GOOSE LAKE REDBAND TROUT
***Oncorhynchus mykiss* ssp.**

Status: Moderate Concern. While Goose Lake redband trout do not face immediate extinction risk, California populations are not entirely secure because they are largely isolated from one other, most are small, and, during drought periods, the lake population disappears and stream populations contract.

Description: Goose Lake redband trout are similar in appearance to other rainbow/redband trout. Their bodies are a yellowish to orange color with a brick-red lateral stripe. The dorsal, anal, and pelvic fins are white-tipped. Stream-dwelling adults retain parr marks, while lake-dwelling adults become silvery-grey in color. The Goose Lake redband trout has two ecological types: a lake-dwelling form that attains lengths of 45-50 cm TL and a stream-dwelling form that rarely grows larger than 25 cm TL. Behnke (1992) examined six specimens collected by J. O. Snyder in 1904 from Cottonwood Creek, in the Oregon portion of the basin. These fish had 21-24 (mean, 23) gill rakers, 61-64 (mean, 63) vertebrae, and averaged 30 scale rows above the lateral line and 139 scales in the lateral series. See Behnke (2002) for color plates of both lake and stream forms.

Taxonomic Relationships: Redband trout are inland forms of rainbow trout (Behnke 1992, 2002) and the Goose Lake redband belongs in the group that Behnke (2002) calls "redband trout of the northern Great Basin." The Goose Lake redband trout is most similar to redband trout of two adjacent basins: the Warner Basin, California, Oregon and Nevada, and the Chewaucan Basin, Oregon (Behnke 2002). This conclusion is based on the lower vertebral counts and higher gill-raker counts of redband trout in these basins and distinct genetic markers (Behnke 2002). The Goose Lake redband trout has not been assigned a subspecific name but Behnke (2002) suggests that Goose Lake redband trout, along with various redband trout populations in isolated Oregon basins, should be placed together in *O. mykiss newberrii*. Berg (1987), using electrophoretic techniques, indicated that Goose Lake redband trout were distinctive enough genetically to warrant subspecies status, although more recent work using DNA (amplified fragment length polymorphism AFLP technique) indicates a close relationship with Warner Valley redband trout (M. Stephens 2007). Simmons (2011), using both mitochondrial and nuclear DNA, found that redband trout from the upper Pit watershed, including Goose Lake, formed a distinctive lineage. No genetic differences between the lake and stream forms in the Goose Lake drainage have been documented. The USFWS lumped Goose Lake redband trout with five other Great Basin redband trout as one Distinct Population Segment when considering a petition for listing them as threatened under the Federal Endangered Species Act (Federal Register 65(54), March 20, 2000, 14932-14936). Although the Goose Lake watershed may have had connections to other Great Basin watersheds during wetter climatic periods, it is clearly isolated from other basins today and, presumably, has been for thousands of years. Regardless of its ultimate taxonomic designation, the Goose Lake redband trout is clearly a distinct evolutionary unit, confined to the Goose Lake basin and nearby headwater streams in the upper Pit River.

Life History: Goose Lake redband trout have two life history strategies: a lake-strategy and a headwater-strategy. Lake-strategy fish live in Goose Lake, where they grow to large size and spawn in tributary streams. Headwater-strategy fish remain small and may spend their entire life cycle in streams. It is almost certain that the two forms represent one population because the aperiodic desiccation of Goose Lake presumably has eliminated the lake form repeatedly in the past. This was demonstrated in 1992 when the lake dried up entirely during a prolonged drought. In the next two years, the lake refilled and, about three years later, small runs of large trout again appeared in the streams. It is assumed that the lake dwelling form was reestablished from tributary stream-resident populations. In the small, cold streams of the Warner Mountains to the east of Goose Lake, scattered populations of resident trout persist, completing their entire life cycle in these streams. They look quite different from lake fish because of small size and more vibrant color patterns, reflecting responses to a stream environment. Many of these populations are above potential barriers to upstream movement of fish from the lake. Presumably, small numbers of headwater redbands always move downstream, a natural mechanism for dispersing to new habitats or for recolonizing streams wiped out by drought or other natural disasters. Some of these fish reach the lake and, a few years later, they mature and spawn, renewing the cycle. It is also possible that progeny of lake trout can persist in some lower-elevation tributaries (e.g., Cold Creek).

