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Redband Trout (*Oncorhynchus mykiss ssp.*) Distribution, Abundance, and Habitat Surveys in the Streams of Hart Mountain National Antelope Refuge, Oregon.

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Redband Trout (*Oncorhynchus mykiss ssp.*) distribution, abundance, and habitat surveys in the streams of Hart Mountain National Antelope Refuge, Oregon.

Prepared by

Sharon E. Crowley
Ronald J. Constable, Jr.

Oregon Department of Fish and Wildlife
Aquatic Inventories Program
28655 Highway 34
Corvallis, OR 97333

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ABSTRACT

The objectives of this study are to compare the current abundance and distribution of Great Basin Redband Trout (*Oncorhynchus mykiss ssp.*) in Rock Creek to previous estimates from 2007, 2009-2012, and 2015, and to determine fish distribution and species composition in Guano Creek. The Rock Creek sampling frame extended from Flook Ranch to the headwater tributaries. We used a GRTS-based sampling design with single pass and mark-recapture electrofishing protocols to estimate 6,124 Redband Trout within the sampling frame in 2022. The majority (4,450) of these fish were in the upper drainage. This is an increase from the population estimate of 1,487 in 2015, though distribution of redband and patterns of stream drying in Rock Creek were similar. Redband Trout density and abundance are highly variable and may be in part due to a response to annual precipitation among water years. Both 2015 and 2022 sampling occurred during periods of consecutive low water years and have lower population estimates than 2007-2012 sampling which took place during years with higher annual precipitation. The lower portion of Rock Creek (downstream of Willow Creek) was predominantly dry and puddled during the census habitat survey conducted from July 13 through August 2, 2022, after completion of fish sampling. The Guano Creek sampling frame started upstream of Jacobs Reservoir and extended to the headwaters. A GRTS-based sampling design and a single pass electrofishing protocol were used to sample trout. Guano Creek was previously stocked with Lahontan Cutthroat Trout (*Oncorhynchus clarkii henshawi*), coastal Rainbow Trout (*Oncorhynchus mykiss*), and possibly Alvord Cutthroat Trout (*Oncorhynchus clarkii alvordensis*), and some hybridization is presumed between redband and stocked trout. However, genetic analyses have not been completed to assess the level of introgression between redband and previously stocked fishes. We captured 23 trout from 1km downstream of Box Creek to the headwaters of Guano Creek during June 16-21, 2022. Water temperatures ranged from 7°C to 12°C throughout this portion of the sampling frame. High water made the lower portion of the sampling frame inaccessible at the start of the field season. When we returned on June 30, 2022, the stream was puddled, marshy, and dry with water temperatures ranging from 12°C to 16°C. No fish were captured in the lower portion of the sampling frame. Further stream drying was recorded when crews returned to Guano Creek to conduct a census style stream habitat survey July 14 – August 11, 2022. The lower portions of both the Rock Creek and Guano Creek sampling frames where no fish were captured had low levels of shade and higher stream temperatures. Lower stream temperatures and higher levels of canopy cover, shade, riparian vegetation, and fish densities were present in the upper portions of both drainages. Promoting a more complex composition of riparian vegetation throughout Rock Creek and Guano Creek would enhance the quality and quantity of available stream habitat, especially in areas where higher water temperatures and stream drying appear to be limiting factors for redband productivity and resiliency in low water years and periods of drought.

INTRODUCTION

Great Basin Redband Trout (*Oncorhynchus mykiss ssp.*) have declined in abundance across their range and are a species of conservation concern (Interior Redband Conservation Team 2016). The Catlow Valley Redband Trout Special Management Unit (SMU), which includes the Rock Creek and Guano Creek populations, has been classified as 'at risk' under the Oregon Native Fish Status Report (Oregon Department of Fish and Wildlife 2005). Our primary objective was to inform the 'at risk' classification by comparing redband distribution and abundance estimates from surveys conducted in 2022 to estimates from previous surveys in 2007 and 2009-2012 (Meeuwig and Clements 2014) and in 2015 (Meeuwig and Clements 2015).

In 2022, census stream habitat surveys were conducted on Rock Creek and Guano Creek after the completion of fish sampling. Changes in summer (June to August) water depth and stream temperature were compared to the 2015 patterns of stream drying, which may have limited habitat availability (Meeuwig and Clements 2015).

The second objective of this study was to determine fish distribution and provide an updated fish species composition in Guano Creek. The Oregon Native Fish Status Report (Oregon Department of Fish and Wildlife 2005) suggests the Guano Creek redband population is potentially threatened by hybridization with cutthroat trout, though the assumption that Catlow Valley Redband Trout were historically present in Guano Creek is debatable based on the geographic isolation of the Guano basin (Behnke 2007). The most recent Oregon Department of Fish and Wildlife (ODFW) Guano Creek fish survey was conducted in 1992, and cutthroat trout and unidentified salmonids were recorded. Introduced Lahontan Cutthroat Trout (*Oncorhynchus clarkii henshawi*) and presumed redband x cutthroat hybrids have been observed in the Guano Creek basin.

The fish and habitat survey we conducted in 2022, and their comparisons to previous surveys, will help inform the conservation status and management planning for Redband Trout and their habitats.

METHODS

Study Area

Rock Creek and Guano Creek are located within the boundaries of the Hart Mountain National Antelope Refuge (HMNAR), in southeastern Oregon's high desert and Northern Basin and Range Ecoregion (Omernik 1987). Climate characteristics include cold winters and hot, dry summers. Precipitation, primarily winter snow and spring rain, generally averages 30cm per year (USFWS 1994). Despite the occurrence of stream drying over relatively large sections of the sampling frame in past years, redband were resilient to changes in environmental conditions and the quantity of available habitat (Meeuwig and Clements 2015).

Rock Creek and Guano Creek are located within hydrologic unit code (HUC) 17120008. The Rock Creek drainage sampling frame consisted of 40km of perennial stream, extending from Flook Ranch to the headwaters of Rock Creek, including two named tributaries, Willow Creek and Bond Creek. The upper extent of the sampling frame in Willow Creek and Bond Creek was based on the first tributary to each stream (Figure 1).

