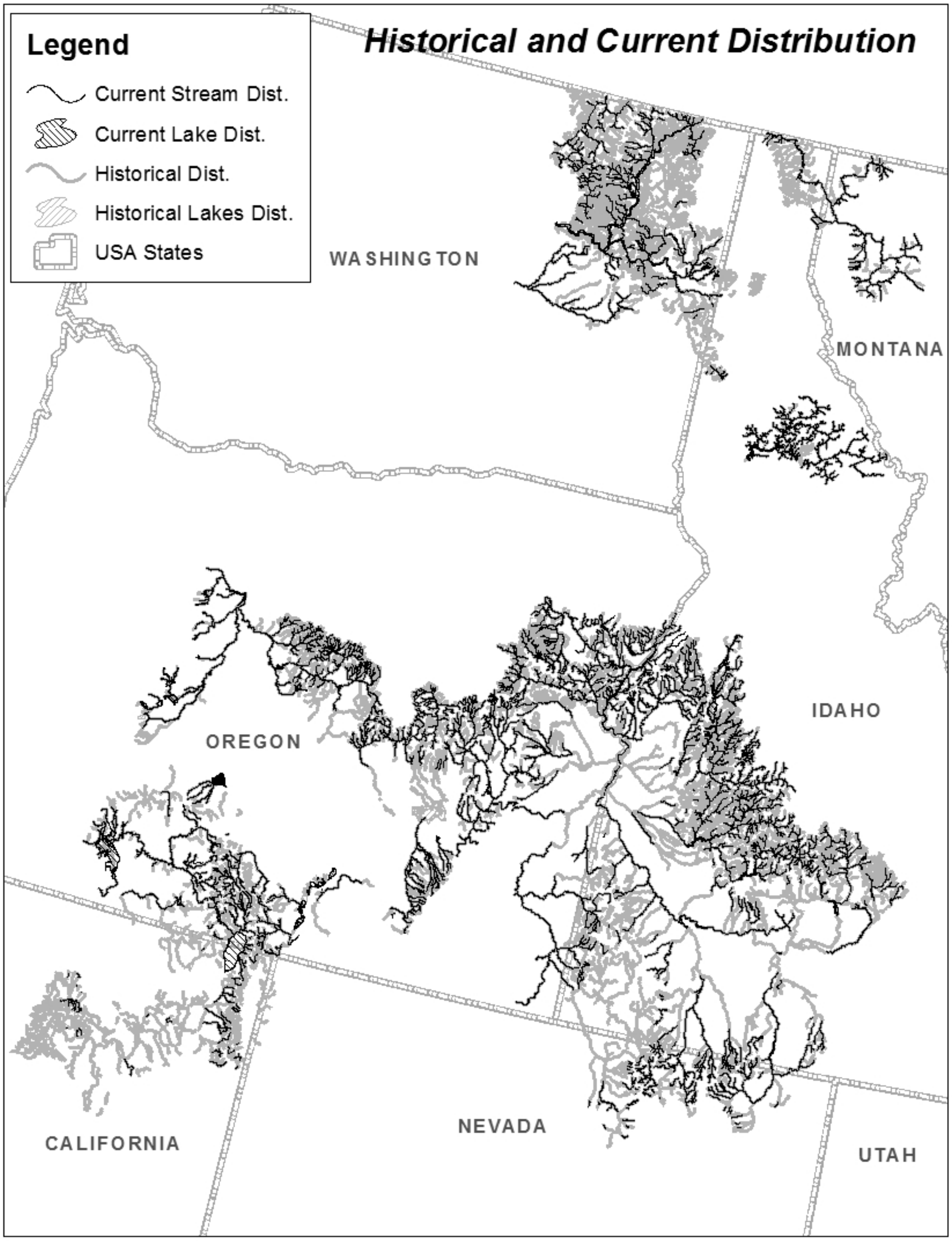

Figure 2. Distributional map of redband trout current distribution (dark) over laying the historical distribution coverage (light) determined in 2012.

Table 3. Projected historically occupied habitat for the hydrologic units (eight digit HUC's) analyzed.

Watershed Number	Watershed Name	Stream Length (km))	Lake Area (ha)	Watershed Number	Watershed Name	Stream Length (km)	Lake Area (ha)
17010101	Upper Kootenai	326	0	17050121	Middle Fork Payette	714	1
17010102	Fisher	485	210	17050122	Payette	944	0
17010103	Yaak	270	23	17050123	North Fork Payette	1366	0
17010104	Lower Kootenai	823	123	17050124	Weiser	1541	0
17010105	Moyie	3	0	17050201	Brownlee Reservoir	995	0
17010305	Upper Spokane	568	779	17050202	Burnt	1544	0
17010306	Hangman	579	0	17050203	Powder	2341	0
17010307	Lower Spokane	150	30	17060307	Upper North Fork Clearwater	651	0
17010308	Little Spokane	653	858	17060308	Lower North Fork Clearwater	877	0
17020001	Franklin D. Roosevelt Lake	3360	89	17070301	Upper Deschutes	738	8628
17020002	Kettle	1179	0	17070302	Little Deschutes	359	3823
17020003	Colville	1106	1480	17070303	Beaver-South Fork	884	0
17020004	Sanpoil	1529	0	17070304	Upper Crooked	1400	0
17020013	Upper Crab	723	13	17070305	Lower Crooked	884	0
17040212	Upper Snake-Rock	531	0	17120001	Harney-Malheur Lakes	470	72978
17040213	Salmon Falls	1181	0	17120002	Silvies	14251	0
17040219	Big Wood	1309	0	17120003	Donner Und Blitzen	716	0
17040220	Camas	413	0	17120004	Silver	343	0
17040221	Little Wood	885	0	17120005	Summer Lake	262	0
17050101	C.J. Strike Reservoir	501	0	17120006	Lake Abert	671	0
17050102	Bruneau	1806	0	17120007	Warner Lakes	463	37328
17050103	Middle Snake-Succor	1133	0	17120008	Guano	265	0
17050104	Upper Owyhee	1427	0	18010201	Williamson	373	0
17050105	South Fork Owyhee	800	0	18010202	Sprague	883	0
17050107	Middle Owyhee	518	0	18010203	Upper Klamath Lake	333	0
17050108	Jordan	716	0	18010204	Lost	639	0
17050109	Crooked-Rattlesnake	4	0	18020001	Goose Lake	904	0
17050110	Lower Owyhee	278	0	18020002	Upper Pit	1442	192
17050111	North and Middle Forks Boise	1236	0	18020003	Lower Pit	1382	0
17050112	Boise-Mores	1151	0	18020004	McCloud	832	0
17050113	South Fork Boise	1604	0	18080001	Surprise Valley	485	0
17050114	Lower Boise	636	0				
17050115	Middle Snake-Payette	118	0				
17050116	Upper Malheur	1891	0				
17050117	Lower Malheur	332	0				
17050118	Bully	500	0				
17050119	Willow	456	0				
17050120	South Fork Payette	7345	0				

Table 4. Projected currently occupied habitat for the hydrologic units (eight digit HUC's) analyzed.

