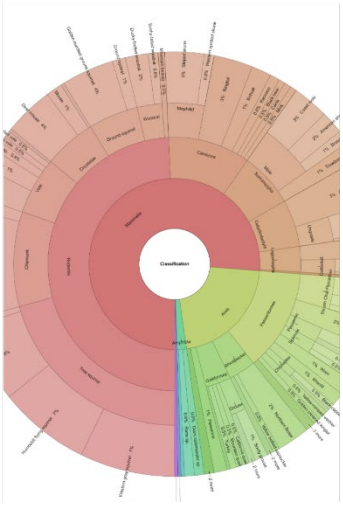
Progress Report for the Wildlife Conservation Initiative

Pacific Southwest and Northwest Regions



The National Council for Air and Stream Improvement, Inc. (NCASI) is a non-profit organization with a mission of providing cost-effective environmental and sustainability opportunities for the forest sector through applied research, technical support, and education. Dr. Katie Moriarty and her teams (NCASI) and the Wildlife Conservation Initiative (WCI) partnered during 2020 to focus on three independent projects in two U.S. Fish and Wildlife Service (USFWS) regions (Pacific Northwest, Region 1; Pacific Southwest, Region 8). Our research focuses on topics of contemporary interest to the USFWS, National Alliance of Forest Owners (NAFO), and NCASI Member Companies. Data collection on these projects is either recently completed or still ongoing with partial or continued funding from the WCI, and thus this report represents a subset of the expected total activities of the projects. Within, we describe progress on (1) quantifying pollinator use of stands in both regions with selection stratified across a gradient of forest management intensity and fire severity, (2) genetically identifying carnivore scats using DNA metabarcoding to better define the range of Humboldt martens, (3) completing canopy research to evaluate tree vole demography, and (4) evaluating Humboldt marten movement in Oregon.

Pollinator patches within a forested matrix: describing biodiversity along a gradient of stand, watershed age, and fire severity
FY 2022-2023

Lead Investigator:
Katie Moriarty, National Council for Air and Stream Improvement, Inc (NCASI)
2438 NW Professional Way, Corvallis OR 97330
Email: *kmoriarty@ncasi.org*
Phone: 541-249-3987

Collaborators and roles:
Lauren Ponisio, University of Oregon. Focus: bee ecology, fire influences, and bioinformatics
Rose McDonald, University of Oregon. Focus: Field crew leader, logistics, plant and insect identification
Felix Bruner, NCASI. Project focus: Field crew leader, logistics, plant and insect identification
Claire Massaro, NCASI. Project focus: Field crew leader, logistics, plant and insect identification
Kylie Weeks, NCASI. Project focus: Field crew leader, logistics, plant and insect identification
Laura Six, Weyerhaeuser. Focus: Plant ecology; floral phenology, richness, and diversity
Angie Larsen-Gray, NCASI. Focus: Multi-state coordination and collaboration
Alan Yanahan, U.S. Fish and Wildlife Service. Focus: regional coordination, GIS, and technical support
AJ Kroll, Rosinante. Focus: Overarching study design, manuscript development
Jake Verschuyl, NCASI. Focus: Overarching study design, manuscript review
Lincoln Best, Oregon State University. Focus: Bee taxonomy and capture design

Background:

Several pollinator species have been proposed or petitioned for listing under the Endangered Species Act and/or are species of greatest conservation need as determined by several western States (Table 1). To date, broad-scale surveys (e.g., Oregon Bee Atlas, California, and Pacific Northwest Bumblebee Atlas) have largely been confined to areas with public access (state and federal lands), which creates a considerable gap for describing species' distributions. Open stands and young forests appear to provide unique value to native pollinators, providing nectar, pollen, nesting sources, and floral resources absent in older forest stands (Figure 1). Similarly, fires of various severities may provide additional floral resources, although high severity fire is expected to kill all nesting bees., causing concerns over potential colonization. In partnership with landowners that are NAFO and/or NCASI Member Companies, we collected pollinator and plant community data on both private and public lands. Specifically, we collected data to quantify pollinator (bee) richness paired with floral resources in stands that differed in age (young <4 years, older), by burn severity, and by distance (m) into high severity patches (colonization). We used a generalized random-tessellation stratified (GRTS) design which provides a spatially balanced random sample that allows for unequal probability sampling. Our goals included contributing to our understanding of species distributions in understudied private forests and providing robust data to evaluate potential conservation alternatives, focused on the fundamental ecology and resource needs of inhabiting pollinators following fire.

Figure 1. Crew members Felix Bruner and Chelcie Pierce setting up a blue vane trap to sample pollinators in an open stand in the Holiday Fire with abundant floral resources. Photo by Tim Lawes.

Table 1**.** List of pollinators of concern and their conservation status across California, Oregon, Idaho, and Washington. California recently (9/2022) upheld that insects can be listed within the California Endangered Species Act.

Species	Federal	California	Idaho	Washington	Oregon
Monarch Butterfly (*Danaus plexippus*)	Warranted but precluded (21)	SGCN	SGCN	SGCN	SGCN
Western bumble bee (*Bombus occidentalis*)	PR (due FY 23)	SGCN, SC	SGCN	SGCN	SGCN
Suckley cuckoo bumble bee (*Bombus suckleyi*)	90 day (May 2021), Status Review	SGCN, SC	SGCN	SGCN	DG
Morrison's bumble bee (*Bombus morrisoni*)		SGCN	SGCN	SGCN	DG
Obscure bumble bee (*Bombus caliginosus*)		SGCN			DG
Franklin's bumble bee (*Bombus franklini*)	Federally Endangered (Aug 2021)	SGCN, SC			SGCN
Crotch bumble bee (*Bombus crotchii*)		SGCN, SC			
Yellow bumble bee (*Bombus fervidus*)			SGCN		DG
Hunt's bumble bee (*Bombus huntii*)			SGCN		

Species of Greatest Conservation Need (SGCN), State Candidate (SC), and State Data Gap (DG) bumble bee species in California, Idaho, Oregon, and Washington State Wildlife Action Plans (SWAPs); Proposed Endangered (PE), Petitioned for listing (P), and Received a Positive 90-day finding (PR) under the U.S. Endangered Species Act.

Summary of Efforts:

We completed summer 2022 field sampling between April and September and subsequent taxonomic ID of bumblebees was accomplished during spring 2023 (solitary bee taxonomy is still in progress). We sampled 3 regions representing 133 stands across Oregon and Northern California. Twelve NCASI staff members surveyed sites aiming to go to each sampling location on 4 occasions, including one short round of passive trapping during a time when capturing queen bumblebees was less likely (mid-summer). Passive sampling resulted in capturing 3,891 bumblebees, 775 honey bees, and 22,290 solitary and semi-social bees. We combined resources from the WCI with contributions from NCASI, Weyerhaeuser, and U.S. Forest Service.

