GOOSE LAKE SUCKER
Catostomus occidentalis lacusanserinus (Fowler)

Status: High Concern. The Goose Lake sucker does not face immediate extinction risk but its restricted distribution makes it vulnerable to land and water use practices, climate change, and other factors which could compromise its status.

Description: The Goose Lake sucker is a catostomid that can reach 350 mm SL. As a subspecies, it shares many characteristics with the Sacramento sucker (Ward and Fritzsche 1987), including the number of lateral line scales (64-73), scales above (12-16) and below (8-12) the lateral line, and scale rows before the dorsal fin (27-36). They also have similar numbers of fin rays (11-13 dorsal rays, 7 anal rays, 16-18 pectoral rays, 9-10 pelvic rays), lip papillae (5-6 upper-lip papillae, 5 lower-lip papillae), and gill rakers (21-27). The number of post-Weberian vertebrae in Goose Lake suckers ranges from 42 to 44. They are characterized by a caudal peduncle that is 8-10 percent of the standard length, lack of pelvic axillary processes and a black peritoneum. Body coloration is dark grey to black dorsally and light grey to dull brown ventrally. The head is steel-grey to brown dorsally, but is lighter ventrally. A darker lateral stripe is present in larger fish. The caudal, pelvic, and pectoral fins are light grey to cream. Males develop breeding tubercles on branched and unbranched anal rays and on lower caudal rays. Females have no tubercles (Martin 1967). In reproductive males, the pelvic fins become extremely enlarged, elongated and cupped, presumably to aid in dispersal of sperm during reproduction (Martin 1967).

Taxonomic Relationships: The Goose Lake sucker was first described as a subspecies of Sacramento sucker, *Catostomus occidentalis,* by Fowler (1913) from a single specimen. Since then, the original subspecific name, *lacus-anserinus*, has been modified to eliminate the hyphen and the present name is *C. o. lacusanserinus* (Shapovalov et al. 1959, Kimsey and Fisk 1960, Hubbs et al. 1979). Martin (1967) compared Goose Lake suckers with Sacramento suckers from the Pit River. He concluded that the two forms belonged to different subspecies but that the differences were minor. Ward and Fritzsche (1987), using standard meristic and morphological measurements, looked at *C. occidentalis* from a number of localities, including Goose Lake. Although their multivariate analysis could separate the suckers of Goose Lake from other populations, they concluded that the morphological differences were too small for the Goose Lake form to merit subspecies status. Both Martin (1967) and Ward and Fritzsche (1987) indicated that the Sacramento sucker is a highly variable species morphologically. Therefore, the conservative course of action is to retain the various subspecies names until a thorough genetic study is done on the Sacramento sucker throughout its range.

Life History: Little is known about the life history of the Goose Lake sucker, except that they spawn during spring in streams that are tributary to Goose Lake (Martin 1967). Adults are found in tributaries and the lake throughout the year. Young suckers 40-70 mm SL are very abundant in shallow water during summer in the lake, "packed" in among aquatic macrophytes (R. White, unpubl. data, 1989). Fish become sexually mature by the second year when they are 80-90 mm SL. Martin (1967) found several fish (141-216 mm SL), both male and female, with mature

gonads at the beginning of April and concluded that Goose Lake suckers breed during April or May, depending on water temperature. J. Williams (BLM, unpubl. observ. 1984) observed 246-430 mm FL fish on a spawning migration in Willow Creek during May 14-16, 1984. Surveys in 2007 (Heck et al. 2008) found that length frequencies of Goose Lake suckers in Oregon streams represented individuals from young of year to adults, although individual age classes were not established. Goose Lake suckers positively identified by these surveys ranged in size from ~50 mm to 200 mm. Smaller (~20 mm) suckers were captured but were not separated from a group that included Modoc suckers (*Catostomus microps*). In Oregon streams, Goose Lake suckers are closely associated with speckled dace (*Rhinichthys osculus*) and northern roach (*Lavinia mitrulus*) in mid-elevation habitats (Scheerer et al. 2010). Goose Lake suckers feed primarily on algae and diatoms (Martin 1967). Like other suckers, they have a long intestine and ventral mouth adaptive to this diet.