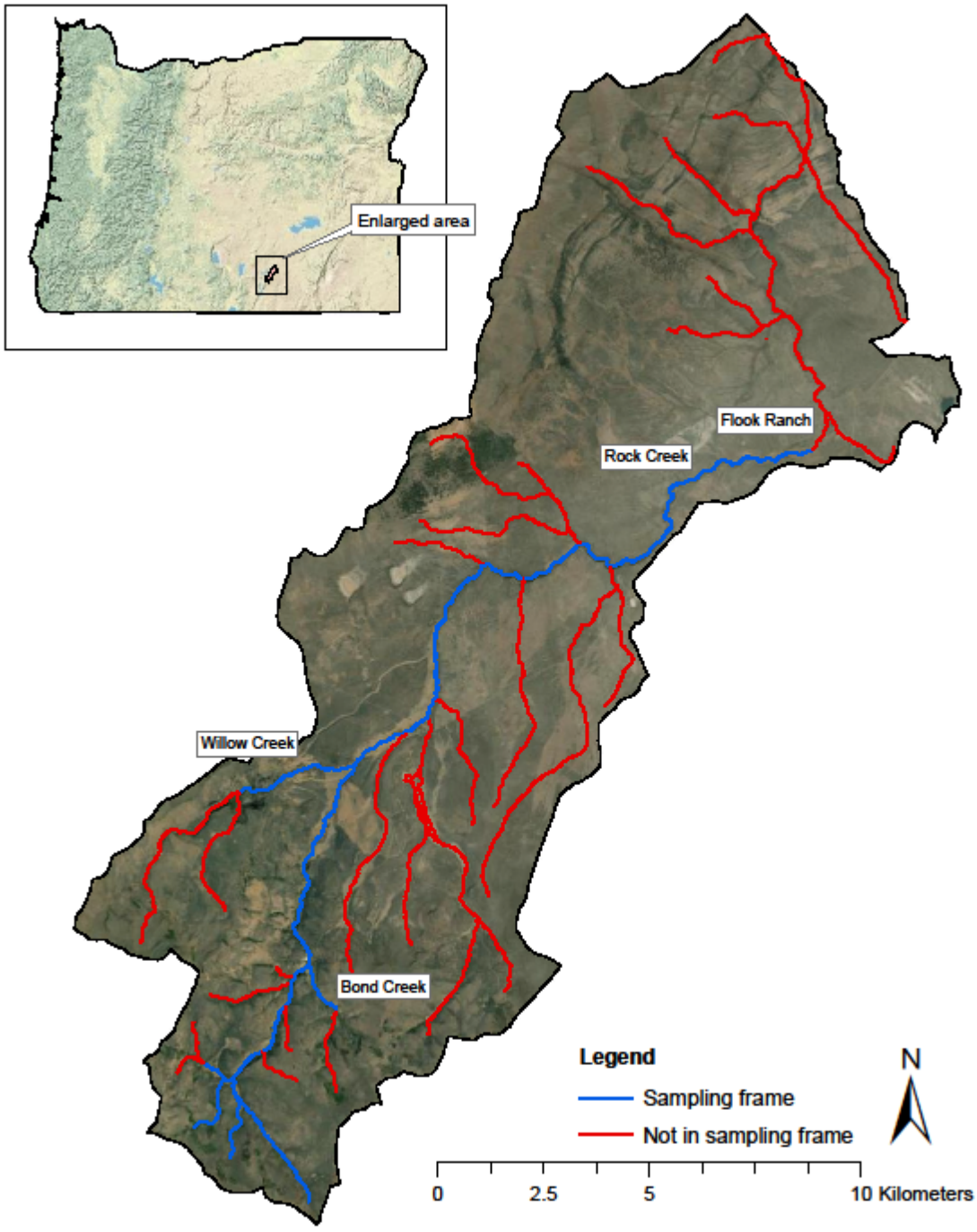

Figure 1. Location of Rock Creek drainage sampling frame, extending from Flook Ranch to the headwaters, including two named tributaries, Willow Creek and Bond Creek.

The Guano Creek drainage sampling frame consisted of 24.3km of perennial stream, extending from the head of Jacobs Reservoir to the headwaters of Guano Creek (Figure 2).

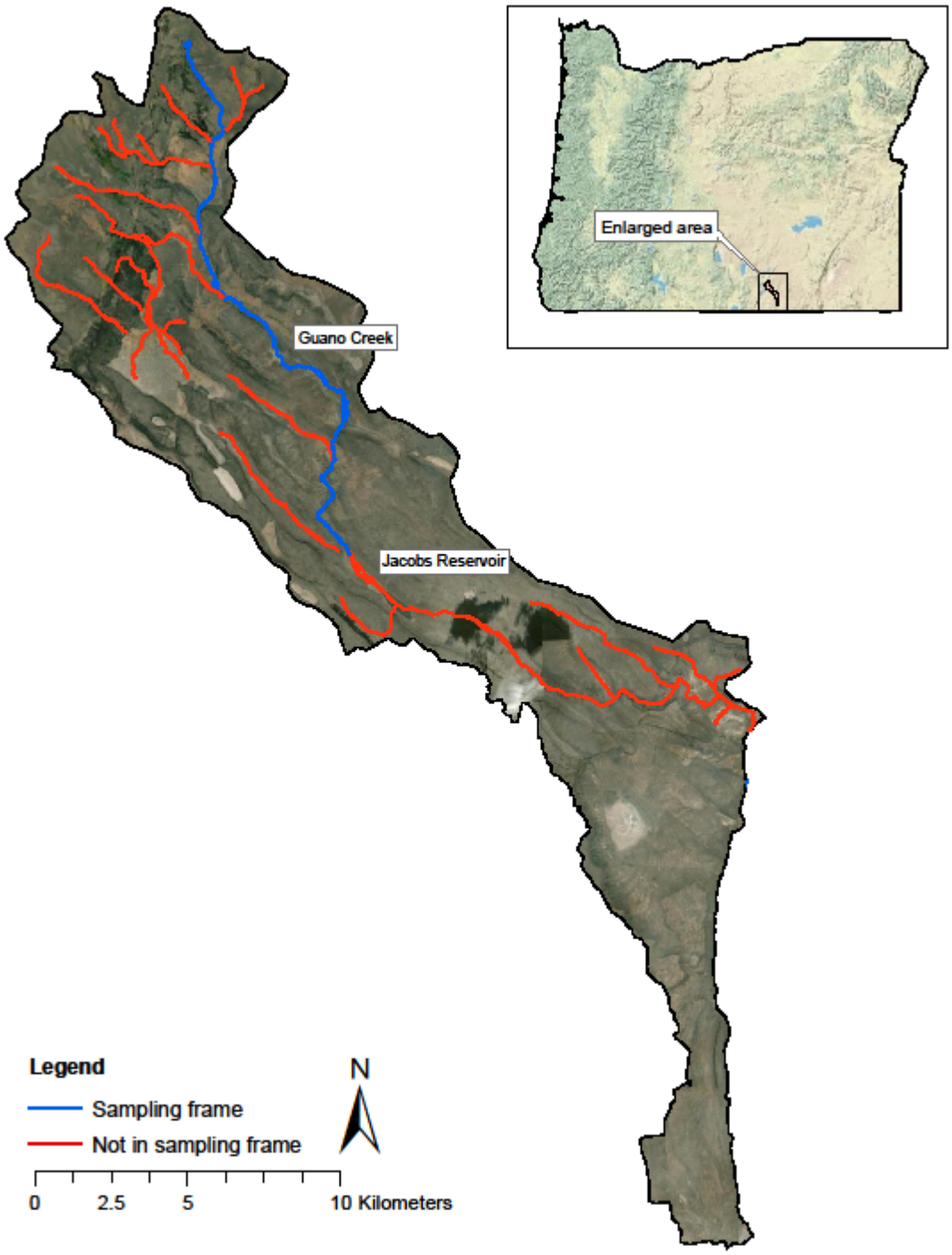

Figure 2. Location of Guano Creek drainage sampling frame, extending from Jacobs Reservoir to the headwaters.

Fish and Habitat Sampling

Fish and habitat sampling occurred from June 15 through July 11, 2022. A generalized random tessellation stratified (GRTS) design (Stevens and Olsen 2004) was used to select survey sites within the Rock and Guano Creek sampling frames. The GRTS design provided randomly selected, spatially balanced geographic coordinates (GRTS points) that determined survey site locations. The lower boundary of the survey site was identified as the tail of the first pool downstream of the GRTS point. The crew measured upstream for approximately 100m to identify the upper boundary. If the 100m mark was in a pool, the upper boundary was at the upper extent of the pool. If the 100m mark was in a fastwater habitat unit, the boundary was at this point regardless of where it occurred in the habitat unit. Habitat unit types (pools and fastwaters) were identified following Moore et al. (2007). Crews recorded the stream temperature using a standard Celsius thermometer placed in the water column. If the stream temperature was below 21°C, block nets were placed at the upstream and downstream boundaries of the survey site. Electrofishing was not conducted and survey site dropped if the stream temperature exceeded 21°C. If the entire survey site was dry, it was recorded as a dry site and no other sampling was conducted. Further details of redband survey site selection and sampling protocols were described in Meeuwig and Clements (2015).

Single Pass Sampling

Fish were sampled using a backpack electrofisher (model LR-20B; Smith-Root, Inc.; Vancouver, Washington) and single pass sampling. The LR-20B was set at the minimum settings needed to capture fish and adjusted incrementally until field crews identified appropriate and efficient voltage settings for Rock Creek. A two to four-person field crew sampled in an upstream direction starting at the downstream block net and systematically covering all areas of the survey site, ending at the upstream block net (Dunham et al. 2009). The length and reason for unsampleable portions of each survey site was noted. Captured fish were placed in holding buckets, which were filled with fresh stream water, placed in the shade, or covered with vegetation, and fitted with battery powered aerators to maintain high levels of dissolved oxygen. After electrofishing was completed, redband were anesthetized using MS-222, measured for fork length (mm), counted, and placed in shaded recovery buckets with fresh stream water and aerators. Physical habitat was then quantified (see below) and block nets removed. Once fully recovered from the anesthetic and swimming well, fish were evenly distributed back into the survey site.

Mark-Recapture Sampling

Since regression analysis revealed that abundance estimates of redband based on mark-recapture sampling were strongly related to the number of fish captured on the marking pass (Meeuwig and Clements 2015), we employed mark-recapture sampling to calibrate our single pass sampling. A subset of survey sites was sampled following the mark-recapture sampling protocol of Hayes et al. (2007). Initially, every third survey site from the GRTS draw was

designated as a mark-recapture site. However, because of the unknown distribution of redband, we revised the protocol to use mark-recapture at all survey sites where more than 10 fish were captured on the first pass. Mark-recapture sampling included a first phase marking pass and a second phase recapture pass. Each pass followed the single pass protocols. Fish were marked with a fin clip on the first pass. After the fish marked in phase one recovered, they were returned to the survey site, and the block nets were left in place overnight. The site was allowed to recover for approximately 24 hours before the recapture pass was performed (Temple and Pearsons 2007). This period of time allowed mixing of marked and unmarked fish, and it allowed our assumption that captured efficiency was similar between passes to be met (Peterson et al. 2004, Rosenberger and Dunham 2005). Equal effort was made on each pass. At the conclusion of the recapture pass, fish were counted as either marked or unmarked.

