Community Monitoring for Forest Health

Boulder County Nature Association
Final Report
February 2022

Boulder Watershed Collective
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The Boulder Watershed Collective (BWC) is working with the Town of Gold Hill and numerous other local and state partners to develop wildfire risk reduction projects in and around Gold Hill. A portion of this work includes a 100-acre forest restoration project to improve forest health and decrease wildfire risk for the town. These types of projects are designed by skilled foresters to remove a significant number of trees which will improve the structure and composition of forests and return them to state in which they are better able to receive wildfire with less severe long-term impacts. Communities often have many questions and concerns related to these projects, specifically surrounding community values of wildlife, healthy forests and aesthetics. To support Gold Hill's values in relation to this project BWC developed a community monitoring program to collect pre and post project data to monitor habitat and wildlife populations. In 2021, BWC completed breeding bird monitoring, large mammal monitoring through the Wildlife Picture Index (WPI) and understory vegetation monitoring to better understand the food web, over time, which support the wildlife populations.

The Boulder County Nature Association granted BWC funds to support the development of this project. These funds were used to purchase binoculars and other supplies for bird monitoring and game cameras to monitor large mammals. These funds assisted with the up-front costs needed to begin the program. BWC was fortunate to work with graduate students through the Masters of the Environment Program at the University of Colorado, multiple dedicated volunteers and AloTerra Restoration Services to complete monitoring in 2021. Other funding to support staff time was contributed by the Colorado Water Conservation Board and Action and Implementation for Mitigation (AIM).

BWC collected baseline data in 2021 and intends to continue monitoring at the Gold Hill location annually to capture wildlife trends associated with the forest restoration project. 2021 data will be shared with the community at the April 2022 Town Meeting, Shutterfly books with pictures will be given to the Gold Hill School and the Gold Hill Store, copies of the reports will be posted on the BWC website, Town website and hard copies left at the Store for locals and visitors to read. BWC is working with the Gold Hill School to host learning activities associated with the mammals identified through the WPI process.

PROJECT BUDGET

	Item	Total
1	Game cameras	$ 2,645.86
2	SD cards for cameras	$ 153.86
3	Batteries for cameras	$ 38.66
4	Bird field guides	$ 48.82
5	Binoculars	$ 401.16
6	Kestrels	$ 228.44
7	Shutterfly Books	$ 199.84
	TOTAL	**$ 3,716.64**

APPENDIX A
2021 BIRD MONITORING REPORT

THE BOULDER WATERSHED COLLECTIVE

BIRD MONITORING REPORT 2021

PICTURED: BROAD-TAILED HUMMINGBIRD AT GOLD HILL

PICTURED: BLACK-HEADED GROSBEAK AT GOLD HILL

Funders:

AIM PROGRAM GRANT
BOULDER COUNTY
NATURE ASSOCIATION

Reported by:

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Photos courtesy of:
NATHANIEL GOECKNER PHOTOGRAPHY

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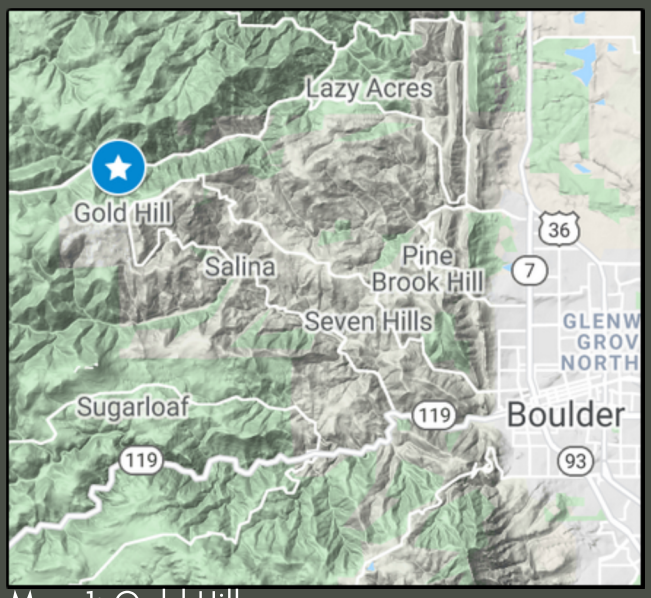
boulderwatershedcollective.org