During 2023, we focused on stands that varied in fire severity. Fires during 2020 and 2021 were among the largest and most severe on record in the western United States a. Insect pollinators may benefit from large openings in the canopy created by fire which commonly led to more abundant floral resources. Nonetheless, during these fires, many insect pollinators would have been killed and thus species would need to recolonize into high severity patches. We used a Generalized Random-Tessellation Stratified (GRTS) design which provided spatially balanced sampling locations stratified both by fire severity and distance into high severity patches in 4 fires.

Team members surveyed 70 stands across the Oregon Cascades (34 stands in the Holiday Farm and Beachie fires; Figure 3a) and the California Sierra Nevada (36 stands in the Claremont-Bear and Dixie fires; Figure 3b). between April and August 2023 (Figures 2a, 2b). All stands were previously surveyed in 2022 using the same protocol (protocol available upon request).

Figure 2a. NCASI and University of Oregon crew members training in-field in May 2023. From left to right: Kylie Weeks (NCASI), Mel Allen (NCASI), Rose McDonald (UO), Alejandro Santillana Fernandez (UO), Felix Bruner (NCASI), Andrés Castro-Siller (UO).

Figure 2b. NCASI crew member Kiara Milcoff collecting transect data on a smart phone in a bare, burned stand in northern California.

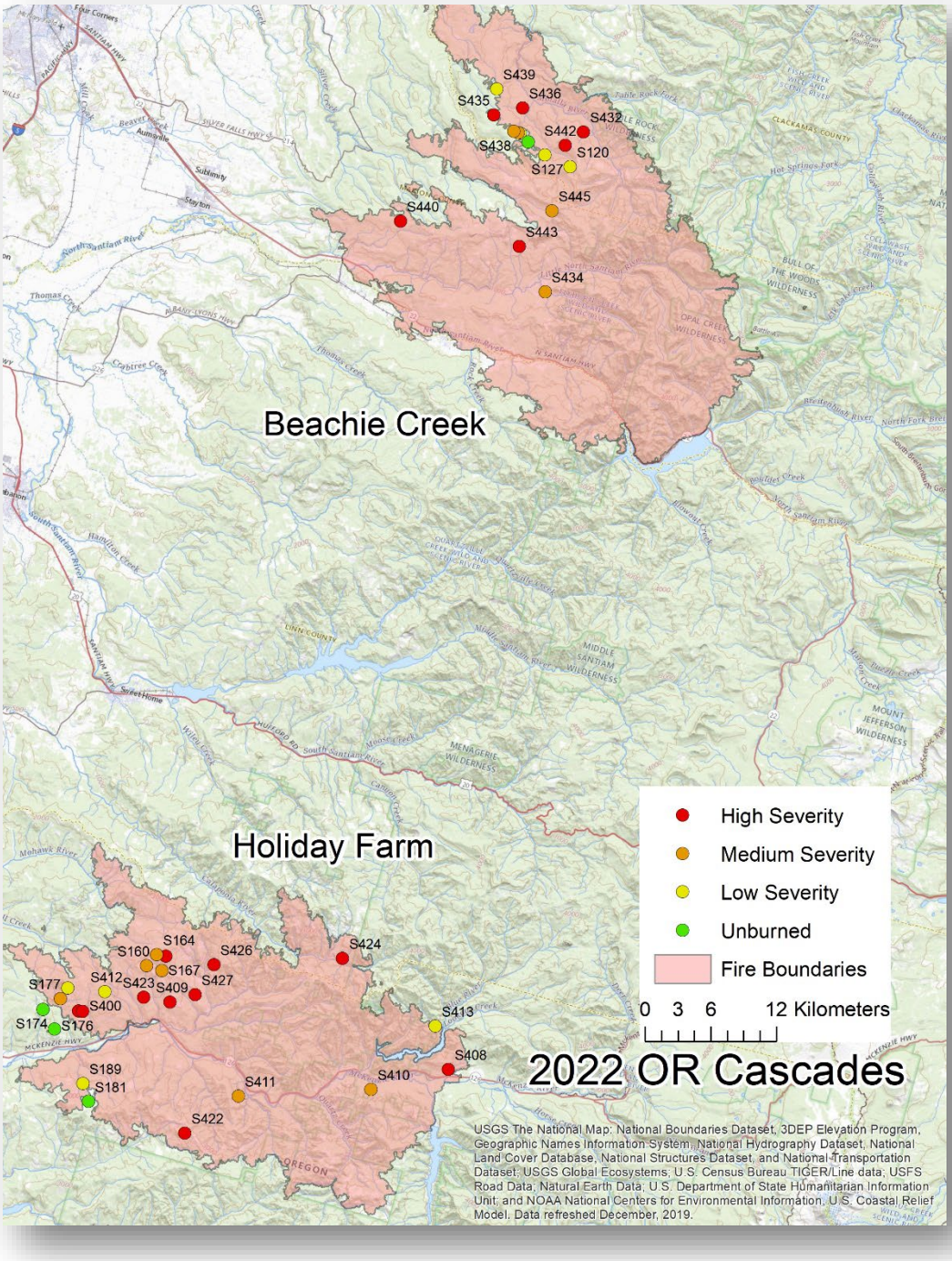


Figure 3a. We surveyed two fires and adjacent forested stands in the forested Cascade mountains of Oregon burned in wildfires during September 2020 (Beachie Creek and Holiday Farm fires).

