OCRF 2024-39 Mainstreaming Beaver-based restoration as a Natural Climate Solution in Oregon Phase II

Spring 2024 OCRF Project Proposal

Bonneville Environmental Foundation

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FollowUp Form

Introduction

Project Title*

Insert the full project name assigned by ODFW, including the unique code before the Project Title that was given in the agreement.

(Example) OCRF XXXX-XX_ ProjectTitle

OCRF 2024-39 Mainstreaming Beaver-based restoration as a Natural Climate Solution in Oregon Phase II

Upon completion of the project, please complete this Final Report document and submit it before the Project Expiration Date on the Project Agreements. The information you provide will be used for accountability and reporting and displayed to the general public. Please be as clear and concise as possible and avoid jargon or acronyms.

Project Location

Provide the nearest city and the county where project work will be completed, if multiple locations will be used provide them as a bulleted list.

- Corvallis
- Tillamook
- Newport
- Redmond
- Independence
- Stayton
- Lebanon

Anticipated Impact Measurement Unit*

Other (please explain below)

Anticipated Impact Measurement Unit - Other

If you selected other above, please explain here.

Approximately 60 miles will be surveyed and data collected during the project period.

Anticipated Impact Value

(from the original application)

60

Anticipated Impact Value 2*

(from the original application) the anticipated miles, acres, volunteers engaged, etc.

4

Actual Impact Value*

Enter the ACTUAL impact value (miles, acres, # of volunteers engaged) after completion of the project.

51

Actual Impact Value 2*

Enter a second ACTUAL impact value, after completion of the project, if original application had two. Otherwise, use this question to further explain actual impact value of the project.

Approximately 51 miles were surveyed through 275 surveys across 4 major regions in the state. We have also engaged at least 15 volunteers and several student interns via this process.

Oregon Conservation Strategy Species*

List the Oregon Conservation Strategy Species and Oregon Conservation Strategy Opportunity Areas that the Project benefited.

Beaver habitats benefit a long list of strategy species, and this project addresses key barriers to mainstreaming beaver based restoration by providing access to data that will aid in prioritizing projects where they are most likely to succeed. Below is a list of species that benefit from increased beaver managed wetland habitat:

STRATEGY HABITATS

- Flowing Water and Riparian Habitat
- Wetland Habitat
- Aspen Woodlands Habitat
- Off-Channel Specialized and Local Habitats

FISH

- Chinook Salmon
- Steelhead
- Coho Salmon
- Bull Trout
- Westslope Cutthroat Trout
- Redband Trout
- Warner Sucker
- Pacific Lamprey
- Western River Lamprey
- Western Brook Lamprey
- Pacific Brook Lamprey

AMPHIBIANS

- Columbia Spotted Frog

- Inland Tailed Frog
- Western Toad

REPTILES

- Western Painted Turtle

BIRDS

- Trumpeter Swan
- Yellow Rail
- Greater Sage-Grouse
- Columbian Sharp-tailed Grouse
- Lewis's Woodpecker
- Willow Flycatcher
- Olive-sided Flycatcher

MAMMALS

- Townsend's Big-eared Bat
- Fringed Myotis
- Spotted Bat
- River Otter
- Mink
- Muskrat

INVERTEBRATES

- Columbia Clubtail
- Western Ridged Mussel

PLANTS

- Arrowleaf Thelypody
- Oregon Semaphore Grass

Final Report Questions

Project Statement*

Briefly describe what the project accomplished and the problem(s) it addressed. Make a clear and concise statement; avoid jargon and acronyms.

This project addressed critical gaps in mainstreaming beaver-based restoration and coexistence in Oregon. Project activities supported a statewide data collection effort recording beaver habitat, dam locations, and activity data used to localize and calibrate a decision-support GIS tool that helps practitioners identify priority areas for beaver-based restoration and coexistence investment. Data collection efforts were concentrated in four regions: the mid-Oregon Coast Range, several NE Oregon watersheds, the Portland Metro area, and the Umpqua and Crooked watersheds, engaging community members and students throughout. The project also completed an imagery-based census of all visible beaver dams statewide. Finally, funding supported beaver-based restoration training and coexistence certification of two watershed council staff and one Tribal staff member through the Beaver Institute — addressing a critical expertise gap among on-the-ground practitioners.

Summary of Goals*

Describe how project goals, objectives, and/or milestones were completed. Discuss any measurable and achieved benefits (# of volunteers engaged, acreage restored, retrofits, planning documents created, research results, etc.).

Bellow is a list of each of our project objectives with a description of how each were completed including achieved benefits:

- **Continue to convene the Oregon BRAT advisory team –** As previously reported the advisory team transitioned to better accommodate the growing regional network of practitioners and agencies involved in this work. We convened a new advisory team with both Oregon and Washington representatives that meet monthly. Over the course of the grant we convened the advisory team 10 times.
- **Conduct two in-person workshops** – We conducted four workshops and trainings over the course of this grant to train local partners on the survey protoco.. These occurred in Prineville, Enterprise, Newport and Roseburg areas.
- **Develop regional field BRAT calibration protocols –** Working with the Riverscapes Analysis and Monitoring Lab out of Utah State University (USU), we developed unique BRAT calibration protocols for NE Oregon, Central Oregon, Oregon Coast, Portland Metro Area and the Umpqua basin.
- **Conduct virtual beaver dam census for Oregon Coast and Central Oregon watersheds –** A virtual beaver dam census (aka. imagery based census) for the entire state of Oregon was completed by USU. This data is being used to calibrate and validated the PNW BRAT model and is being used by local practitioners for restoration and conservation planning. A full report for this data has not been produced. Data is being kept private except for special use cases.
- **Carry out field data collection in Oregon Coast and central Oregon watersheds** - Over 250 field data surveys were collected in Central OR watersheds and Mid-Coast watersheds. Data collection is now also being collected in the Umpqua basin and NE Oregon watersheds bringing our total up to 275 surveys at the time of this report.
- **Engage new partners to participate in the BRAT calibration process in other parts of the state** - Several new partners were engaged to participate in the BRAT calibration process. This includes the Greater Hells Canyon Council, N. Fork John Day, staff from the Natural Resources Department of the Nez Perce Tribe, Friends of Tryon Creek and the Partnership for Umpqua Rivers. A map showing all current and previous BRAT efforts is attached.
- **Process calibration data and localize BRAT model to different regions -** Crooked River data collected by the Crooked River Watershed Council and Western Beavers was calibrated by USU. USU has produced a report already in use by our Crooked River partners attached to this report. Mid-Coast data is being processed by USU. BRAT for all perennial streams in Oregon is expected to be fully calibrated and localized by June 2027.
- **Archive and share BRAT data with partners** – We archived Willamette BRAT results (data collection completed prior to this grant) and Central OR BRAT results. Both have been shared. When OR Coast BRAT data is fully complete we will share that data with the local partners. When the entire state is completed, we will make the data accessible and interactable via our PNW Beaver Hub website.
- **Initiate development of an online resource hub** – We initiated the development of the the online resource hub. We have a landing page for the PNW Beaver Hub currently located at: https://floodplainsbydesign.org/resources/beaver-hub/ . We just secured a web developer firm to expand the page into a full website and resource hub that will feature the BRAT data and other important datasets. The site will also serve as a story telling hub to share lessons learned, relevant research, and showcase local successes.