Watershed Number	Watershed Name	Stream Length (kms)	Lake Area (Ha)	Watershed Number	Watershed Name	Stream Length (km)	Lake Area (ha)
17010101	Upper Kootenai	268	0	17050120	South Fork Payette	558	1198
17010102	Fisher	348	185.393	17050121	Middle Fork Payette	274	0
17010103	Yaak	200	25.464	17050122	Payette	217	96
17010104	Lower Kootenai	198	0	17050123	North Fork Payette	578	13107
17010105	Moyie	3	0	17050124	Weiser	959	395
17010305	Upper Spokane	81	0	17050201	Brownlee Reservoir	679	5538
17010306	Hangman	74	0	17050202	Burnt	759	373
17010307	Lower Spokane	315	4649.784	17050203	Powder	1120	1956
17010308	Little Spokane	303	106.458	17060307	Upper North Fork Clearwater	572	0
17020001	Franklin D. Roosevelt Lake	688	28954.574	17060308	Lower North Fork Clearwater	707	6622
17020002	Kettle	363	0	17070301	Upper Deschutes	574	10259
17020003	Colville	36	439.269	17070302	Little Deschutes	167	0
17020004	Sanpoil	568	0	17070303	Beaver-South Fork	412	0
17020013	Upper Crab	458	213.059	17070304	Upper Crooked	698	1305
17040212	Upper Snake-Rock	163	0	17070305	Lower Crooked	455	708
17040213	Salmon Falls	628	1452.365	17120001	Harney-Malheur Lakes	153	387.346
17040219	Big Wood	424	1422.195	17120002	Silvies	760	13.398
17040220	Camas	72	140.734	17120003	Donner Und Blitzen	537	689.254
17040221	Little Wood	267	333.216	17120004	Silver	228	0
17050101	C.J. Strike Reservoir	223	2542.729	17120005	Summer Lake	119	4725
17050102	Bruneau	981	0.594	17120006	Lake Abert	404	0
17050103	Middle Snake-Succor	435	77.709	17120007	Warner Lakes	294	13177
17050104	Upper Owyhee	292	0	17120008	Guano	119	160
17050105	South Fork Owyhee	188	38.452	18010201	Williamson	89	0
17050107	Middle Owyhee	387	0	18010202	Sprague	676	84
17050108	Jordan	299	0	18010203	Upper Klamath Lake	183	34917
17050109	Crooked-Rattlesnake	4	0	18010204	Lost	115	1543
17050110	Lower Owyhee	151	0	18020001	Goose Lake	455	39887
17050111	North and Middle Forks Boise	604	0	18020002	Upper Pit	254	78
17050112	Boise-Mores	266	2043.361	18020003	Lower Pit	46	0
17050113	South Fork Boise	795	1877.439	18020004	McCloud	89	0
17050114	Lower Boise	138	0	18080001	Surprise Valley	57	115
17050115	Middle Snake-Payette	68	0				
17050116	Upper Malheur	1327	2528.771				
17050117	Lower Malheur	162	0				
17050118	Bully	232	12.928				
17050119	Willow	105	129.508				

For each habitat segment, certain specific characterizations were recorded. These characterizations were associated with origin (were the habitat segments occupied by fish from an aboriginal origin or were they restored or reintroduced), information related to non-native or native fish stocking, information on genetic status, estimates of adult (sexually mature) redband trout density, habitat quality determinations, stream widths, and identification of non-natïve fish that were currently coexisting with redband trout. It should be noted that the abundance characterization included only reproductively mature fish (to be used to approximate "effective population size") and was intended to approximate the density for each occupied stream segment. For lake environments currently supporting redband trout, there were two major differences in the attribute characterizations. Habitat quality was not addressed for lakes and population numbers were presented as a estimate of total abundance of adult redband trout rather than as a density (i.e. number/unit of area).

Origin The vast majority of redband trout reviewed in this assessment were identified as being from aboriginal origin, meaning that the current distribution of redband trout was populated by descendants of aboriginal stocks. Over 99 percent of redband trout occupying both stream (15,678 miles) and lake (454,938 acres) environments were of aboriginal origin. Redband trout that had been restored or reinstated to either stream or lake environments occurred in less than 1 percent of the current distribution. All redband trout in the watersheds analyzed were identified as reflecting a non-anadromous life form.

Genetics As of 2012, genetic testing had been conducted on an estimated 2,774 kilometers of occupied stream habitats (approximately 11% of the total occupied streams; Table 5). No evidence of introgression was found from samples associated with 1,930 kilometers of stream (8% of the total occupied stream) habitat. Introgression (1% and greater) was detected in samples from 4,773 kilometers of occupied stream habitat. Stream habitat tested and found to support genetically unaltered redband trout that were co-existing with altered redband trout amounted to 134 kilometers of habitat. The vast majority of redband trout in stream habitats (20,944 kilometers) had not been genetically tested. To account for the probable genetic make up of redband trout in these untested stream habitats, the assessment postulated what the probable outcome of testing might be based on two factors. These factors were associated with past or current stocking of contaminating species and the current presence of contaminating species co-existing with redband trout in these untested stream habitats. Based on that review, it was estimated that redband trout in 11,179 kilometers of stream would likely be introgressed to some extent. Redband trout in the remaining 9,765 kilometers were likely to be genetically unaltered because there was no record of stocking and no presence of contaminating species being present. It should be noted that the state of Oregon has amassed a large number of tissue samples from redband trout which will be analyzed pending the availability of funding. Most of these samples are from stream habitats.

Genetic results for redband trout from approximately 184,504 hectares of lake habitat indicated that 35,030 hectares (19% of total lake acres) were judged to be genetically unaltered. Another 8,779 kilometers (5% of total lake hectares) had introgression levels ranging from 1% to over 20%. Lake habitats tested and found to support genetically unaltered redband co-existing with genetically altered redband trout amounted to 36,628 hectares of lake habitats. Redband trout in approximately 104,067 kilometers of lake habitats had not been genetically tested (56% of total lake hectares). Similar to redband trout occupying stream environments, the probable genetic make up of the genetically untested redband trout in these lake habitats was postulated to be 60,376 hectares with some level of introgression and 43,691 hectares likely to support redband trout in a genetically unaltered condition.

Table 5 Genetic status for redband trout by stream (kilometers) and lake (hectares) within the occupied habitat reported identified in 2012.

		Stream			Lake	
Genetic Status		Stream Kilometers	% of Occupied		Lake Hectares	% of Occupied
Tested, Unaltered		1,930	8%		35,030	19%
Tested; 1% to 10% Introgression		1,303	5%		6,765	4%
Tested;11% to 20% Introgression		469	2%		393	<1%
Tested; >20% Introgression		637	3%		1,621	<1%
Suspected Unaltered		9,765	38%		43,691	24%
Potentially Altered		11,179	44%		60,376	33%
Mixed Stock; Altered and Unaltered		134	1%		36,628	20%
Totals		25,417	100%		184,504	100%

<u>Redband Trout Density</u> The 2012 status protocol called for addressing redband trout density (expressed as fish/kilometer) based on the number of sexually mature fish within a given stream segment. Addressing fish density in this fashion allowed for a subsequent approximation of effective population size for each conservation population. Total densities would have been considerably greater if juvenile fish were included in the density estimates. The protocol provided two options: 1. density ranges were provided; or, 2. specific density value could be entered into the database if sampling was sufficient to allow for developing an actual fish density estimate. The majority of density information was derived from using the density ranges. These density ranges for stream segments included: 0 to 35 fish per km; 36 to 100 fish per km; 101 to 250 fish per km; 251 to 625 fish per km; 626 to 1250 fish per km; and, over 1250 fish per km. There was an unknown category provided also. The density ranges and the associated kilometers of occupied stream within each state are provided in Table 6. For 40% of the stream

segments, there was no information available for projecting redband trout density. In stream segments where density estimates were made, low fish densities (less that 35 fish per km) were most prevalent (9,040 kilometers of stream habitat). The next largest mileage (2,997 kilometers) was associated with redband trout with a density of 36 to 100 fish per kilometer. Redband trout densities over 100 fish per kilometer were identified in approximately 13% of currently occupied stream habitat. A large percentage (40%) occupied stream length had unknown redband densities. Redband trout density information will be used to project population estimates utilized in a subsequent assessment of relative population health.