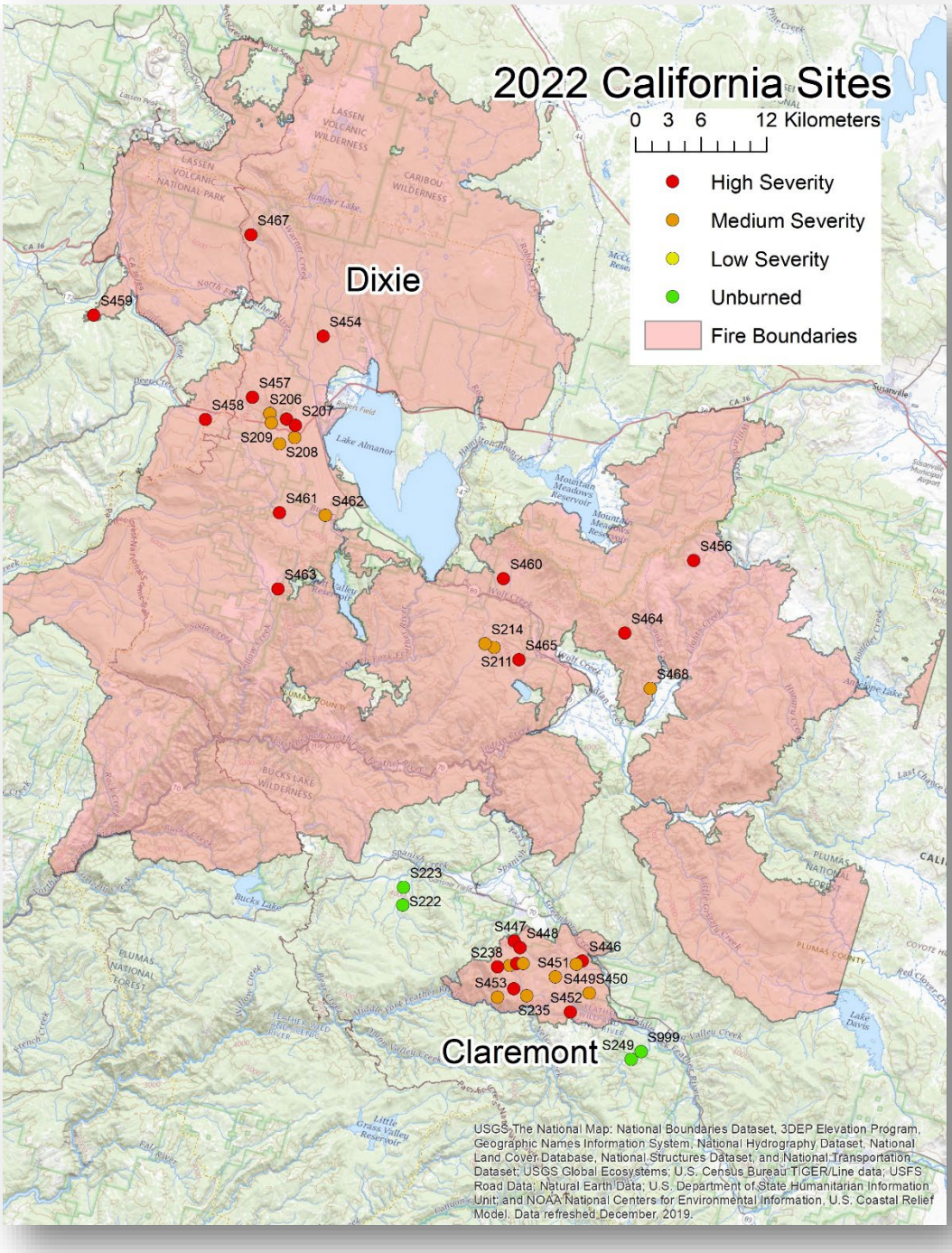


Figure 3b. We surveyed stands burned in two wildfires during 2020 (Claremont-Bear) and 2021 (Dixie) and adjacent forested stands in the crux of the northern Sierra Nevada and southern Cascade mountains of California Here, the higher density of stands surveyed in the Claremont Bear fire represents the increased density of differing severity patches and our attempt to use fire as a replicate.

During 2023, we began northern California surveys in May due to snow. We collected data on flowering vegetation, available nesting habitat, forest metrics, and plant-pollinator interactions once per stand in 35 stands, with 5 of these stands resurveyed an additional time as flower availability permitted (Figure 4). Fewer bees were netted than expected due to weather and personnel limitations during these visits. We hand-netted 210 insects. Netted bumble bees and honeybees will be dissected and analyzed for gut parasites, and pollen will be extracted for metabarcoding. We collected insects using passive blue-vane traps (BVT) in 34 stands. One stand received a BVT round but no vegetation sampling, and two stands received vegetation sampling but no BVT round due to access issues earlier in the summer. Of the 36 sampled stands, 14 were burned during 2020, 18 were burned in 2021, and 4 were unburned.

Figure 4. Field crew member Kylie Weeks transferring a hand-netted bee from the net into a sterilized vial with a unique identification code. Because we added an objective of disease, field crew members wore gloves and sterilized both the gloves and net between captures. Photo by Tim Lawes.

Fieldwork for 2023 concluded after the first week of August. We are still processing specimens and exact numbers of captured insects have not yet been generated. Passive BVT occurred in all stands for 7-10 days with an average of 8.26 days (Figure 5). Under our CDFW collection permit, we checked each trap's contents every other day to limit accidental take of the western bumble bee (*Bombus occidentalis*). To our knowledge prior to taxonomic review, no western bumble bees were trapped this year. Trapping occurred in one round from June 26th to July 5th. We collected trap contents during these checks when traps seemed full enough that additional collection would be limited. We set traps in 70 different locations and collected 355 bumble bees and 8,263 specimens. These average to 1.3 bumble bees/day/stand and 29.4 specimens/day/stand. This appears to be substantially more than 2022 when accounting for length of time traps were deployed. Comparatively, in 2022, traps were set for two rounds for an average of 28.5 days, catching 696 bumble bees and 9,669 specimens. These average to

0.63 bumble bees/day/stand and 8.70 specimens/day/stand. While we currently are waiting for taxonomic identification of captured bees from 2023, this suggests that changes in bee communities, and potential floral resource availability, have occurred following post-fire regeneration.

Figure 5. Blue vane traps, brightly colored fluorescent yellow and blue to attract bees, were placed on gardening Shepard's hooks and reinforced with a labelled stake. We tilted the device at a 45-degree angle to reduce any likelihood of excessive rain flooding the trap as per suggestions by Lincoln Best and the Ponisio lab. Photo by Tim Lawes.

During 2021, we noticed queens emerging around late May and early June (OR Coast Range) and netted foraging fall queens July 17-July 29 that same year (OR cascades and CA coast). During 2022, with a very wet spring, we noticed a delay in the emergence of these queens in addition to blooming flowers in Oregon. California experienced one of the largest snowpacks on record this year, and queen flights seemed to adjust accordingly. Overlap between spring and fall queen presence was observed in the field. All netted queens were photographed and released (e.g., Figure 6).

Figure 6. A bumblebee queen caught during net surveys and photographed for later identification. Queens seen foraging during net surveys are photographed and released.

Because of the combined resources, we were able to survey all accessible sites in 2023. We continued to partner with Dr. Lauren Ponisio (University of Oregon) to further our study objectives. We used her strict field protocol for hand netting bees to evaluate diseases and internal parasites, which are expected to be a significant threat for rare bee conservation, particularly for bumblebees in the subgenus *Bombus sensu stricto* (e.g., the recently endangered Franklin's bumblebee, the endangered Rusty-patched bumblebee, and the Western bumblebee). This sampling protocol required the team to wear latex gloves in the field (Figure 6), sanitize gloves and nets between captures, and carry solid nitrogen (dry ice) for specimen storage. Dr. Ponisio and her lab will use their own funding to process and genetically analyze the bees' stomach contents. As of September 2023, 231 bees from 2022 have been screened for a housekeeping gene as a positive control, *Ascosphaera*, *Apicysits*, *Crithidia sp.*, *Crithidia expoeki*, *Crithidia bombi*, *Nosema ceranae*, and *Nosema bombi*. Approximately 750 bees from 2023 will be dissected and screened this winter with the addition of bees captured as part of Dr. Ponisio and PhD student Rose McDonald's floral enhancement project.

Floral Enhancements

The first season of in-situ burn pile enhancement monitoring occurred in 2023. We seeded 14 sites in the late fall of 2022 prior to winter snowfall with 6 different mixes of 16 native flowering plant species (Figures 7, 8a, 8b). We monitored 11 enhanced sites both in the seeded plots and in the surrounding stand and compared these with additional control sites using our same survey protocol, with some adjustments for seeded plots. Specimen processing is ongoing and the number of specimens has not yet been tabulated.