- **Provide comprehensive co-existence and beaver based restoration training for the MWBP** – Three Mid-Willamette Beaver Partnership staff (two watershed councils and one Tribe) are now trained up via the Beaver Institute's BeaverCorps program and are actively installing co-existence projects. One has fully completed their certification and the other two are in the process of receiving their certifications.

Lessons Learned*

Describe lessons learned and challenges faced during the grant performance period. Examples being delays, contractual issues, permitting, funding, changes to the project Scope of Work or amendments, etc.

We did not experience any serious challenges that were not insurmountable or that put the project goal at risk. Some of the challenges of carrying out a bottom-up statewide data collection effort include customizing the approach so that it works for each of the regions and local organizations involved; coordinating with several partners ((11 local organizations, staff from three tribes, and our contractor) to carry out all objectives; and maintaining consistency and quality in data collection across all regions. We have experience with this kind of work but it took some time to get processes established to coordinate and carry out tasks efficiently. Additionally, there were some delays in data collection in the heavily forested areas of the coast range which led to some delays in the project. The biggest lesson learned is that there are a lot of benefits gained in keeping our processes and protocols flexible and customizable in working with each individual group. This ultimately allowed us to significantly improve our overall data collection effort over time, collect data relevant to each region, and allow us to identify other barriers and opportunities for mainstreaming beaver based restoration. This process has led us to develop the PNW Beaver Network, a community of practice for beaver based restoration and coexistence work.

Next Steps*

Describe any next steps for the project, if any.

Next steps include:

- Continue to convene the PNW Beaver Network advisory team - Ongoing
- Completing data collection in NE Oregon and the Umpqua basin - Fall 2026
- Launch of the expanded PNW Beaver Hub website - Fall 2026
- BRAT reports for Mid-Coast, NE Oregon watersheds, and Umpqua
- Process field data and dam census data for BRAT model calibration and validation - Spring 2027
- Publishing of validated/calibrated BRAT results on the Beaver Hub for all perennial streams in the state - early Summer 2027

Attachments

Include all project data collected, such as surveys, reports, PDF maps, photo monitoring and planning documents. Upload any color photographs of the Project area(s) before and after the Project completion taken at the pre-set photo points as one document.

Optional Document URL
If documents are stored in an accessible location such as Dropbox, you may enter the url here.

Attachment 1
Crooked_River_Basin_2022_NAIP_Imagery-based_Beaver_Dam_Census.pdf

Attachment 2
Oregon BRAT Data Collection Map_6-26.pdf

Attachment 3

Attachment 4

Attachment 5

Attachment 6

Attachment 7

Attachment 8

Attachment 9

Attachment 10

Certification

Drafts of final reports for review may be submitted to ODFW.OCRF@odfw.oregon.gov

Certifying Statement*
I certify that the above and attached information is true and accurate.

Yes

Applicant Authorized Representative Name*
Jean-Paul Zagarola

Authorized Representative Title*

Senior Program Manager

File Attachment Summary

Applicant File Uploads

- Crooked_River_Basin_2022_NAIP_Imagery-based_Beaver_Dam_Census.pdf
- Oregon BRAT Data Collection Map_6-26.pdf

CROOKED RIVER BASIN 2022 NAIP IMAGERY-BASED BEAVER DAM CENSUS



Prepared by:
William W. Macfarlane, Alex Fielder, Chase Gunnell, Dallin Baker, Lukas McGee, Jordan Gilbert and Chole Seeborg

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November 2025

Recommended Citation:

Macfarlane WW, Fielder A, Gunnell C, Baker D, McGee L, Gilbert J, Chloe Seeborg. 2025. Crooked River Basin 2022 NAIP Imagery-Based Beaver Dam Census. Prepared for Bonneville Environmental Foundation. Prepared by Riverscapes Assessment & Monitoring Lab, Department of Watershed Sciences, Utah State University, Logan, UT 25 pages.

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EXECUTIVE SUMMARY

Purpose and scope: This report presents a 2022 NAIP imagery–based census of beaver dams across the Crooked River basin to inform beaver-based conservation and restoration planning.

Key findings:

- **Total dams identified:** 756 beaver dam locations across the basin.
- **Survey extent:** 2,574 km of NHD perennial stream network.
- **Basin-wide density:** 0.29 dams per km.
- **Spatial concentration:** 58% of dams occur in three HUC10 watersheds — *McKay Creek* (178 dams; 4.75 dams/km), *Upper North Fork Crooked River* (152 dams; 0.50 dams/km), and *Mill Creek* (107 dams; 1.47 dams/km). Fifteen of 29 HUC10s had no dams detected.
- **Dam condition and certainty:** 71% of recorded dams were classified as *active*; 48% of observations are *high certainty*.

Methods and efficiency: Photointerpretation of 2022 NAIP (leaf-on) imagery using CIR/NDVI and NHD streamlines required 24 person-hours (107 km of stream assessed per hour).

Limitations: Imagery is a temporal snapshot (summer 2022) and likely undercounts dams in forested or heavily vegetated reaches.

Recommended next steps: Conduct field ground-truthing for accuracy assessment; use these mapped points to calibrate/validate BRAT; prioritize conservation in high-density HUC10s.

INTRODUCTION

Field-based inventorying of beaver dams is both time-consuming and costly, making it impractical for assessing dam distribution across large geographic areas such as entire river basins. Fortunately, photointerpretation offers a reliable and efficient alternative in many regions. High-resolution satellite and aerial imagery have been successfully used to identify beaver dams across Idaho (Macfarlane et al., 2019a), Montana (Macfarlane et al., 2024), Utah (Wheaton et al., 2014), Wyoming (Macfarlane et al., 2019b), New Mexico and large portions of California (Macfarlane et al., 2020). These studies demonstrate that remotely identifying beaver dams is both feasible and accurate at broad spatial scales.

Inventorying beaver dams is valuable for several reasons. First, because beavers function as both keystone species and ecosystem engineers, locating their dams helps identify where they are exerting geomorphic, hydrologic, ecological, and even social influences on riverscapes. Beaver dams affect ecosystem structure, geomorphology, water resources, water quality, freshwater ecology, and human communities (Brazier et al., 2021). Second, mapping where beaver dams occur—along with their densities—is essential for identifying beaver conservation reaches: stream segments where active dam building is occurring without causing beaver–human conflict. Conversely, identifying stream reaches where dams are absent supports the delineation of beaver-based restoration opportunities. These may include reaches with suitable hydrologic or vegetative conditions that currently lack dam-building beavers, as well as degraded streams that could support beaver activity following interventions such as Beaver Dam Analogs (BDAs) or Post-Assisted Log Structures (PALS). Knowledge of current dam locations also aids watershed-scale restoration planning by highlighting areas where beavers are most likely to colonize and maintain restoration structures. Finally, spatial information on beaver dams can help pinpoint where human–beaver coexistence strategies may be needed.

Beavers typically construct multiple dams in succession over relatively short stream segments, creating a stair-stepped valley profile (Morgan, 1868). These “beaver dam complexes” are characterized by ponded areas separated by abrupt gradient transitions (Pollock et al., 2003) (Figure 1). Complexes disperse flood energy, provide redundancy against single-dam failure (Graham et al., 2022), increase water retention, and enhance the availability of woody and herbaceous vegetation important for beaver foraging and construction (Cooke & Zack, 2008). Riverscapes with beaver dam complexes are also more resilient to wildfire (Fairfax et al., 2024), drought and flooding (Hood & Bayley, 2008; Fairfax & Small, 2018), and exhibit enhanced water quality (Dewey et al., 2022; Bason et al., 2017), greater wetland extent (Burchsted et al., 2010; Hood & Bayley, 2008), higher biodiversity (Law et al., 2019), and increased carbon storage relative to undammed reaches (Wohl et al., 2012). As a result, beaver dam building is increasingly recognized as fundamental to the formation and persistence of healthy riverscapes (Larsen et al., 2021). Beaver-based restoration—efforts to mimic, promote, or sustain beaver activity—has emerged as a cost-effective and sustainable strategy for geomorphic and ecological restoration and for improving climate resilience. However, because dam-building suitability varies with hydrology, vegetation, and the built environment, thoughtful reach selection remains essential.



