Photo: Jacob Dickey

Assessment of native fish population status and species distribution in Goose Lake Basin (ODFW Agreement 044-22)

Final Project Report Prepared by:

Melanie Davis (U.S. Geological Survey)
Katherine Carey, Aleah Dew, Jacob Dickey (Oregon State University)

for Oregon Department of Fish and Wildlife (ODFW) and the Oregon Conservation and Recreation Fund (OCRF)

Background: The Goose Lake Basin is an endorheic desert basin that runs north-to-south on the border of Oregon and California. The Basin's watersheds drain into Goose Lake — a slightly alkaline system that has historically dried up during severe drought years, and drains into the Pit River to the south during very high-flow years. There are several endemic fish species that occupy Goose Lake and its adjacent rivers, wetlands, and riparian areas: Goose Lake redband trout, Goose Lake lamprey, Goose Lake tui chub, and Goose Lake sucker. These endemic species coexist with a variety of native and non-native species. Goose Lake and its surrounding watersheds are highly sensitive to climate-mediated disturbances such as drought. An increased frequency of disturbance events in the region may limit the accessibility, quantity, and quality of available habitat for native fishes, while increasing range expansion of non-native fishes may put undue stress on vulnerable species.

The goal of this project was to aid agency partners in conducting a population status assessment for at-risk native species in the Goose Lake ecosystem and to determine which areas are most at risk of declining populations due to disturbances such as drought and invasive species. Consistent surveys have not been conducted in many of Oregon's high desert basins for more than a decade. We were able to successfully collect data related to species abundance, distribution, and habitat during the 2022 field season, and additional funding from the Oregon Watershed Enhancement Board (OWEB) will allow us to extend our project for an additional two field seasons. Updated abundance and distribution estimates from this project will inform state and federal managers as to the population status of at-risk native fish species, while an assessment of habitat quality will support actionable management outcomes.

Study Area and Site Selection: Sampling efforts took place in the Oregon portion of the Goose Lake Basin. In 2007, ODFW visited 144 sites over 655 stream km of available summer habitat (Fig. 1). Roughly 330 points were generated using a spatially-balanced, Generalized Random Tessellation Stratified design (GRTS), and of those points, the 144 sampled sites were selected based on accessibility, site characteristics (e.g., depth, temperature), and time limitations. For our project, we randomly selected a subset of these 144 sites to monitor. Sites were stratified by HUC10, elevation, and burn status (Drews-Low, Drews-High, Thomas-Low, Thomas-High, Thomas-Burned, Dry, and Willow/Eastside), and five sites each were selected from each stratum. We also used GRTS to randomly generate a suite of about 250 similarly stratified sites, from which we selected a subset to collect eDNA samples. We recorded any sites that were dry upon arrival or were otherwise inaccessible.