Table 6 Density ranges of reproductively mature redband trout that currently occupy current distribution stream segments. Numbers represent the total number of kilometers of occupied stream habitat. Miles are indicated in Parentheses.

		Streams Only	
Fish Density (fish/.km)		Stream Kilometers	% Occupied
0-35 fish/km		9,040 (5,617 miles)	36%
36-100 fish/km		2,997 (1,862 miles)	12%
101-250 fish/km		1,565 (9,72 miles)	6%
251-625 fish/km		1,125 (699 miles)	4%
626-1250 fish/km		451 (280 miles)	2%
>1250 fish/km		158 (98 miles)	<1%
Unknown		10,081 (6,264 miles)	40%
Totals		25,417 (15,793 miles)	100%

Redband trout abundance estimates were also made for lake environments (Table 7). For most occupied lake environments that were occupied by redband trout, abundance levels exceeded 2,500 individuals in 39 % of the occupied habitat. No estimate of redband trout abundance was identified for 107,488 hectares of occupied lake habitat.

Table 7. Abundance ranges for reproductively mature redband trout that currently occupy lake habitats within the watersheds analyzed. Numbers represent the total number of hectares occupied. Hectares are indicated in parentheses.

		Lakes and Reservoirs	
Fish Abundance (# of fish)		Lake Hectares	% Occupied
0-500 fish		2,759 (6,819 acres)	2%
501-1500 fish		1,396 (3,451 acres)	1%
1501-2500 fish		400 (998 acres)	<1%
> 2500 fish		72,460 (179,053 acres)	39%
Unknown		107,488 (265,609 acres)	58%
Totals		184,504 (455,919 acres)	100%

Habitat Quality   Habitat quality was viewed as an important aspect of the redband trout status assessment. To access habitat quality, each stream segments was given a quality rating based on a number of habitat attributes (e.g. pool quality and quantity, substrate conditions, water temperature, stream cover and other considerations). Ratings were based on how close current habitat conditions aligned with optimal conditions for redband trout. An excellent rating would be associated with stream habitat having the majority of attributes reflecting optimal conditions. A good rating would be consistent with habitat having a few attributes that are slightly less than ideal. A fair rating would have a greater number of habitat attributes in less than ideal condition. Poor habitat would be associated with most attributes reflecting inferior conditions. Habitat quality ratings were only completed for the stream segments occupied by redband trout. Evaluation of the quality of lake environments occupied by redband trout may be completed at some future date.

Across the redband trout range approximately 32% (1,113 kilometers or 4,946 miles)) of redband trout habitats were judged to be in either excellent (5%) or good condition (27%). Fair habitat conditions were assigned to 34% of the currently occupied habitats and poor conditions were associated with 18% of occupied habitat. There was no quality rating given to 16% of the occupied habitats (Figure 3). For those habitats rated as good to excellent, the three attributes that were identified as being most important included: 1. summer water temperatures within an optimum range of 10 – 16 C; 2. ample pool habitats for juvenile rearing and adult resting; and, 3. adequate stream flows. The most important habitat characteristics that resulted in a fair to poor quality rating were: 1. summer water temperatures exceeding 16 C; 2. substrate fines being greater than 25%; and, 3. lack of stream shading.

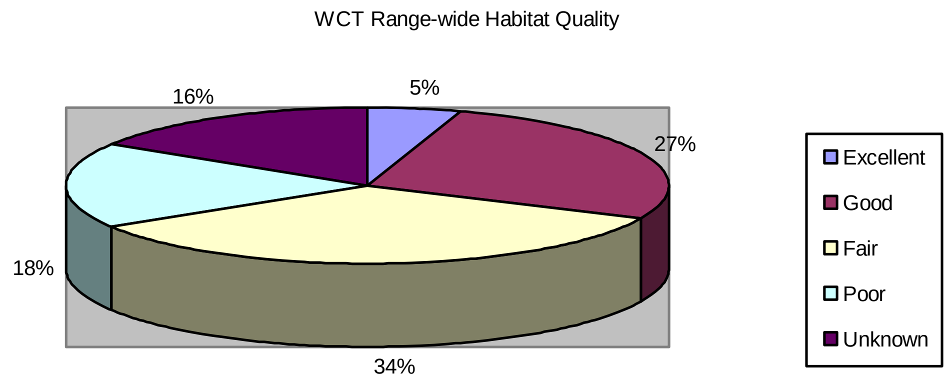

Figure 3. Habitat quality ratings associated with the current distribution of redband trout based on stream miles for each habitat quality rating.

Habitat quality estimates for the current distribution for each state reflect a somewhat finer level of resolution (Table 8) of habitat quality based on the stream kilometers within each state. Oregon had the greatest amount of redband trout stream habitat (11,016 kilometers) and the majority of that habitat (64%) was rated as being in fair and poor condition. Only 22% was rated as being in excellent (3%) or good (19%) condition. Idaho had the second highest amount of stream habitat (8,928 Kilometers) and most of that habitat (46%) was rated as either excellent (7%) or good (39%). Redband trout stream habitats in Idaho that were rated as fair (31%) or poor (10%) totaled 41 %. Washington had the next highest amount of redband trout habitat (2,828 kilometers) and a substantial amount of that habitat (36%) was not rated due to very limited information. Washington's streams that were rated as being in excellent (4%) or good (16%) totaled 20%. Forty four percent of Washington's redband trout stream habitat was rated as either fair (26%) or poor (18%) condition. Nevada had no redband trout stream habitat rated as being in excellent condition. The majority of Nevada's 1,301 kilometers of stream habitat was rated as good (33%) or fair (53%). Thirteen percent of Nevada's stream habitat was rated as being in poor condition. Montana (788 kilometers) and California (535 kilometers) had the least amount of redband trout stream habitat. Most of Montana's stream habitat was rated as being in fair (52%) condition. Montana's streams rated as excellent and good totaled 31%. Most of California's stream habitats (52%) were not rated due to limited information. California's streams rated as excellent and good totaled 32%.

Table 8. Habitat quality estimates within the states supporting current distributions of redband trout based on kilometers of stream habitat. Percentages as based on total length of occupied stream.

	Excellent	Good	Fair	Poor	Unknown
California	8 (1%)	164 (31%)	67 (13%)	17 (3%)	278 (52%)
Idaho	620 (7%)	3475 (39%)	2731 (31%)	943 (10%)	1159 (13%)
Montana	67 (8%)	217 (23%)	409 (52%)	91 (12%)	4 (<1%)
Nevada	--	423 (33%)	691 (53%)	179 (14%)	8 (<1%)
Oregon	289 (3%)	2077 (19%)	4100 (37%)	5964 (27%)	1586 (14%)
Washington	129 (4%)	469 (16%)	724 (26%)	495 (18%)	1011 (36%)

<u>Record of Stocking</u> Information related to known records of fish stocking, primarily non-native fish species, within the current distribution area of redband trout were reviewed and that information was included in the status database. The focus was on fish species that would have the potential to hybridize and/or compete with redband trout. The hybridizing species of most concern were coastal rainbow trout, primarily of hatchery origin, and cutthroat trout. Competitive species of concern included brown trout, brook trout, hatchery rainbow trout, cutthroat trout and several warm water fish species.