Project Background

The Boulder Watershed Collective (BWC), in partnership with the Town of Gold Hill and numerous other partners, is working to improve forest health and reduce wildfire risk in Gold Hill, Colorado. This work includes community engagement and education, forest restoration, wildlife monitoring, and collaborative home-ignition zone projects. The forest restoration project will treat 150 acres between 2022 and 2024. The restoration will enhance previous treatments on United States Forest Service lands, decrease wildfire risk adjacent to the town of Gold Hill, improve wildlife habitat and work toward creating a mosaic forest structure across the landscape. BWC initiated bird monitoring in spring 2021 to collect baseline data prior to forest restoration. These data will help to understand the effect of forest treatments on breeding avian populations and will inform future management decisions. The data will evaluate bird populations in denser forests (pre-restoration) and how more open forest structures may impact avian communities (post-restoration). Monitoring will be conducted annually to capture the long-term effects of forest restoration treatments on bird communities of the mixed conifer ecosystem.

Gold Hill, Colorado, is located northwest of Boulder, Colorado, and east of the Continental Divide. Gold Hill sits at an elevation of 8,400 feet above sea level. Forests in the Gold Hill area were impacted by mining activity from the 1840s to the 1870s. In 2010, the Gold Hill area was affected by the Fourmile Canyon Fire which burned over 6,000 acres on the south side of the town. The treatment site is adjacent to the town of Gold Hill on the north and western sides. The treatment area has a predominately north aspect with steep slopes on the north side.



Map 1: Gold Hill area

Previous Research

Human-caused wildfire suppression has excluded wildfire from forested ecosystems of Colorado's Front Range, altering the historical forest structure, fire regime, and fire severity. Some of the most impacted forests are lower elevation ponderosa pine forests and medium elevation-dry mixed conifer forests, such as the Gold Hill treatment area. (1)

According to Shonagel et al. (2004), "With fire suppression, forests that historically experienced mixed-severity fire regimes have developed a more homogenous forest structure across the landscape, resulting in larger areas of continuously dense forest and perhaps in larger patches of crown fire than were witnessed historically."

Land management agencies and non-governmental organizations are working to address these departures of historical forest conditions through restoration treatments that restore and simulate ecological disturbance. These management philosophies are being adapted and refined through continued monitoring and research to address the effectiveness and ecological relationship to plant and animal species. Numerous factors implement forest restoration treatment designs, including the site's aspect, elevation, moisture, and forest composition. There is research about the interactions and behavior of fire within managed forests. However, the effect of forest restoration treatments on wildlife and, specifically, avian communities of the Rocky Mountain Region is an area that requires further research.

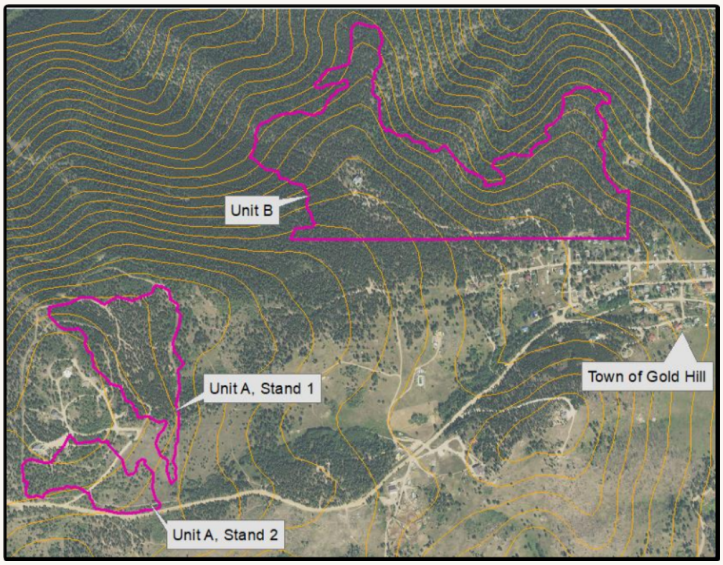
Research done by Latif et al. (2020) surveyed bird communities at forest restoration sites completed by The U.S. Forest Service's Collaborative Forest Landscape Restoration Program (CFLRP) on the Front Range of Colorado. The primary sampled units comprised of 141 1-km2 grid cells, with each containing up to 16 points spaced 250 meters apart in a 4 9 4 array creating a total of 1,972 points.