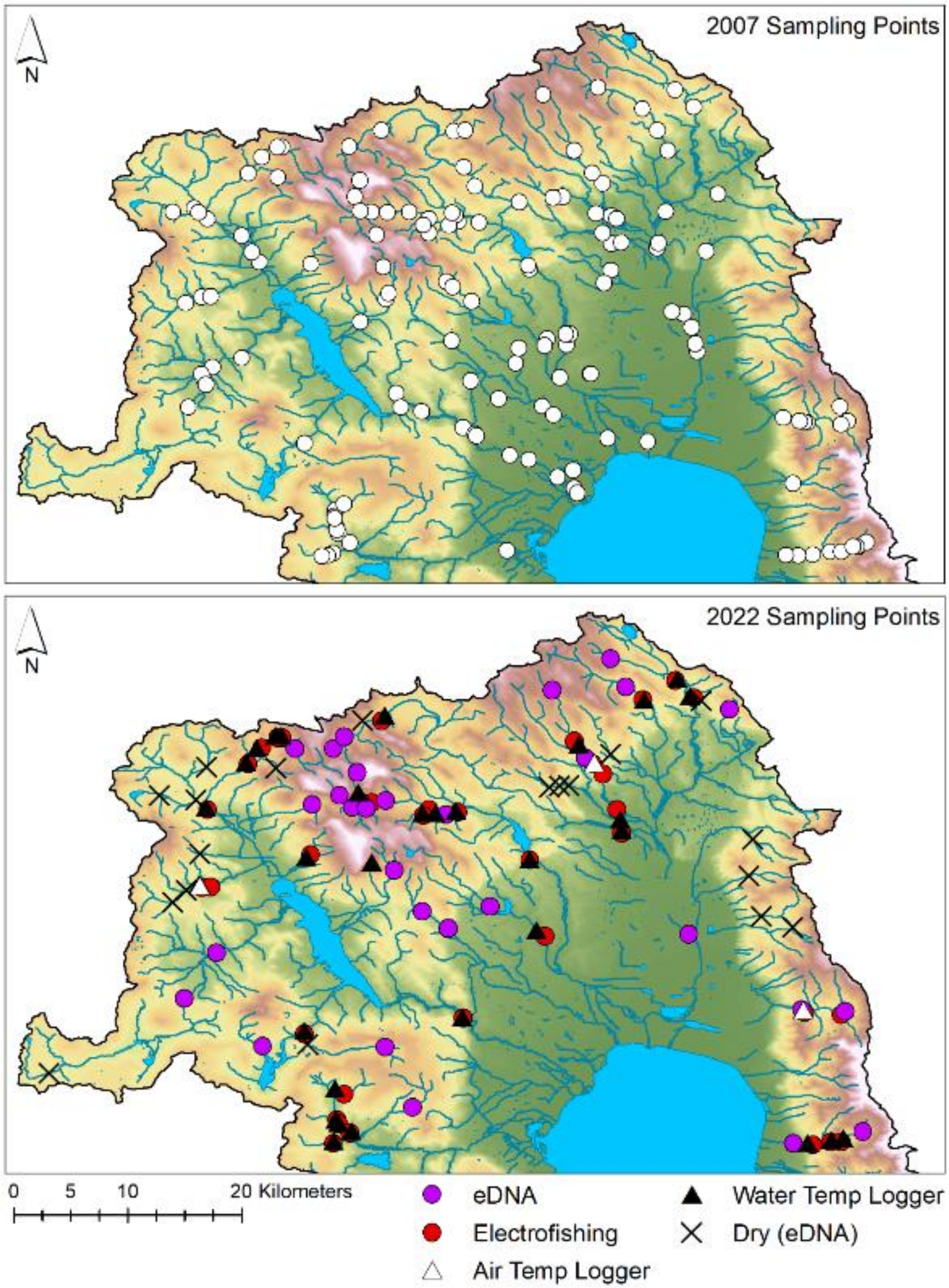

Figure 1. Sampling sites from 2007 ODFW field efforts (top) and 2022 field efforts (bottom).

Objective 1) Generate a spatial database of permanent and ephemeral riparian and wetland systems, including sites that have been previously surveyed and those that have not yet been surveyed.

To identify permanent and ephemeral wetlands in the Goose Lake Basin, we have cataloged historic and contemporary spatial wetlands data produced by the US Fish and Wildlife Service (USFWS) and successfully compiled other datasets from a variety of publicly available sources. Data have been actively archived in a database including information on the data type, date of collection, file type, file name and extension, file size, resolution (for raster data), projection/coordinate system, data source, website of origin, and relevant notes. Important raster data files include a 13 arc-second (approximately 10 m) USGS DEM with associated elevation, slope, hillshade, and aspect data, NAIP imagery, Landsat imagery, NLCD classification maps, Oregon wetlands soils, and Oregon vegetation classification maps. Important shapefiles include state lines and municipal boundaries, watershed boundaries, NHD hydrology data, transportation networks from Oregon Department of Transportation, historical fire boundaries (NIFC), land ownership, restoration sites (OWEB), existing stream barriers (ODFW), and sampling locations. We have also compiled model output from climate simulations like NorWEST, which includes spatial stream networks for South-Central Oregon.

Hand digitization of Basin watercourses was initiated by a GIS intern in Spring 2022. Improvements to the process will continue (e.g., including spatial stream network data, smoothing lines using a handheld tablet rather than mouse, identification of wetland habitat) through the extended duration of the project. Using USGS Landsat Dynamic Surface Water Extent products, we hope to generate an automated procedure to delineate lake and wetland area. Conducting this procedure at set intervals across multiple decades of available data will allow us to determine how stream and lake morphology has shifted through time for major watercourses (Fig. 2).