Physical Habitat Sampling

At each survey site, the site length (m) was measured from the downstream boundary to the upstream boundary. The sampled site length (i.e., the proportion of stream that was electrofished) and the wetted site length (i.e., the site length minus any dry portions) were also measured. Transects were conducted at 10m increments throughout the survey site, starting 5m above the downstream site boundary. Wetted width and stream depth (measured at 25%, 50%, and 75% of the wetted width) were measured and recorded at each transect. We calculated mean width as the average of wetted widths within each survey site. To calculate mean transect depth, the three depths recorded for each transect were summed and divided by 4 to account for 0 depth at each bank. The mean transect depths were then averaged among transects to calculate mean depth within each survey site (Meeuwig and Clements 2015).

Stream Habitat Surveys

Upon completion of fish and habitat sampling at each survey site, census style stream habitat surveys were conducted on Rock Creek, Rock Creek headwater tributaries, and Guano Creek. Data collection adhered to protocols developed by Moore et al. (2007). Attributes collected and summarized at the reach level described physical habitat, channel morphology, substrate composition, instream wood, and riparian vegetation. This information was used to describe the status of habitat during the period of July 13 to August 11, 2022, and to compare stream habitat conditions to earlier in the summer when redband sampling occurred.

Redband Trout Density and Abundance

Following Meeuwig and Clements (2015), we estimated site-level Redband Trout abundance for mark-recapture sites using the Chapman estimator (Seber 1982):

$$N_{MR} = \frac{(M+1)(C+1)}{(R+1)} - 1$$

where, N_{MR} is the mark-recapture abundance estimate, M is the number of fish captured and marked on the marking pass, C is the total number of fish captured on the recapture pass, and R is the number of marked fish captured on the recapture pass. The analysis was based on redband ≥ 65mm to maintain consistency with past protocols and allow estimates to be comparable (Meeuwig and Clements 2015). We assumed capture efficiency was similar between the marking and recapture passes. Mortalities recorded in the marking pass were not available for recapture and were not included in mark-recapture estimates. Mortalities recorded in the recapture phase were included in mark-recapture estimates.

In previous sampling of redband at HMNAR, abundance estimates from mark-recapture were strongly related to the number of fish captured during the marking phase (Meeuwig and Clements 2015). Following the methods of Meeuwig and Clements (2015), we fit a linear regression model without a y-intercept where N_{MR} was the dependent variable and M was the independent variable (Figure 3). One outlying observation was not included in our model. The resulting model was $N_{MR} = 2.144 * M$ ($R^2 = 0.996$, $p = 0.002$). Because the number of fish captured during the marking phase of mark-recapture is analogous to the number of fish captured during the single-pass sampling, our model to estimate abundance based on the single-pass sampling was:

$$N_{SL} = 2.144 * P_1$$

where, N_{SL} is the site-level abundance estimate and P_1 is the number of fish captured using single pass sampling. This analysis was based on redband ≥ 65mm. Site-level Redband Trout density (D_{SL}) was estimated by dividing the site-level abundance estimate (N_{SL}) by the survey site length. Abundance for the entire sampling frame and the upper portion of the frame (Rock Creek above Willow Creek) was calculated by multiplying N_{SL} by the corresponding survey site weights. Survey site weights were the frame length divided by the number of survey sites completed within the frame (Stevens and Olsen 2004).

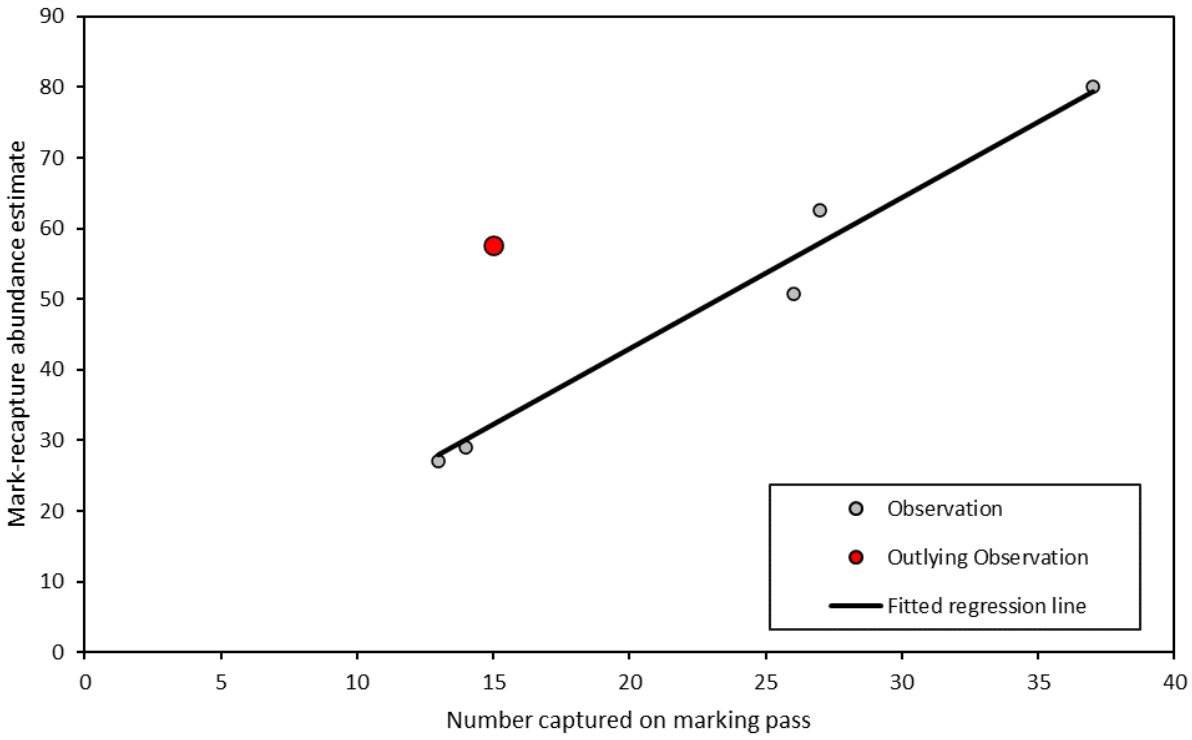

Figure 3. Redband Trout abundance estimated from mark-recapture sampling. The regression model (N_{MR} = 2.144*M) was fit without an intercept and with the outlying observation omitted (R^2=0.996).

RESULTS

Rock Creek

We visited a total of 37 survey sites and conducted fish and habitat sampling at 30 sites. Seven survey sites were either dry, covered in dense willow, or too shallow to effectively sample. Single pass sampling was conducted at 24 sites. Mark-recapture sampling was conducted at 6 of the survey sites. Fish were captured at a total of 13 survey sites. These 13 survey sites were spatially distributed from the confluence of Willow Creek to the headwater tributaries entering Rock Creek at Barnhardy (Figure 4).

We sampled a total of 258 redband varying in length from 59-197mm (Figure 5). No redband were observed in the lower 22.8km of the sampling frame, downstream of Willow Creek. In 2022, we estimated Redband Trout abundance was 6,124 (SD = 361, 95%CI ±707) for the whole drainage and 4,450 (SD = 304, 95%CI ±596) for the upper drainage (above Willow Creek), with a site-level density ranging from 0.02 – 0.93 fish per meter (Figure 4).