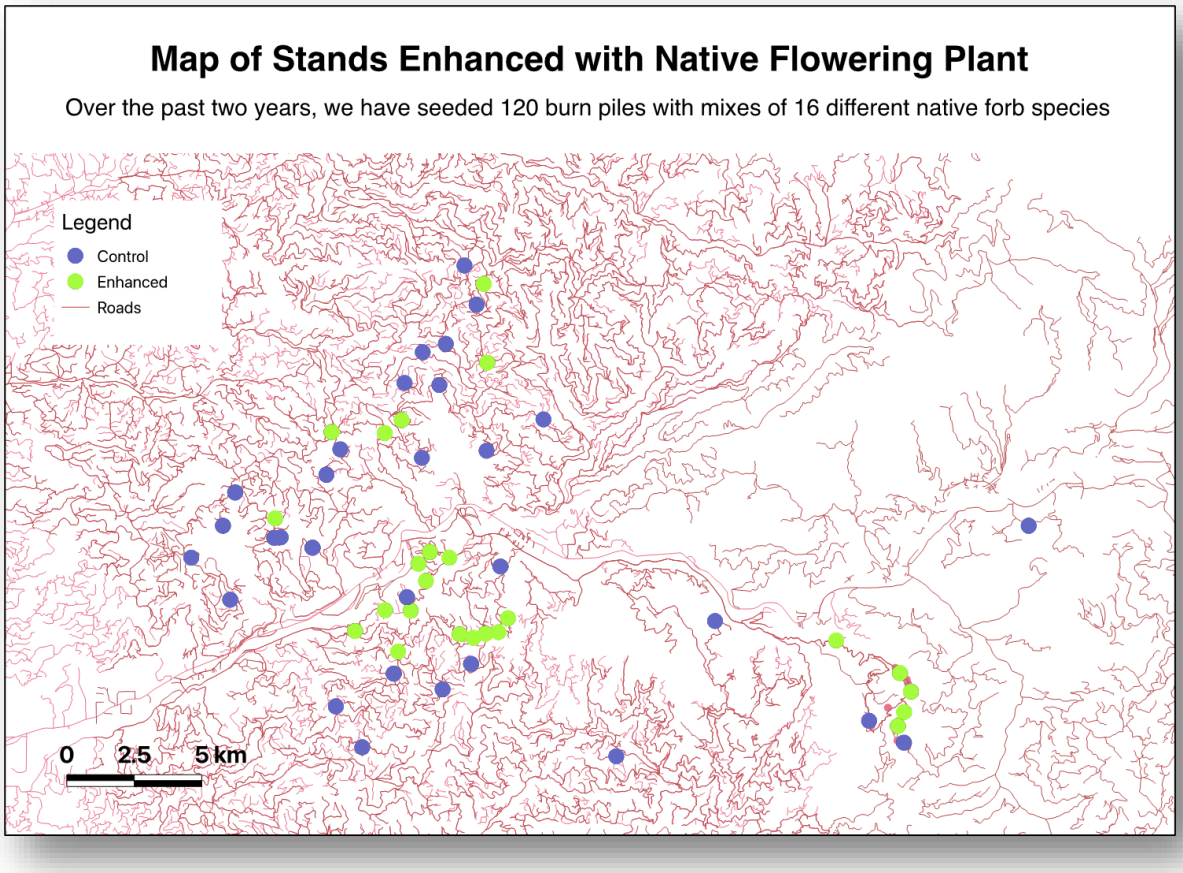


Figure 7. Map of 2023 Enhancement sites and controls in the Holiday Farm Fire. Enhanced sites include planned seeding this fall. Controls (purple) were not enhanced with flowers, and locations with green dots had one of 6 seed mixes planted not only to evaluate bee diversity but also plant competition.

Figure 8a. Crew members seeding in burn piles in fall 2022. Each site was seeded with 6 mixes of native plants, and single seeds of the mix species were planted in half-meter plots in the surrounding burn pile area to monitor individual seed success.

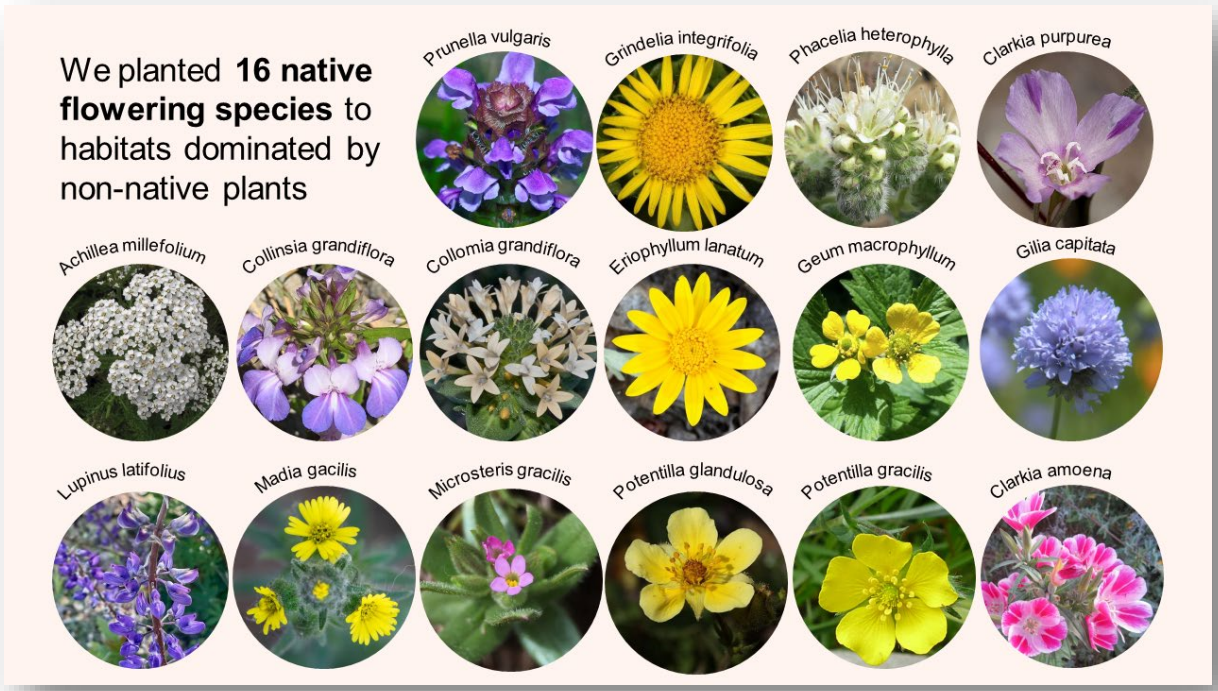


Figure 8b. Plant species seeded in burn piles. All species are native to the Oregon Cascades.

Limitations

In 2023, our crew faced unique challenges. We had a long hiring process in 2022 but were ultimately able to fill positions with qualified applicants. This year we attempted to hire half as many crew members and were unable to hire all positions and additionally had late hires. We also started surveys much later than anticipated (late May) due to high snowpack across our California sites, while the summer heat resulted in floral resources lasting for a shorter window than previous years. As such, we had to change our expectations and priorities to still meet project objectives with a much smaller team. Rather than visit each site multiple times, we visited all sites once, except for one. While we were unable to collect data on floral and bee phenology in California, we still surveyed available floral resources across stands and the bee communities within those stands.

