Upper Klamath Basin Redband Trout

Existing Populations

The Klamath River basin consists of discrete upper and lower segments separated near Klamath Falls. The lower portion of the basin resembles fish fauna assemblages of Rogue River and other coastal streams. The upper portion is characterized by a fish assemblage typical of other interior basins and is distinct from the lower river (Minckley et al. 1986). The Upper Klamath Lake basin contains the remnants of Pleistocene Lake Modoc, which redband trout likely invaded from interior connections (Behnke 1992). Lake Modoc eventually drained when it cut an outlet to the Pacific Ocean. Coastal steelhead trout are native to Klamath River and migrated into Upper Klamath Lake until 1917 when the construction of Copco Dam blocked fish passage. The steelhead trout in Klamath River are genetically and morphologically distinct from the native redband trout in Upper Klamath Lake (Behnke 1992). Currently, the Upper Klamath Lake basin supports the largest and most functional adfluvial redband trout populations of Oregon interior basins.

The Upper Klamath Basin Redband Trout SMU is comprised of ten populations. These populations are highly variable in regard to genetics, life history, and disease resistance, and appear to share little gene flow among populations in spite of proximity and absence of physical barriers (Buchanan et al. 1994). However, the population structure of the upper Klamath Basin is still uncertain. Redband trout populations are identified based on genetic and life history studies (Buchanan et al 1994), current ODFW management plans (Fortune 1997), and review by ODFW Staff (Table 1). The population structure, as defined in this review, is not definitive, but reflects populations as they are currently managed. Additional genetic analysis and life history studies are necessary to better define populations.

Table 1. Description, existence status, and life history of redband trout populations in the Upper Klamath Basin SMU.

Exist	Population	Description	Life history
Yes	Jenny	Jenny Creek above falls and tributaries.	Resident
Yes	Klamath River	Klamath River and tributaries below Link River Dam; includes Spencer Creek.	Resident/Migratory
Yes	Cascade Complex	Cherry, Sevenmile, Rock, Nanny, Threemile, Moss, Denny and Fourmile creeks and tributaries.	Resident/Migratory
Yes	Wood River	Wood River and tributaries including Annie, Sun, Fort, Crooked and Agency creeks.	Resident/Migratory
Yes	Lower Williamson	Lower Williamson River up to falls, including Spring, Larkin, and Sunnybrook creeks and Kirk Springs.	Resident/Migratory
Yes	Upper Williamson	Williamson River above falls & tributaries including Klamath Marsh.	Resident
Yes	Lower Sprague	Lower Sycan River up to Sycan Marsh and Sprague River up to the Forks.	Resident/Migratory
Yes	Upper Sycan	Streams above Sycan Marsh outlet.	Resident/Migratory
Yes	Upper Sprague	N.F. and S.F. Sprague River and tributaries.	Resident/Migratory
Yes	Lost River	Lost River including Miller and Rock creeks, Gerber Reservoir and tributaries.	Resident/Migratory

Redband trout in individual streams of the Cascade Complex population may prove to be separate populations. Irrigation diversions and habitat degradation in the lower reaches likely

prevent movement among streams, limiting the ability of fish in these streams to function as a single population. Redband trout in the streams of the Cascade Complex are treated as one population, however, if isolating factors persist then the population may need to be re-defined.

Redband trout in the Upper Sycan and Upper Sprague rivers show unique allozyme characteristics, which suggest they are more closely related to redband trout in Jenny and Upper Williamson, than those in the Lower Sprague (Buchanan et al. 1994). Based on these findings the Upper Sycan and Upper Sprague are considered separate populations, however further genetic research is necessary to more accurately delineate populations in the Sprague River basin. Passage to and from the Upper Klamath Lake is possible and has been documented for redband trout and shortnose sucker (R. Smith, ODFW Klamath District Office, pers. comm.).

Distribution

Redband trout in the Upper Klamath Basin are widely distributed throughout the watershed. Trout are present in the major tributaries of Upper Klamath and Agency lakes and in headwater streams in the Gearhart and Cascade mountains. Connectivity between most populations is likely with habitable water conditions in the lakes and adequate flow over irrigation diversions in the lower reaches of many rivers.