There were no records of fish stocking within 55% of stream habitats associated with the current redband trout distribution (Figure 4). Records of various fish species being stocked were linked 45% of the currently occupied habitat. For lake environments, the record of stocking was significantly different (Figure 5). Records of fish stocking in lake habitats were associated with 98% of lake habitats occupied by redband trout. Rainbow trout, of non-native origin, were the most stocked species followed by cutthroat trout subspecies, brook trout and brown trout. Records of fish stocking within habitats supporting redband trout were shown to vary by state (Table 9).

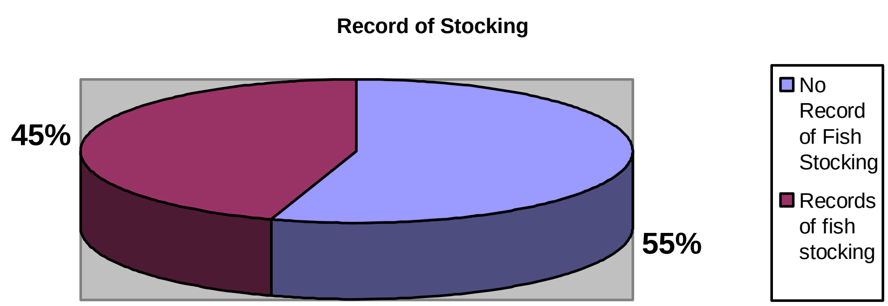

Figure 4 Records of fish stocking within streams of the current distributional area of redband trout. Percentages are based on the total amount of occupied stream habitat (kilometers).

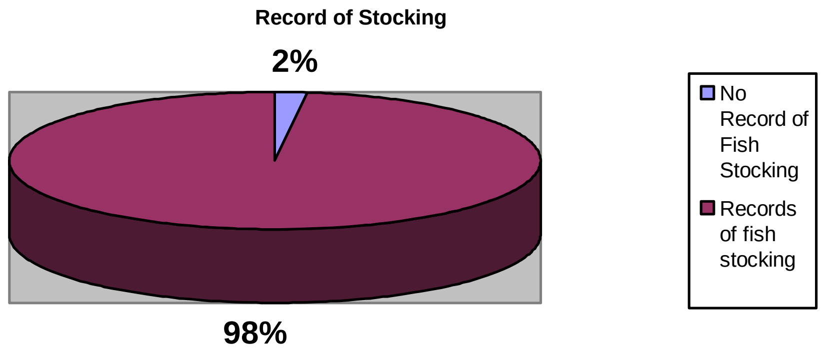

Figure 5. Records of non-native fish stocking in lake environments within the current distributional area of redband trout. Percentages are based on the total amount of occupied lake habitat (hectares).

Table 9. Record of stocking of non-native fish in redband trout streams (kilometers) and lakes (hectares) within currently occupied habitat associated with the various states.

	Stream (# kilometers)		Lake (# hectares)	
States	No Record of Stocking	Record of Stocking	No Record of Stocking	Record of Stocking
California	283	252	0	37847
Idaho	4364	4563	63	31245
Montana	255	533	0	211
Nevada	726	574	0	39
Oregon	7039	3977	778	79957
Washington	1209	1619	2771	31592
Totals	13897	11520	3613	180891

Presence of non-native and other fish species A substantially more important metric was information on the actual presence of other fish species, mostly non-native, currently co-existing with redband trout. From a genetics perspective, presence of non-native rainbow trout of hatchery origin increases the probability of introgression with redband trout. Non-native cutthroat trout can also hybridize with redband trout. Competition between introduced non-native fish species can also have significant impacts on native redband trout. Approximately 33% of stream habitats were reported to have no non-native fish present (Figures 6 and 7.). Non-native fish, represented by one or more species, co-existed with redband trout in 13,490 kilometers (53%) of stream habitat (Table 10.). Non-native fish co-existing with redband trout primarily included coastal rainbow trout from hatchery origins, cutthroat trout, brook trout, brown trout, and small mouth bass. Other non-native species were identified also. Presence of non-native fish in lake habitats supporting redband trout were also shown to vary by state (Table 10).

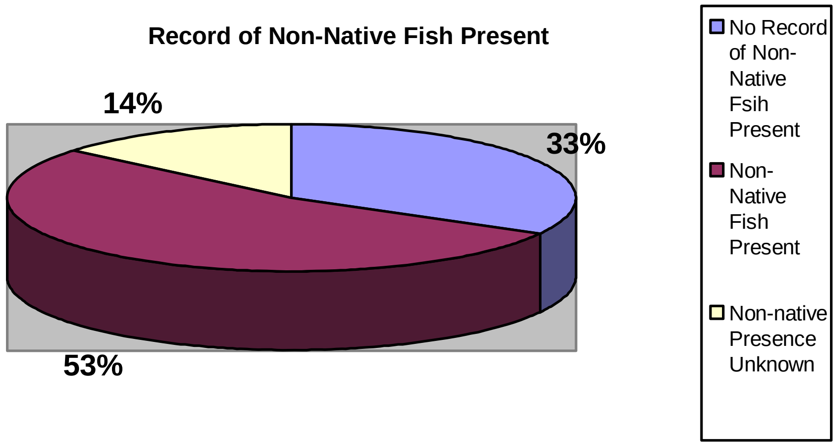

Figure 6. Information associated with the presence of non-native fish co-existing with redband trout. Percentages are based on the total amount of occupied stream habitat (kilometers).

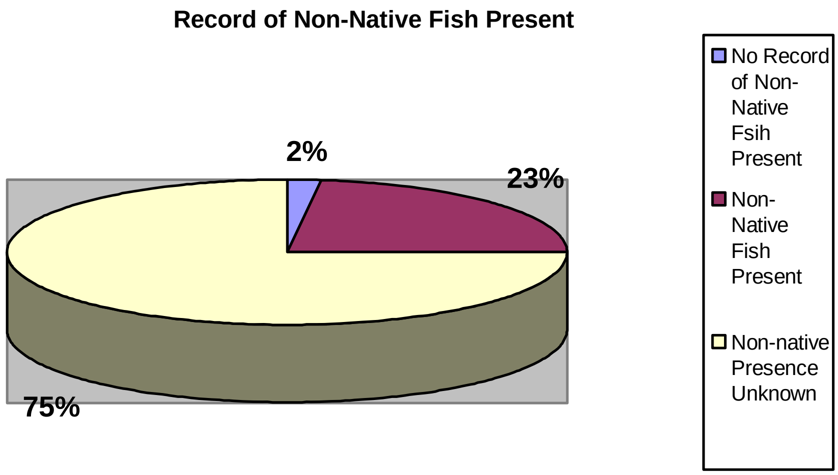

Figure 7. Information associated with the presence of non-native fish co-existing with redband trout. Percentages are based on the total amount of occupied lake habitat (hectares).

Table 10. Record of non-native fish co-existing in redband trout streams (kilometers) and lakes (hectares) within currently occupied habitats associated with the various states.