Figure 1: An example beaver dam complex with each beaver dam identified as a red point on the dam crests and the NHD flowline shown as a purple line.

Beavers build dams across a range of geomorphic contexts. Bush and Wissinger (2016) identify three dominant dam-building settings: classic, steep, and floodplain (Figure 2). Our inventory approach explicitly included all three settings, acknowledging that beaver activity in steep and floodplain environments remains under-documented despite its ecological significance. Understanding how dam-building frequency varies across these settings can help refine conservation priorities and broaden restoration opportunities.

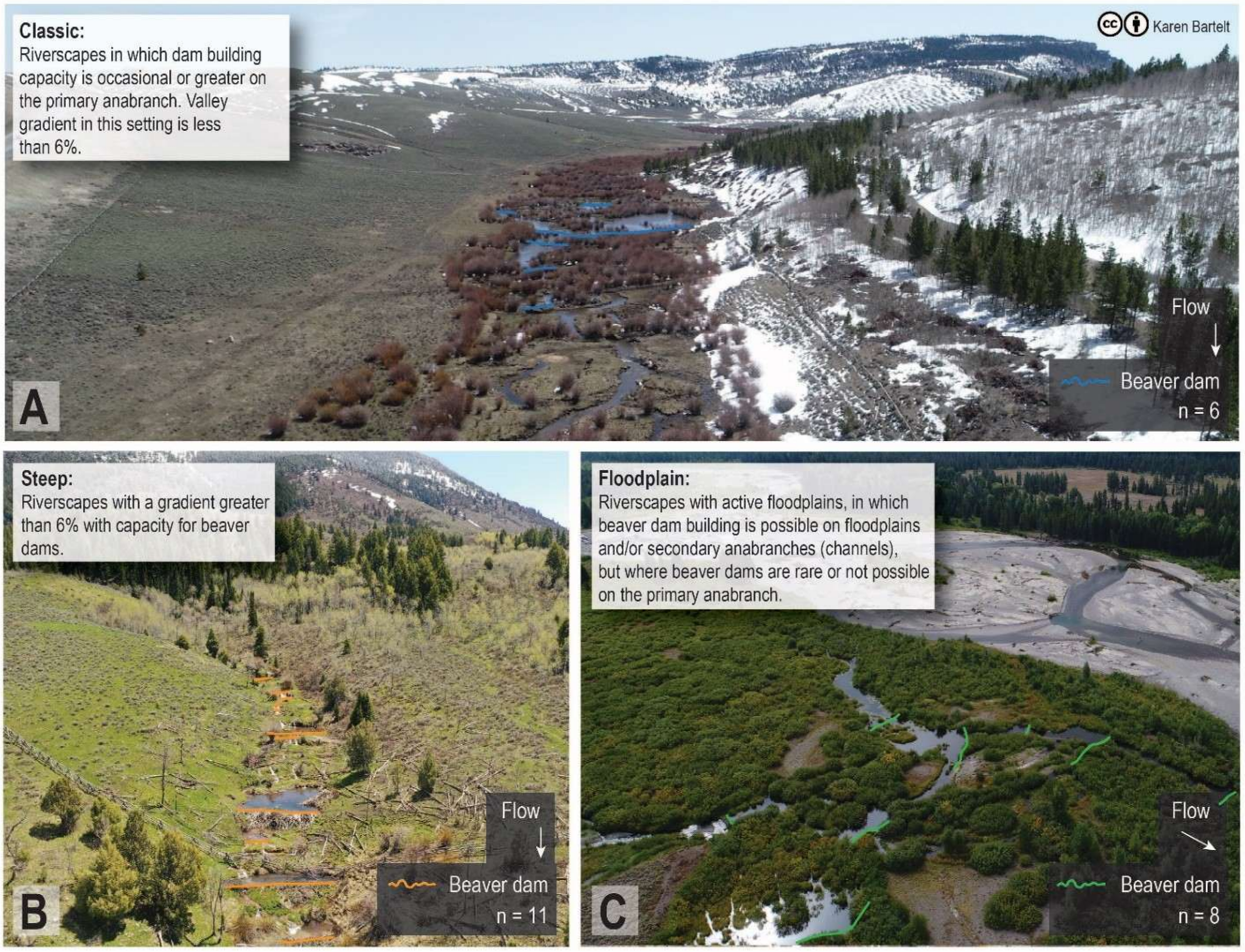

Figure 2. Dominant riverscape dam building opportunities for beaver. A) The classic setting in the top panel represents the beaver dams typically studied in the literature. B) Even though beaver dams in steep riverscapes with gradients over 6% represent over 1/3 of early reported observations in the literature, they are often ignored. C) The floodplain settings along typically larger rivers where beaver dam building is concentrated on the floodplains. This figure was inspired by Bush and Wissinger (2016).

The purpose of this report is to present the results of the 2022 beaver dam census for the Crooked River Basin, derived from the 2022 NAIP imagery. This census is intended to provide a foundational dataset for planning beaver-based conservation and restoration strategies throughout the basin.

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METHODS

Aerial Imagery

We utilized publicly available high-resolution multispectral aerial imagery from the United States department of Agriculture (USDA) National Agriculture Imagery Program (NAIP) (0.60 m spatial resolution) (National Agriculture Imagery Program - NAIP Hub Site, 2024). Imagery was captured in the summer of 2022, in leaf-on conditions. The NAIP imagery was sourced from an ArcGIS REST imagery service used by the Oregon Statewide Imagery Program (OSIP), a program started in 2016 to meet demand for current and historical high quality resolution aerial imagery across the state (https://imagery.oregonexplorer.info/arcgis/rest/services/OSIP_2022/OSIP_2022_SL/ImageServer).

The NAIP imagery was served over the Internet through both a Web Map Service (WMS) and a Web Coverage Service (WCS). The WMS consists of a mosaic of various imagery dates, served out as a static true color image. The WCS allowed us to change the symbolized band combination and run 'on the fly' raster calculations giving us the ability to visualize 'false color composite, also known as color-infrared (CIR) as well as Normalized Difference Vegetation Index (NDVI) (Figure 3).

Color infrared is sensitive to red, green, and near infrared wavelengths, making infrared data appear with a red tone, red wavelengths appear green, and green wavelengths appear blue. Healthy green vegetation appears bright red, and ponding from beaver dams appears dark blue. Vegetation material used in beaver dam crests appears noticeably different from surrounding vegetation using this technique. NDVI is used to assess plant health by normalizing the amount of red energy that is absorbed by chlorophyll and the amount of near-infrared energy that is reflected by the cellular structure of the leaf, resulting in a simplified image that allows one to quickly delineate vegetation and vegetation stress.