Achievements and Next Steps:

Information sharing: We built on our 2021 informal, 2-hour webinar focused on transferring information on forest-associated bumblebees and included talks from managers and researchers throughout North America (https://www.ncasi.org/resource/pollinators-and-current-activites/) by focusing on a special session at The Wildlife Society (TWS) conference in Spokane, WA (November 2022). Here, we showcased our study design and integration with southeastern projects (Texas, Mississippi, Georgia). Poster presentations of our data were shared at TWS-Spokane, TWS-Western Section Meeting in Riverside, and the Oregon TWS-Bend meetings. Graduate students in the Ponisio Lab presented at the Ecological Society of America's 2023 National Meeting in Portland. As such, the WCI will have preliminary citable research products within a few months after field work being completed.

Data collection and professional development: Our field crew included dedicated and resourceful early career professionals – four of which took on roles as crew leads and logistic coordinators. Their continued focus on plant and bee identification and overall safety was impressive. On the UO Enhancements crew, over 10 individuals from varying professional and educational backgrounds participated in seeding and monitoring plots.

Next steps: We are still pinning insects (e.g., Figure 9) for delivery to our taxonomist, Dr.? Lincoln Best. Pollen will be extracted from netted honey and bumble bees for DNA metabarcoding in the Ponisio lab over winter. Plant diversity and richness will be analyzed, and floral resources will be paired with our insect observations. Cumulative analyses of pollinator diversity along a gradient of stand and watershed age will occur after we identify our insects from this season – anticipated in fall of 2024. We hope to collect 3 more years of data in the fires because the influence of salvage logging can seem dire for several years but may provide more resources for bees in the late future. We will have preliminary data on this aspect of the project for conferences in 2024.

Figure 9. Our field crew sorting and pinning insects from blue vane traps.

Vision to maintain data collection during 2024 to evaluate recent fires: We aim for at least 1 additional field season to have a temporal data set of bees in fires. We surveyed an impressive number of stands and would like to maintain continuity.

Due to the limitations that we experienced this year, we collected fewer bees and surveyed on fewer occasions than expected. Seasonal differences across years may confound our results as both years using the GRTS design experienced unusual weather conditions. These data could also be interpreted as influences from salvage logging. Moderate severity fire is likely better for bee communities in some forested systems (Lazarina et al. 2019). Seemingly, data within the first 4 to 5 years post fire is most critical (Lazarina et al. 2016). We expect to observe differences in post-fire landscapes, but nearly all studies have extremely small sample sizes (e.g., <4 stands/plots per strata) (Peralta et al. 2017). Galbraith et al. (2019b) collected data in 35 stands along the gradient of fire burn severity in a single fire (Douglas Complex) and this remains the only western research on bees and a diversity of fire severity. Similarly, Galbraith et al. (2019a) is the only study evaluating salvage logging and bee communities – here with a sample size of 8 BLM stands in each treatment in the Douglas Complex. It seems imperative that at least one additional season of data is collected due to our low bee counts during 2022 and 2023 and a lack of information on these topics overall.

Based on the data collected from 2020 to 2023, we have the capacity to better understand pollinator diversity in recent burns along a gradient of severity. Preliminary review of the data indicates fire and salvage logging both have a strong influence on floral resources and the pollinator community. Whether or not these disturbances result in floral and bee diversity is unclear and is likely influenced by the size and composition of the fire.

Using DNA metabarcoding to evaluate complicated relationships and inform restoration opportunities for species of conservation concern: describing plant-pollinator networks and diet of forest carnivores FY 2022-2023

Lead Investigator:
Katie Moriarty, National Council for Air and Stream Improvement, Inc (NCASI)
2438 NW Professional Way, Corvallis OR 97330
Email: *kmoriarty@ncasi.org*
Phone: 541-249-3987

Collaborators and roles:
Carol Aron, Bureau of Land Management. Focus: Humboldt marten distribution gaps
Jennifer Hartman, Rogue Detection Dog Teams. Focus: Dog teams lead
Taal Levi, Oregon State University. Focus: Bioinformatics of genetic data.
Jenn Allen, Oregon State University. Focus: Lead lab manager for extraction and processing.
Jess Fan Brown, NCASI. Project focus: Pollinator field crew leader, plant and insect identification
Laura Six, Weyerhaeuser. Focus: Plant ecology; floral phenology, richness, and diversity
Lauren Ponisio, University of Oregon. Focus: bee ecology, fire influences, and bioinformatics
Deanna Williams, U.S. Forest Service. Focus: federal land management opportunities
Lincoln Best, Oregon State University. Focus: Bee taxonomy and capture design

Background:

Better understanding what resources both native bees and endemic forest carnivores use have been highlighted as urgent information gaps related to active forest management and forest restoration efforts. Humboldt marten (*Martes caurina humboldtensis*), a distinct population segment of Pacific martens, was determined to be Federally Threatened (Aug 2020) and is State Endangered in California. Similarly, several bumble bee species have been recently listed as endangered (Franklin's, 2021) and proposed (Table 1, prior section). Here, we provide an update of a novel application of DNA metabarcoding to identify both distribution of elusive species and elucidate aspects of their ecology. We finished DNA metabarcoding from 2020 and 2021 pollen samples to identify the floral resources they visited.

We focused on sequencing carnivore scats collected with the shape and type assumed to be Humboldt marten – specifically focusing in areas with little information (e.g., the eastern extent of the Oregon coast range). Teams also collected potential predator scats (e.g., coyote, bobcat, mountain lion) to quantify species' diet and the risk of predation to Humboldt martens. In the prior year, scats were collected at sample units stratified by the subspecies' predicted distribution (Moriarty et al. 2021b) by trained Detection Dog Teams. Here, we used WCI funding to genetically analyze a key portion of the collected scats to identify the defecator and their diet. Since 2021, we've assembled a team of early career scientists and have been meeting monthly to summarize diet data for the purpose of writing species-based natural history papers (3-12 papers expected).

Summary of Efforts:

From every hand-captured bee in 2021, 2022, and 2023 the Ponisio lab has extracted pollen, amplified, and obtained results. Bioinformatics will occur in the next 6 months with expected preliminary results in spring 2024.

Between 2019 and 2021, dog teams collected 828 scats. We have genetically verified data regarding the defecator and their diet contents from 554 scats. We located 48 (8.6%) Humboldt marten scats from 15 distinct locations (independent sample units). We provided a description of the Humboldt marten locations to the USFWS with our comments for proposed marten Critical Habitat and will submit our data to inform the recent request for the updated fisher (*Pekania pennanti*) Species Status Assessment (due Oct 26, 2023).