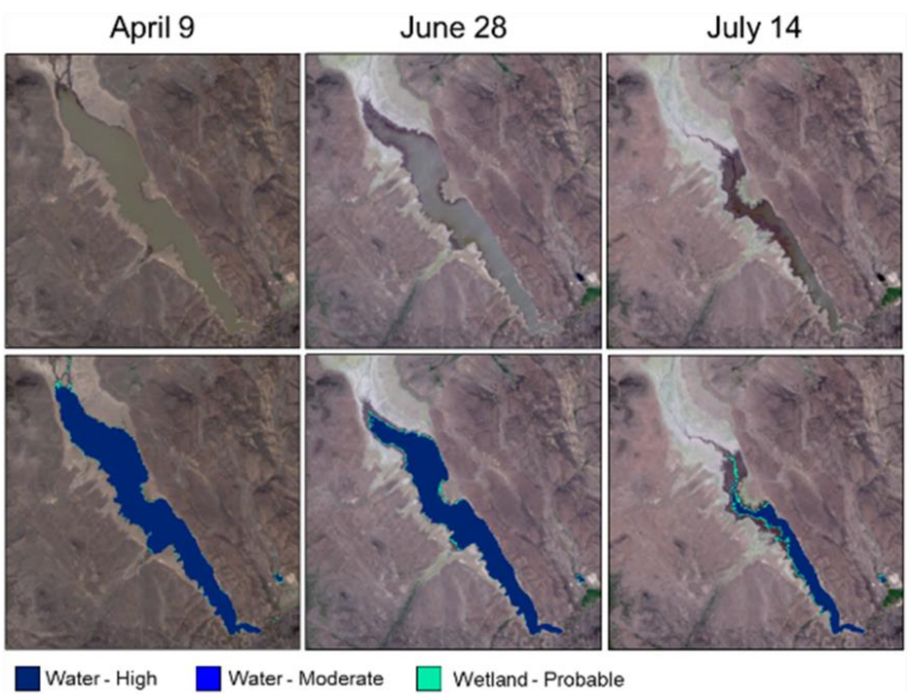

Figure 2. Landsat 8 multi-band (RGB) imagery and Dynamic Surface Water Extent products showing seasonal reductions in the surface area of Drews Reservoir during 2022.

Objective 2) Revisit sites with known populations of sensitive native species and conduct updated surveys.

For 2022 sampling efforts, we conducted updated surveys using both traditional (electrofishing) and novel (eDNA metabarcoding) methods. Fish species abundance and distribution in the Basin was assessed using three different methods; electrofishing to depletion, mark-recapture, and eDNA sampling. We sampled 36 sites with traditional and novel sampling methods and 35 additional sites using only eDNA. Additional funding from OWEB allowed us to extend our project by two field seasons. In 2023, 33 sites were sampled using electrofishing and 58 additional sites were sampled for eDNA. Six sites were changed or dropped between 2022 and 2023 due to spatial redundancy, lack of water/fish, or failure to obtain access permissions.

During electrofishing efforts, we measured fish abundance and local habitat variables including water temperature, dissolved oxygen, conductivity, stream depth and width, substrate type, and percent canopy cover. For eDNA sample collection, we collected triplicate samples plus one (distilled water) control sample for each site. eDNA samples were processed by the Levi Lab at Oregon State University. We used summary statistics and multivariate statistical techniques to evaluate changes in fish abundance and community structure between 2007 and 2022 and among sites. We used eDNA metabarcoding to assess current population distributions and compare to contemporary and historical data, taking advantage of new eDNA metabarcoding primers for fish developed by OSU and ODFW. Output from the eDNA metabarcoding analysis was compared to electrofishing survey data to assess its utility for system and basin-wide monitoring efforts.

A summary examination of electrofishing data comparing 2007 to 2022 findings indicates that fish communities did not change substantially, but that numbers of native trout and minnows have declined over the last 15 years (Fig. 3). In the Thomas Creek watershed, low elevation sites (1495 ± 36 m) were characterized by a mix of lamprey, trout, and native minnows, with occurrences of non-native fathead minnows in Thomas Creek. High elevation sites (1759 ± 138 m) were characterized by speckled dace (in Thomas and Cox Creeks) and redband trout (in Cottonwood Creek), with some introduced brook trout below Cottonwood Meadow Lake and some juvenile and adult lamprey in Cox Creek. In the Cougar Peak burn zone, most of which was high elevation (1658 ± 67 m), redband trout and lamprey predominated. Redband trout abundances appeared to have declined substantially between 2007 and 2022 at all sites while larval lamprey abundances increased in Upper Cottonwood and Camp Creeks. A seemingly isolated population of Pit sculpin at Thomas-Bauers 26 in Camp Creek was still present in 2022.