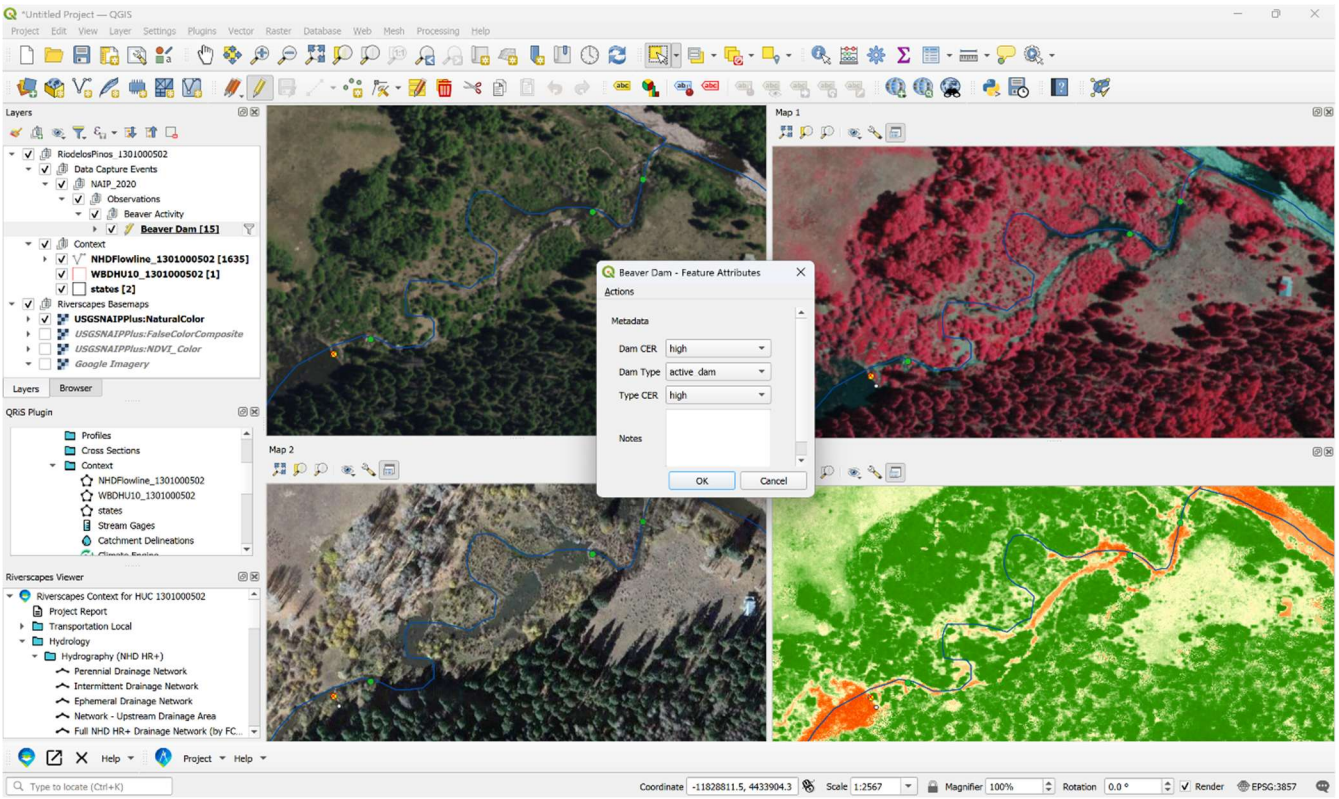

Figure 3. NAIP imagery shown as 'true color' imagery on the left and as 'false color composite' upper right and Normalized Difference Vegetation Index (NDVI) lower right. Beaver dam points are color coded based on type (active, inactive, relic) and dam certainty and dam type certainty are recoded as high, medium or low.

Sampling Design

To effectively conduct and manage a basin-wide beaver dam census, analyses were conducted on a watershed basis using watershed boundaries at the 10-digit Hydrologic Unit Code (HUC10) level from the Watershed Boundary Dataset (WBD) (USGS, 2025). We displayed NAIP Imagery and conducted beaver dam inventories using QGIS v. 3.40.10-Bratislava with the Riverscapes Viewer and QRiS plugins (*Riverscapes Consortium*, 2025). The Riverscapes Viewer allows for the acquisition and exploration of 'riverscape projects', which are collections of data related to riverscapes sourced from the Riverscapes Data Exchange (*Riverscapes Consortium*, 2025). Using the Riverscapes Viewer, we accessed datasets generated by the Riverscapes Context Tool to acquire nationally available spatial data, including watershed boundaries from the WBD and filtered perennial streamflow networks from the National Hydrography Dataset (NHD). The QRiS plugin facilitates data capture and organization for riverscapes projects and was used to keep track of our progress. A perennial stream network was derived from the USGS NHD and was split by each of the 24 HUC10 watersheds that make up the Crooked River basin. The HUC10 scale was also used for analysis and display in tables, and figures.

Aerial Photointerpretation

Beaver dam observations were assessed by photointerpretation of NAIP imagery. Observers surveyed the NHD perennial stream network at a digital altitude of approximately 200 – 800 meters above the Earth's surface to visually locate beaver dams. A beaver dam is typically a linear feature, which can be relatively easy to identify on aerial imagery, and is constructed of tree branches, mud, and stones that disrupt the flow of a stream or river and causes water pond at the foot of the dam. When a potential beaver dam was identified, additional lines of visual evidence

were evaluated to determine validity (conical pond shape, slightly curved or s-shaped crest structure, riparian harvest, skid trails, and lodges). When evidence of beaver activity was determined to be likely, an observation point was placed on the crest of the potential beaver dam. These beaver dam points were then attributed by: (1) confidence level (high, medium or low) on whether the observation is a beaver dam, (2) dam type (active, inactive or relic), and (3) confidence level (high, medium or low) on whether the observation is of a certain dam type (Figure 3 and Table 1).

Table 1. Beaver dam point location attributes.

Variable	Assessments	Explanation
Dam Certainty	Low, Medium, High	The confidence level on whether the observation is a beaver dam
Feature Type	Active Dam, Inactive Dam, Relic Dam	The condition of the dam at the time of imagery capture.
Feature Type Certainty	Low, Medium, High	The confidence level on whether the observation is of a certain dam type

Quality Control

After all beaver dam point locations were collected and their attributes were recorded per HUC10 watershed, all dam points were reviewed for quality by a senior photo interpreter who either "signed off" on the census or provided feedback on how the census should be modified. About 10% of the points required revisions as suggested to the reviewer.

The initial data cleaning consisted of ensuring points contained all relevant fields, fell within respective HUC10 boundaries, and were not double counted. Points with invalid geometry from incorrect removal following the initial review were additionally removed, bringing the total number of points to the expected count. Data cleaning was performed using QGIS v. 3.40.10 and R v. 4.4.1 (QGIS.org, 2025; R Core Team, 2024). The final points were cross-checked with the expected count, assured to not have remaining errors, and were checked off by the project's Principal Investigator.

Analysis

The analyses we conducted using the final aggregated beaver dam points file are as follows: calculating the total number of dams and the number of dams per kilometer of NHD perennial stream network for the entire basin, each HUC10 watershed, Environmental Protection Agency (EPA) level IV Ecoregions (US EPA, 2015), and each landowner type. We then calculated the total number and proportion of dam types and dam certainties.

RESULTS

The 2022 NAIP imagery-based Crooked River basin beaver dam census identified 756 dams across the 2,574 km NHD perennial stream network for an overall dam density of 0.29 per km (Figure 4). The photointerpretation took a total of 24-person hours to complete, which equates to assessing 107 km of stream per hour or 32 dam locations per hour. A field-based census would take 1000s of hours to complete. Thus, this remote approach proved to be much quicker than what a field-based approach would take. The accuracy of this census has yet to be determined, and we recommend conducting a field-based analysis as described in the Discussion section.