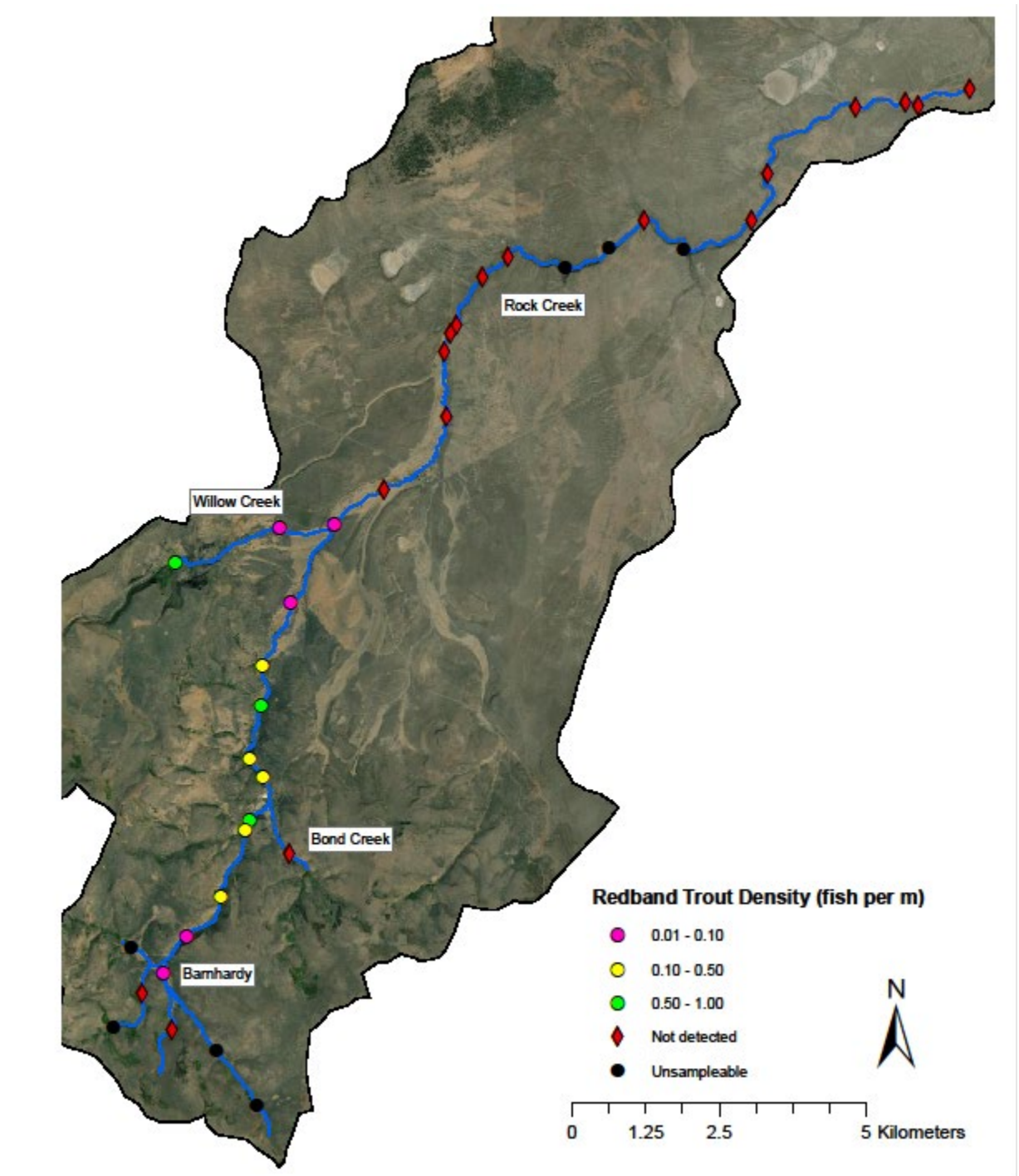

Figure 4. Site-specific Redband Trout density and distribution during sampling conducted from June 15 through July 4, 2022.

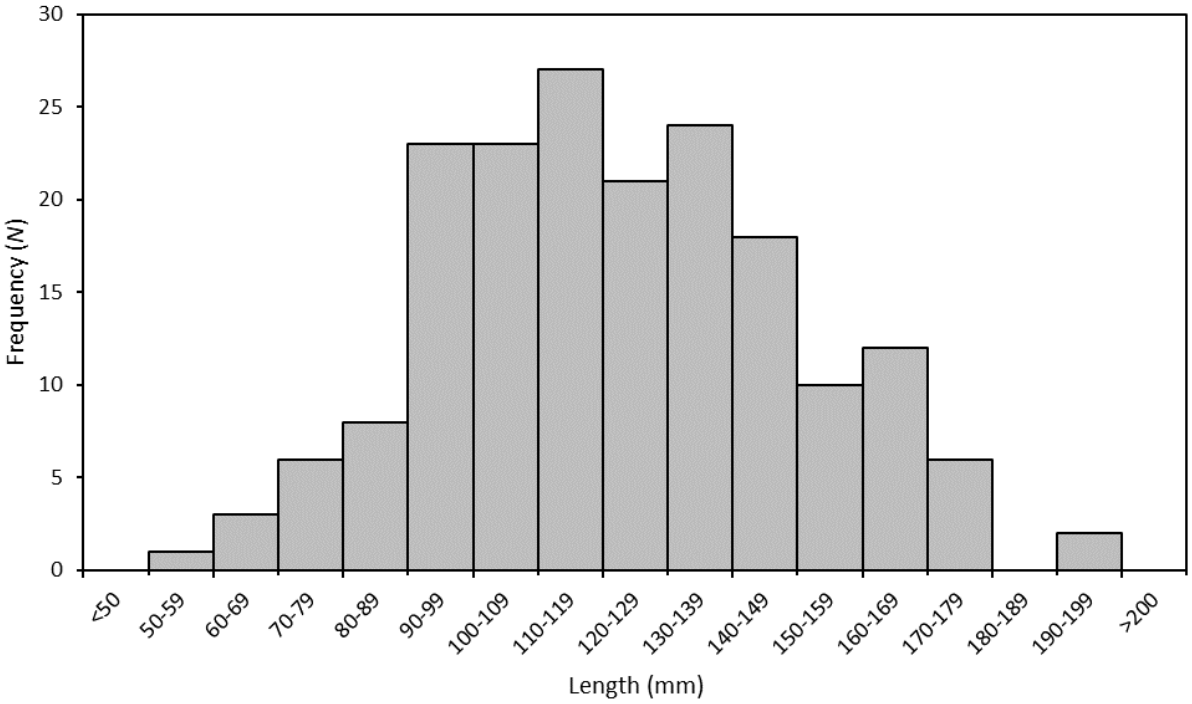

Figure 5. Length frequency histogram for Redband Trout sampled in Rock Creek in 2022.

Stream temperatures in lower Rock Creek (downstream of the confluence with Willow Creek) ranged from 10.0°C to 18.5°C with a median temperature of 14.4°C (Figure 6). The mean wetted width was 0.72-2.88m and the average water depth was 3-25cm. No fish were detected at these survey sites. Mainstem Rock Creek temperatures ranged from 6.0°C to 13.0°C from the confluence of Willow Creek and upstream. The median temperature was 9.4°C and redband were captured at all sites within this subset of the sampling frame where the mean wetted width was 0.76-2.00m and the average water depth was 6-28cm. Willow Creek, Bond Creek, and headwater tributaries to Rock Creek had stream temperatures ranging from 4.5°C to 16.0°C with a median temperature of 8.0°C. The mean wetted width was 0.47-1.41m and the average water depth was 2-9cm. Redband were only captured at the Willow Creek survey sites; no fish were detected in Bond Creek or the headwater tributaries.