According to Latif et al. (2020), "Our findings of increased bird species richness and the benefits for many open-forest associated bird species with treatment were consistent with the potential for treatments to restore the historical range of variation, from which the landscape as a whole has departed." Latif et al. l (2020) further elaborates, "Our results provide evidence for a commonly expected but rarely verified pattern of increased species richness with forest heterogeneity. We suggest restoration treatments will most benefit forest bird diversity by reducing canopy cover, encouraging herbaceous ground cover, limiting ladder fuel species, and encouraging shrub diversity in canopy openings while maintaining some dense forest stands on the landscape."

(1) Latif, Q. S., R. L. Truex, R. A. Sparks, and D. C. Pavlacky Jr. 2020. Dry conifer forest restoration benefits Colorado Front Range avian communities. Ecological Applications 00(00):e02142. 10.1002/eap.2142

(2) Tania Schoennagel, T. T. Veblen & W. H. Romme (2004), The Interaction of Fire, Fuels, and Climate across Rocky Mountain Forests, BioScience, Volume 54, Issue 7, July 2004, Pages 661-676, https://doi.org/10.1641/0006-3568(2004)054[0661:TIOFFA]2.0.CO;2

Current Forest Conditions



The Gold Hill Forest Restoration Project is comprised of two units, A and B. Unit A is 25.8 acres, and Unit B is 57 acres. Both units are on private property.

Unit A

The current average basal area in the treatment unit is 136 ft2/ac; average TPA is 328 (excluding any trees < 5" Diameter at breast height). This site is composed of a mosaic of lodgepole pine, Douglas-fir, and ponderosa pine stands and aspen groves.

Unit B

The current average basal area in the treatment unit is 103ft2/ac; the average TPA is 280 (excluding any trees < 5" DBH). Basal is defined as an average amount of an area occupied by tree stems. The eastern end of the unit is composed of a mosaic of lodgepole pine, Douglas-fir, and ponderosa pine, while the western end is characterized by dense lodgepole forest. Forest metrics and mapping were provided by the *Boulder Valley and Longmont Conservation Districts*.

Soil conditions are an important factor and nutrient source for forest ecosystems and can play a role in forest composition and conditions. Soil parent material on-site consists of Colluvium and/or residuum derived from igneous and metamorphic rock. Further taxonomic information on soils within the treatment site can be seen below in Table 1.

Soil name	Family or higher taxonomic classification
Allens Park	Fine-loamy, mixed Typic Eutroboralfs
Fern Cliff	Mixed Psammentic Eutroboralfs
Juget	Sandy-skeletal, mixed Lithic Haploborolls
Peyton	Fine-loamy, mixed Aridic Argiborolls
Rock outcrop	

Table 1. Soil taxonomy of treatment site via USGS Web Soil Survey

Methods

Point counts were utilized across the treatment area and a non-treated control area on adjacent United States Forest Service land. Point counts were conducted to aid in estimating occupancy, richness, relative abundance, and a species index that can be used for outreach and engagement with private landowners and community members. All observed breeding species were counted based on their specific breed's auditory signals at set points for each observation day and time.

All observed breeding species were recorded on data sheets during a standard duration of five minutes. The points were distanced a minimum of 100 meters. The points were sampled every 11 days, beginning the first week of June to early July.

There are five points selected within the Gold Hill treatment area.

Point count locations were determined using the randomize point function on ArcGIS Pro. Smartphones and other smart devices were used to record the five-minute count via the Merlin Bird ID app's song identification and volunteer Naturalists were used in identifying bird songs and observations. Breeding bird lists were given ahead of time to help familiarize and train volunteers.

PICTURED: VIOLET-GREEN SWALLOW

Analysis

Four-point counts were completed during the summer season of 2021. A total of 30 species were found across five different points within the forest restoration treatment area. A list of identified species is included below.