In California, the lake-dwelling form spawns in Cottonwood, Lassen and Willow creeks. If sufficient flows are available, they spawn primarily in Cold Creek, a small tributary of Lassen Creek, and in Buck Creek, a small tributary of Willow Creek. Upstream of its confluence with Cold Creek, a steep, rocky gorge apparently prevents spawners from ascending further up Lassen Creek. In Oregon, they formerly spawned in Thomas Creek and its tributaries and, possibly, in Cottonwood and Drews creeks. Spawning migrations occur following snow melt and rain in the spring, usually during late March or in April. Spawning fish are rather pale looking, perhaps as a result of time spent in Goose Lake's highly turbid waters. Adults return to the lake following spawning. Young trout apparently spend one or more years in streams before dispersing downstream (if they leave at all) into Goose Lake. In the lake, the trout likely feed on Goose Lake tui chub, tadpole shrimp, and other super-abundant food. Growth appears rapid; scales from 6 spawning fish (27-48 cm TL) taken in 1967 indicated that they were all 3 years old (CDFG unpublished data).

The life history of the stream-dwelling form has not been studied but it is thought to be similar to other redband and rainbow trout that live in small, high-elevation streams. Surveys by CDFW (CDFG unpublished data; Hendricks 1995) indicate that headwater streams have 4-5 length classes of trout, with a maximum size around 24 cm TL. It appears that fish in their third summer are 9-12 cm TL. Lake fish were observed spawning May 14-15, 2007 (CDFG unpublished data), though spawning time is highly dependent on variable water years and amount of runoff.

Habitat Requirements: Goose Lake is a large, alkaline lake that straddles the California border; it is shallow (mostly < 3 m when full), extremely turbid, and highly variable in area (about 500 km^2). Because of its high elevation (1430 m), the lake generally remains cool (<22°C) although summer temperatures in the lake may reach 24°C or higher during the day. During calm days, water temperatures stratify with warm water within the first

25-50 cm of the surface; on most days the wind causes temperatures to be uniformly cool (R. White and P. Moyle , unpublished data, 1989). Goose Lake redbands nevertheless survive warm temperatures, high alkalinities, and high turbidity that exist in Goose Lake during summer months. Presumably, a major factor contributing to their survival is the extraordinarily high abundance of fish, tadpole shrimp (*Lepidurus lemmoni*) and other food in the lake (P. Moyle and R. White, unpublished observations).

Spawning takes places in March-May, whenever flows in Willow and Lassen creeks are high enough to attract trout for an upstream migration (M. Yamagiwa, USFS, and S. Reid, pers. comm. 2007). Most spawning areas are located in reaches and tributaries with permanent flows, such as Cold Creek, a tributary to Lassen Creek about 15 km upstream from the lake. Spawning sites are reaches with clean gravels and riparian cover that maintain cool water temperatures. Goose Lake redbands have been observed to spawn in the lower reaches of Willow and Lassen creeks when access to upstream areas is blocked (P. Chappell, pers. comm. 1995), but most spawning areas are upstream of the Highway 395 crossing. However, spawning migrations and behavior of Goose Lake redband trout has been poorly recorded in California.

Tate et al. (2005) evaluated temperatures in the two largest California tributaries to Goose Lake, Lassen and Willow creeks. Lassen Creek, the larger of the two (1-2 cfs flows in late summer), became progressively warmer from headwaters to mouth, so that headwater reaches were typically <16°C in summer, while lower reaches typically averaged 18-21°C, all reasonable temperatures for trout. However, in the summer of 2007, temperatures in some reaches supporting trout regularly reached 24-26°C (S. Purdy, unpublished data). Likewise, Tate et al. (2005) found temperatures in Willow Creek (< 1 cfs flow in summer, often dry in lowermost reaches) in both headwaters and lower reaches could reach 24°C on occasion, although intermediate reaches in a shaded canyon were considerably cooler.