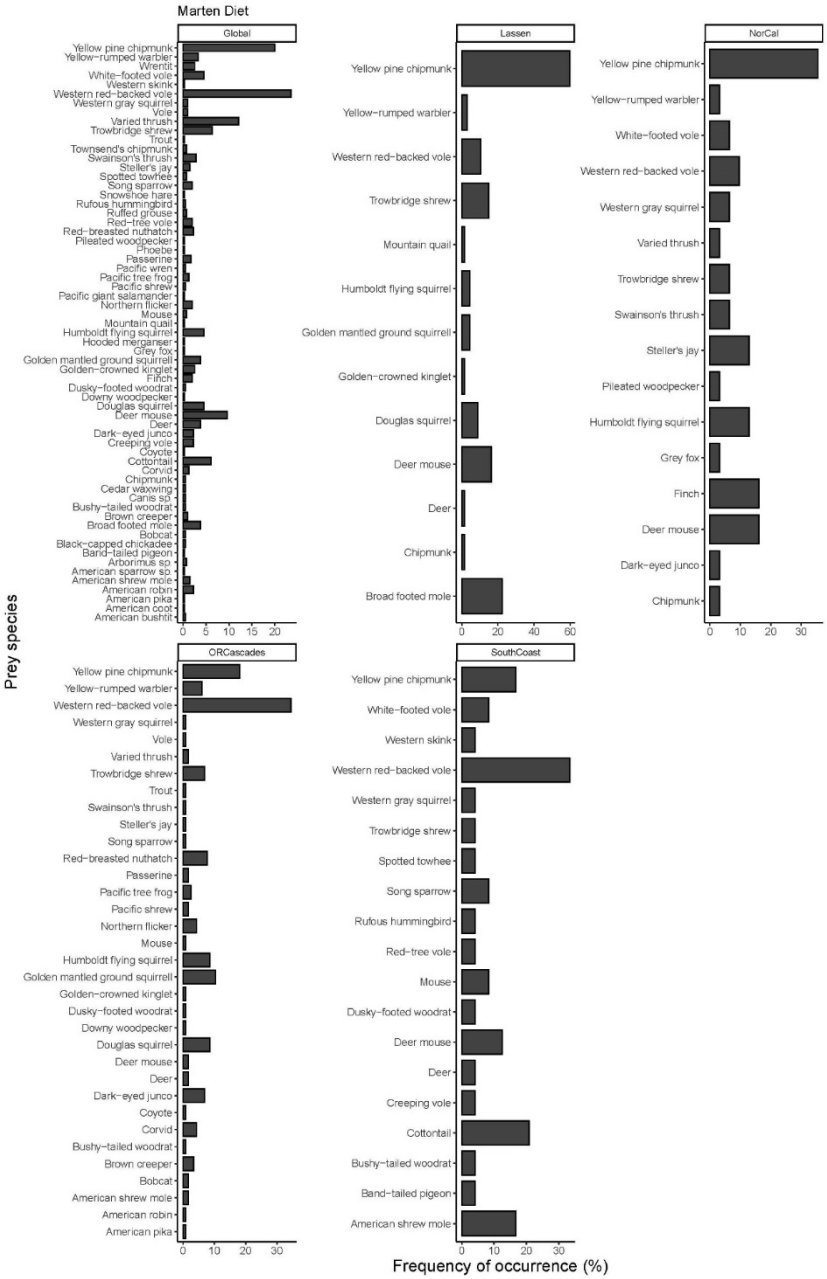


Figure 1. A bar plot of diet data from Humboldt martens with locations described in (Moriarty et al. 2021b) and with all data (global) with subfigures for each region. Overall, diet was very diverse for martens as noted by the multitude of species described. Of the new 554 scats, 114 were identified as fisher (*Pekania pennanti*), 25 were identified as ringtail (*Bassariscus astutus*), 236 scats were identified as bobcat (*Lynx rufus*), 102 scats were identified as cougar (*Puma concolor*), 18 scats are either coyote (*Canis latrans*) or wolf (*C. lupus*), requiring amplification of a different region to distinguish the 2 species. The Levi lab ran a second amplification of 17 scats identified in the *Canis* genus, 14 were coyote and 3 were wolf (2 locations in the southern Oregon Humboldt marten EPA).

We have created *preliminary* interactive diet charts allowing the user to double click and explore data and proportions for bobcat, coyote, fisher (image below), and additional carnivores.

Figure 2. A still image of an interactive "Krona" plot that allows the user to zoom in and out to explore the taxa represented by DNA in collected scats. Similar charts could be created for bumble bees once bioinformatics is complete.

Achievements and Next Steps:

Pollen metabarcoding: The Ponisio lab dissected ~130 pollen specimens from bees collected in 2021 and ~100 samples from 2022. We waited for the 2022 specimens to have a larger data set and make the genetic extractions and sequencing more cost efficient. Bioinformatics will be completed this fall.

Carnivore location data: We have used broad scale distribution data for both Humboldt marten (Moriarty et al. 2021b) and Pacific fisher (Barry et al. 2021) to help land managers and decision makers better visualize population extents. Further, we will evaluate diet of not only martens and fishers, but their potential predators and competitors. Preliminary results were reported (Moriarty et al. 2021a), and we anticipate finishing the paper on multi-species distributions and risk. Moriarty and colleagues intend on summarizing the novel diet data through a series of natural history papers, several of which will be reported in regional conferences and venues.

Describing red tree vole demographics in younger forests FY 2023-2024

Lead Investigator:
Katie Moriarty, National Council for Air and Stream Improvement, Inc (NCASI)
2438 NW Professional Way, Corvallis OR 97330
Email: *kmoriarty@ncasi.org*
Phone: 541-249-3987

Collaborators and roles:
Mackenzie McCoy, NCASI. Crew lead and new graduate student
Jason Piasecki, OSU master's student under Dr. John Bailey
Brendan Pate, NCASI. Field technician
Salix Scoresby, NCASI. Temporary field technician.
Katie Dugger, USGS/Oregon State University co-advising student

Red tree vole male resting on a branch. Photo by Jason Piasecki.

Background:

The north Oregon coast Distinct Population Segment (DPS) of the red tree vole (*Arborimus longicaudus*) was found to be not warranted for listing under the federal Endangered Species Act in 2019. In April 2020, the Service was sued over the finding. The litigants cite timber harvest and catastrophic fire as their concerns, which contributed to an estimated 18% habitat loss through recent time series modeling since 1994 (Linnell et al. 2023).

Red tree voles are often associated with older forests and complex canopy structure, often found in >80-year-old, and especially >200-year-old, Douglas-fir (*Pseudotsuga menziesii*) stands. However, our research indicates tree vole nests are also regularly found in younger forests, including managed forests 20-40 years old that are close to old forest patches (e.g., <1.4 km) (Piasecki 2023). The capacity of young forest to provide habitat for red tree voles is not well-understood. Individual young forest stands may provide habitat ephemerally, but it is not clear if this is sustained for multiple generations of tree voles, and if connectivity is facilitated among patches of older forest. A more comprehensive examination of whether young forests expand availability of habitat for red tree voles will provide needed information for conservation and management decisions. NCASI and Oregon State University, with multiple private and public landowners, are collaborating to complete an ambitious tree vole research project spanning private and public forests in the Oregon coast range.