Habitat Requirements: In streams, Goose Lake suckers are typically found in water depths of 15-150 cm and in moderate to slow water velocities (Martin 1967). The streams which they inhabit are up to 4.5 m wide, with summer water temperatures of 15-19°C. Little aquatic vegetation is present. Substrates consist primarily of rock and gravel in headwater sections and mud, silt, and gravel in lower sections. In Oregon, Goose Lake suckers are most abundant in mid-elevation streams flowing through sagebrush, with fine substrates (Scheerer et al. 2010). Goose Lake is shallow, muddy, and alkaline. Gillnetting and trawling surveys indicate that suckers are found throughout the lake (R. White, unpubl. data, 1989). Populations of Goose Lake suckers are apparently also present in small reservoirs in the Cottonwood and Thomas creek drainages, Oregon, but the characteristics of these reservoir populations are not well documented. Juvenile fish have been observed in shallow water among emergent vegetation.

Distribution: The Goose Lake sucker is endemic to the Goose Lake basin and has been reported from Goose Lake and Willow, Lassen, Davis, Branch, and Badger-Cloud Corral creeks, Modoc County, California; and from Dog, Hay, Dent, Drews, Cottonwood, Augur, Cox, Warner and Thomas creeks, Lake County, Oregon (GLFWG 1996, Heck et al. 2008). Individuals have also been documented in Drews, Dog and Cottonwood reservoirs in Oregon, but it is unknown if permanent populations are established in these reservoirs. Apparent spawning runs from these reservoirs, however, have been recorded (J. Williams, unpubl. obs., 1984), which suggests that self-sustaining populations may exist in one or more of these potential refuge sites.

Trends in Abundance: This subspecies is fairly common in streams in its limited range and is common in Goose Lake during periods when the lake is inundated. Individuals were collected in brief surveys of the lake by CDFW (King and Hansen 1966), by USFWS (J. Williams, 1984, unpubl. data), and by University of California, Davis (R. White, 1989, unpubl. data). However, their abundance presumably declined when Goose Lake dried up in 1992-1993 and again in 2010, recovering once lake levels rose again. Although only one Goose Lake sucker (320 mm SL) was caught by the authors from the lake in June, 2008 (Moyle et al. unpubl. data), juvenile and adult Goose Lake suckers are widespread in Oregon streams (Heck et al. 2008).

Nature and Degree of Threats: The principal threat to the Goose Lake sucker is loss of habitat in Goose Lake and its tributaries (GLFWG 1996, Heck et al. 2008; Table 1). Diversions, combined with loss of natural water-storage areas (e.g., wet meadows lost to bank erosion and downcutting of streams), likely cause the lake to dry up more rapidly during prolonged drought as occurred in 1986-1992. While the lake has dried up naturally multiple times (1851, 1852, 1926, 1929-1934, 1992, 2010), it may do so now more quickly or frequently, becoming too alkaline to support freshwater fishes such as suckers, even if drying is not complete.

Agriculture. Diversions, dams, culverts and other obstructions can prevent suckers from reaching spawning habitat and refuge areas in tributary streams (Tate et al. 2005). An estimated 35% of the inflow to Goose Lake is currently diverted for irrigation (Heck et al. 2008). Streams can provide refuge to fishes when low water level and poor water quality become unsuitable for fishes in the lake. Currently, high water temperatures impair ecosystem function in the lower reaches of some streams (e.g. Lassen and Willow creeks), primarily through solar input in open meadows and irrigation water return (Tate et al. 2005), although stream restoration on Lassen Creek have improved conditions in this stream. Temperature gains are partially mediated by seeps and spring along many streams, accentuating the importance of groundwater input. Nonetheless, 20% of streams draining the Oregon portion of the Goose Lake basin are listed as impaired, generally because of high temperatures (NRCS 2006).

Grazing. Livestock grazing is widespread throughout the basin and its effects are often inseparable from other agricultural practices (e.g., irrigated pasture). Most Goose Lake basin streams have experienced some habitat loss due to the effects of grazing and other factors (logging, roads etc.) that degrade watersheds. While improved management of most grazed lands has reduced the threat of grazing in the short-term, as the climate becomes warmer and more variable (see Effects of Climate Change section), there is considerable potential for grazing impacts to increase without reductions in livestock numbers or other mitigation measures (e.g., exclosure fencing along streams). Populations in Oregon reservoirs may provide sources for natural or artificial (translocation) reestablishment after periods of extended drought, provided that water levels and quality are maintained in these refuge locations.

Transportation. Virtually all streams used by Goose Lake suckers are crossed by roads, which often present passage barriers and sources of siltation. Many culverts have been improved (e.g., under Highway 395) for fish passage but most roads crossing streams are unimproved and have unknown effects on sucker populations.