Over half (58%) of the dams identified were in only 3 of the 29 HUC10's: McKay Creek (178 dams), Upper North Fork Crooked River (152 dams) and Mill Creek (107 dams) (Figure 4, Figure 5 and Table 2). Over half of the HUC10s (15 of 29) had no beaver dams identified (Figure 5 and Table 2).

Beaver dam densities per watershed had a similar spatial pattern to number of dams across the basin (Figure 6). The three HUC10's with the highest dam densities were McKay Creek (4.75 dams/km), Mill Creek (1.47 dams/km) and Lower Ochoco Creek (Figure 6 and Table 2).

In terms of Level IV EPA ecoregions, the John Day/Clarno Highlands has the highest dams per kilometer at 0.34, with the second highest dam count at 298 (Figure 7 and Table 3). The second highest density is followed by the Deschutes River Valley at 0.3 and John Day/Clarno Uplands at 0.29 dams per kilometer (Table 3). Dam counts for these regions are 67 and 390 respectively (Table 3). All other regions, excluding Cold Basins (0.01 dams per kilometer and 1 censused dam) have no censused dams within their respective areas (Table 3). All four regions with censused dams are adjacent to the Crooked river, Beaver Creek and Ochoco National Forest. Ecoregions such as the High Lava Plains, Pumice Plateau and Pluvial Lake Basins appear to lack the hydrologic and vegetative resources required to sustain dam building.

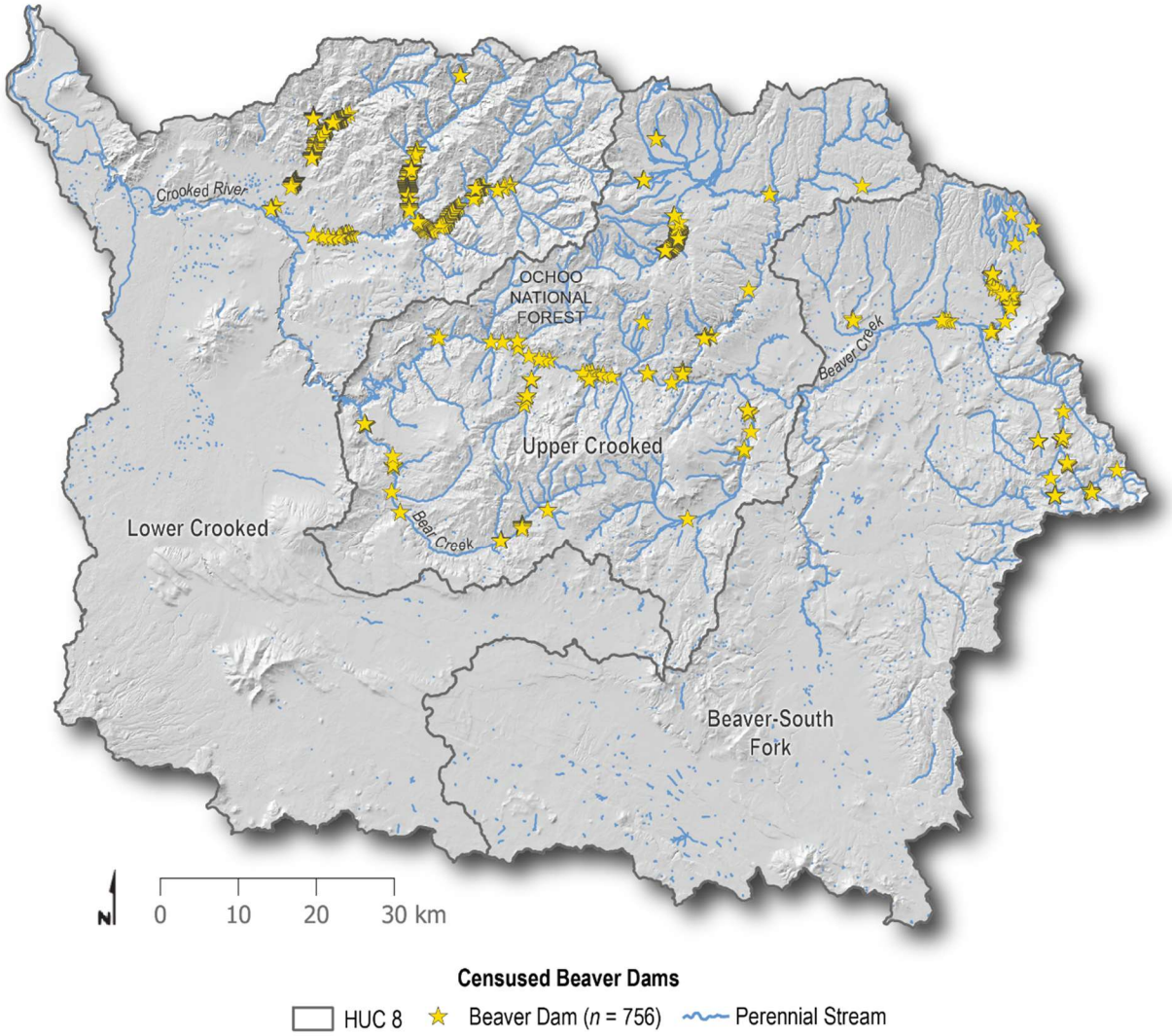

Figure 4. Beaver dam locations by USGS HUC8 watershed based on 2022 NAIP imagery-based beaver dam census.