The Drews Creek watershed was punctuated by widespread declines in fish abundances. At lower elevation sites (1541 ± 46 m), sucker, Pit roach, speckled dace, and Tui chub were all highly abundant in Dent Creek and Dog Creek in 2007, but were absent in 2022. The ODFW crew had difficulty sampling Non-Game 23 in lower Drews Creek in 2007; however, we were able to electrofish this site successfully in 2022 and observed speckled dace and non-native fathead minnows. In upper Drews Creek (1754 ± 71 m), communities were characterized by lamprey and redband trout, with abundances lower in 2022 than in 2007. Pit sculpin at Drews 06 in upper Drews Creek were still present in 2022.

The Dry Creek stratum (1563 ± 46 m) also appeared to experience widespread fish declines. In Falls Creek and upper Dry Creek, redband trout were absent or depressed. In Dry Creek, previously robust populations of larval lamprey, sucker, Pit roach, speckled dace, and Tui chub were absent in 2022, although speckled dace were observed at Dry 21 when they were not observed in 2007. Pooling at these sites may have contributed to some differences. On the Eastside (1658 ± 48 m), the only species observed in Crane and Kelly Creeks was still redband trout, and fewer were observed in 2022 than in 2007.

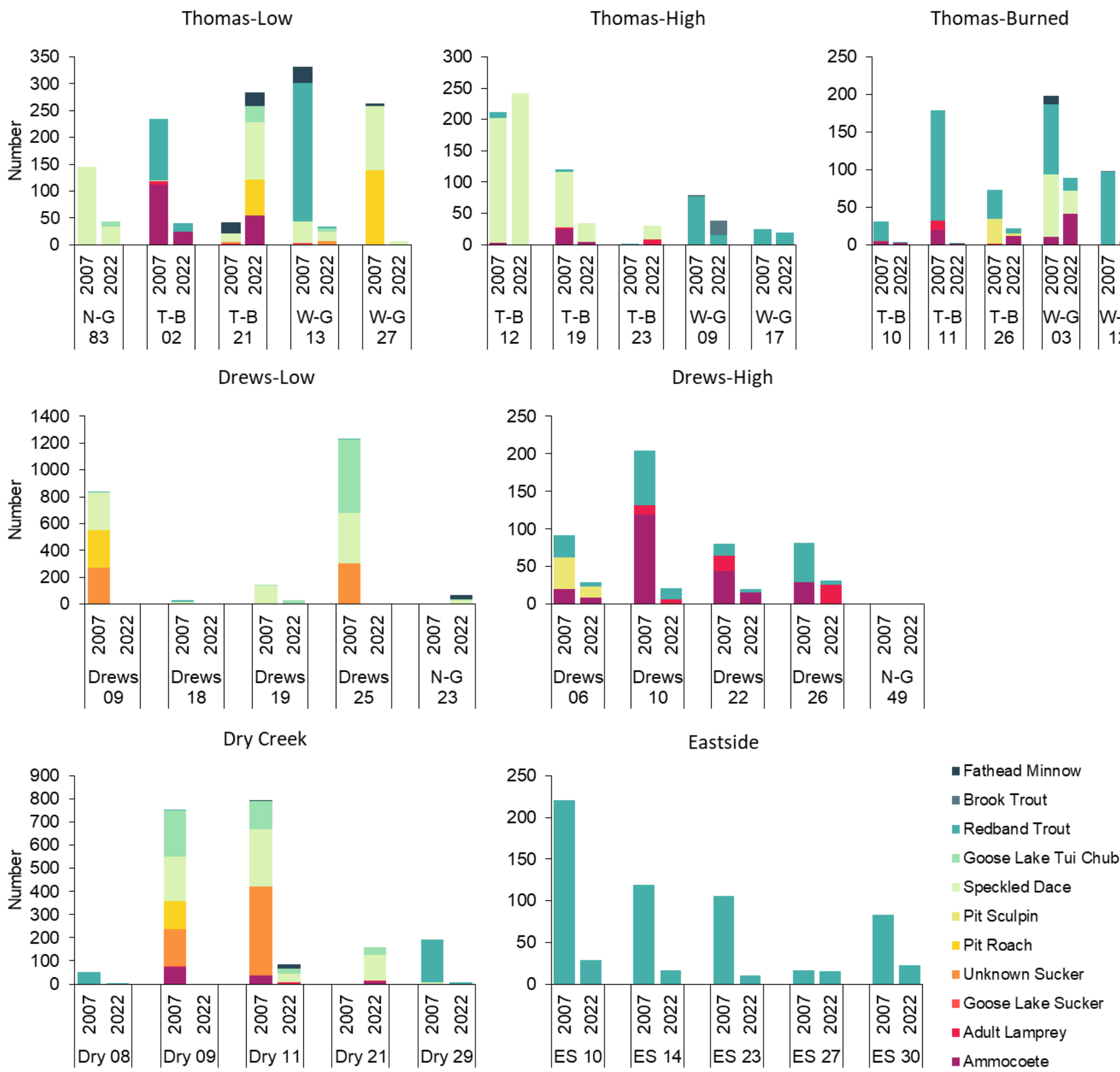

Figure 3. Species abundances for non-rare fish species in 2007 and 2022 for each stratum.

eDNA appears to be a viable monitoring method for detecting fish in the Goose Lake Basin, with greater sensitivity than electrofishing for most species; however, at this point eDNA metabarcoding is best used for presence-absence data and cannot be effectively used to gauge abundance.

Site	Lamprey (All)	Sucker (All)	Pit Roach	Pit Sculpin	Speckled Dace	Tui Chub	Redband Trout	Brook Trout	Fathead Minnow	Yellow Perch
DREWS-LOW										
DREWS 9		O			O		O		O	
DREWS 18					O		O			
DREWS 19										
DREWS 25	MiFish				O	O	MiFish		O	
NON 23		O			O	O	MiFish		O	
DREWS-HIGH										
DREWS 6	Meta	MiFish		O	MiFish	MiFish	O			
DREWS 10	Meta						O			
DREWS 22	Meta						O			
DREWS 26	O						O			
NON 49										
THOMAS-LOW										
NON 83					Meta					
TB 2	Meta				O		O			
TB 21	Meta	O			O	O	MiFish		O	
WEST 13		O			O	MiFish	O		O	
WEST 27					O	O	O		MiFish	
THOMAS-HIGH										
TB 12	Meta	MiFish			O					
TB 19	Meta				O		O			
TB 23	Meta				O					
WEST 9					MiFish		O	O	O	