1	American Crow	House Wren
2	American Robin	Lesser Goldfinch
3	Black-Billed Magpie	Mountain Chickadee
4	Black-capped Chickadee	Mourning Dove
5	Broad-tailed Humming Bird	Northern Flicker (Red-Shafted)
6	Cassin's Finch	Olive-sided Flycatcher
7	Chipping Sparrow	Pine Siskin
8	Cordilleran Flycatcher	Pygmy Nuthatch
9	Common Raven	Red-Breasted Nuthatch
10	Common Yellowthroat	Ruby-crowned Kinglet
11	Dark-eyed Junco	Stellar's Jay
12	Hammond's Flycatcher	Townsend's Solitare
13	Hairy Woodpecker	Violet-green Swallow
14	Hermit Thrush	Warbling Vireo
15	House Finch	Yellow-rumped Warbler

Total Counts per Species

Figure 1 displays the total bird counts by species across all 5 points and all days that data were collected. Birds' species common names are represented by their universal four-letter alpha codes. The most counted species were American Crows, Broad-tailed Hummingbird, Dark-Eyed Junco, Mountain Chickadee, and Red-Breasted Nuthatch. Figure 2 displays the sum of bird counts by point (1-5) in the treatment site. These data were collected in the summer of 2021 before forest restoration implementation and will serve as pre-treatment data.

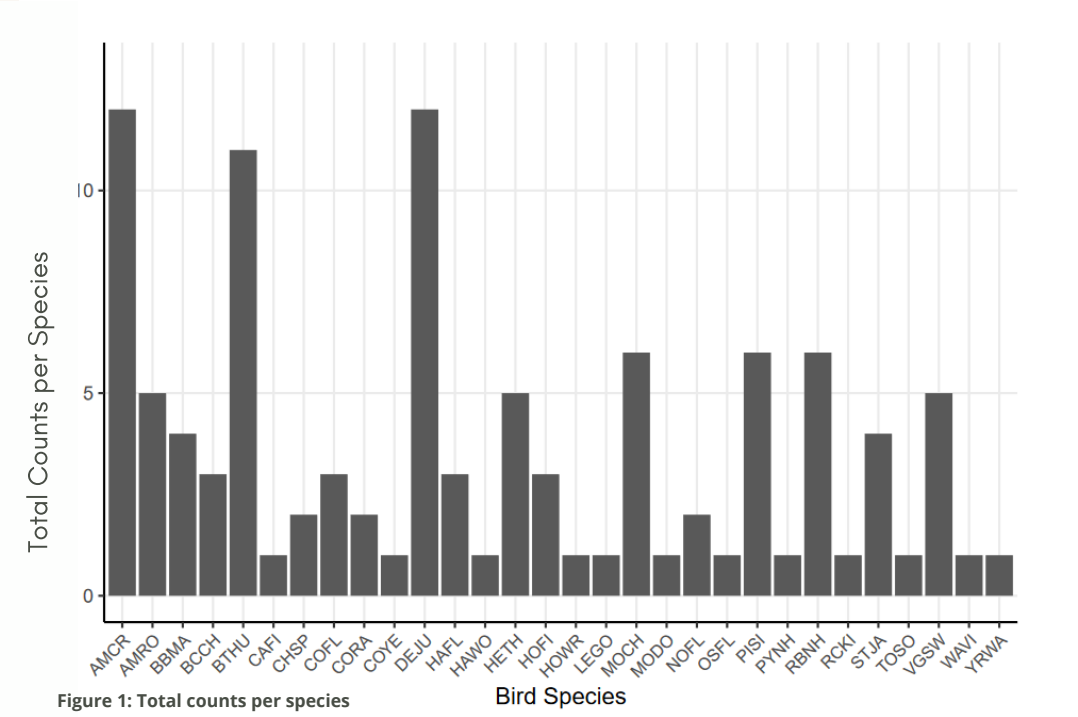
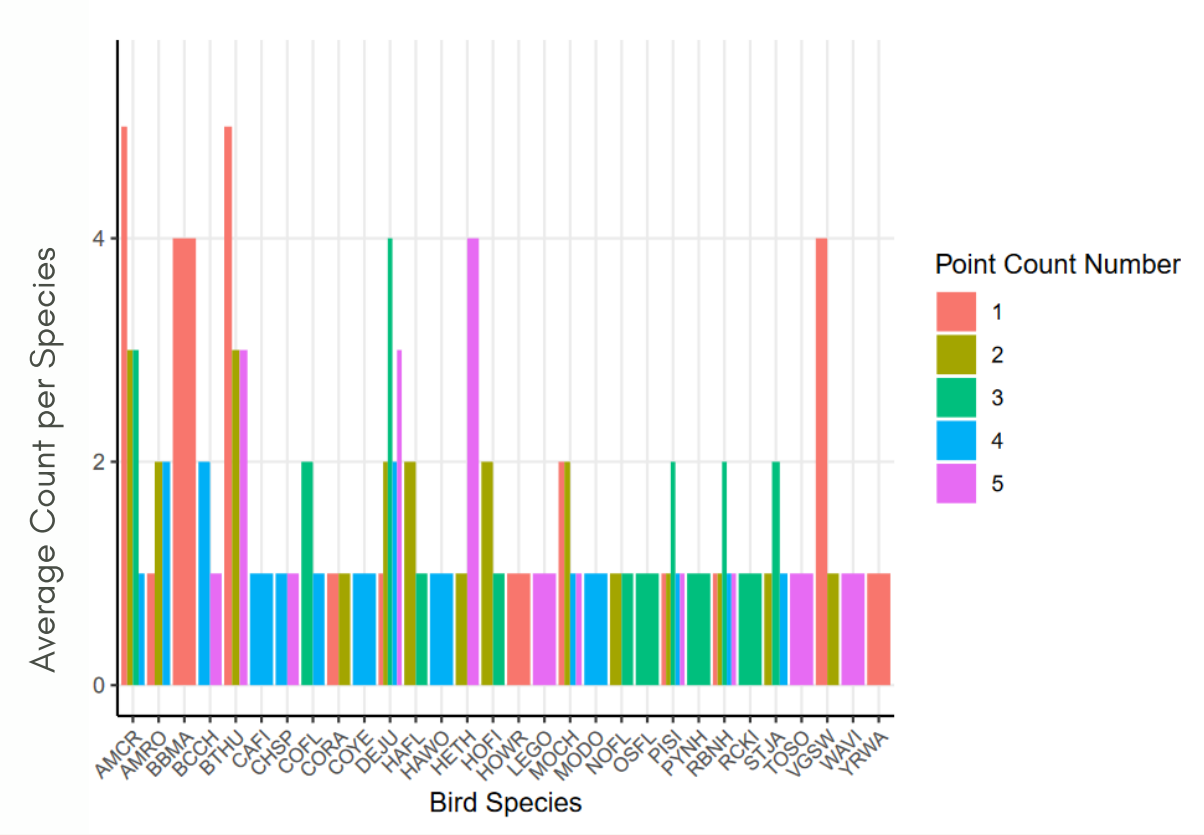