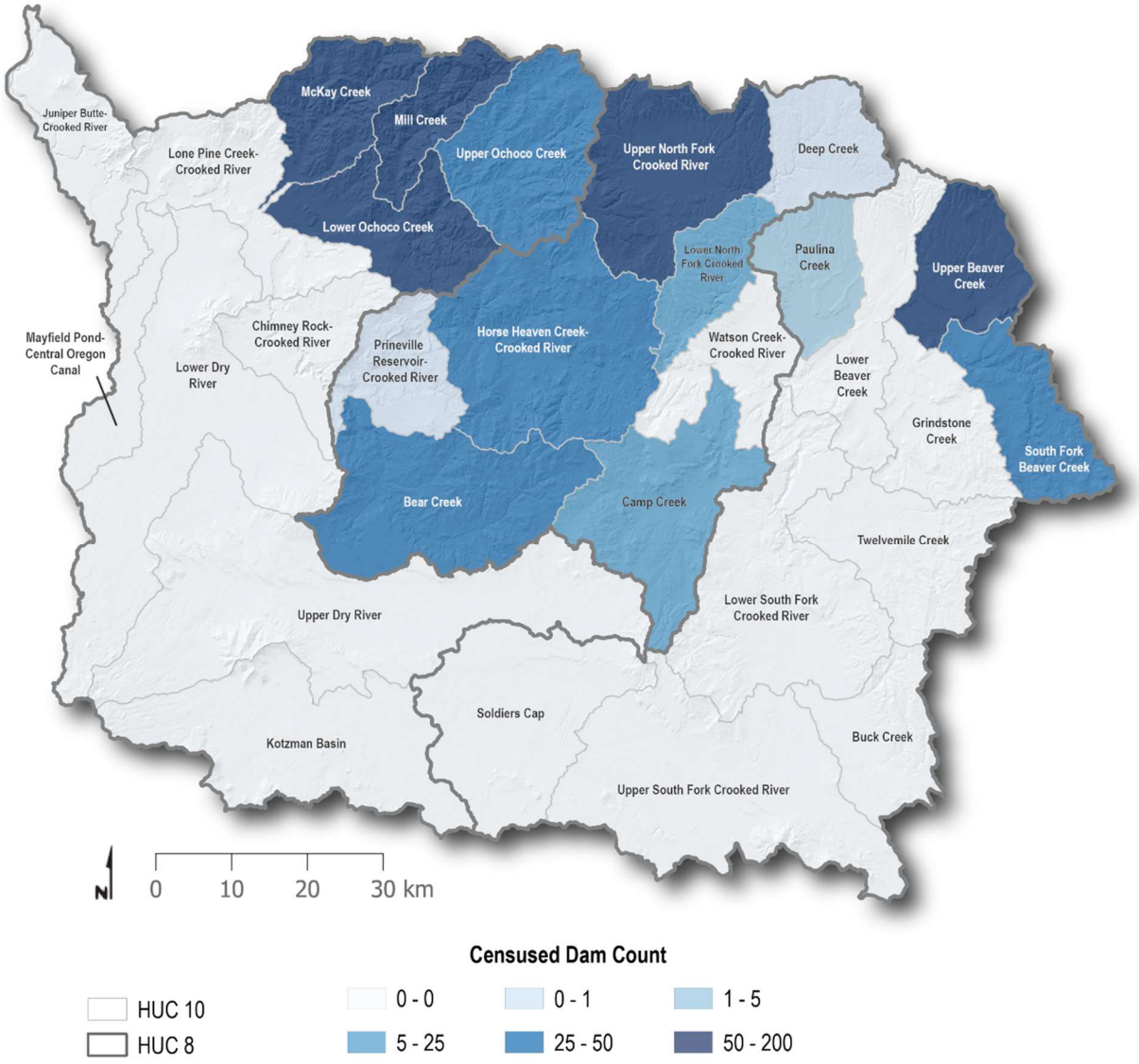

Figure 5. Beaver dam counts per USGS HUC10 watershed based on 2022 NAIP imagery-based beaver dam census.

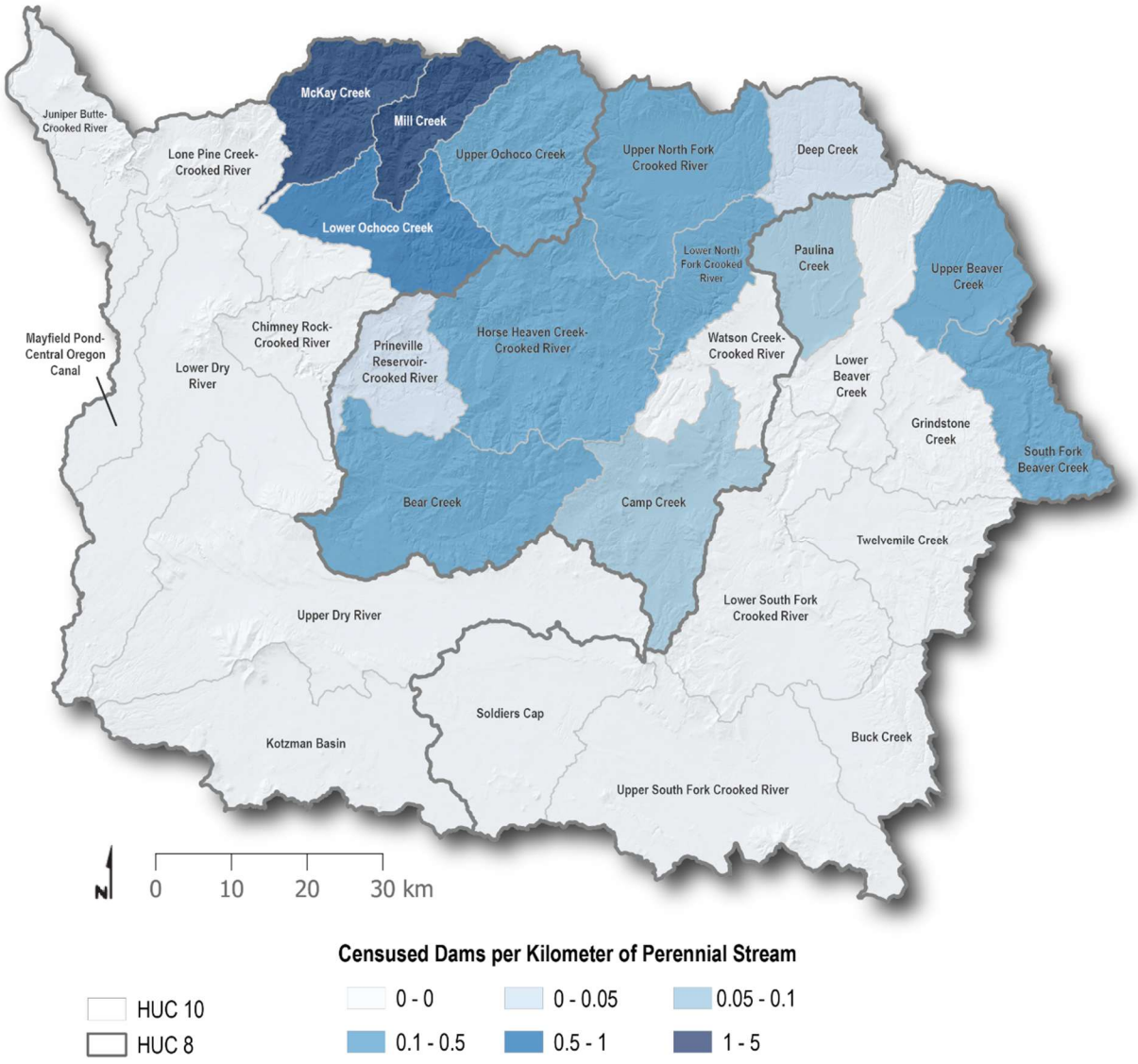

Figure 6. Beaver dam density (dams per kilometer of NHD perennial stream network) per USGS HUC 10 watershed based on 2022 NAIP imagery-based beaver dam census.

Table 2. The 2022 NAIP imagery-based Crooked River basin beaver dam census outputs by HUC10. The table shows the number of beaver dams and associated dam density per HUC10 watershed. The table is sorted by highest to lowest dam density.