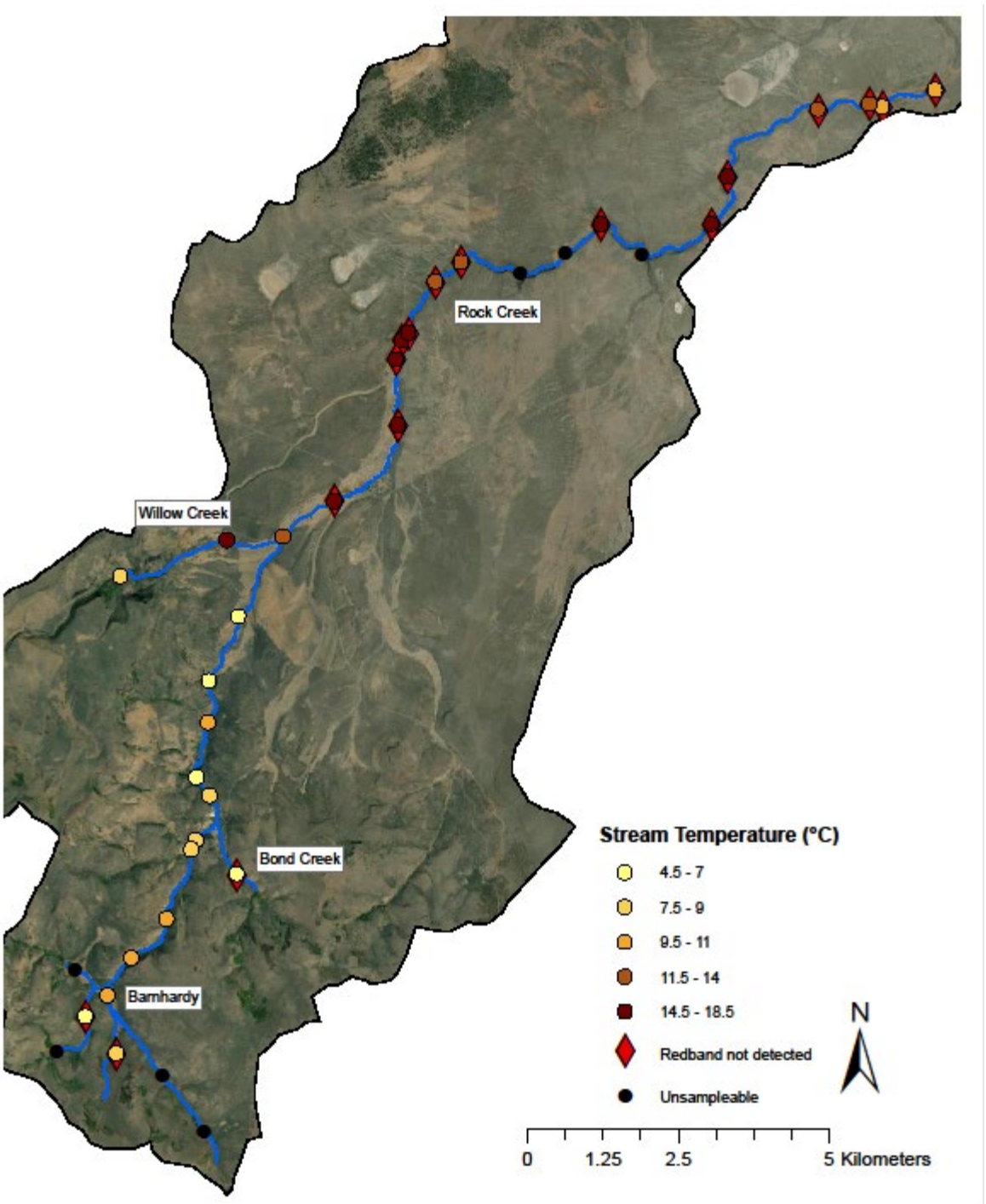

Figure 6. Stream temperatures measured during Redband Trout surveys conducted in the Rock Creek drainage from June 15 through July 4, 2022.

A census stream habitat survey was conducted upon the completion of fish sampling. The lower portion of the sampling frame, from Flook Ranch to Willow Creek was mostly dry with some puddled sections, isolated mainstem pools, and intermittent flow; this area was characterized by variable but generally shallow water depths (Figure 7). Riparian vegetation consisted primarily of grasses and sagebrush, with little shade or canopy cover. The stream channel was devoid of large wood and all tributary confluences were dry. Undercut banks were present in 25% of the habitat units from Flook Ranch to Lyons Meadow and in 47% of habitat units from Lyons Meadow to Willow Creek. Upstream of Willow Creek, undercut banks were present in 38% of habitat units and shade increased with the presence of hardwood trees and shrubs in the riparian, though the stream remained mostly dry with puddled units for another 3.8km. We observed 11 redband mortalities at the transition from a dry and puddled stream to low flow, coinciding with an area of increased redband density. No additional mortalities were observed upstream where shade and canopy cover were consistently high, instream large wood was present, water temperatures ranged from 14.0°C to 18.5°C with a mean temperature of 16.2°C.

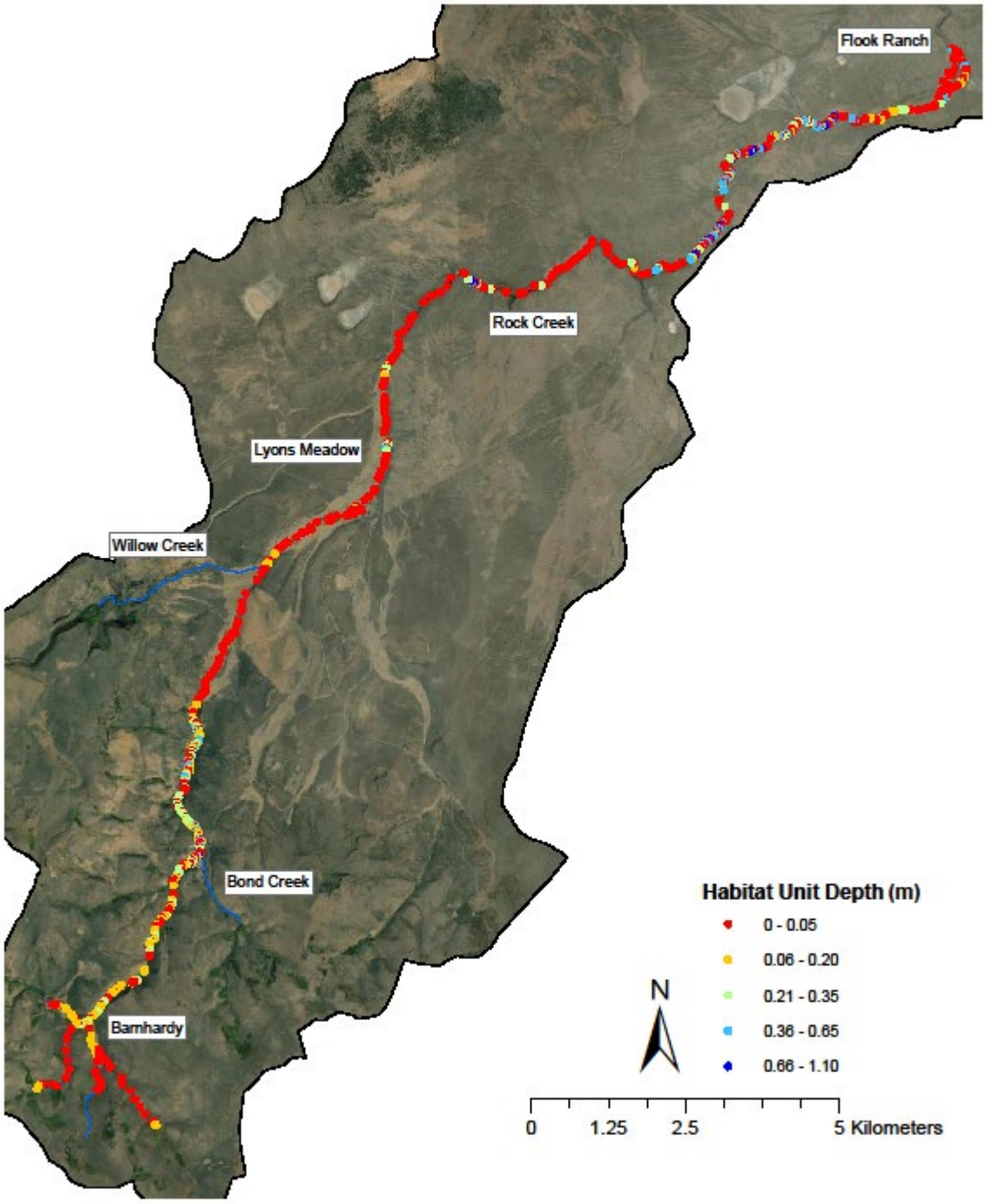

Figure 7. Spatial distribution of habitat unit depth collected during the Rock Creek stream habitat survey July 13 – August 2, 2022.

Guano Creek

We visited a total of 18 survey sites and conducted fish and habitat sampling at 12 of these. Six survey sites were dry, marshy, or covered in dense willow. Single pass sampling was conducted at 12 sites; fish were captured at 6 of these 12. These ranged from approximately 1km downstream of the Box Creek confluence to the headwaters of Guano Creek (Figure 8). We sampled a total of 23 trout ranging in length from 47mm to 258mm (Figure 9). Larger trout were captured from approximately 1km downstream of the confluence with Box Creek to the confluence with Goat Creek. These fish were predominantly >160mm fork length (12 of 13 fish), and the mean fork length was 197mm. Stream temperatures were 7.0°C to 12.0°C, the mean wetted width was 1.05-1.54m, the average water depth was 17-25cm, and canopy cover was grasses or nonexistent. The mean fork length of fish captured further upstream, from the confluence of Stockade Creek to the headwaters, was 109mm. Stream temperatures in this upper drainage were 9.0°C to 11.0°C, the mean wetted width was 0.92-1.53m, and the average water depth was 9-12cm, with willows covering portions of the stream. Stream temperatures in the lower drainage of Guano Creek, downstream of the confluence with Box Creek, ranged from 12.0°C to 16.0°C with a median temperature of 14.0°C. Fish were not detected in this lower portion of Guano Creek (Figure 10).