The habitat requirements of the stream-dwelling form are similar to other populations of redband trout that occupy small, cool, high-elevation streams. Streams in the Warner Mountains are generally dominated by riffles with undercut banks. Pools in meadow areas provide habitat for larger fish. Dense overhanging vegetation, especially willows, provide essential cover.

The environmental tolerances of Goose Lake redband trout have not been measured but it can be inferred that they can survive temperatures of 24°C for short periods on a regular basis, highly turbid, alkaline water (pH 8-9), and dissolved oxygen levels at <50% of saturation, although growth may be inhibited under more extreme conditions.

Distribution: Goose Lake redband trout are endemic to Goose Lake and its major tributaries and a few tributaries to the upper Pit River. In California, Lassen and Willow creeks are their principal streams although they are also present in smaller streams (Pine, Cottonwood, Davis, Corral creeks). In Oregon, they inhabit the extensive Thomas-Bauers Creek system as well as 12 smaller streams (Fall, Dry, Upper Drews, Lower Drews, Antelope, Muddy, Cottonwood, Deadman, Crane, Cogswell, Tandy, and Kelley creeks) (Oregon Department of Fish and Wildlife 2005). Berg (1987) reported that Joseph, Parker, and East creeks, tributaries of the North Fork Pit River in California, contained trout genetically similar to Goose Lake redband. Similar results for upper Pit

River redbands were found by M. Stephens (2007). Simmons (2011) identified genetically similar fish in North Fork Fitzhugh Creek, tributary to South Fork Pit River and in Parker Creek, Tributary to North Fork Pit River, south of Goose Lake. In addition, two populations in the eastern Warner Mountains above Surprise Valley seem to be Goose Lake redbands, perhaps as the result of historic introductions (Stephens 2007).

Trends in Abundance: According to local history, in the 19th century these trout were once abundant enough in the lake that they were harvested commercially and sold to logging camps. Conversations with local residents (P.B. Moyle 1989) indicated that both sport and commercial fisheries existed for Goose Lake redband trout and that large runs occurred in local creeks, especially Thomas Creek in Oregon. The Goose Lake redband trout population historically has undergone major fluctuations, being depleted during series of dry years and recovering in wet periods. The lacustrine population was severely depleted during the 1976-1977 drought, recovered during the wet early 1980s, and dropped precipitously during the 1986-1992 drought. Most recently, the lake was dry in 2010 and remained very low through 2012.

In California, Lassen Creek and its tributary, Cold Creek, have been the principal spawning streams. Numbers of spawning fish have fluctuated from ten or so individuals to several hundred, but the creek appears to have the potential to support perhaps 1,000 spawning fish under optimal flow conditions (E. Gerstung, CDFW, pers. comm. 1995). The only large run documented in recent years in Lassen Creek (1988) was comprised of several hundred spawners (J. Williams, unpubl. data), which suggests that there were fewer than 1,000 adults from California streams in Goose Lake, assuming many of the lake fish were immature one and two year old fish. In 1989, in the middle of a drought, only about a dozen fish appeared in the creek and there was no evidence of successful spawning.

Goose Lake dried up in 1992 but, by March, 1997, a run was reported in Lassen Creek and spawning was reported in April in Cold Creek (M. Yamagiwa, USFS, pers. comm. 2007). In May, 1999, S. B. Reid (pers. comm. 2007) observed "…big fish (40-70 cm) stacked four deep (literally) in the pools (estimated 75 at Hwy. 395)." This suggests that runs of several hundred fish had redeveloped in these tributaries and others in a relatively short period of time.