Name	HUC	Area (km^2)	Perennial Stream Length (km)	Total Dams	Dams Per km Perennial Stream
McKay Creek	1707030505	256.9	37.5	178	4.75
Mill Creek	1707030503	185.4	72.8	107	1.47
Lower Ochoco Creek	1707030504	302.7	94.4	82	0.87
Upper North Fork Crooked River	1707030403	459	306.3	152	0.5
Upper Beaver Creek	1707030307	251.6	137.2	52	0.38
Lower North Fork Crooked River	1707030405	181.8	68.6	22	0.32
South Fork Beaver Creek	1707030305	267.1	152.4	44	0.29
Bear Creek	1707030407	559.2	144.1	35	0.24
Upper Ochoco Creek	1707030502	388.7	199.4	32	0.16
Horse Heaven Creek-Crooked River	1707030406	660.2	293.9	37	0.13
Camp Creek	1707030401	452	159.7	10	0.06
Paulina Creek	1707030308	209.8	55.2	3	0.05
Deep Creek	1707030404	224.3	88.8	1	0.01
Prineville Reservoir-Crooked River	1707030408	219	89.4	1	0.01
Soldiers Cap	1707030301	528.9	13.3	0	0
Upper South Fork Crooked River	1707030302	803.4	43	0	0
Buck Creek	1707030303	259.6	23.8	0	0
Twelvemile Creek	1707030304	364.3	65.8	0	0
Grindstone Creek	1707030306	278.4	82.1	0	0
Lower Beaver Creek	1707030309	329.3	78.4	0	0
Lower South Fork Crooked River	1707030310	672.1	88.4	0	0
Watson Creek-Crooked River	1707030402	238.4	65.3	0	0
Chimney Rock-Crooked River	1707030501	242.2	28.3	0	0
Kotzman Basin	1707030506	619	4.7	0	0
Upper Dry River	1707030507	1100.9	13.5	0	0
Lower Dry River	1707030508	845.7	22.1	0	0
Mayfield Pond-Central Oregon Canal	1707030509	183.8	2.9	0	0
Lone Pine Creek-Crooked River	1707030510	407.7	83.7	0	0
Juniper Butte-Crooked River	1707030511	254.1	77.3	0	0

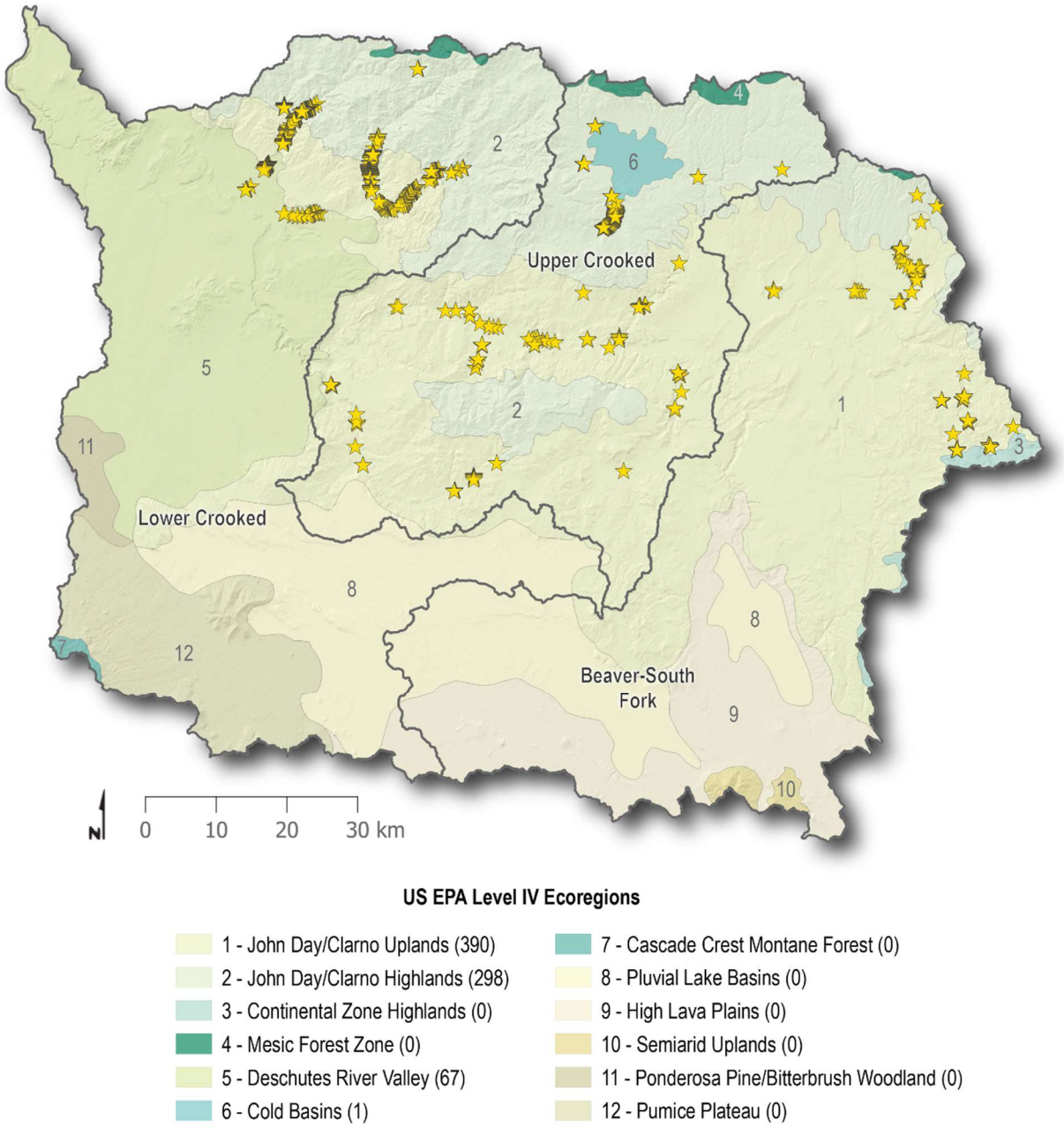

Figure 7. Beaver dams per EPA Level IV Ecoregion based on 2022 NAIP imagery-based beaver dam census.

Table 3. Beaver dam density per US EPA Level IV Ecoregion based on 2022 NAIP imagery-based beaver dam census.

Level IV Ecoregion	Area (km^2)	Perennial Stream Length (km)	Total Dams	Dams Per km Perennial Stream
John Day/Clarno Highlands	1987.9	864.8	298	0.34
Deschutes River Valley	1804.7	224.4	67	0.3
John Day/Clarno Uplands	4338.4	1329.3	390	0.29
Cold Basins	81.3	126.4	1	0.01
Continental Zone Highlands	53.5	25.9	0	0
Mesic Forest Zone	0	44.8	0	0
Pluvial Lake Basins	1446.1	38.9	0	0
High Lava Plains	978.7	63	0	0
Semiarid Uplands	20.6	0.6	0	0
Ponderosa Pine/Bitterbrush Woodland	95	0.6	0	0

When we intersect the beaver dam data with landownership interesting patterns emerge (Figure 8). For instance, state lands have by far the highest beaver dam densities at 0.55 dams per km, the next highest density is private at 0.37 dams per km (Table 4). Also, private lands had the largest proportion of the perennial stream network and the highest number of dams illustrating the importance of the need to work with private landowners to achieve successful beaver-based conservation and restoration.