		Streams (Kilometers)				Lakes (Hectares)		
State		No Non-Native Fish	Non- Native Present	Unknown		No –Non-Native Fish	Non-Native Fish Present	Unknown
California		155	326	54		0	192	37,655
Idaho		2,379	5,485	1,064		23	31,132	153
Montana		155	631	2		7	204	0
Nevada		865	421	15		1	38	0
Oregon		4,635	4,610	1,771		469	75,042	5,225
Washington		251	2,017	559		2,551	31,764	49
Totals		8,440	13,491	3,487		3,051	138,372	43,082

<u>Current Barriers</u> There were a total of 561 barriers identified in the current distribution evaluation. The highest number of current barriers (221) identified were in Idaho and the second highest (209) were in Oregon. The remaining 131 current barriers were located as follows: Washington had 68 barriers, Montana had 28 barriers, Nevada had 19 barriers and California had 18 barriers. It is important to note that the protocol called for the identification of only those barriers believed to have a significant influence on redband distribution or population integrity. As such, the inclusion of most barriers was the result of professional judgment on the part of the biologists. Current barriers were identified based on barrier type and nature of fish passage blockage (Tables 11 and 12).

Table 11. Current barrier types for the states supporting current distributions of redband trout. Expressed as number of barriers.

Barrier Type	California	Idaho	Montana	Nevada	Oregon	Washington	Total
Beaver Dam		1					
Culvert	4	142	15	1	58	48	268
Debris					1	3	4
Fish Culture Facility		1					1
Insufficient Flow	1	3			5	2	11
Man-made Dam (Temporary)	1						1
Man-made Dam	4	38	3	6	90	15	158
Temperature					1		1
Velocity		5	2		3		10
Waterfall	1	13	6	2	13		35
Unknown		1			2		
Total	18	221	26	19	209	68	561

Table 12. The nature of barrier blockage for the states supporting current distributions of redband trout. Expressed as number of barriers.

Blockage	California	Idaho	Montana	Nevada	Oregon	Washington	Total
Complete	7	201	14	13	154	47	436
Partialt	8	18	11	3	44	13	97
Unknown	3	2	1	3	11	8	28
Total	18	221	26	19	209	68	561

<u>Conservation Populations</u>

In 2012, there were 210 populations of redband trout considered to be conservation populations as defined in the status protocol. As such, conservation populations represent a combination of mapping segments (lake and stream) that when combined represent a discrete conservation unit for redband trout. Within each conservation population, it was assumed that there was the potential for genetic exchange at a frequency adequate to minimize the risks of inbreeding and to maintain genetic variation (Rieman and Allendorf 2001). Within a given conservation population the exchange of genetic material could not be obstructed by a complete passage barrier. Each conservation population was believed to be an intact, separate entity. These 210 conservation populations occupied approximately 15,252 kilometers of stream habitat (60% of the currently occupied Stream habitat) and 95,158 hectares of lake habitats (approximately 52% of the currently occupied lake habitat). One conservation population occupied only lake habitat. Several occupied both stream and lake habitats. Most occupied only stream habitats. Conservation populations were found within 56 of the 69 HUC's that supported the current distribution of redband trout. The number of conservation populations within each HUC ranged from 1 to 16 populations. In several instances, conservation populations occupied portions of more than one HUC and/or occurred in more than one state. A visual display of conservation populations overlain on the current distribution map is found in Figure 8.

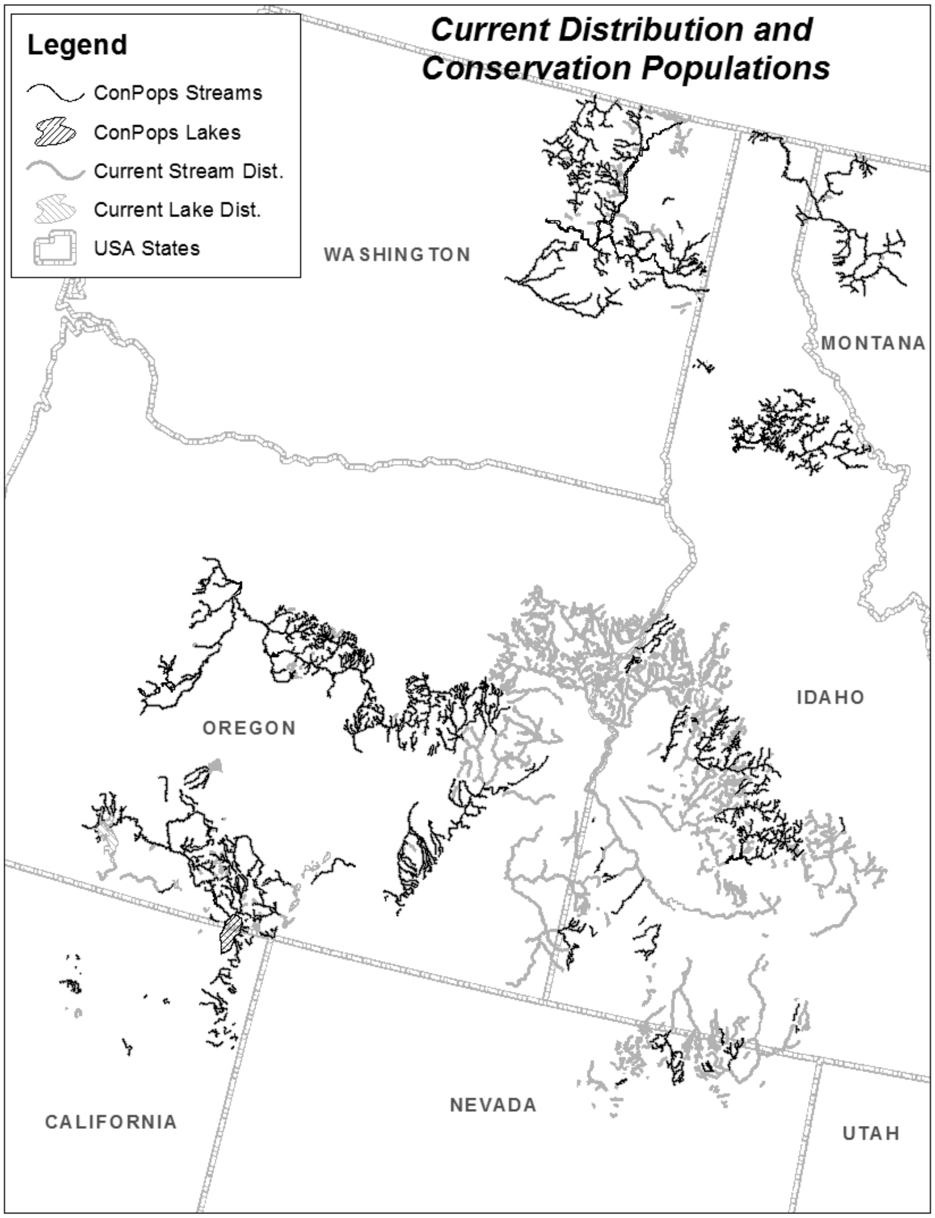

Figure 8. Distributional map of redband trout conservation populations (dark) over laying the current distribution coverage (light) determined in 2012.

A review of the individual conservation populations indicated that redband trout conservation populations occupied an average of 72.6 kilometers of stream (median of 18.8 kilometers) and 453 hectares of lake habitats. Occupied stream length ranged from 0.1 to 1,279 kilometers of habitat. Partitioning of the conservation populations into stream length groupings revealed that the largest grouping (68 populations) occupied stream habitats of less than 10 kilometers. The next largest number of populations (61 populations) occupied stream habitats of from 10 to 29.9 kilometers. The remaining groupings were as follows: 46 populations occupying 30 to 99.9 kilometers of stream; 17 populations occupying 100 to 249.9 kilometers of stream; 11 populations occupying 250 to 499.9 kilometers of stream; and, 8 populations occupying more than 500 kilometers of stream (Figure 9).