Oregon Basin redband trout populations pass the distribution criterion if they satisfy two of three metrics – the current distribution must 1) occupy >10% of the total stream distance in the populations basin, 2) total more than ten km (six miles), or 3) be connected to other populations. The redband trout SMUs are quantitatively evaluated based on a 1:100,000 GIS hydrography of redband trout distribution. Similar GIS data for Upper Klamath Basin do not exist. Current knowledge of distribution in the Upper Klamath Basin includes rivers, streams, and tributaries where redband trout are present but does not define upper and lower limits, therefore quantitative analysis of distribution is not possible. Instead, Upper Klamath Basin redband trout populations are assessed based on professional judgment and knowledge of Klamath Basin geography. A population passes the criterion if year-round distribution is thought to be greater than ten km and is not isolated from other populations. Although this metric is not as rigorous as those used in the other Oregon basin redband trout SMUs, it provides a similar and adequate assessment of the interim criteria and identifies populations where distribution is drastically constricted. Four populations; Jenny, Cascade Complex, Upper Williamson, and Lost River, fail the distribution criterion (Table 2).

Table 2. Status evaluation of the distribution criterion for redband trout populations in the Upper Klamath Basin SMU.

Population	Greater than 10 km	Connected to Other Pops.	Pass/Fail
Jenny	Yes	No	Fail
Klamath River	Yes	Yes	Pass
Cascade Complex	No	Yes	Fail
Wood	Yes	Yes	Pass
Lower Williamson	Yes	Yes	Pass
Upper Williamson	Yes	No	Fail
Lower Sprague	Yes	Yes	Pass
Upper Sycan	Yes	Yes	Pass
Upper Sprague	Yes	Yes	Pass
Lost River	No	No	Fail

Jenny Creek and the Upper Williamson River are isolated by natural barrier falls and fail the distribution criterion. Both populations are unable to mix with other populations prohibiting gene flow and genetic mixing, and increasing risk of extinction due to inbreeding and genetic drift if populations become very small.

Redband trout distribution in Lost River is not well documented or understood. The presence of redband trout appears to be dramatically impacted by habitat degradation and water withdrawal. Redband trout may only exist in a few locations, including Miller Creek where flow is subject to the operation of Gerber Reservoir and may go dry in fall and winter (Smith and Messmer 2001). The Lost River population fails the criterion until distribution can be better documented.

Redband trout distribution in the Cascade Complex is highly fragmented. The total stream distance occupied by redband trout in the complex is thought to be less than ten km. (R. Smith, ODFW Klamath District Office, pers. comm.). In addition some streams in the complex lack regular connection to Klamath Lake and other populations. This population fails the distribution criterion.

The Klamath River population is impacted by three large dams and associated impoundments. Very few fish have been documented moving through fish ladders at each dam. Adult redband trout passage over the J.C. Boyle Dam has declined dramatically over the past 50 years. In 1959 5,529 redband trout moved over the J.C. Boyle Dam; 70 redband trout passed the dam in 1991 (Buchanan 1992). Water quality within the impoundments is poor during the summer months limiting connectivity and productivity. Lake Ewauna typically is characterized by high temperatures, low dissolved oxygen, and a high pH in the summer (Smith and Messmer 2001). Even though the population passes the criterion, these factors significantly impact distribution .

Abundance

Data describing the constituent populations of the Upper Klamath Basin SMU over the past 30 years do not exist; therefore minimum abundance thresholds can not be calculated. Current data sets describing abundance vary among populations in type, consistency, and temporal and spatial extent. As a result a consistent evaluation across all populations based on one metric is not feasible. Instead populations are assessed using one of three metrics; number of spawning adults, estimated biomass, or estimated densities.