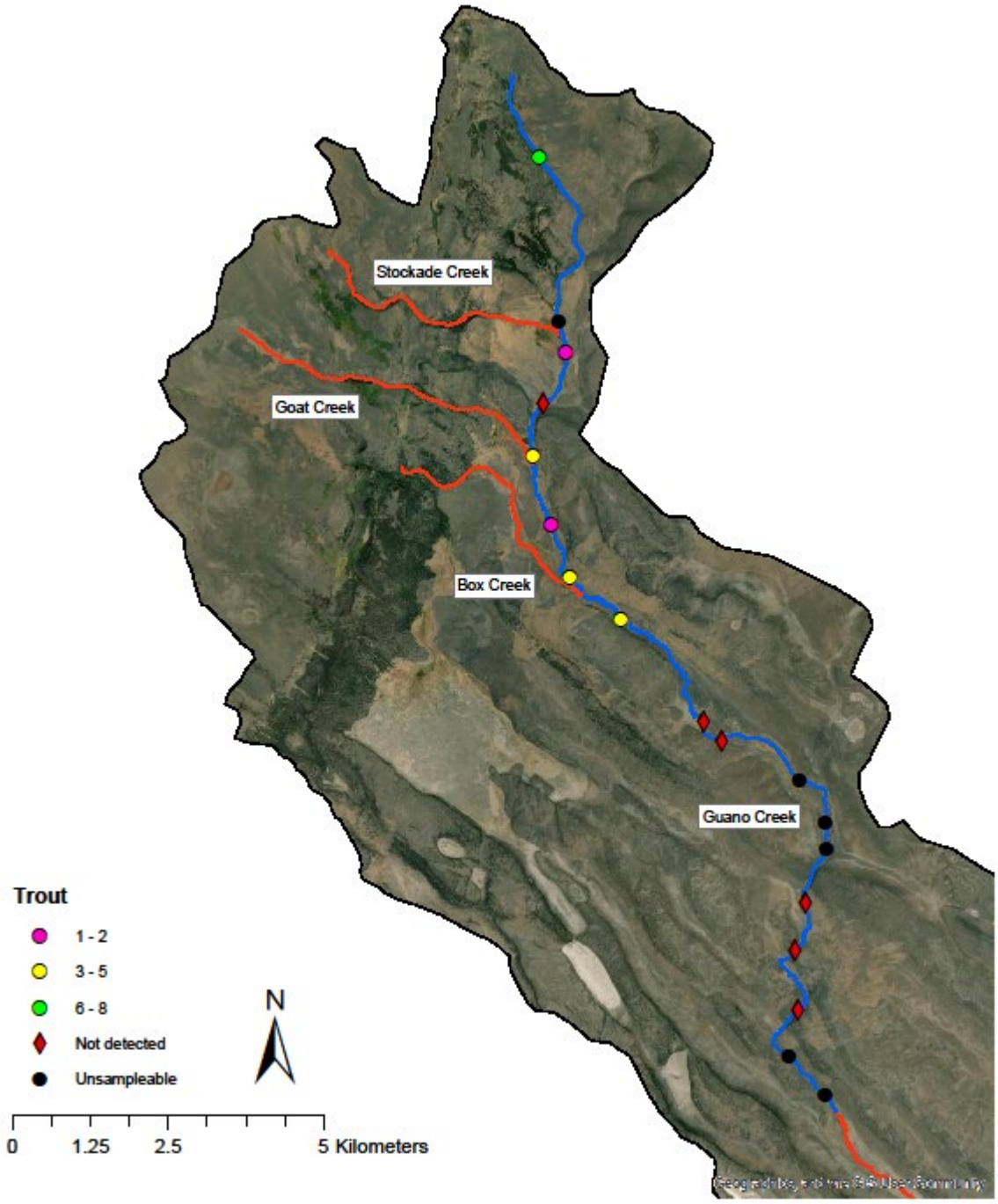

Figure 8. Site-specific sampling results from fish surveys conducted in the Guano Creek drainage from June 16 through July 11, 2022.

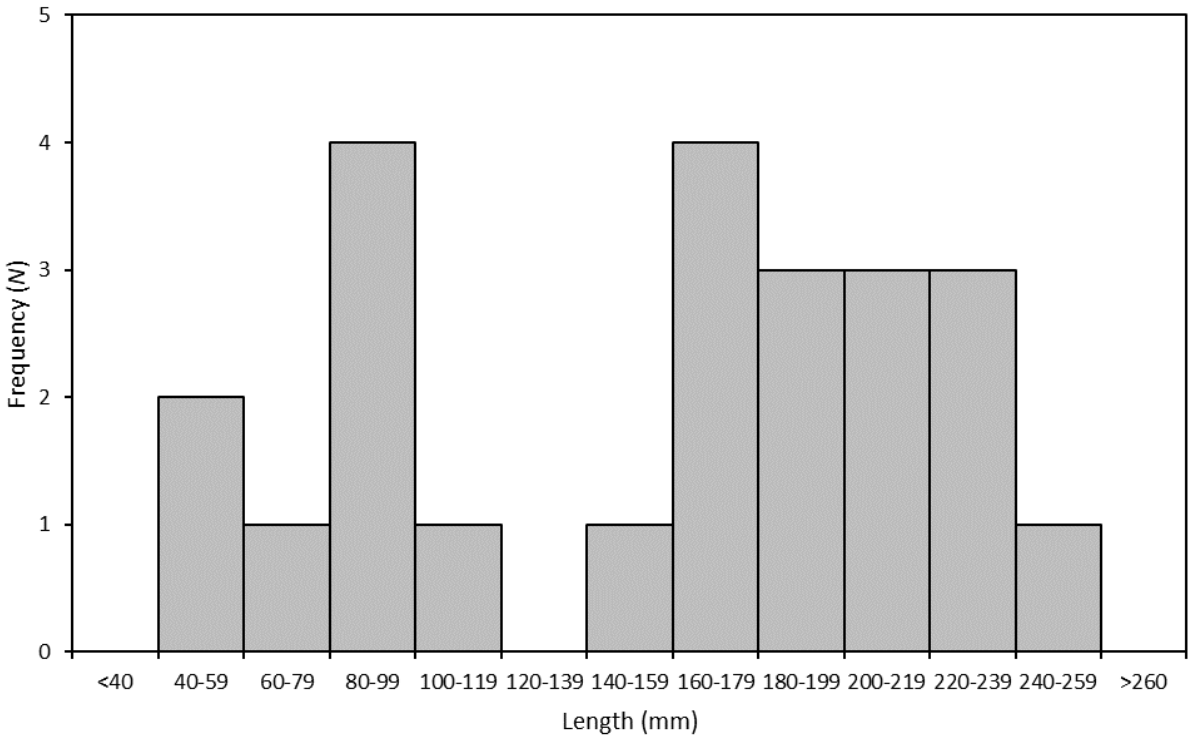

Figure 9. Length frequency histogram for trout sampled in Guano Creek in 2022.