Here, the WCI provided an opportunity to expand our current study to focus on vole reproduction and survival by supporting a new master's student (starting September 2023) - Mackenzie McCoy.

Figure 1. We surveyed young stands 20-40 years within 1.5-hours of Corvallis using methods described in Piasecki (2023). In nests with recent sign, we attempted to capture and radiocollar voles that were large enough for the weight of a radio collar. Radio collars weighed between 0.42g and 2.0g.

Summary of Efforts:

During 2023, the field team ground-surveyed 12 stands and climbed 458 trees with arboreal nests. We captured 33 voles: 14 adult females that were lactating or with kits, 5 adult males, and 14 juveniles. We were able to collar 30 individuals.

Figure 2. Adult female red tree vole with collar and unique marking on her pelage for remote camera identification.

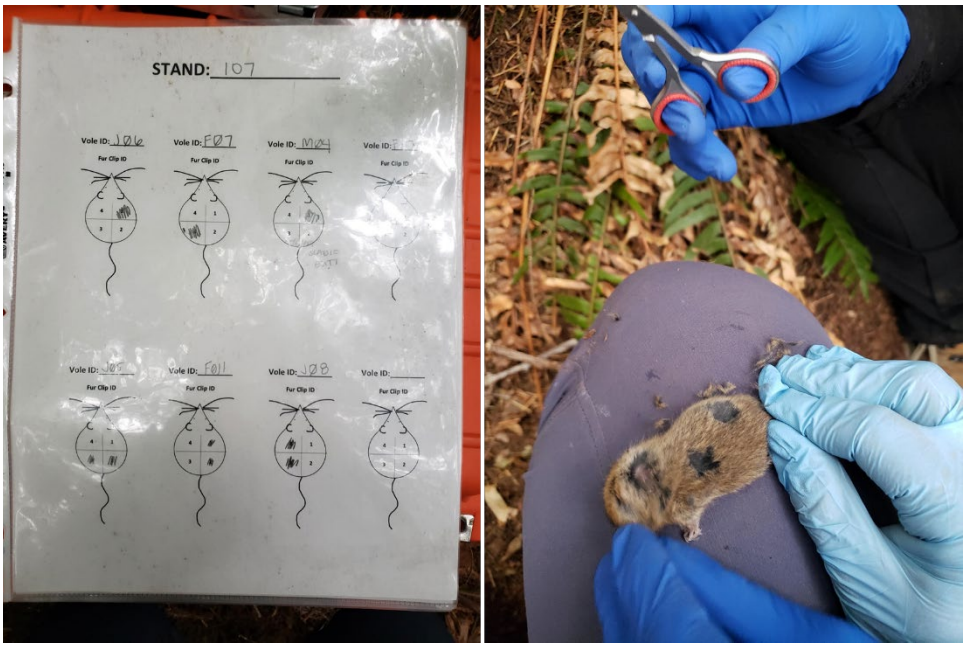


Figure 3. Each vole had a clipped pattern on their dorsal back as their outer pelage is red and underfur black. Within a stand, each individual had a recorded pattern in one of 4 locations.

Figure 4. We both provided a unique tree tag at the base of all trees with arboreal nests a**nd** a unique tree tag at each nest within the canopy (subset image). By doing so, we will be able to quantify nest survival and colonization/extirpation over time building on work by Piasecki (2023). In addition, at nests

with recent tree vole sign, we installed remote cameras facing the nest. When the infra-red camera detects motion or heat, it will take a picture and collect images for approximately a year. The main photograph is an observer looking up at the bottom of a tree vole nest with a rectangular camera on the right portion of the tree bole.

Literature Cited:

Barry, B. R., K. Moriarty, D. Green, R. A. Hutchinson, and T. Levi. 2021. Integrating multi-method surveys and recovery trajectories into occupancy models. Ecosphere 12:e03886.

Linnell, M. A., and D. B. Lesmeister. 2020. Predator–prey interactions in the canopy. Ecology and Evolution 10:8610-8622.

Moriarty, K. M., B. R. Barry, D. S. Green, and T. Levi. 2021a. Assessing evidence of risk: using DNA metabarcoding (diet) and predicted occupancy overlap to evaluate competition and predation risk of fishers and martens, *abstract within:* Conference Western Section of the Wildlife Society Annual Meeting. Virtual, recorded presentation available on Whova.

Moriarty, K. M., J. Thompson, M. Delheimer, B. R. Barry, M. Linnell, T. Levi, K. Hamm, D. Early, H. Gamblin, M. Szykman Gunther, J. Ellison, J. S. Prevéy, J. Hartman, and R. Davis. 2021b. Predicted distribution of a rare and understudied forest carnivore: Humboldt marten (*Martes caurina humboldtensis*). PeerJ 9:e11670.

Describing Humboldt marten movement and basic population demographics in areas that differ in management intensity FY 2022-2023

Lead Investigator:
Katie Moriarty, National Council for Air and Stream Improvement, Inc (NCASI)
2438 NW Professional Way, Corvallis OR 97330
Email: *kmoriarty@ncasi.org*
Phone: 541-249-3987

Collaborators and roles:
Jessica Buskirk, NCASI. Crew lead and field coordinator.
David Lamphear, Green Diamond Resource Company, GIS and spatial resources
Keith Hamm, Green Diamond Resource Company, ownership coordination and conservation planning
Desiree Early, Green Diamond Resource Company, safety coordination and conservation planning
Dr. Taal Levi, Oregon State University. Advisor, genetics and innovation
Maggie Hallerud, Oregon State University. PhD student focused on SNP development
Dr. Micaela Szykman Gunther, Cal Poly Humboldt. Coordinator between university, project, and IACUC committees
Dr. Greta Wengert, Integral Ecology Research Center. Advisor, carnivore interactions and anesthetics.
Dr. Mourad Gabriel, USDA Forest Service. Advisor, disease and parasite ecology.
Dr. Deanna Clifford, DVM, California Department of Fish and Wildlife. Advisor, capture and anesthetics.
Dr. Jennifer Tavares, DVM, Sequoia Park Zoo. Advisor, capture and anesthetics.
Dr. Sean Matthews, Oregon State University. Coordinator for marten density estimation projects.

Field staff: Jessica Buskirk, James Mackenzie, Fiona McKibben, Brad Smith, Alyssa Roddy, and Mark Stevens

Scope of Work and Vision

Humboldt martens (*Martes caurina humboldtensis*) are a federally threatened distinct population segment with populations separated between private and federal ownerships. We are executing a multi-faceted telemetry study paired with non-invasive techniques to evaluate critical information gaps for Humboldt martens. Available research does not provide adequate information to inform habitat-related management decisions. Connectivity and dispersal were identified as focal areas of concern – especially connectivity between the southern Oregon and central Oregon populations (USFWS 2019, Schrott and Shinn 2020). This work was requested by the US Fish and Wildlife Service and can directly inform Critical Habitat. It is unknown how Humboldt martens move across or in proximity to privately managed lands. Humboldt martens in actively managed and Tribal ownerships appear to have high fecundity and survival (PSW 2019, Martin et al. in review). However, Oregon's forests differ in management practices and vegetation associations, so fecundity and survival rates should not be extrapolated to these regions. Identifying commonalities among study areas and among populations, like whether martens will travel through openings of certain sizes, or if such behavior is dependent on landscape composition or ground based cover (e.g., slash piles, shrub density), is paramount for providing science-based cohesive management direction across populations.