Unlike bull trout, guidelines to identify populations at risk of inbreeding and genetic drift do not exist specifically for redband trout species. Instead we relied on more general recommendations. For the purposes of this review, populations of redband trout with less than 50 adults are considered to be at risk of inbreeding depression and potential decrease in viability or reproductive fitness (Franklin 1980). Populations less than 500 adults are at risk of loss of genetic variation due to genetic drift (Franklin 1980, Soule 1980, Lande 1988, USFWS 2004). Populations with fewer than 50 adults fail the abundance criterion. The sum of interconnected populations also must exceed 500 adults to avoid the risk of genetic drift. Thus, an SMU or an isolated population must exceed 500 adults in order to pass the abundance criterion.

When available, mean density and biomass estimates are compared to density and biomass benchmarks for redband trout populations in eastern Oregon streams (Dambacher and Jones In press) (Table 3). The benchmarks were developed using the interquartile values of density from 82 samples and of biomass from 50 samples in Crooked River and Catlow Valley basin streams pre-1998. A population passes the abundance criterion if the average density or biomass is classified as ‘moderate’ or ‘high’ in three of the previous five years. Populations with a ‘low’ rating for three of the last five years fail the criterion and are warranted for further investigation.

When estimates for the last five years are not available, the criterion is applied to only those years for which data are present.

Table 3. Benchmarks of abundance for ≥ age 1+ redband trout taken from interquartile values of 82 estimates of density and 50 estimates of biomass in eastern Oregon pre-1998 (Dambacher and Jones In Press).

Abundance rating	Fish/ m^2	Grams/ m^2
Low	≤ 0.059	≤ 2.0
Moderate	0.06 - 0.19	2.1 – 4.9
High	≥ 0.20	≥ 5.0

All density and biomass estimates included in the assessment were calculated using depletion-removal methods (Zippen 1958). At a minimum, sample sites were block-netted and a two-pass removal procedure was followed with backpack electrofisher and a 50% reduction criterion between passes for age 1+ redband trout. Not all sample sites were randomly selected, therefore density estimates may not always be representative of the population. In all cases, mean estimates are an average of individual density estimates and are not extrapolated to total stream area.

Measures of density and biomass are intended to be an approximate indicator of abundance. Abundance within a population varies widely and fluctuates with water year and habitat condition. Water years 1998 and 1999 were particularly wet with above average precipitation and snowpack. Conversely, 1994 and 2003 were extremely dry years. Fluctuations in precipitation between years were considered when evaluating abundance and trends of redband trout. Low densities may be attributed to a dry year, but low densities during a wet cycle are a cause for concern.

In summary, Upper Klamath Basin populations must either exceed 50 spawning adult fish, have densities greater than 0.059 age 1+ fish/m^2, or biomass greater than 2.0 g/m^2 to pass the abundance criterion, depending on available data. The three measures are not assumed to be equivalent. We recognize these metrics are not directly comparable to the other Oregon basin redband trout SMUs, but given the available datasets for the Upper Klamath Basin, they are able to adequately identify populations of extremely limited abundance and effectively evaluate the interim criteria. Six populations pass the abundance criterion (Table 4).

Table 4. Abundance, density, and biomass ratings for Upper Klamath Basin redband trout populations.

Population	> 50 adults	Density Rating	Biomass Rating	Pass/Fail
Jenny	--	--	--	Pass
Klamath River	Yes	Moderate	--	Pass
Cascade Complex	--	--	--	Fail
Wood	Yes	--	--	Pass
Lower Williamson	Yes	--	--	Pass
Upper Williamson	--	--	Low	Fail
Lower Sprague	--	--	Moderate/high	Pass
Upper Sycan	--	Low	Low	Fail
Upper Sprague	--	Moderate	--	Pass
Lost River	--	--	--	Fail

Abundance measures for Jenny Creek do not exist, however local biologists describe this population as abundant (Smith and Messmer 2001). Large redband trout are observed at

relatively high densities in the lower reaches (W. Tinniswood, ODFW Klamath District Office, pers. comm.). This population passes the criterion until abundance can be better addressed.