The stream form of Goose Lake redband trout apparently exists in about 20 small headwater streams. ODFW (2005) estimated that about 102,000 trout (+/-32%) age 1+ and older ($0.14/m^2$) live in 13 Oregon streams under typical conditions; this number is presumably low compared to numbers that existed before streams were degraded by grazing and other activities. Surveys of California streams made in 1993 and 1999, showed 600-1600 trout per km in Lassen Creek, which suggests that densities/numbers in California and Oregon streams are roughly comparable (unpublished surveys, CDFW). More recent CDFW multiple-pass electrofishing surveys (Weaver and Mehalick 2010) showed 114-747 trout per km in Lassen Creek and 313-451 trout per km in Cold Creek, considerably lower than previous estimates but with the caveat that section lengths were estimated in 1999 (J. Weaver, CDFW, pers. comm. 2013), so abundance estimates may or may not be accurate for that year.

ODFW (2005) indicated that most Oregon redband trout streams are impaired to some degree by accumulated effects from irrigation diversion dams, dewatering of

streams, and generally poor habitat (from grazing, mining, and roads). Most of the streams also suffer from loss of connectivity to each other and to Goose Lake. Streams in California suffer from similar problems although the largest stream, Lassen Creek, seems to be in better condition than most, largely due to extensive habitat restoration efforts. Overall, the carrying capacity of Goose Lake streams is presumably a fraction of their historic carrying capacity. Since 1995, conditions for Goose Lake redband trout in California have steadily improved because large sections of Lassen Creek and other streams have been protected from grazing and otherwise restored. These conservation measures have likely improved habitat conditions and allowed runs of lake fish to re-establish themselves. Presumably, headwater populations have increased as well, thanks to better management.

Nature and Degree of Threats: Goose Lake redband trout populations have been affected by many stressors, but habitat degradation and diversions have been the greatest threats (Table 1). ODFW (2005) indicated that these two factors, combined, put Goose Lake redband trout "at risk" in 80% of Oregon streams. Overexploitation and introduced species are, at present, minor problems. However, all threats are exacerbated during periods of severe drought. Goose Lake dried up in the 1420s, in the 1630s, 1926 (with low lake levels from 1925 to 1939), 1992, and 2010-2012. Thus, the key to survival of the Goose Lake redband trout (and other Goose Lake fishes) is maintenance of populations in tributaries that may have severely reduced habitat during these drier periods.

Agriculture. Populations of the lake-dwelling form were reduced because access to spawning areas was blocked by dams, diversions, culverts, and channelization in the lower reaches of many streams but, since 1995, most of these impacts have been mitigated or eliminated. Much of the critical stream habitat for Goose Lake redband trout is on private land and, at times, large volumes of water are diverted to irrigate fields. On some streams, small diversion dams are barriers to fish movement (ODFW 2005). Diversions may have disproportionate impacts in dry years because they have the potential to dry longer stream reaches that are refuges for trout and other fishes when the lake is dry.

Grazing. Headwater streams containing redband trout have been heavily grazed, resulting in reduced riparian cover and, in places, down-cutting to bedrock. The impact of grazing has been reduced in recent years through a combination of fencing, rotational grazing, installation of erosion control structures, and planting of willows.

Transportation. All streams in the watershed have been degraded by roads to some degree. Highway 395 crosses all tributaries to the east side of the lake and culverts under the highway were once a partial barrier to migration, an issue which has largely been fixed. Roads also impact headwater streams, especially where culverts may be barriers to fish movement or where the road-cuts are a source of silt. Some streams face multiple threats from poor water quality as the result of road building, channelization, and waste materials from uranium mines.

Logging. Timber harvest is a prominent use of the watershed's forests and has contributed to habitat degradation in streams through siltation, road-crossings, and other factors. Logging impacts were more severe historically; many regulations exist today to protect stream habitats from the effects of timber harvest operations.

Harvest. When lake-dwelling fish are moving upstream to spawn, they are extremely vulnerable to angling or poaching, especially when confined below culverts or other partial barriers. This may have been a factor in the decline of the Lassen and Willow Creek populations. At present, only catch-and-release angling for redband trout is permitted in Goose Lake's California tributaries.