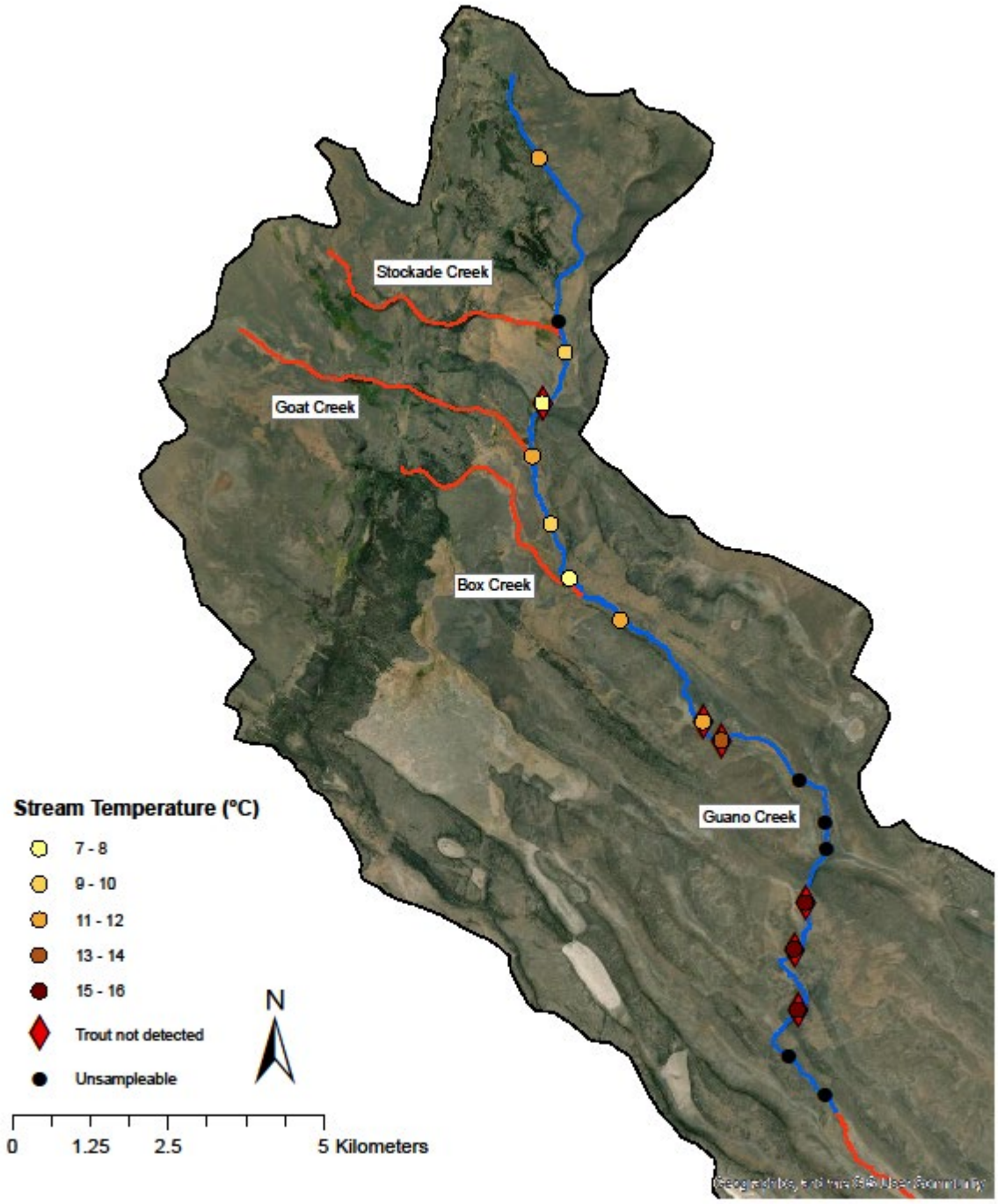

Figure 10. Stream temperatures measured during trout surveys conducted in the Guano Creek drainage from June 16 through July 11, 2022.

A census stream habitat survey was conducted upon the completion of fish sampling. The stream was puddled and dry downstream of Goat Creek, with a water temperature of 30.0°C. Undercut banks were present in 3% of habitat units from Jacobs Reservoir to Box Creek and in 12% of habitat units from Box Creek to Goat Creek. Over a third of the stream area (35.7%) was secondary channel habitat which provided valuable resting and over-wintering habitat for fish. Three fish survey sites, where a total of 8 fish were captured, had an average water depth of 17cm to 25cm during the week of June 16, 2022, and were puddled on July 16, 2022, with 7cm to 15cm average water depth. Between Goat Creek and Stockade Creek, the habitat units consisted of glides, pools, and riffles, and water temperature ranged from 14.0°C to 17.0°C. Undercut banks were present in 12% of habitat units. The gradient increased to 2.4% upstream of Stockade Creek where the habitat was primarily riffles and rapids, and water temperature ranged from 12.0°C to 15.0°C. Three percent (3%) of habitat units had undercut banks. Riparian vegetation consisted primarily of grasses and sagebrush, with little shade or canopy cover downstream of Stockade Creek. Canopy cover increased with the presence of hardwood trees in the riparian zone upstream of Stockade Creek. The stream channel was devoid of large wood, and all tributary confluences downstream of Stockade Creek were dry.

DISCUSSION

Rock Creek

Redband Trout density and abundance in the Northern Great Basin is highly variable (Meeuwig and Clements 2014, 2015) and may be in part due to a response to annual precipitation among water years. When plotted against the relative mean annual discharge of streams located near and representative of Rock Creek, we saw a pattern in the response of redband abundance to high and low water year data in 2007 through 2012 (Figure 11). During and following peak water years, redband abundance was high. Abundance was lower following consecutive years of low water. The abundance data are limited in the Rock Creek population, but the 2015 population estimate of 1,487 seems to follow this pattern as it was the fourth consecutive year of low water (Meeuwig and Clements 2015). From 2015 to 2022, there were two moderate water years which may have allowed redband abundance to rebound and persist in Rock Creek prior to the next three consecutive years of low water.

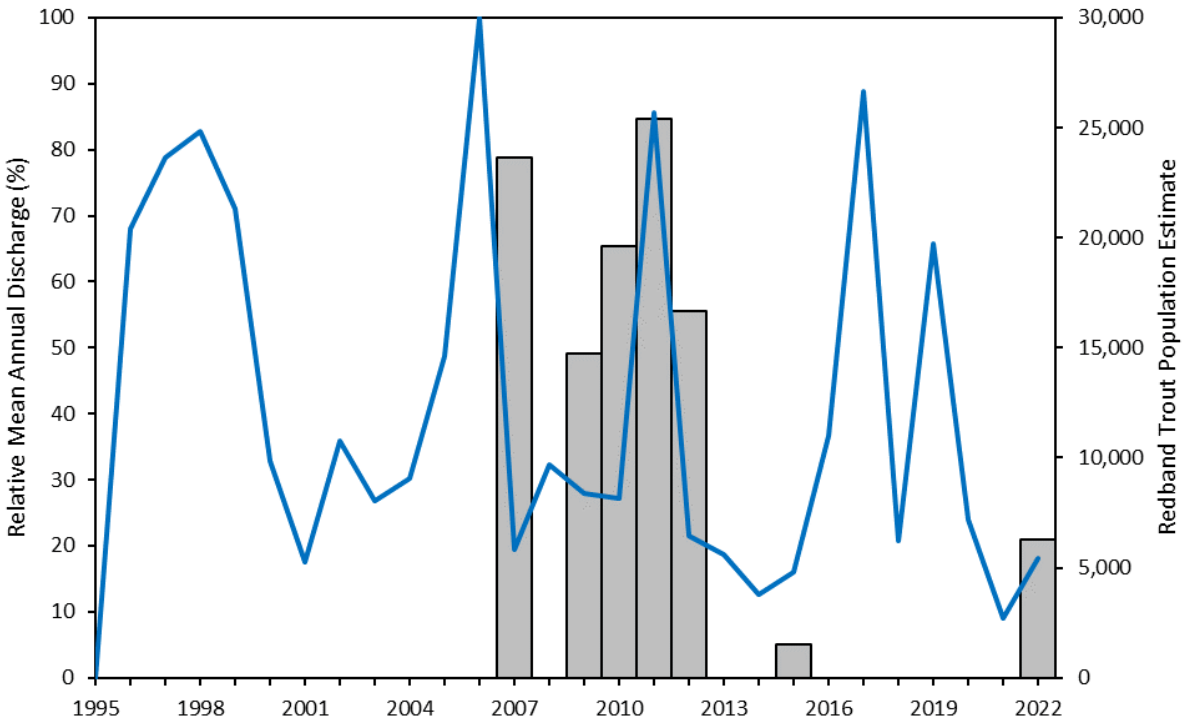

Figure 11. Relative mean annual discharge for Deep Creek, Honey Creek, and Twentymile Creek, Oregon for the past 27 water-years. These streams are located near and are representative of Rock Creek. Publicly available discharge data were downloaded from the Oregon Water Resources Department (https://apps.wrd.state.or.us/apps/sw/hydro_near_real_time/; accessed 31 January 2024) for the last 27 water-years. For the combined annual discharge of the streams, relative mean annual discharge was calculated by estimating the mean annual discharge for each year, dividing the mean annual discharges by the maximum mean annual discharge among years, and multiplying that number by 100 (Meeuwig and Clements 2015). The secondary axis plots the Redband Trout population estimates for 2007-2012, 2015, and 2022 (Meeuwig and Clements 2014, 2015).