Spencer Creek is the primary spawning ground for redband trout in the Lower Klamath population. ODFW staff conduct redd surveys on Spencer Creek every year as conditions permit. Even though redd surveys do not translate into absolute number of adults present in the population, the redd counts do provide a general indication of the minimum number of fish present in the system. Redd counts in Spencer Creek averaged 113 (range = 83 - 134) between 1998 and 2004 (ODFW, Klamath District Office, unpublished data) indicating the population exceeds a minimum of 50 adults. Population surveys in Spencer Creek in 2004 documented densities of 0.148 age 1+ redband trout/m^2 (moderate) (ODFW, Klamath District Office, unpublished data). In addition, PacifiCorp biologists observed redband trout spawning in the bypass reach below J.C. Boyle dam in 2003. Based on these data the Lower Klamath population passes the abundance criterion.

Quantitative abundance data are not available for redband trout in the Cascade Complex. Redband trout in Rock Creek were thought to be non-existent in the early 1990s after seven years of drought (Buchanan 1994) and since have been reported as present in low numbers. Redband trout abundance has also been reported as low in Threemile and Sevenmile creeks. ODFW and USFS attempted to estimate density for redband trout in Sevenmile Creek in 2002 and found only two redband trout juveniles (Smith and Tinniswood 2002). However, sampling in Cherry Creek in 2004 found redband trout at moderate densities (Table 4). Given observations of extremely low abundance in most streams except Cherry Creek, the Cascade Complex population fails the abundance criterion until abundance can be fully assessed.

Assessments of both the Wood and Lower Williamson populations were based on the minimum number of adults and long term redd and adult counts. Even though redd surveys do not translate into absolute number of adults present in the population, redd counts can provide a general indication of the minimum number of fish present in the system. Redd counts in Fort Creek (Wood population) exceed at least 80 redds annually and typically are much greater (Fig 30a). Fish counts in Wood River have documented peak counts greater than 200 redband trout each year since 2001 (ODFW, Klamath District Office, unpublished data). Similarly, redd counts in Spring Creek and Lower Williamson regularly exceed 100 redds per year (Fig. 30b & c). Both populations pass the abundance criterion.

The Upper Williamson, Lower Sprague, and Upper Sycan populations are assessed based on datasets describing mean biomass (ODFW and The Nature Conservancy, Klamath District Office, unpublished data) (Table 5). Estimates collected between 1995 and 2003 at a few sites serve as an indication of abundance for each population. We recognize the limitations of these data given the inadequate temporal and spatial extent of the dataset. At both sites on the Upper Sycan and two sites in the Upper Williamson biomass measurements are consistently low. A density estimate in Long Creek (Upper Sycan) in 2004 also reflects low abundance (Table 6). Considering these data, the Upper Williamson and Upper Sycan populations fail the criterion until abundance can be thoroughly assessed. The Lower Sprague population passes the criterion.

Table 5. Biomass estimate (g/m^2 of age 1+ fish) and assessment of native redband trout in populations of the upper Klamath basin.

Population	Stream	1995	1997	1998	1999	2000	2003	Rating
Upper Williamson	Royce	0.99	1.77	0.92	0.87	0.45	--	Low
	Deep	0.49	2.01	1.04	0.40	--	--	Low
	Bull	--	5.76	2.74	--	--	--	High/Moderate
Lower Sprague	Trout	--	--	--	11.45	4.66	--	High/Moderate
Upper Sycan	Long	--	--	1.18	1.41	1.62	0.55	Low
	Sycan	--	--	--	--	1.30	--	Low

The Upper Sprague population is evaluated based on datasets describing mean density (Table 6) (ODFW, Aquatic Inventory Project and Klamath District Office, unpublished data). The dataset is limited both temporally and spatially, but for the purpose of this review is treated as indicative of population abundance. Densities are expected to fluctuate with water year and stream flow. Density of the Upper Sprague population is generally rated as moderate and the population passes the abundance criterion until abundance can be better assessed.

Table 6. Density estimate (age 1+fish/m^2) and assessment of native redband trout in populations of the upper Klamath basin.