	Rating	Explanation
Major dams	n/a	
Agriculture	High	Water diversion and return flows from irrigation lower base flow and increase water temperatures; dams may block migration
Grazing	High	Pervasive in the area, especially in meadows with redband streams; reduced impacts in recent decades with improved management
Rural residential	n/a	
Urbanization	n/a	
Instream mining	n/a	
Mining	Low	Old uranium mines in watershed; unknown impacts
Transportation	Medium	Roads are a source of sediment input into streams and culverts have blocked access in the past
Logging	Medium	Logging and associated roads have likely contributed to stream degradation; greater impacts in the past
Fire	Low	Fire suppression, coupled with increasing aridity, predicted with climate change, may contribute to increased fire frequency and intensity
Estuary alteration	n/a	
Recreation	Low	Off road vehicles a potential threat but not demonstrated
Harvest	Medium	Poaching is potentially a problem; legal fishing pressure is light and limited to catch-and-release
Hatcheries	n/a	
Alien species	Medium	Major potential threat in streams if introduced; less so in lake

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of Goose Lake redband trout in California. Factors were rated on a five-level ordinal scale where a factor rated "critical" could push a species to extinction in 3 generations or 10 years, whichever is less; a factor rated "high" could push the species to extinction in 10 generations or 50 years whichever is less; a factor rated "medium" is unlikely to drive a species to extinction by itself but contributes to increased extinction risk; a factor rated "low" may reduce populations but extinction is unlikely as a result. A factor rated "n/a" has no known negative impact. Certainty of these judgments is moderate. See methods section for descriptions of the factors and explanation of the rating protocol.

Alien species. Brook, brown, and rainbow trout have been introduced into streams of the Goose Lake drainage and brown trout are known to persist in California in Davis and

Pine creeks (Hendricks 1995, S. Purdy, UC Davis, unpublished data, 2006, P. Divine, CDFW, pers. comm. 2012). Brook trout are still present in at least one Oregon stream (ODFW 2005, Scheerer et al. 2010). California has not stocked any rainbow trout in the drainage since 1980, when electrophoretic studies indicated that the native redband trout were distinct; planting of hatchery rainbow trout apparently was discontinued in Oregon tributaries in 1961, although Cottonwood Meadows Reservoir, on Cottonwood Creek, is still planted with hatchery rainbow trout (ODFW 2005). Behnke (1992) thought that some Goose Lake redband trout populations in California showed evidence of past hybridization with rainbow trout, based on meristic measurements, but there is no biochemical evidence of this.

The potential for future unauthorized, illegal introductions to impact native trout and other sensitive Goose Lake fishes remains although is unlikely. Possible effects to native fishes could occur through disease, hybridization, predation, or competition; however, some past introductions of warm-water fishes were largely unsuccessful because of the lake's extreme environment.

Although it is uncertain whether beavers were historically distributed in the Goose Lake basin, beaver dams in Lassen Creek's middle reaches have created intermittent barriers to upstream migration and may have blocked recent lake fish runs from reaching preferred spawning habitat (J. Weaver, CDFW, unpublished observations, 2012). The California Department of Fish and Wildlife has, in the past, periodically used explosives to remove beaver dam complexes in Lassen and Willow creeks in order to improve upstream passage for Goose Lake redband trout, although this practice is no longer utilized (P. Divine, CDFW, pers. comm. 2012). Beaver dams may need to be evaluated in the future to determine if fish passage is being impeded.

Effects of Climate Change: Goose Lake is located in an arid, high desert region so any reduction in precipitation or increased frequency of droughts will further stress streams and the lake. Both are predicted by climate change models (Moyle et al. 2012). During low flow periods, streams in the Goose Lake basin already reach temperatures (24-26°C) that are lethal or nearly so to redband trout. Thus, an increase in air temperature, especially when combined with reductions in stream flow through diversions, could reduce or even eliminate most California populations. An increase in fire frequency or intensity could reduce riparian shading, add sediment, and otherwise impair streams in which redband trout are found. In addition, increased frequency of Goose Lake's known aperiodic dessication or increased temperatures in the lake could have negative effects on the lake dwelling and migratory part of the population. Moyle et al. (2013) rated Goose Lake redband trout as critically vulnerable to climate change, with extinction likely in California in the next 100 years if present climate change trends continue.