Figure 1: Total counts per species



Species Diversity - Shannon-Weiner Index, PIE

To better understand the diversity of bird populations within the treatment site, the Shannon-Weiner index was used to calculate the diversity of bird species found. The Shannon-Weiner Index estimates roughly how evenly distributed species are relative to each other in a sample by considering each species' proportion in the relative sample and the species richness of the sample. The H-values from indexing were 3.015 for Unit A and 2.62 for Unit B. Further monitoring seasons will provide comparative data for accessing diversity index values.

$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

Shannon-Weiner Index Formula

The Probability of Interspecific Encounter Value (PIE) of the two treatment units was calculated for an additional measurement of diversity. For computing, calculate N/N-1 single value for each location and then calculate the squared proportions of each species, finishing by summing all those proportions and subtracting from 1, and multiplying by N/N-1 for each location.

The value provides the percentage of times there are different species rather than one species. There is a 95.39% chance you would randomly choose two different species from the Unit A sample, which is a high value. There is a 92.9% chance you would choose two different species at random from the Unit B sample.

Conclusions and Observations

The H-Value from the Shannon-Weiner Index and PIE value for the pre-treatment data indicate there is a high diversity baseline of species in our pretreatment site. Higher H-values mean a higher diversity of species in the studied sample size. The lower an H-Value is, the lower diversity; for example, with a sample of birds you collected, there would be no diversity = 0 H value if there were only one species.

This is one year of data does not allow us to conclude the effects and relationship of forest treatments on avian communities but continued monitoring will allow for comparative observations in H-values and relative abundance from our pre-treatment data to our post-treatment data.

Due to the relatively small size of the treatment area, it was challenging to get random points to fall in areas with manageable slopes and accessible to volunteers. Ideally, point locations would have been better spaced and in more representative locations across the treatment site.

Continued monitoring in the future will allow comparisons between baseline data collected in 2021 and post-treatment data. An added control site will help measure the changes in diversity, occupancy, relative abundance, and other observations in avian communities due to 1) the treatment and 2) random fluctuation.