Population	Stream	Density	Year	Rating
Cascade Complex	Cherry	0.108	2004	Moderate
Upper Sycan	Long	0.025	2004	Low
Upper Sprague	Deming	0.050	1997	Low
	Brownsworth	0.091	1995	Moderate
		0.246	2004	High
	Boulder	0.150	1992	Moderate

The abundance of redband trout in Lost River is thought to be very depressed (Smith and Messmer 2001). Abundance is greatest in Miller Creek, but is dependant on outflow from Gerber Reservoir. Redband trout are present in the tributaries of Gerber Reservoir, but there is a high likelihood these fish are hatchery origin coastal rainbow trout. The Lost River population fails the abundance criterion until abundance can be better assessed and the origin of fish in Gerber Reservoir can be properly identified.

Productivity

Data are not available to quantitatively assess potential productivity of populations of redband trout in the Upper Klamath Basin SMU. A population that is widely distributed and exhibits high densities is assumed to have minimally rebounded from past drought or disturbance events. Connectivity to a diversity of high quality habitats capable of supporting multiple life history types during extreme environmental conditions enables populations to rebound quickly. The expression of a migratory life history can produce large, highly fecund adults that further increase the intrinsic productivity. Thus, a population passes the criterion if it: 1) is connected to habitat capable of supporting multiple life histories and/or serving as refuge during periods of environment constraint, 2) expresses multiple life history strategies, 3) is widely distributed, and 4) relatively abundant. A population may also pass the criterion if data indicate an increasing or stable trend in abundance. These qualities suggest populations are resilient and minimally able to rebound rapidly after periods of low abundance. This assessment, however, does not attempt to describe the degree to which populations may rebound. A population may pass the

productivity criterion and not attain total abundance equivalent or greater than that prior to the previous low period. The presence of non-native species, hatchery fish, or significant habitat degradation may negatively affect productivity and cause a population to fail the criterion. In many populations the potential intrinsic productivity is uncertain; these populations fail the criterion until productivity can be adequately assessed.

Table 7. Factors influencing productivity of Upper Klamath Basin SMU redband trout populations.

Population	Factors	Pass/Fail
Jenny	Isolated population; adequate distribution and apparently abundant; habitat in lower reaches likely support a fluvial life history.	Pass
Lower Klamath	Adequate distribution and abundance; habitat supports a migratory life history; Spencer Creek is the only known spawning tributary; high water temperatures, poor water quality during summer months in mainstem; dams and impoundments compromise habitat condition; productivity considered below potential.	Fail
Cascade Complex	Extremely limited distribution and abundance; only periodic connection to Klamath Lake due to irrigation withdrawals and diversions; upper habitat impacted by road building and logging; limited expression of migratory life history.	Fail
Wood	Highly abundant; adequate distribution; adfluvial life history; habitat quality impacted by diversion and agricultural irrigation withdrawal; Fort Creek redd counts suggest population trend is stable (Fig. 30a).	Pass
Lower Williamson	Highly abundant; wide distribution; adfluvial life history; Spring Creek and mainstem Williamson redd counts indicate recent population trend is stable (Fig. 30b & c).	Pass
Upper Williamson	Isolated above a barrier falls; distribution adequate; abundance undocumented but likely limited; resident life history; Klamath Marsh drained and channelized, river often dry below the marsh in the summer; upper river impacted by grazing and irrigation withdrawal.	Fail
Lower Sprague	Adequate distribution and apparently abundant; adfluvial life history; habitat heavily impacted by grazing and agricultural use; limited by poor habitat quality (Smith and Messmer 2001).	Fail
Upper Sycan	Limited abundance; adequate distribution; habitat potentially capable of supporting a migratory life history; upper portion of river designated as federal Scenic River; Sycan Marsh is heavily channelized and drained to support livestock grazing; The Nature Conservancy is taking action to restore the marsh's natural function including restoring perennial flow from the marsh.	Fail
Upper Sprague	Adequate distribution and abundance; limited expression of a migratory life history; presence of brook trout and brown trout; poor habitat condition.	Fail
Lost River	Extremely limited distribution and abundance; Gerber Reservoir capable of supporting a migratory life history; habitat severely degraded; limited by stocking hatchery rainbow trout.	Fail