Status Determination Score = 3.3 - Moderate Concern (see Methods section Table 2). Goose Lake redband trout face no immediate extinction risk (Table 2) but their populations are not entirely secure because: (a) the 19 extant populations, 6 in California and 13 in Oregon, are largely isolated from each other, (b) most stream populations are small, and (c) drought periods are predicted to increase over the coming century, during which the lake population disappears and stream populations shrink. Warmer temperatures will also reduce the quantity and quality of stream refuges.

The Goose Lake redband trout has been given various designations by state and federal agencies: (a) USFWS, Category 2 Candidate Species (now, Species of Concern); (b) USFS, Region 5, Management Indicator Species; (c) USFS, Region 6, Sensitive Species, and (d) ODFW, Vulnerable or At Risk species. The American Fisheries Society lists it as "Vulnerable," while NatureServe lists it as "Imperiled" (T2) (Jelks et al. 2008).

In 1997, the USFWS was petitioned to list Great Basin redband trout, which includes Goose Lake redband trout, as threatened or endangered. In 2000, the petition was denied (Congressional Record, March 20, 2000:65 (54):14932-14936) for the following reasons:

> "…the Great Basin experienced a drought from 1987 to 1992, with 1994 also being a very dry year. The drought caused Goose Lake …to go dry in 1992. This second drought eliminated the lake habitat and, consequently the lacustrine redband trout that made spawning runs up connected creeks. This drought also undoubtedly reduced the available stream habitat. However… the numbers of redband trout… appear to have rebounded… An analysis of historic and current distributions based on area concluded that Great Basin redband trout currently occupy 59 percent of their historic distribution."

Metric	Score	Justification
Area occupied	4	Present in six streams in California and 13 in Oregon
Estimated adult abundance	4	Lake spawners are <1000 but headwater populations presumably contain more fish
Intervention dependence	4	Long-term decline reversed by restoration actions which must continue to protect remaining habitats
Tolerance	4	Indirect evidence suggests they are more tolerant than most salmonids of adverse water quality
Genetic risk	3	Genetic risks are currently low although hybridization with introduced rainbow trout is possible; potential impacts from isolation of headwater populations need investigation
Climate change	2	Distribution in isolated, small streams increases probability of extirpation in California due to prolonged drought
Anthropogenic threats	2	See Table 1
Average	3.3	23/7
Certainty (1-4)	2	Mostly 'grey' reports and expert opinion

Table 2. Metrics for determining the status of Goose Lake redband trout in California, where 1 is a major negative factor contributing to status, 5 is a factor with no or positive effects on status, and 2-4 are intermediate values. See methods section for further explanation.

The USFWS analysis also cites the many successful restoration projects in the Goose Lake Basin as further reason for finding that listing was not justified. However, because fish in California depend largely on just two streams, Lassen and Willow creeks, for survival, they could face extirpation from California even if there are viable populations in Oregon. It is likely that better and more current information on California populations and better resolution of levels of movement (or lack thereof) of lake dwelling fish between tributaries, both in Oregon and California, would change their status.