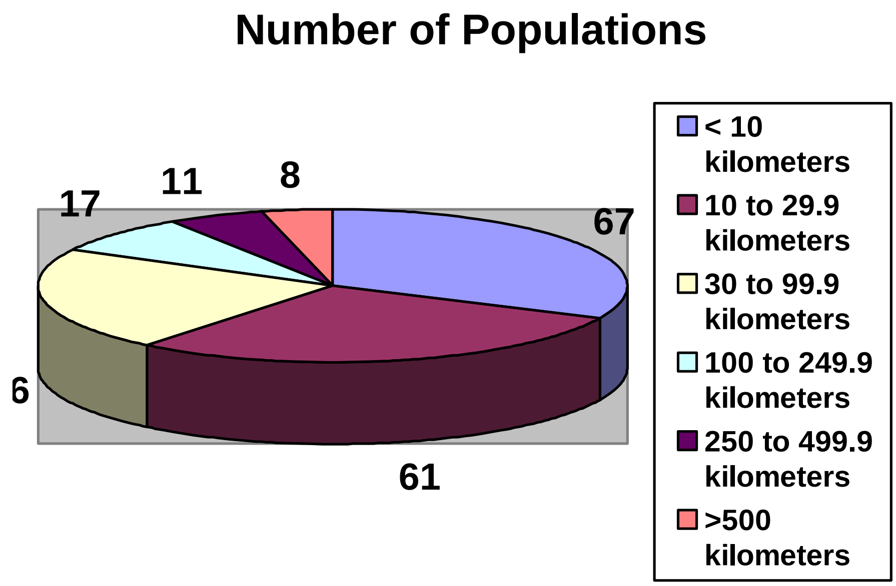

Figure 9. Partitioning of conservation populations based on the length of habitat occupied.

The amount of stream and lake habitat occupied by redband trout conservation populations in California were 513 kilometers and 37,847 hectares, respectively. In Idaho there were 4,042 kilimeters and 8,501 hectares occupied by redband populations. Montana had 771 kilometers and 121 hectares of habitat occupied. Nevada had 339 kilometers of habitat occupied. Nevada had no lake environments with conservation populations. Oregon had the largest amount of stream habitat (7,090 kilometers) and there were 14,899 hectares occupied by redband trout conservation populations. Washington had the largest amount of lake habitat (33,789 hectares) and there were 2,417 kilometers of stream habitat occupied by redband trout (Table 13).

Table 13 Amount of habitat occupied by conservation population for each state in 2012.

		Streams			Lakes	
State		Kilometers	Percentage		Hectares	Percentage
California		513	3%		37,847	40%
Idaho		4,042	27%		8,501	9%
Montana		771	5%		121	<1%
Nevada		399	3%		0	
Oregon		7,090	45%		14,899	15
Washington		2,417	16%		33,789	36
Totals		15,254			95,158	

Conservation Population Qualifier   For each population, a specific determination was made identifying the paramount reason for their inclusion as a conservation population. Core conservation populations were those with the highest potential of being genetically unaltered[5]. They represented redband trout populations that had been genetically tested and found to be unaltered (less than 1% variant genes) or where testing had not been completed and there were no records of stocking of hybridizing fish and there were no hybridizing fish associated with the population. Other classifications included populations having a unique life history (e.g. fluvial, ad-fluvial, ad-fluvial-lacustrine or lacustrine outlet spawning), or populations with known or probable ecological adaptations, or populations having a predisposition for large size or unique coloration. The conservation population qualification also included populations that functioned as a mixed stock of genetically introgressed and non-introgressed sub-populations. There was also an "other" category that represented populations of redband trout where reasons for inclusion were based on something other than those previously mentioned. An example would be a population where there is uncertainty in the genetic makeup but there was an interest in managing that population under a conservation focus until the genetics of the situation is better understood.

Of the 210 redband trout populations, 49 populations (23%) were identified as core conservation populations The other conservation population categories included 24 populations (11%) identified as having a unique environmental adaptation, 1 population located in the upper Pit River drainage was identified as having unique coloration and spotting similar to cutthroat trout, 48 populations (23%) were included based on life histories, 33 populations (16%) were included based on mixed genetics, and 55 populations (26%) were placed in the "other" category.

Nature of Habitat Networks   Another attribute of importance was the nature of the habitat network associated with each conservation population. Strongly networked populations were those that occupied habitats associated with more than 5 streams (some stream systems may have included lake habitats) with open, unobstructed migration corridors. Redband trout in any individual stream may be considered as a sub-population within the overall population. At the other end of the network spectrum were those populations that occupied habitats in a single stream or even a segment of stream. As such these non-networked populations functioned as independent entities with no interaction with other populations or sub-populations.

There were 51 (24%) strongly networked redband trout conservation populations identified in 2012. Even though, strongly networked populations made a fairly low percentage of the total number of populations, they occupied the greatest amount of habitat (11,380 kilometers; or about 75%). Table 14 provides information on the breakdown of habitat networks for all conservation populations.

[5] See 2000. Cutthroat Trout Management: A Position Paper, Genetic Considerations Associated with Cutthroat Trout Management.

Table 14 Habitat network information for the 210 redband trout conservation populations identified.

Nature of Habitat Network	Number of Conservation Populations (%)	Kilometers of Occupied Habitat (%)
Strongly Networked	51 (8%)	11,380 (75%)
Moderately Networked	30 (14%)	1,335 (9%)
Weakly Networked	45 (22%)	1,397 (9%)
Non-Networked	84 (40%)	1,141 (7%)
Totals	210	15,252

<u>Genetic Risk Evaluation</u> Each of the 210 redband trout conservation populations were evaluated for risks associated with genetic contamination and catastrophic diseases. These evaluations rated the risks based primarily on the distance the conservation population was removed from a contamination source. The presence of a complete passage barrier also increased the protection to each population.

Genetic stability was ranked from 1 to 4 with a 1 representing the most secure situation (i.e. potentially hybridizing fish cannot interact with a redband trout population because a complete passage barrier is in place or hybridizing fish are not present in the same or any adjacent drainages). The opposite end of the ranking would be a 4 which reflected the least secure situation due to hybridizing fish being sympatric with redband trout. A genetic risk ranking was not completed on 24 redband trout populations and they were placed in an unknown category.

The number of redband trout conservation populations judged as having no risk of genetic alteration was 75 populations (36%). There were 16 population (8%) rated as having a low risk of genetic contamination. Sixty one populations (29%) were rated as being at moderate risk. There 34 populations (16%) known to occupy habitats where redband trout co-existed with hybridizing species (Table 15.).

Table 15. Genetic risk ratings for the 210 redband trout conservation populations.

Nature of Genetic Risk	Number of Conservation Populations (%)	Kilometers of Occupied Habitat (%)
No Risk	75 (36%)	2,519 (17%)
Low Risk	16 (8%)	1,430 (10%)
Moderate Risk	61 (29%)	3,869 (25%)
High Risk	34 (16%)	6,754 (44%)
Totals	210	15,252

Disease Risk Evaluation The results of the disease risk evaluation completed in 2012 are presented in Table 16. The number of redband trout conservation populations judged as being at limited risk from serious diseases was 137 populations (65% of total populations). Th next highest number of redband trout populations was 57 and risk of disease was identified as unknown. The complete results of the disease risk assessment are presented in Table 16. It should be noted that there were no populations identified as being at high risk as a result of co-existing with known diseased fish.

Table 16. Disease risk ratings for the 210 redband trout conservation populations.