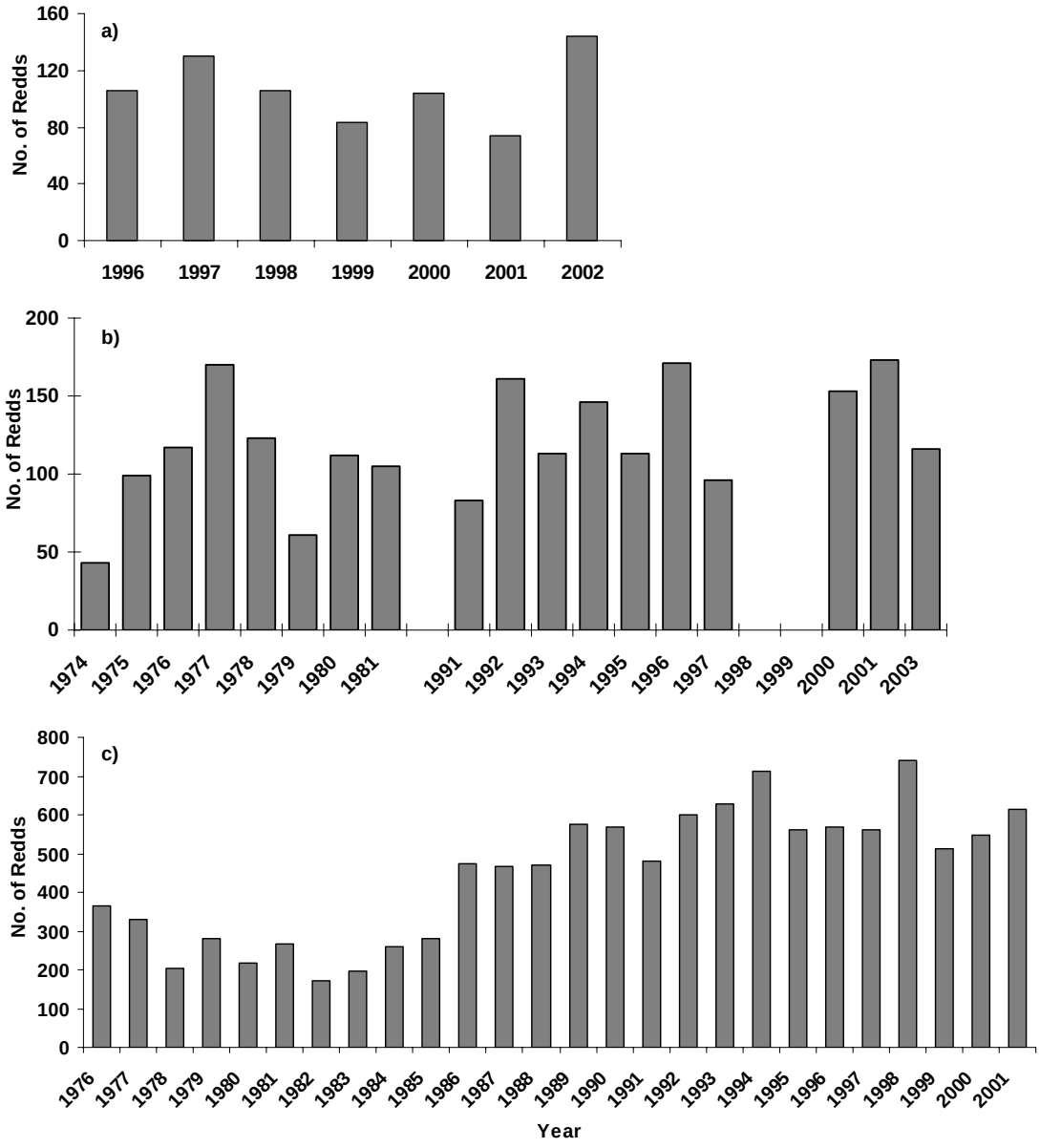

Figure 30. Redband trout redd counts in: a) Fort Creek (Wood population), b) Williamson River between Spring Creek and Pine Ridge (Lower Williamson population), and c) Spring Creek (Lower Williamson population) (ODFW Klamath District Office, unpublished data).