WEST 17					MiFish		O			
THOMAS-BURNED										
TB 10	Meta						O			
TB 11	O						O			
TB 26	O			MiFish	MiFish		O			
WEST 3	Meta				O		O		MiFish	
WEST 12	O			O			O	MiFish	MiFish	
WEST 28				MiFish			O			
DRY										
DRY 8							O			
DRY 9	O	O			O	O	O			
DRY 11	Meta	O			O	O	O		O	
DRY 21	Meta	O			O	O	O		O	
DRY 29							O			
EASTSIDE										
EAST 10							O			
EAST 14							O			
EAST 23							O			
EAST 29							O			
EAST 30					MiFish		O			

Table 1. Comparison of fish species detected by electrofishing and eDNA in 2022 at each site. Green cells indicate a species was detected using both electrofishing and eDNA, blue cells indicate a species was detected by electrofishing only, and red cells indicate a species was detected by eDNA only. A circle specifies that both the “Meta” and “MiFish” eDNA primers detected a species. Three non-native species (brown bullhead, crappie, and pumpkinseed) were detected in 2007, but were not detected at the reduced subset of 36 “full suite” sites in 2022 by either electrofishing or eDNA.

Objective 3) Assess population status and habitat quality using survey and remote sensing data.

Preliminary species distribution models (SDMs) have been developed to analyze the distribution of larval lamprey using historical fish sampling data. SDMs offer insights into the relationships between species and their habitats, and can be used to make predictions about areas where data are lacking. We ran SDMs in a spatial stream network (SSN) framework using logistic regression models of presence/absence. The SSN framework is designed to consider spatial autocorrelation and potential biases in sampling methods. The best fit model indicated that larval lamprey presence was positively associated with elevation, upstream catchment area, and natural drainages and negatively associated with catchment surface roughness, slope, and artificial drainages (i.e., irrigation ditches). Lithology was also included in the best fit model as a proxy for substrate type. The model appears to effectively predict lamprey presence at basin-wide scales; however, there are parts of the basin where data are scarce for lamprey and other native fishes (Fig. 4). In these areas, we hope that future iterations of these SDMs can assist with guiding future research priorities and identifying areas where conservation efforts should be concentrated.