Nature of Genetic Risk	Number of Conservation Populations (%)	Kilometers of Occupied Habitat
Limited Risk	137 (65%)	8,943
Minimal Risk	11 (5%)	1,568
Moderate Risk	5 (2%)	3,869
Unknown Risk	57 (28%)	6,754
Totals	210	15,252

Relative Conservation Population Health Evaluation. A generalized population health evaluation (adapted from Rieman et al. 1993) based on four indicators, viewed as being indicative of relative population health, was completed for only 68 of the 210 redband trout conservation populations (Table 17). Missing information for one or more of the health indicators for 141 populations made it impractical to complete the relative health evaluation for those conservation populations. A relative health evaluation was also not completed for the single conservation population occupying only lake habitat. Components of the health evaluation included: 1. temporal variability associated the amount of occupied stream habitat as an indicator of potential resiliency; 2. population size of sexually mature adults (≥15cm or larger) as a course estimator of effective population size; 3. population production potential based on habitat quality and presence of non-native competitive fish; and, 4. degree of habitat connectedness based on the nature of the stream network associated with each population. These indicators of general health were analyzed individually and as a composite based on a weighted formula.[6] It is important to note that individual health indicators and the composite rating for these indicators do not represent absolutes in terms of definitive population health. Rather they are presented as a relative indicator of general health much like a physician's general physical exam or a general health screening.

Table 17. Relative population health ratings by individual health component rating and by overall composite rating.

	Population Health by Number of Populations				Population Health by Kilometers of Stream Occupied			
Relative Health Factor	High	Moderately High	Moderately Low	Low	High	Moderately High	Moderately Low	Low
Temporal	11	15	26	16	1,425	673	446	72
Population Size	25	17	21	5	1,800	610	198	8
Production Potential	12	55	1	0	216	2382	18	0
Network	15	8	12	33	1,315	421	285	595
Composite Score	15	33	19	1	1,537	945	132	2

Relative Health Component Results. Temporal variability addresses how stochastic events might influence a whole population by tracking the total length of habitat occupied by each conservation population. The assumption is that larger habitat patch sizes will be less likely to be in synchrony with regard to stochastic, and to some extent deterministic, events and influences. Inclusion of lake environments within the occupied habitat was also factored into a population's resistance to stochastic influences. Twenty six populations (38%) had either high (11 populations) or moderately high (15 populations) ratings for temporal variability. The same number of populations had a moderately low temporal variability rating. Only 16 populations had a low rating for temporal variability.

There were 42 populations that had redband numbers sufficient to put them into the high to moderately high health rankings. Twenty one populations were rated as having a moderately low score due to low population numbers. Only 5 populations received a low health rating for population health. Production potential was viewed as being the most important health factor for most redband trout populations. High quality habitat and lack of competitor species greatly improves a population's ability to withstand many stochastic and deterministic influences. For the redband populations reviewed, 68 were

[6] Personal communication with Dr. Danny Lee, systems analyst, Fisheries Research,, USDA-Forest Service. Initial correspondence in 1998 with follow up validation 2008.

rated as having either a high production potential score (12 populations) or a moderately high (55 populations) production potential score. The remaining population had a moderately low rating for production potential. The final population health attribute utilized in the relative health score was associated with the degree and/or the complexity of habitat networks. For the purposes of this redband trout assessment, habitat networks were linked to the number of streams that provided habitat for a given population. Twenty three populations had either a high rating (15 populations) or a moderately high health rating (8 populations) based on having four or more occupied streams. Most of the populations (45), however, had lower health scores as a result of occupying only 1 to 2 streams.

When the individual health attributes were combined into a composite score (Figure 10.) the results indicated that 48 (71%) populations had either a high composite rating (15 populations) or moderately high composite rating (33 populations). Nineteen (19) of the remaining populations had a moderately low composite score. Only one population had a low composite score.

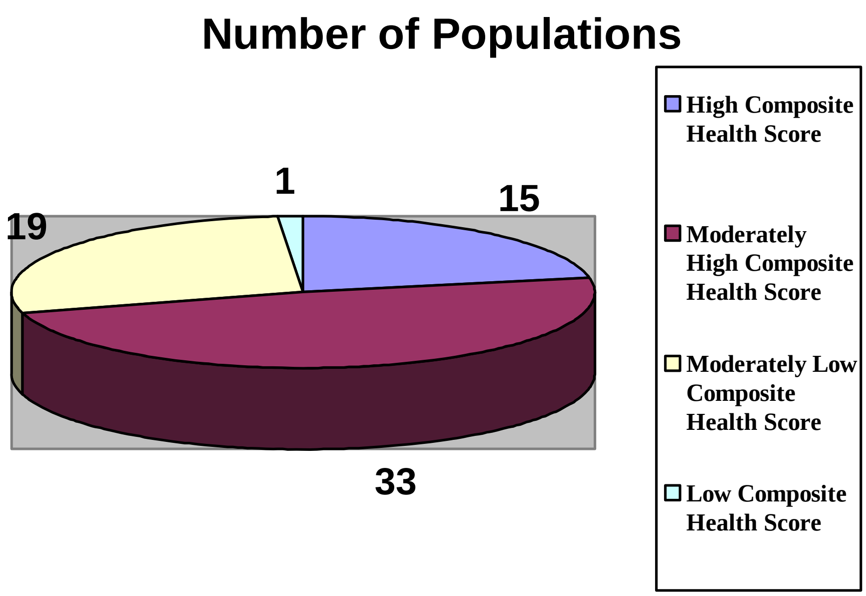

Figure 10. Composite relative health scores for 68 populations of redband trout.

Conclusions

The intent of this 2012 status update was linked to the objective of providing a better and more uniform assessment of the status of non-anadromous redband trout across the entire distributional area. This was a major effort involving numerous biologists and data base technicians. Redband trout information was collected at 13 workshops, each convened to analyze a specific set of 4th level watersheds (HUC's) In total, 69 watersheds were reviewed and specific redband trout status information was obtained and entered into a geo-referenced database. A second effort planned to address watersheds supporting habitat for anadromous redband trout will be completed in the future. When the entire redband trout status effort is complete, the effort will have reviewed nearly 120 HUCs, involved upwards of 150 biologists and data entry personnel and convened in up to 25 workshops. As a result of this first effort, a database has been established that contains nearly 109,000 GIS records and almost 96,000 attribute records. This report provides an initial summary of information contained in the database. To complement this abbreviated report and to make fuller use of the ArcGIS database, it is recommended that other "peer reviewed" publications be developed.

Historical Perspective. The historical perspective of redband trout distribution within the analysis area was anchored to a historical date of approximately the year 1800. The choice of this date was used to develop a historical perspective that was the time period when colonization of the western landscape, by European explorers, was about to begin. This time period allowed for a more realistic and comparable view of how redband trout distributions may have changed over a more contemporary time period. While it is hard to determine exactly what the historical distribution of redband trout could have been in the year 1800, it is probable that making comparisons between now and 200 years ago provide a clearer picture and prove much easier when making comparisons that extend back 1,000 or more years age. The results of the historical determination produced a picture that identified 60,295 kilometers of stream habitats and 53,251 hectares of lake environments reasonably believed to have been historically occupied by redband trout. The amounts and locations of historical occupancy for redband trout may change as more thought is given to the subject and more information becomes available.