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APPENDIX B
WILDLIFE PICTURE INDEX REPORT
2021

Wildlife Picture Index
2021 Report

Project Background

The Boulder Watershed Collective (BWC) works to create thriving social and ecological systems within watersheds. BWC has been working closely with local communities within the Boulder Creek Watershed to better understand community values and concerns as they pertain to wildfire and forested watersheds. One primary value that resonates across mountain communities is preserving wildlife and the habitat which supports robust and healthy wildlife populations.

The BWC and partners are working to restore 150 acres of mixed conifer forest adjacent to the Town of Gold Hill. The project will reduce wildfire risk for the community, enhance previously completed USFS and Boulder County fuels treatments and improve habitat and understory diversity to create a more resilient forest. While habitat improvements are often objectives of forest restoration projects, only a small portion of restoration treatments are monitored over the long-term. For this reason, the long-term impacts of restoration on wildlife populations are not often tracked and successes and habitat improvements are not well communicated to local communities.

To be responsive to community values, BWC integrated wildlife monitoring into the forest restoration project through breeding bird surveys and a Wildlife Picture Index (WPI). The 2021 monitoring collected baseline data within the restoration site.

What is a Wildlife Picture Index?

A WPI is an innovative method combining photos from wildlife cameras with other environmental data to enable land managers and communities to learn about the presence of wildlife, the species richness, and relative species abundance in a defined area. The WPI technology is internationally used and recognized as a method of passively collecting reliable, accurate, and rigorous scientific data on wildlife diversity and relative abundance (Marin County Wildlife Picture Index). The WPI uses a network of motion active game cameras to capture images of different kinds of wildlife. Camera trapping offers a non-intrusive, low cost, and verifiable means of sampling mammals that may react to sampling methods that require human presence. The WPI is suitable for monitoring medium to large sized terrestrial forest mammals and birds.

This data will help establish baseline abundance of individual species and mammals in general, identify wildlife hotspots, and determine population trends to indicate the well-being of wildlife in the area. Abundance is a metric that tells you the relative representation of animals within a given area. The WPI acts as a composite indicator to derive estimates of relative occupancy based on the sampling taken from each camera site (Buckland et al., 2005). WPI provides only a relative estimate because species abundance can be difficult to measure without tagging or tracking of animals. Because of the charismatic appeal of camera trap photographs and the potential to monitor mammals the WPI will be well-suited for outreach and engagement with communities and stakeholders interested in the impact that forest restoration projects have on wildlife populations.

Study Design

Study objectives were developed after a literature review of academic papers, conversations with project managers in implementing WPI projects such as Colorado Parks and Wildlife and the Pepperwood Preserve, consideration of objectives for the forest restoration project, and a review of community value data derived from recent surveys and interviews with community members. Objectives for the WPI project include:

1) Document baseline species occupancy and relative abundance within the forest treatment area,
2) Better understand how forest management activities affect habitat and species,
3) Support community values by integrating wildlife monitoring into the forest restoration project.

BWC was awarded a grant from the Boulder County Nature Association to purchase game cameras. Cuddeback motion sensor cameras were selected for installation. The cameras have a 50 foot to 100-foot flash range and ¼ trigger speed. Random locations for camera locations were generated through ArcGIS across a 10-acre grid system within the treatment area (see map below). The grid method provides a non-biased sampling method to determine the occupancy and frequency of wildlife in different areas.