Management Recommendations: There has been considerable interest in conserving populations of this unusual trout and those of other endemic fishes in the Goose Lake basin. During the 1987-1994 drought, a proposal was developed to list the Goose Lake fish fauna as Threatened under the federal ESA. In response, the Goose Lake Fishes Working Group was formed in 1991, made up of representatives from both California and Oregon, and comprised of private landowners, state and federal agencies, nongovernmental organizations, and universities. The organization signed a Memorandum of Understanding in July, 1994, to protect and, where needed, reestablish native fishes in the Goose Lake basin. In 1995, the Goose Lake Fishes Conservation Strategy was completed. According to USFWS (Congressional Record, March 20, 2000:65 (54): 14936)

> "The goal of this strategy was to conserve all native fishes in Goose Lake by reducing threats, stabilizing population numbers, and maintaining the ecosystem. The Conservation Strategy identified factors in each stream that were affecting fish and provided a list of actions since 1958 that were implemented to benefit potential problems. Since publication [of the conservation strategy] in 1996, a number of additional projects have been completed or long-term projects begun. These include 2 culvert improvements, 11 diversion or passage projects, 10 fencing projects, 16 habitat improvement projects, 11 fish surveys, and road improvement project to reduce sedimentation."

In the lower reaches of most streams, restoration actions included making road under-crossings passable to trout. A fish ladder was installed over a major diversion dam on Thomas Creek in 1992 by the Oregon Department of Fish and Wildlife. In Willow and Lassen creeks, the California Department of Fish and Wildlife has removed natural and artificial migration barriers. Headcut control, bank stabilization, stream fencing, planting of riparian vegetation, modified grazing practices and other protective measures have also been undertaken on a number of streams in recent years. These measures have greatly improved habitat and water quality in Goose Lake tributaries, including the lower reaches that flow through agricultural land. Monitoring of water quality, insects, and fish demonstrate the improvements (Tate et al. 2005); however, continued effort is needed to maintain (and ideally increase) the populations of trout and other fishes, especially during periods of severe drought.

Management recommendations (not in order of priority) include:
1. Identification and modification of barriers to fish movement, especially diversion dams.

2. Identification, protection, and improvement of stream reaches that are critical for spawning, rearing, and refuge during drought. Cold Creek (tributary to Lassen Creek) and Buck Creek (tributary to Willow Creek) have already been identified as important habitats. At present, a diversion structure often diverts the flows of lower Buck Creek. Lower Willow Creek habitat conditions are poor (bank sloughing, minimal riparian or instream cover, heavy sedimentation), along with multiple diversion dams. Although these dams were, at some point, improved with fish ladders, some of these structures appear badly deteriorated and fish passage needs to be reevaluated (J. Weaver, CDFW, unpublished observations, 2012).
3. Regular quantitative monitoring (every 3-5 yrs) of fish populations in both upstream and downstream reaches of Lassen and Willow creeks, and at least qualitative monitoring of fishes in other streams. In 2012, CDFW received a Sport Fish Restoration Act grant from the US Fish and Wildlife Service for the purposes of implementing quantitative fish population and habitat monitoring in California tributaries to Goose Lake, so data gaps should be filled and trend monitoring can occur. Collaborative planning between CDFW and ODFW is occurring and basin-wide monitoring strategies should be developed in the next several years (P. Divine, CDFW, pers. comm. 2012).
4. Improved management of headwater areas to protect streams from livestock grazing and other stressors, including predicted impacts of climate change.
5. Prevent the illegal importation/stocking of non-native fish in the Goose Lake basin, including eradicating existing populations where possible. The abundant tui chubs and aquatic invertebrates in Goose Lake have been an excellent food resource which, presumably, contributes to the large size attained by lake-dwelling trout. Introductions of alien fishes or invertebrates that could alter the forage base or otherwise negatively impact native fishes should continue to be banned and enforced.
6. Adult lake-form trout attain large sizes and spawn in small streams; as such, they are susceptible to poaching. Regular patrol by wardens and others should be conducted to prevent poaching as adults amass in pools and shallow spawning areas.
7. The Goose Lake Fishes Conservation Strategy should be fully implemented and revisited periodically to ensure it is up to date. The continued involvement of private landowners and public agencies is crucial to this effort, as is the continued involvement of University of California Cooperative Extension, which has provided coordination and scientific studies to support conservation efforts.