Objectives:

(1) Quantify fine-scale habitat characteristics used by martens by pairing a combination of movement, resting, and den locations with LiDAR and ground-based measurements of forest structure in areas of differing management history and landscape composition;

(2) Evaluate movement distances into openings that differ in vegetation density and composition using both non-invasive trials and GPS telemetry;

(3) Better understand relative influences of purported threats to populations by tracking individuals for >2 years and documenting their fitness (e.g., reproductive history, body condition, cause of morbidity);

(4) Contribute to fundamental information on population ecology, including minimum population size and extent, sex and age ratios, home range, density of potential predators, and diet (likely requires multiple study areas)

Summary of Accomplishments toward Objectives:
Since Fall 2022, we collected additional fine-scale movement data from nine martens in Oregon (Figure 1). We also used remote cameras to: perform a giving up densities experiment, set baited remote camera stations in search of further marten detections, and set unbaited remote camera stations to monitor GPS collar clusters for potential rest sites and better understand marten movement paths (Figure 2).

Last year (2022), funds from WCI allowed us to begin the first season of our giving up densities experiment to examine how martens perceive risk within different forest structure and composition, and we completed a second trial to conclude the experiment this year (2023). Within this experiment framework, we examined how martens tradeoff foraging and vigilance behavior in forest stands differing in age, canopy closure, shrub density, and percent down woody debris (Figure 3). So far, our preliminary analysis showed that martens visited older stands with less down woody debris cover slightly more than younger stands with more down woody debris cover. We also found that martens perceived slightly more risk in stands with less overstory cover. However, the strongest negative predictor of marten perceived risk was number of visits, meaning as martens visited sites more often, they would spend more time foraging and less time vigilant. These results are only preliminary, but we will be able to pair them with our collected GPS collar data to better understand how martens perceive and use habitat associations.

Additionally, in late summer 2023, we set 38 more baited camera stations in the Rogue Siskiyou National Forest between Agness and Port Orford, and another 44 cameras near Elkton, Oregon. These camera efforts will aid in searching for additional locations where martens may occur and represent collaboration with the Bureau of Land Management and US Forest Service.

Finally, we have been using a combination of telemetry and GPS collar clusters to identify potential rest structures (Figure 4). Identifying used rest structures will allow us to collect critical data on rest site habitat associations which will aid managers in improving Humboldt marten conservation strategies.

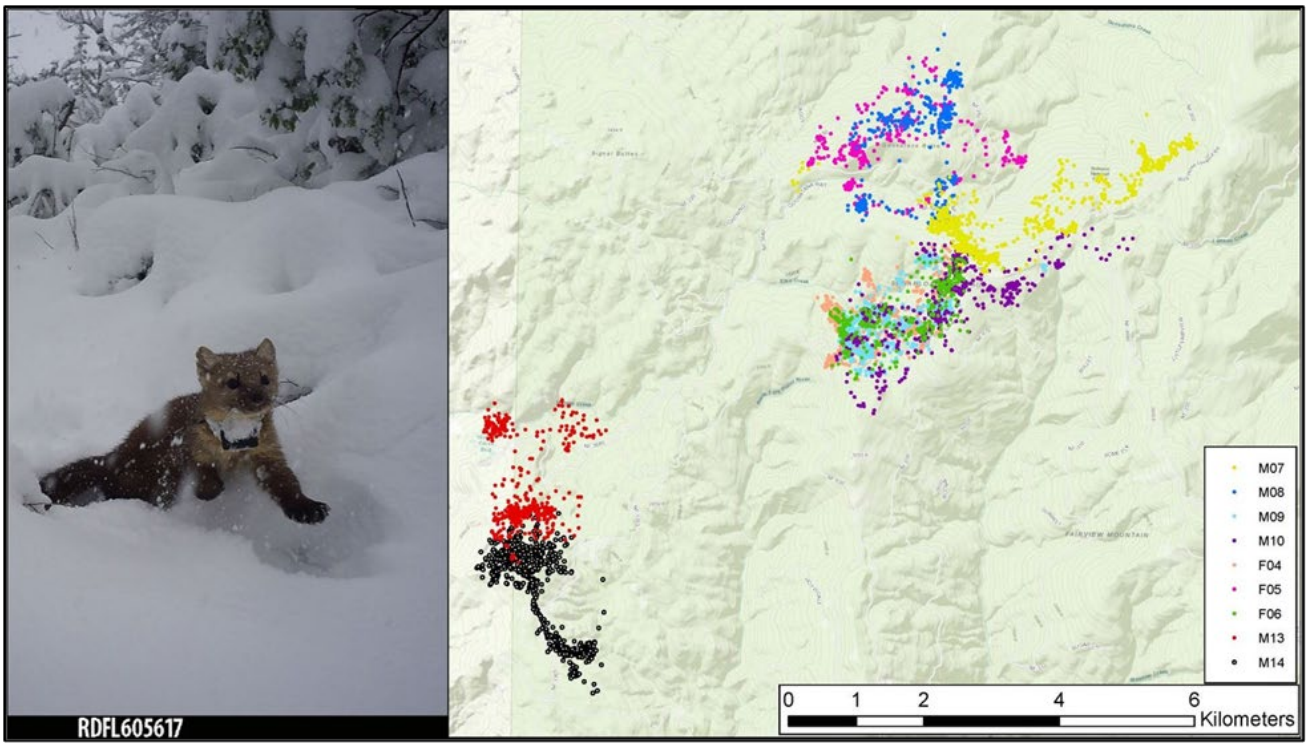


Figure 1. *Left:* A collared Humboldt marten (*Martes caurina humboldtensis*), male 13 (M13), moving through the landscape is captured on remote camera. *Right:* GPS collar data from nine Humboldt martens in southern Oregon. These data were collected from September, 2022 to February, 2023. Collars recorded a GPS location every five minutes for approximately 14 days each. All capture and processes were compliant under the USFWS Recovery Permit ESPER0011953, Cal Poly Humboldt Institute for Animal Use and Care permit 2020W98A, Oregon Scientific Take Permits 086-22 and 001-23, and with permission from the California Department of Fish and Wildlife with previous supervision by the State Wildlife Veterinarian.

Figure 2. Movement data from male marten 14 (M14) indicated potential use of a culvert for road crossing, so we set remote cameras in this area to ground truth the use of this area. Here, M14 is observed coming out of a culvert that passes under Forest Road 1703 in the Rogue Siskiyou National Forest.

Figure 3. A Humboldt marten visiting a baited density experiment station exhibits both foraging (*left panel*) and vigilance (*right panel*) behavior.

Figure 4. We use a combination of very high frequency telemetry (*left panel*) and GPS collar clusters (*right panel*) to identify and monitor structures, such as snags, that may serve as marten rest sites (*center panel*).