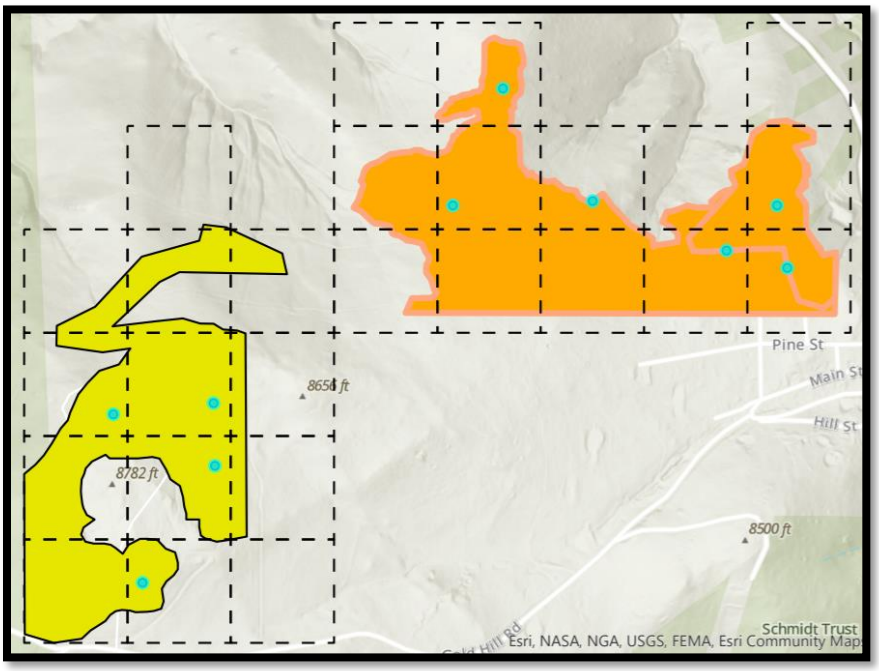

Figure 1: Colored areas indicate forest treatment units. Grid is overlayed with randomized camera locations points.

Cameras were fastened onto a tree closest to the GIS generated point. The cameras were set up at a variety of heights to capture an array of mammals at differing heights. Each camera was positioned to face North to reduce the likelihood of images being washed out by direct sunlight. The camera settings were standardized to capture one image per event, with a 15 second delay between intervals to avoid a double count of the same animal. Each camera, and an SD card, were marked with a unique number to ensure data collected from a specific camera is associated with the correct location during data

processing. SD cards are rotated, approximately monthly, during maintenance checks to ensure there is ample data storage on each SD card.

WPI Data Processing Methods

The WPI index allows the creation of several metrics regarding the wildlife species that were captured using game cameras. Wildlife species were identified by their scientific and common names and were entered into a corresponding WPI data sheet with the date and time of detection. Computer programs may be used to identify images to streamline species identification. A species list of occupancy within the treatment site was completed from the first-year data.

Future data will be analyzed utilizing RStudio, a data analytics program. RStudio computations will give Shannon-Weiner diversity H-values, total detections, and the probability of interspecific encounters. These measurements can inform managers on the relative abundance of species and level of diversity for the study area. The Shannon-Weiner Index estimates roughly how evenly distributed species are relative to each other in a sample by considering each species' proportion in the relative sample and the species richness of the sample. Probability of Interspecific Encounter (PIE) provides the percentage of times there are different species rather than one species and further elaborates on the richness of the studied sample. The continued monitoring and collection of future data will allow for comparative observations in H-values and relative abundance from our pre-treatment data to our post-treatment data.

Preliminary Data

Developing the study design and installing cameras took more time than expected. For this reason, cameras were only active from August through December. This short period of time allowed the team to collect some baseline species data (see table below). These data were collected prior to the forest restoration project commencing.

	Common Name	Scientific Name
1	American Black Bear	Ursus americanus
2	American Red Squirrel	Tamiasciurus hudsonicus
3	Bobcat	Lynx rufus
4	Mountain Cottontail rabbit	Sylvilagus nuttallii
5	Coyote	Canis latrans
6	Moose	Alces alces
7	Mountain Lion	Puma concolor
8	Mule Deer	Odocoileus hemionus
9	Red Fox	Vulpes Vulpes
10	Red Fox (black var.)	Vulpes Vulpes
11	Wild Turkey (Merriam's)	Meleagris gallopavo merriami

Figure 2: 2021 species list representing mammals identified within the study area.

Conclusion

Wildlife populations are impacted by many factors including climate and weather fluctuations, human growth and development and land management decisions like fire suppression. Forest restoration and wildfire mitigation are increasingly common across the western landscape and the design and implementation of those projects can vary greatly. Better understanding how the design and implementation of forest restoration projects impact wildlife populations over the long term a critical component is of improving management practices, conserving biodiversity and building community support for continued restoration. Monitoring change in biodiversity requires gathering data on many species and ecosystem indicators. Baseline vegetation data was also collected in the study area including an inventory of tree species and density and understory vegetation species richness. Combining biodiversity monitoring with management interventions will reveal trending and help inform future management actions.

BWC will continue to collect wildlife data through the restoration project and for multiple years after it is completed. These data sets will be analyzed to better understand if the treatment is supporting improved wildlife habitat and populations. As the quantity of wildlife points is increased, more complex analysis will occur using the Shannon-Weiner Index.

In 2022 BWC will focus on developing community engagement connected to the WPI project. BWC will determine the best methods for sharing visual data and engaging with the community to provide more in-depth information about species, habitats, forest restoration and the relationships between these.

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