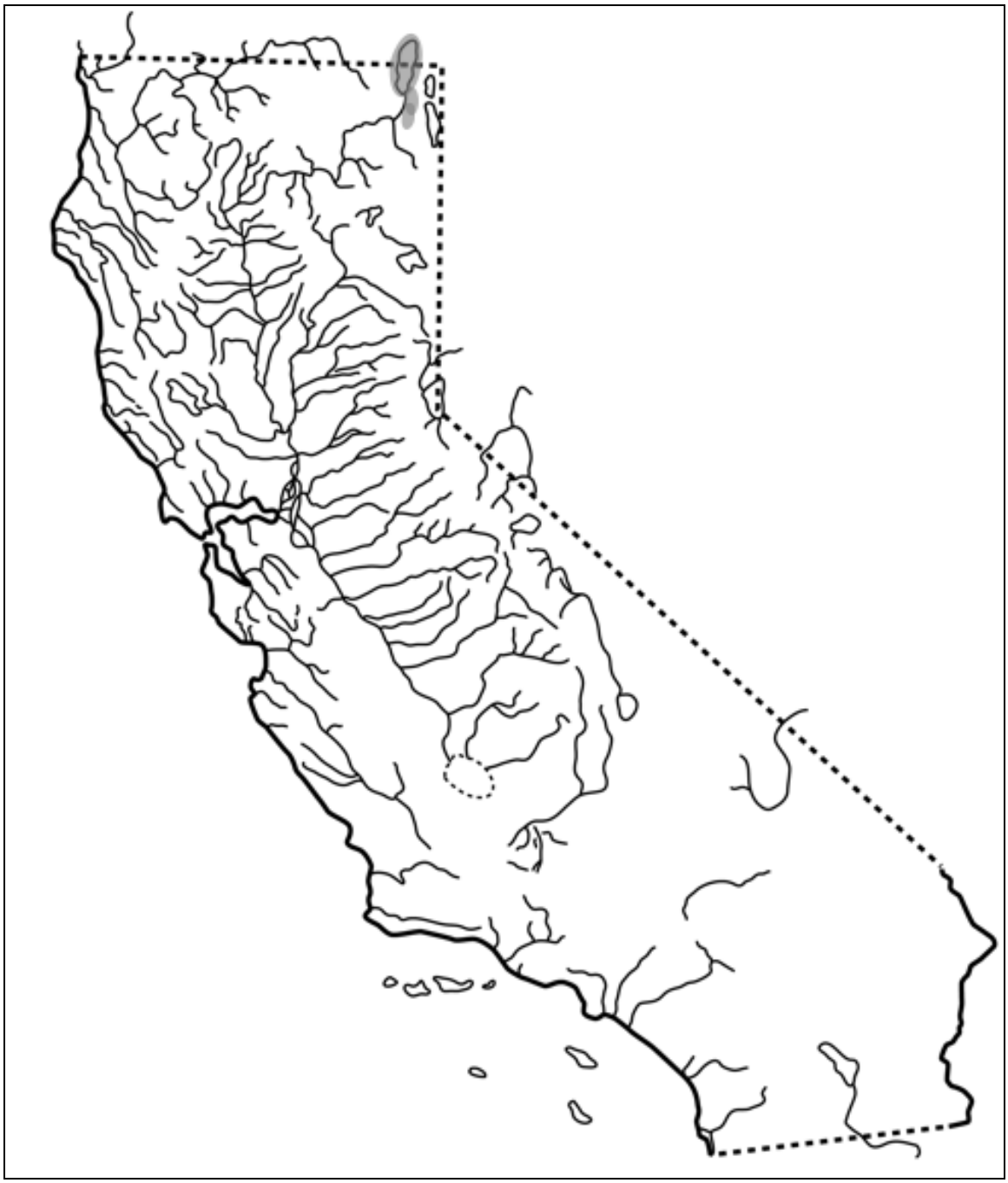

Figure 1. Distribution of Goose Lake redband trout, *Oncorhynchus mykiss* ssp., in Goose Lake, upper Pit River, and above Surprise Valley, in California.