Current Distribution. A review of the current status information for redband trout provides a quintessential example of the "glass half full or glass half empty" conundrum. Redband trout were identified as currently occupying stream and/or lake habitats in all 69 watersheds that were analyzed. This extent of current redband trout distribution, by watershed, was the same as that determined for the historical distribution. This judgment could support a "glass half full" view point. There was, however, a substantial difference in the amounts of occupied habitat (both stream and lake) when comparing occupied kilometers and hectares. Historical occupancy stream habitat was estimated at 60,295 kilometers while the currently occupied stream length was 25,417 kilometers. This reflects a 42% reduction in occupied stream habitat. Just the opposite determination was made for occupied lake environments. The historic projection of 53,251 hectares was approximately 29% of the amount of lake habitat (184,504 hectares) identified as being currently occupied.

The most probable explanation for the difference in the lower amount of stream habitat, currently occupied by redband trout, could have been related to competition with introduced non-native fish and/or probable habitat changes that could have been detrimental to redband trout. Non-native fish were identified in 53% of the occupied stream habitat. There was an additional 14% of occupied stream habitat where the introduction of non-native fish was uncertain. It is very possible that non-native fish do co-exist with redband trout in some of these waters. The status assessment only addressed stocking within the context of occupied habitat and did not address stocking within the context of what was believed to have been historically occupied. It is probable that introduced non-native fish could have been responsible for elimination of redband trout from some historical waters. With regard to possible habitat changes that might have been detrimental to redband trout, there was a substantial amount of currently occupied stream habitat that was judged to be in fair to poor condition (52%). Here again, the assessment did not address habitat conditions associated with the historical distribution. It is possible that poor stream habitat conditions could have created conditions completely unsuitable to redband trout or provided conditions that favored non-native fish to the exclusion of redband trout. These conditions could contribute to a "glass half empty" point of view.

With regard to redband trout adult densities in stream environments, redband numbers appeared to be robust enough to meet minimum population maintenance requirements in most situations. The 0 to 35 fish/kilometer density range accounted for 36% of occupied stream length. The next largest density range (36 to 100 fish/kilometer) accounted for an additional 12% of stream length. When redband trout densities were converted into probable adult numbers, more that 62% of the populations were judged to meet population maintenance levels. These conditions could contribute to a "glass half full" point of view. The fact that redband density was not identified for 40% of occupied stream habitats contributes to the converse argument supporting a "glass half empty" view point.

The relatively limited amount of genetic testing that had been completed makes generalities regarding the genetic status for redband trout difficult at best and highly speculative. Oregon has obtained a considerable number of tissue samples that are currently not tested. As these and other samples are collected and analyzed, a more definitive picture of genetic status should materialize. Until more information becomes available it would be unwise to draw specific conclusions regarding redband trout genetic status. With regard to possible genetic risks associated with past stocking of genetically contaminating species or the presence of contaminating species co-existing with redband trout, 45% of conservations population were viewed as being at moderate (29%) to high (16%) genetic risk.

<u>Conservation Populations.</u> A total of 210 discrete conservation populations were identified in the 2012 effort. These populations occupied in 60% of the total stream

length and 52% of the lake habitat (total surface area) identified as being currently occupied by redband trout. Conservation populations were identified in 56 of the 69 watersheds analyzed. The range of populations per watershed was 1 to 16. Forty nine conservation populations (core populations) were linked to having either known unmodified genetics or having a high potential of unmodified genetics, because there was no record of contaminating fish stocking in the redband habitat and there were no contaminating fish co-existing with the redband trout. Other population qualifiers were applied to the remaining 161 populations. A single population was identified as having a unique coloration and spotting pattern similar to cutthroat trout. Other populations (24) were linked to an environment adaptation. The primary adaptation was associated with a tolerance to a specific myxosporean parasite (*Ceratomyxa shasta*). A second adaptation was a perceived tolerance to higher water temperatures than most other trout. This tolerance to higher temperatures was not validated in laboratory experiments on redband trout. Conservation population qualifiers were used to provide a rationale associated with the primary conservation focus to be applied to each population. The number of conservation populations identified (210) and the number of watersheds occupied with one or more conservation populations (56) provides hope for the long term persistence of redband trout.

To better evaluate the probable persistence of redband trout, a relative health evaluation was completed on 68 of the 210 populations. The relative health review was based on conditions related to four factors that included the amount of habitat occupied (stream length only), the number of adult redband trout in the population, the production potential of the population based on habitat quality and whether non-native competitive species co-existed with the redband population, and nature of the habitat network (number of streams) associated with the population. Relative importance weights were applied to the individual factors and then the results were combined into a composite score for each population. Given that 71% of the populations were rated as having a high or moderately high relative health score, there is reason to be optimistic for redband persistence. Caution, however, should be applied to any optimistic view point before jumping to the conclusion that "all is well in the redband trout world". It was clear that many of the redband trout habitats as located in very arid geographic areas that are quite prone of dry climatic periods. During these dry periods stream desiccation has been a common event. Based on comments made during the workshops, several instances were identified where redband trout were located in isolated pools that existed in otherwise dry stream channels. Apparently redband trout have been exposed to these harsh conditions many times and have developed compensating behaviors necessary for survival.

It is imperative that long-term conservation and management of redband trout be conducted in a coordinated and comprehensive manner. Individual agency autonomy must give way to structured coordination in order to more efficiently and effectively ensure the long-term persistence of redband trout.

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References

Ashbrook, C., M. Mizell, A. Agun., S. Sears, C. Butler, and D. Pavlik-Kunkel. 2009. Final report for redband trout status and evaluation project. WNTI Project Number RTSPE2008-2. 35 pp.

Bartholomew, J. L. 1998. Host resistance to infection by the myxosporean parasite *Ceratomyxa Shasta*: a review. Journal of Aquatic Anima Health. 10: 112-120.

Behnke, R. J. 1992. Native trout of Western North America. American Fisheries Society, Monograph 6, Bethesda, Maryland.

Behnke, R. J. 2002. Trout and salmon of North America. The Free Press. 359 pp.

Cassinelli, J. 2007. Effects of water temperature on growth and physiology of redband trout (Oncorhynchus mykiss gairderni) from selected Idaho streams. Master's Thesis, University of Idaho, Moscow, Idaho. 135 pp.

Hilderbrand, R. H., and J. L. Kershner. 2000. Conserving inland cutthroat trout in small streams: how much stream is enough? North American Journal of Fisheries Management 20:513-520.

Meyer, K. A.,J. A. Lamansky Jr., and D. J. Schill. 2010. Biotic and abiotic factors related to redband trout occurrence and abundance in desert and montane streams. Western North American Naturalist. 70(1): 77-91

Neville, H. M. and J. B. Dunham. 2011. Patterns of hybridization of of nonnative cutthroat trout and hatchery rainbow trout wit native redband trout in the Boise River, Idaho. North American Journal of Fisheries Management. 31: 1163 -1176.

Rieman, B., D. Lee, J. McIntyre, K. Overton, and R. Thurow. 1993. Consideration of extinction risks for salmonids. FHR Currents, Fish Habitat Relationships, Technical Bulletin 14 December. USDA Forest Service, Boise, Idaho.

Rieman, B.E. and F.W. Allendorf. 2001. Effective population size and genetic conservation criteria for Bull trout. North American Journal of Fisheries Management 21:756-764.

Thurow, R. F., B. E. Rieman, D. C. Lee, P. J. Howell, and R. D. Perkinson. 2007. Distribution and status of redband trout in the interior Coumbia River Basin and portions of the Klamath River and Great Basins. In: Redband Trout: Resilience and Challenge in a Changing Landscape. Oregon Chapter, American Fisheries Society. pp 28-46.

Soellick, B. W. and B. S. Cade. 2006. Evaluating redband trout habitat in sagebrush desert basins in southwestern Idaho. North American Journal of Fisheries Management 26: 268-281.