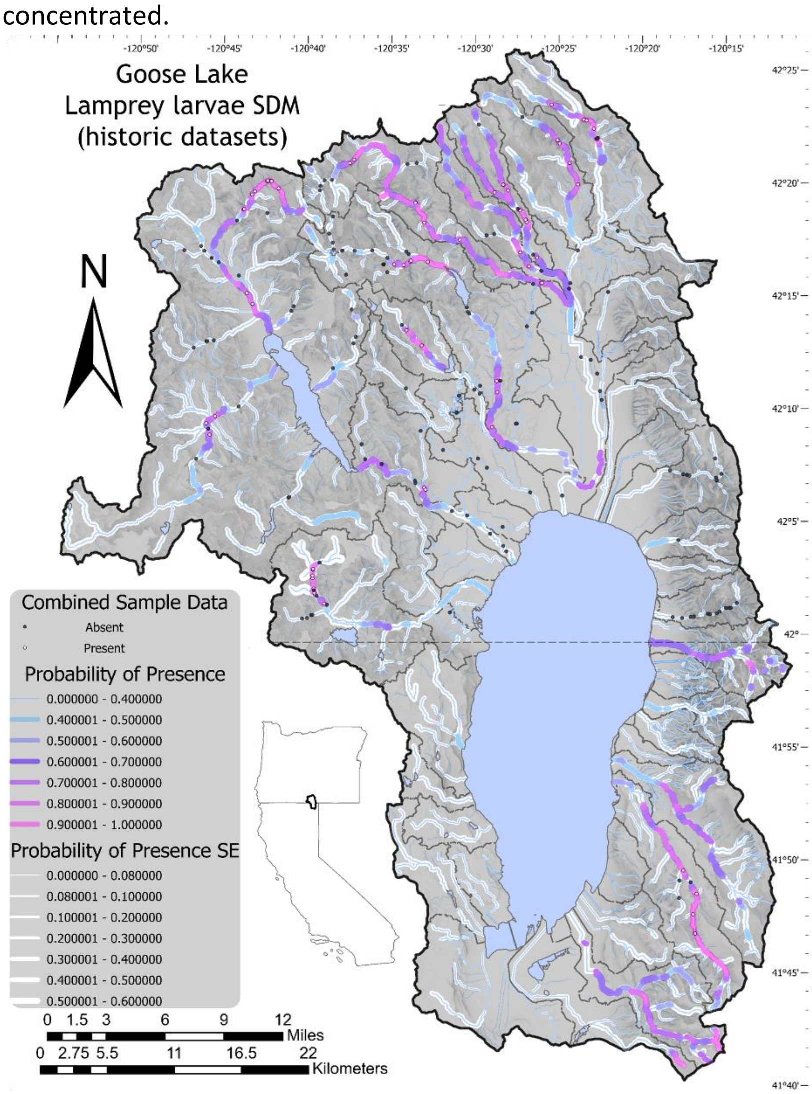

Figure 4. Spatial output from a stream spatial network-based species distribution model for larval lamprey in the Goose Lake Basin.

Outcomes: Successful data collection efforts and preliminary findings from the 2022 field season allowed us to obtain funding through the OWEB Monitoring Grant Program to expand our project for an additional two field seasons and increase the scope of our spatial analyses. Additionally, we have applied for funding through the USGS Northwest Climate Adaptation Science Center to assess hydrological connectivity in the Goose Lake Basin, which if funded, will fill critical knowledge gaps about water availability for species that depend on the Basin's aquatic habitats. We now anticipate the full duration of this project to run through the year 2027. Collaborators with ODFW, USFWS, and USGS are using preliminary findings to inform potential monitoring efforts in other parts of the Oregon Great Basin, especially with respect to eDNA sampling. We expect that as the project continues, our partner agencies will use the resultant deliverables to make important conservation, management, and restoration decisions for vulnerable species and their habitats. With this goal in mind, we have been actively communicating our results with local organizations that plan and carry out restoration actions, such as the Lake County Umbrella Watershed Council.