Logging. The Goose Lake watershed was extensively logged in the past, although timber harvest on national forest lands is substantially reduced from historic levels. Timber harvest, however, remains a prominent use of the watershed's forests and has contributed to habitat degradation in streams through siltation, road-crossings, and other factors.

Fire. Wildfire is a natural component of the forested portions of the watershed; increased fire frequency or intensity associated with land use practices and predicted climate change impacts may increase threats, especially to smaller streams.

Alien species. Alien species that may compete with or prey on Goose Lake suckers are present in some reservoirs and streams in the basin. Alien species in the basin include: trout (*Salvelinus fontinalis, Salmo trutta)*; centrarchids (*Micropterus dolomieui, M. salmoides, Lepomis gibbosus, L. macrochirus, Pomoxis annularis*); yellow perch (*Perca flavescens*); fathead minnow (*Pimephales promelas*); and brown bullhead (*Ameiurus nebulosus*) (GLFWG 1996,

Heck et al. 2008). Scheerer et al. (2010) found suckers were absent or scarce where alien fishes were abundant.

	Rating	Explanation
Major dams	n\a	
Agriculture	High	Water diversion and returns from irrigation lower base flow and increase water temperatures; dams may block migration
Grazing	Medium	Grazing pervasive throughout the basin
Rural residential	Low	Rural development is minimal in the basin; however, pumping for wells and septic effluents, along with other impacts from residences may negatively affect stream habitats
Urbanization	n/a	
Instream mining	n/a	
Mining	Low	Uranium mines are present in the area but their impacts are unknown
Transportation	Medium	Roads increase sediment delivery to streams and culverts block fish passage
Logging	Medium	Logging has occurred in the headwaters with decreased intensity in recent years
Fire	Low	Increased fire frequency or intensity may increase threat
Estuary alteration	n/a	
Recreation	Low	Fishing, camping, off-highway vehicles and other recreational use in the area can have negative effects on fish populations and water quality but impacts are likely low because recreation is dispersed
Harvest	n/a	
Hatcheries	n/a	
Alien species	Medium	More than 10 alien species have been introduced to the watershed; however, most are not abundant

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of Goose Lake sucker 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.

Effects of Climate Change: The most noticeable and widespread impacts of climate change on aquatic habitats in the Goose Lake basin will be continued increases in water temperatures and changes to the frequency and timing of drought and flooding events. Water temperatures will

likely increase by approximately 1°C or more, on average, by 2099, perhaps reducing the individual fitness of fishes already living in temperature impaired streams, such as those found in the Goose Lake basin.

Elevated air temperatures associated with climate change will change the periodicity and magnitude of peak and base flows in streams due to a reduction in snow pack levels and seasonal retention. Stream flow in the basin is primarily fed by snowmelt from the Warner and Fremont mountains, with some baseflow provided by springs (GLFWG 1996). Streams in the Goose Lake basin may be significantly impacted due to the relatively low elevations (< 3000 m) of the Fremont and Warner mountains (Hayhoe et al. 2004). Peak flow currently takes place in the spring, from April to May, but may shift earlier by as much as one month. The lake itself is also fed by a few small springs (Phillips and van Denburgh 1971, in GLFWG 1996). Predictions are that stream flow will increase in the winter and early spring and decrease in the fall and summer (Knox and Scheuring 1991, Field et al. 1999, CDWR 2006), resulting in potential changes to the spawning ecology of fishes. Fish distribution in the basin is already impacted by decreases in streamflow. During dry years (as in 2007 and 2010-12), the distribution of fishes in the basin can be affected by reduction in wetted channel availability. In 2007, 21% of the habitats sampled by Heck et al. (2008) and Scheerer et al. (2010) had gone dry. Moyle et al. (2013) found Goose Lake suckers "highly vulnerable" to extinction as the result of climate change, mainly from prolonged drought. However, Goose Lake suckers are found in some streams that are regulated by small dams that could be managed to mitigate the impacts of climate change on stream flow.