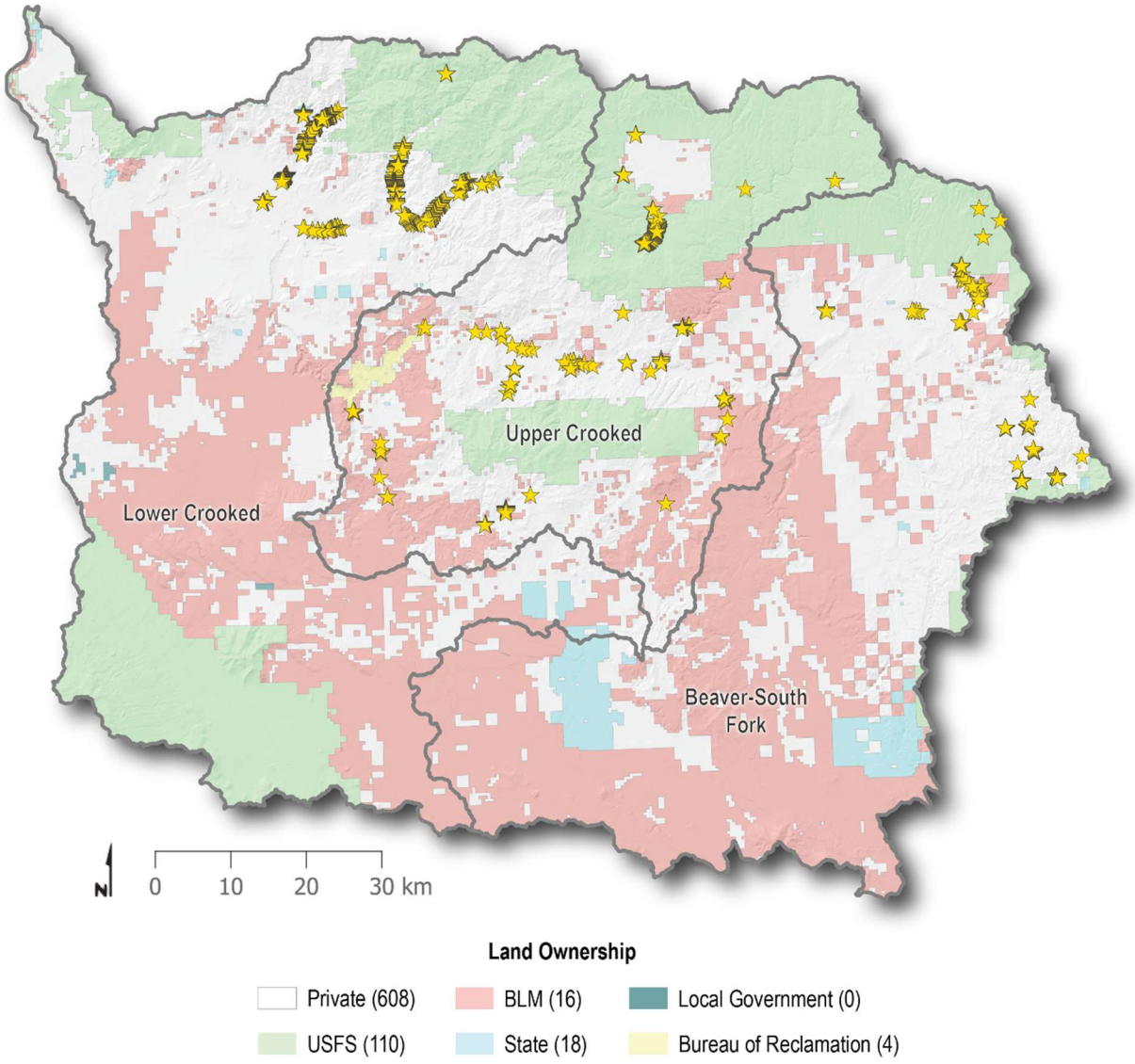

Figure 8. Beaver dams per landownership category based on 2022 NAIP imagery-based beaver dam census.

Table 4. Beaver dam density per landownership category based on 2022 NAIP imagery-based Crooked River basin beaver dam census.

Landowner	Area (km^2)	Perennial Stream Length (km)	Total Dams	Dams Per km Perennial Stream
Private	4660	1634	608	0.37
Forest Service	2690	857	110	0.13
Local	8	0	0	0
State	245	33	18	0.55
BLM	4110	413	16	0.04
Bureau of Reclamation	35	67	4	0.06

Of the three dam types recorded in the survey (active, inactive, and relic), 71% were recorded as active (Table 5). Of the dam certainty types (high, medium and low), 48% were recorded as high certainty, 22% medium and 30% low certainty (Table 5).

Table 5. Dam type and certainty total counts and the proportion of the total number of records based on 2022 NAIP imagery-based Crooked River basin beaver dam census.

Dam Type	Count	Proportion
Active	539	71%
Inactive	215	28%
Relic	2	<1%

Dam Certainty	Count	Proportion
High	363	48%
Medium	167	22%
Low	228	30%

The beaver dam census identified beaver dams that occurred not only in the classic setting, but also within floodplains on secondary anabranches and in steep settings. The occurrence of these dams in floodplain and steep settings illustrates how important these underappreciated beaver dam settings are as habitat.

DISCUSSION

Imagery-based Beaver Dam Censusing: Caveats

We refer to this approach of collecting dam locations as 'censusing' because the entire perennial network is sampled. However, it is important to point out that this is not a complete census of beaver dams, it is a sample from a "snapshot" in time based on the date of imagery. Moreover, this imagery-based method generally under-samples total dams, especially in forested ecosystems where it is difficult to see the stream through the forest canopy.

Crooked River Basin Vs Montana Beaver Dam Density

We recently conducted a similar statewide beaver dam census for Montana and found the dam density to be 0.34 dams per km which was higher than the Crooked River basin at 0.29 dams per km. The higher dam density in Montana is not surprising given regional differences. Overall, Montana is wetter and more mountainous, resulting in the hydrology and woody riparian resources needed to support higher densities of beaver dam building. However, Montana and the Crooked River basin have similarities as both have portions that are too arid to support sufficient stream flow and woody riparian vegetation required for extensive beaver dam building.

Recommended Next Steps

Validation of the Beaver Restoration Assessment Tool (BRAT)

In a forthcoming phase of this project, the beaver dam locations collected from this census will be used to localize, calibrate, and validate BRAT modeled beaver dam capacity estimates. Specifically, the census data will be plotted against predicted capacity counts. This information will be used to determine how close a given watershed is to predicted beaver dam building capacity.

Ground Truthing Beaver Dam Locations

We suggest conducting field-based beaver dam surveys that could be directly compared to the beaver dam locations from the census thus providing an accuracy assessment for this project. Field data collection could be done using a beaver dam survey app that we have developed for Esri Survey123. Beaver dam surveys could be conducted along stream reaches that are selected using a random sample approach that are spatially balanced and stratified by ecoregion across all watersheds. A random sample size of 30 dams would be adequate for this assessment.

CONCLUSIONS

The Crooked River basin 2022 NAIP imagery-based beaver dam census proved to be a cost-effective method for identifying beaver dams across the riverscapes of the basin. In many arid sub-watersheds, this effort ended up being a photointerpretation "needle in the haystack" exercise. As we examined over 2,500 km of streams, we found only 756 dams or 0.29 dams per km. It appears that many riverscapes simply did not have adequate water and/or the woody riparian resources to support dam building beaver and we speculate that there might be a range limit to beaver dam building in southern Crooked River basin.

We believe this basin-wide beaver dam inventory is an important dataset to help plan and prioritize beaver conservation and beaver-based restoration efforts at the basin-wide, watershed and reach levels. Specifically, this dataset can be used to help define both beaver conservation and potential restoration reaches. Our hope is that this inventory will provide Crooked River Watershed Council, Western Beavers Cooperative staff and partners with the

information they need to better manage dam building beaver and to identify opportunities for using beaver in riverscape restoration throughout Crooked River basin.

GIS DATA PRODUCTS

Crooked River basin 2022 NAIP imagery-based beaver dam census points locations as Shapefile, KMZ and Geopackage can be found here.

ACKNOWLEDGMENTS

We would like to thank Jean-Paul Zagarola of Bonneville Environmental Foundation for his help leading and funding the project. We would also like to thank Chris Gannon, Crooked River Watershed Council and Reese Mercer, Western Beavers Cooperative, for their help and guidance in this project.

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Mainstreaming Beaver-based restoration as a Natural Climate Solution in Oregon: Completed and active PNW BRAT data collection efforts