Reproductive Independence

Data specific to reproductive independence are not available for the Upper Klamath Basin Redband Trout SMU. Instead this review uses current and historical stocking records to evaluate the risk of hatchery origin rainbow trout to native redband trout. Planting of a coastal stock of rainbow trout in the Upper Klamath Basin began in 1925 and continues currently in some lakes and reservoirs. Planting of hatchery fish in moving waters ceased in 1991 except in Spring Creek, where stocking currently continues. Populations where hatchery rainbow trout are not currently stocked in water bodies with redband trout pass the reproductive independence criterion. Populations fail where coastal rainbow trout are currently stocked on top of redband trout or able to move into streams inhabited by native redband trout (Table 8).

Table 8. Status of hatchery rainbow trout stocking programs in Upper Klamath Basin Redband trout SMU populations (Klamath River Basin, Oregon, Fish Management Plan, 1997).

Population	Status	Pass/Fail
Jenny	Coastal rainbow trout and steelhead trout are stocked in Hyatt and Little Hyatt reservoirs and are assumed able to leave the reservoirs. Genetic analysis shows some introgression between hatchery rainbow trout and native redband trout (Buchanan et al. 1994).	Fail
Lower Klamath	No hatchery rainbow trout stocks are currently planted.	Pass
Cascade Complex	Hatchery rainbow trout stocking program ceased in 1991.	Pass
Wood	Hatchery rainbow trout stocking program ceased in 1991.	Pass
Lower Williamson	No hatchery rainbow trout stocked in Upper Klamath and Agency lakes since 1979. Spring Creek currently stocked with rainbow trout susceptible to *C. shasta* which are assumed to not survive to spawn with native redband trout. This assumption should be verified with genetic analysis and monitoring activities.	Pass
Upper Williamson	No hatchery rainbow trout planted since 1930.	Pass
Lower Sprague	No hatchery rainbow trout stocks currently planted.	Pass
Upper Sycan	No hatchery rainbow trout stocks currently planted.	Pass
Upper Sprague	No hatchery rainbow trout stocks currently planted.	Pass
Lost River	Not currently stocked, but have been stocked intensely in the past. The impact of stocking is undetermined and it is unknown if native redband trout still exist in tributaries of Gerber Reservoir.	Pass

Hybridization

Non-native cutthroat trout are not present in the Upper Klamath Basin Redband Trout SMU. All populations pass the hybridization criterion.

Assessment Conclusions

The Upper Klamath Lake basin contains the remnants of Pleistocene Lake Modoc, which redband trout may have entered from interior connections. Currently, the Upper Klamath Lake basin supports the largest and most functional adfluvial redband trout populations of Oregon interior basins, however, some populations are severely limited in distribution and abundance by habitat quality and non-native species. The SMU is comprised of ten populations that vary in life history, genetics, disease resistance, and status. Eighty percent of the populations meet three of the six interim criteria, thereby classifying this SMU as 'at risk' (Figure 1). Limited data sets and inferences from other information for populations in this SMU provide a qualified level of confidence in the assessment of the interim criteria.

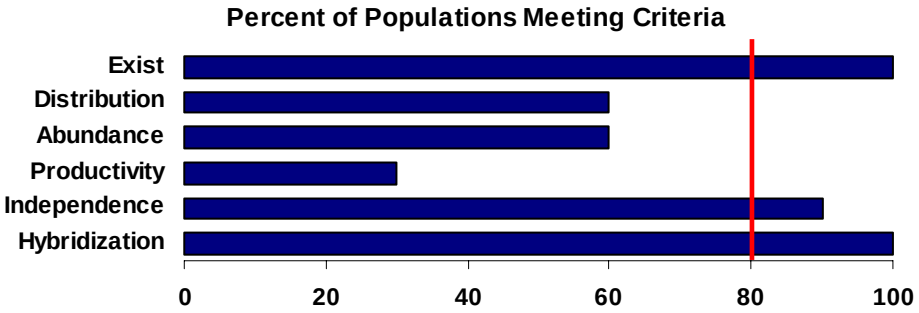

Figure 1. Assessment outcome for each of the six interim criteria with respect to the 80% threshold identified by the NFCP.