Status Determination Score = 2.3 - High Concern (see Methods section, Table 2). The limited distribution of Goose Lake sucker in California (mostly in Goose Lake itself, as well as the Lassen and Willow creek watersheds) puts this subspecies in some danger of extirpation from its limited stream habitat, especially during years when the lake is dry. The Goose Lake sucker is considered a Sensitive Species by the U.S. Forest Service and Oregon Department of Fish and Wildlife. The American Fisheries Society considers the Goose Lake sucker to be "Vulnerable" (Jelks et al. 2008), while NatureServe, ranks it as "Imperiled" (T2T3). A fundamental problem is the Goose Lake sucker's dependence on lower elevation, low gradient streams which are highly altered by diversions, farming and grazing. Populations likely expand when Goose Lake is full but declines and isolation occur when the lake dries. These same factors make it particularly susceptible to the predicted effects of climate change in this region. Extirpation of the subspecies is less likely when Oregon populations are taken into consideration.

Metric	Score	Justification
Area occupied	2	Goose Lake suckers are endemic to the Goose Lake basin, with limited distribution in California
Estimated adult abundance	2	It is unlikely that any spawning or stream population in CA contains more than 1000 adults
Intervention dependence	3	Population persistence requires active management to maintain water level and quality in streams and in Goose Lake itself
Tolerance	3	Prefers cool-water environments
Genetic risk	3	Genetics poorly understood but populations wide spread in Goose Lake basin
Climate change	1	Summer base flows are predicted to decrease throughout the Goose Lake basin
Anthropogenic threats	2	See Table 1; species may persist in refuge sites in Oregon if it disappears from California
Average	2.3	16/7
Certainty (1-4)	2	Information specific to Goose Lake suckers is limited

Table 2. Metrics for determining the status of Goose Lake sucker 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.

Management Recommendations: In 1995, a strategy to protect the Goose Lake sucker and other native fishes was developed by the Goose Lake Fishes Working Group, which includes representatives from federal and state agencies, private landowners, and interested citizen groups (GLFWG 1996). Strategy goals include: reducing threats to fish species, stabilizing populations, and maintaining ecosystem function throughout the Goose Lake basin. Many restoration projects were identified including bank stabilization, riparian fencing, and culvert replacement. Monitoring projects such as telemetry and temperature monitoring were also identified as priorities. Other restoration activities in the basin (mainly in Oregon) have focused on addressing impacts from grazing, erosion, and nutrient influx (NRCD 2006). All of these actions should reduce aquatic impacts and provide needed data and information to inform future management and conservation actions. However, impacts from agricultural irrigation, artificial barriers, grazing, roads (especially culverts) and alien species continue to threaten Goose Lake sucker persistence, especially in California. Additionally, impacts from climate change are predicted to lower base flows, thereby reducing the amount of perennial habitat and increasing summer water temperatures in tributary streams and Goose Lake. Recognizing that persistence of the Goose Lake sucker depends on management actions in both California and Oregon, specific management recommendations include the following:

Dams. Small dams and diversions should be outfitted to allow sucker passage at different life stages. Wherever possible, dams should be removed in a manner that will not expose aquatic habitats to increased sedimentation, scouring, etc.

Agriculture. Open diversions should be replaced by pipes in order to minimize

streamflow diversion and water temperature gains. Improving spawning access and increasing flows in streams in California and Oregon, especially Lassen, Willow, and Thomas creeks, would benefit suckers and other native fish species in the basin. Establishment of living buffers and wetlands may reduce the amount of nutrients delivered to Goose Lake and tributary streams, as well as moderate stream temperatures.

Grazing. Stream restoration projects should continue to be implemented, especially measures that create large pools and expand the amount and complexity of riparian vegetation. Cattle exclusion fencing should be maintained and, where appropriate, expanded. Water sources for cattle outside the riparian area should be developed. Maximum impact levels (vegetative height, minimum ground cover, etc.) should be identified, especially for meadow systems, and implemented. Areas where riparian vegetation has been removed, stream banks destabilized, and/or water quality degraded should be closed to grazing to allow ecosystem recovery.

Transportation. Seasonal roads should be storm-proofed (outsloped, inboard ditch removed) and/or decommissioned (outsloped, inboard ditch removed, access blocked, planted) in order to reduce the amount of sediment delivery to streams. Culverts should be replaced by open arches or bridges (minimum width of 1.5 bankfull width) to reduce the potential for blow outs in winter storms and improve fish passage.

Alien species. Alien species should be eradicated from streams and ponds where possible, with priority placed on the removal of predators (e.g., trout and bass species). Removal plans should be made on a site-by-site basis, using information gathered on the community assemblage and estimated abundances of species present in order to account for the potential incidental impacts to native fishes or other aquatic organisms from either chemical treatments or manual removal via electrofishing or netting.