Consecutive years of low water may influence the distribution of redband in addition to negatively influencing population-level abundance as observed in 2015 (Meeuwig and Clements 2015) and 2022. The distribution of redband in the Rock Creek drainage changed during low water year sampling in 2015 and 2022. During the higher water years of 2007 through 2012, redband abundance was estimated to range from 14,725 to 25,391 and redband were detected throughout the sampling frame (Meeuwig and Clements 2014, 2015). After four consecutive years of low water, redband were not detected in the lower 13.1km of the sampling frame in 2015 (Meeuwig and Clements 2015). The redband abundance rebounded slightly in 2022 to 6,124. However, redband were only captured in upper Rock Creek in 2022 (upstream of Willow Creek), similar to their 2015 distribution, despite large, wetted areas in the lower section of Rock Creek.

Guano Creek

The lower reach of Guano Creek, from Jacobs Reservoir upstream 9km, was inaccessible at the start of the field season due to high water road closures; therefore, all sampling during this period included only survey sites from the middle and upper reaches. Water temperatures were low (e.g., 7.0-12.0°C) and fish were captured at all but one survey site. Crews were able to access the lower reach of Guano Creek on June 30, 2022, by which time five fish and habitat survey sites were either dry, too shallow to sample, or marshy. Stream temperatures in the wetted portions ranged from 12.0-16.0°C with higher temperatures further downstream. The three survey sites with 16.0°C water were partially dry (9-19%). Further stream drying was recorded when crews returned to Guano Creek to conduct a census style stream habitat survey starting July 14, 2022. Much of the stream was either dry or puddled downstream of the confluence of Box Creek and upstream of the confluence with Stockade Creek; the wetted portion of the stream between these two tributaries included the survey sites where we captured the majority of large trout (>160mm) earlier in the summer (Figure 12).

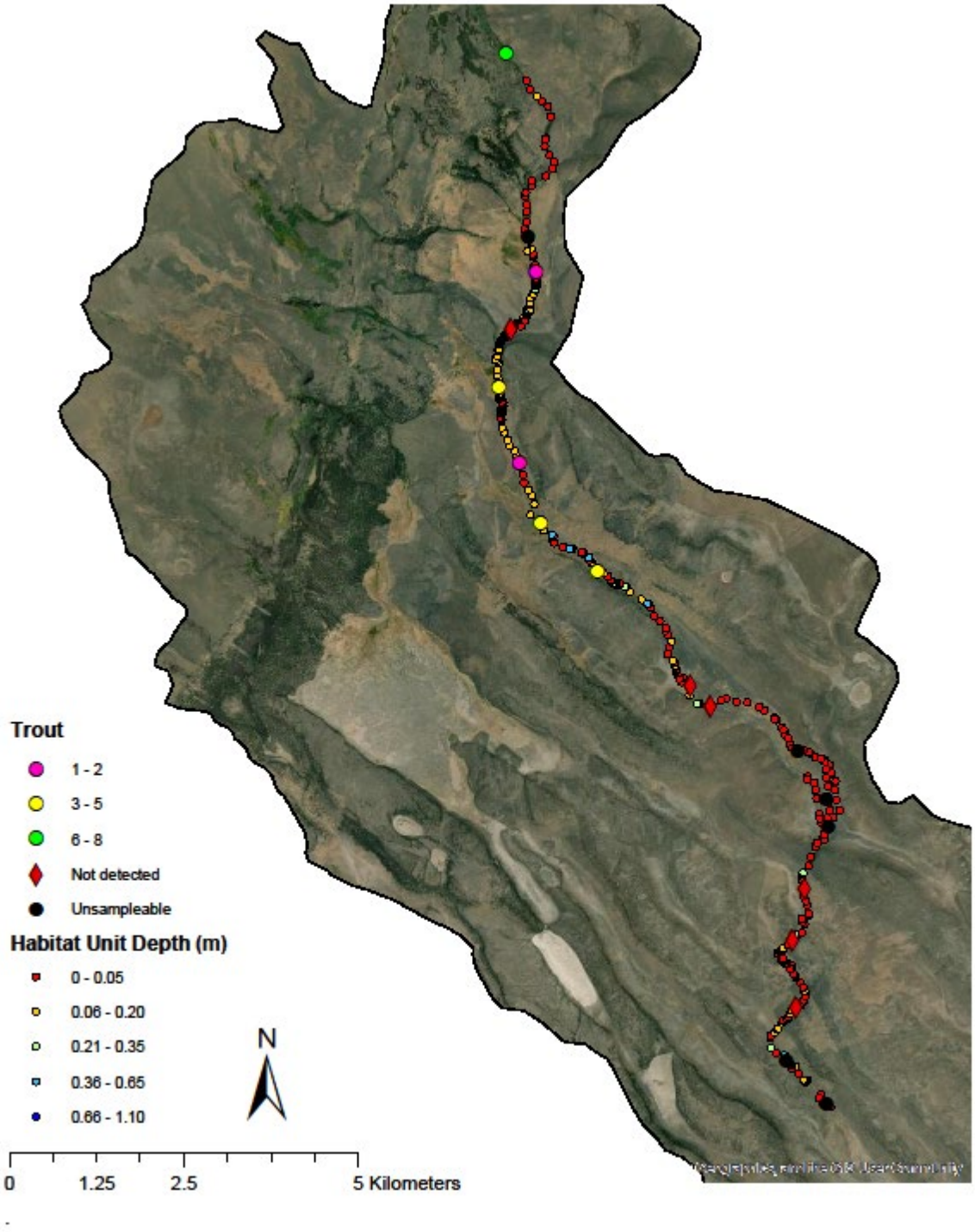

Figure 12. Spatial distribution of Guano Creek site-specific fish survey results and habitat unit depth collected during the Guano Creek stream habitat survey July 14 – August 11, 2022.

According to Behnke (2007), Guano Creek is isolated from other streams in the Catlow Valley and likely did not contain redband. ODFW records show Guano Creek was stocked with Lahontan Cutthroat Trout from 1957 to 1978 and with hatchery Rainbow Trout from 1957 to 1969 (Behnke 2007, ODFW 2005). Alvord Cutthroat Trout (*Oncorhynchus clarkii alvordensis*) may also have been transplanted to Guano Creek prior to 1928 (Behnke 2007). During June 2022, we captured trout with varying patterns and coloration indicative of more than one trout species and potential hybridization (Figure 13). Tissue samples (e.g. fin clips) were taken from trout captured in Guano Creek and are awaiting genetic testing.

Figure 13. Trout sampled in Guano Creek, June 16, 2022. The top photo resembles a Lahontan Cutthroat Trout captured approximately 1km downstream of the confluence of Box Creek. The middle photo is potentially an *O. mykiss* x cutthroat trout captured between Box Creek and Goat Creek. The bottom photo has two trout with potential Alvord or Lahontan Cutthroat Trout phenotypes captured at the same survey site at the confluence of Goat Creek.

The water quantity needed to support Catlow Valley Redband Trout is limited by climate; however, redband productivity is directly linked to the quality and quantity of available habitat (Conservation Strategy 2016). The census stream habitat surveys conducted at the conclusion of fish sampling provides the status of stream habitat in Rock Creek and Guano Creek. With the removal of cattle grazing in Hart Mountain National Antelope Refuge in 1990 and allowing natural and targeted (control burns) processes to restore riparian vegetation, bank stability increased throughout the drainages and shade increased where willow and aspen groves regenerated along portions of upper Rock Creek and Guano Creek headwaters. Although water availability is limited by climate, suitable instream water temperatures are enhanced by riparian vegetation shading the stream channel. The upper sections of Rock Creek and Guano Creek had higher levels of canopy cover, lower water temperatures, and the highest densities of trout. The presence of large shrubs and trees along stream banks will ultimately contribute large wood in the stream, enhancing refuge, food sources, and spawning areas for redband. However, the riparian vegetation in the lower portion of Rock Creek and the majority of Guano Creek is predominantly grass and sagebrush. Promoting a more complex composition of riparian vegetation throughout Rock Creek and Guano Creek would enhance the quality and quantity of available stream habitat, especially in lower Rock Creek (downstream of Willow Creek) where high water temperatures and stream drying appear to be limiting factors for redband productivity and resiliency in low water years and periods of drought. Considering the most current data on the Rock Creek redband population (2015 and 2022) took place during periods of low water, it would be informative if future Redband Trout sampling efforts targeted years with higher annual precipitation and greater availability of suitable stream habitat.

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4034 Fairview Industrial Drive SE
Salem, OR 97302