Other actions. Little is known about the life history, habitat requirements and environmental tolerances of the Goose Lake sucker. Studies are needed in order to better understand Goose Lake sucker requirements and tolerances so that additional management measures can be identified. Establishment of refuge populations in farm ponds and other sites in the drainage should be considered. Populations throughout the basin, particularly in California, should be monitored to establish trend information and preserve genetic diversity.

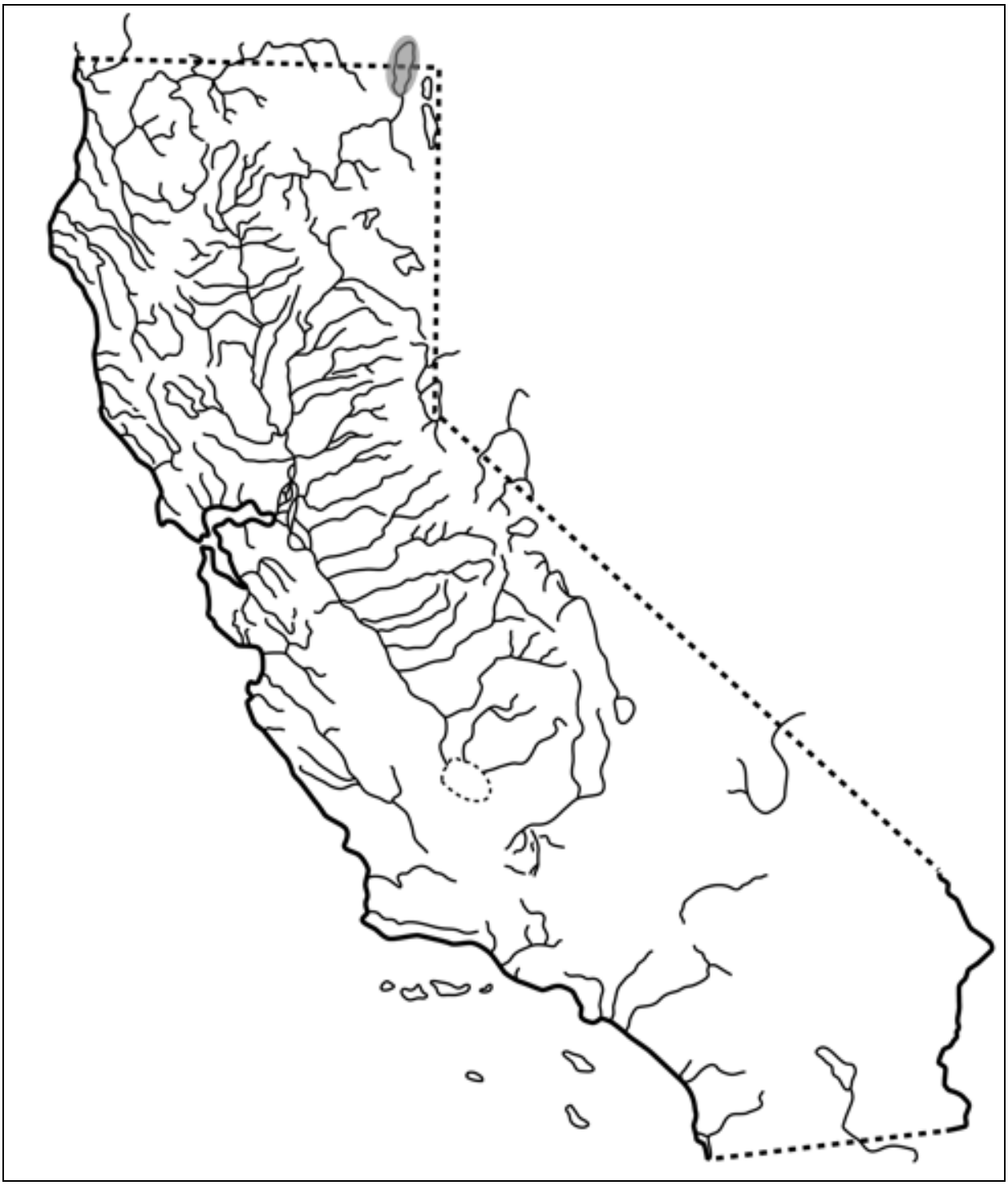

Figure 1. Distribution of Goose Lake sucker, *Catostomus occidentalis lacusanserinus*, in the Goose Lake basin, California.