ADVENTURE SCIENTISTS

EXPLORE. COLLECT. PROTECT.

TIMBER PROJECT REPORT 2019

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ADVENTURE SCIENTISTS

VOLUNTEERS APRIL ANN FONG, MORGAN BEGGS AND FRIENDS COLLECTING SAMPLES FROM A WESTERN REDCEDAR TREE

APRIL ANN FONG

COVER: VOLUNTEER JULIA LITCHBLAU VISITS REDWOODS DURING A SAMPLING EXPEDITION

LEIF ESTES

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SUMMARY

Adventure Scientists' volunteers completed a successful 2019 field season collecting leaf segments, cones, and tree cores from western redcedar (*Thuja plicata*) and Alaska yellow-cedar (*Callitropsis nootkatensis*), as well as basal sprouts from coast redwood (*Sequoia sempervirens*) across western North America. In total, volunteers collected 2,282 samples from coast redwood trees from Monterey County to Del Norte County, representing the extent of the species range in California. They also collected 1,155 western redcedar and 402 Alaska yellow-cedar samples across the species' ranges. Our partners, which include the US Forest Service and Save the Redwoods League, will use these samples to build genetic and chemical reference libraries. These reference

libraries will allow them to enforce anti-poaching regulations, improve forestry management practices, and plan for climate change impacts. For this project, Adventure Scientists created field protocols and volunteer training materials in consultation with project partners, secured permits, and chose where and when to collect samples. We then recruited, trained, and managed volunteers who collected data in the field. When samples returned to us, we inspected and reviewed all physical specimens and metadata to ensure quality. This project brings multiple collaborators to the table. Together, we are building the foundational reference libraries that will help law enforcement combat illegal logging, as well as guide resource managers who can preserve the genetic diversity of these important species.

NEW GROWTH ON A COAST REDWOOD BRANCH

PROJECT CONTEXT

Illegal logging destroys forests, disrupts ecological processes, increases CO^2 in the atmosphere, and provides revenue for other illegal activities (Nelleman et. al. 2012, Nelleman et. al. 2014, May and Clough 2017). Port officials and law enforcement officers need new tools to identify illegal timber within global supply chains and prosecute poachers. Cutting-edge genetic technologies can help, but they require an extensive reference database of genetic and chemical material from high-value timber species.

In 2018, Adventure Scientists helped our partners establish a reference database for bigleaf maple (*Acer macrophyllum*). Throughout 2019, the United States Forest Service (USFS) and Fish and Wildlife Service (USFW) partnered with Adventure Scientists to collect samples from western redcedar, coast redwood, and Alaska yellow-cedar. These samples will allow our partners to build a similar reference library for these valuable species. The U.S. Forest Service and other land managers will use the reference libraries of bigleaf maple, western redcedar, and Alaska yellow-cedar to track the movement of timber through supply chains, enforce anti-poaching regulations, and empower responsible buyers. In addition to using these samples to reduce illegal logging, the USFS and USFW will use samples from Alaska yellow-cedar and coast redwood to improve forestry management practices, improve sustainable resource management, and help forest managers plan for the impacts of a changing climate, which will benefit not only the target species, but also the entire forest ecosystem.

As part of a separate, synergistic project, Save the Redwoods League (SRL) will use the coast redwood genetic samples Adventure Scientist volunteers collected to contribute to their Redwood Genome Project. They began this five-year effort by sequencing the coast redwood and giant sequoia genomes. They are now developing tools to assess genetic diversity across the species range. In 2020, SRL will analyze the samples to determine the genes responsible for the tree's ability to adapt to its surrounding environment.

This allows researchers to identify specific trees that contribute to genetic diversity, are well adapted in their particular regions, and are likely to survive changing environmental conditions. This work can inform forest managers about where timber harvesting can and cannot occur, what groves are critical for the survival and success of the species, and other management considerations. One critical question this research aims to answer is: which redwoods have genes that help them survive drought, disease, and invasion by pests? Knowing this answer will help create targeted conservation efforts.

In addition to the outcomes described above, the reference data obtained from all sampling efforts will be publicly available for use globally by scientists, enforcement officers, and government stakeholders, enabling greater collaboration on scaling efforts.

A CONIFER STAND IN MT. HOOD NATIONAL FOREST, OREGON CHRISTY CAROVILLANO

STAFF MEMBER JESSIE KAY COLLECTS A CORE SAMPLE FROM A WESTERN REDCEDAR

PROJECT DESIGN

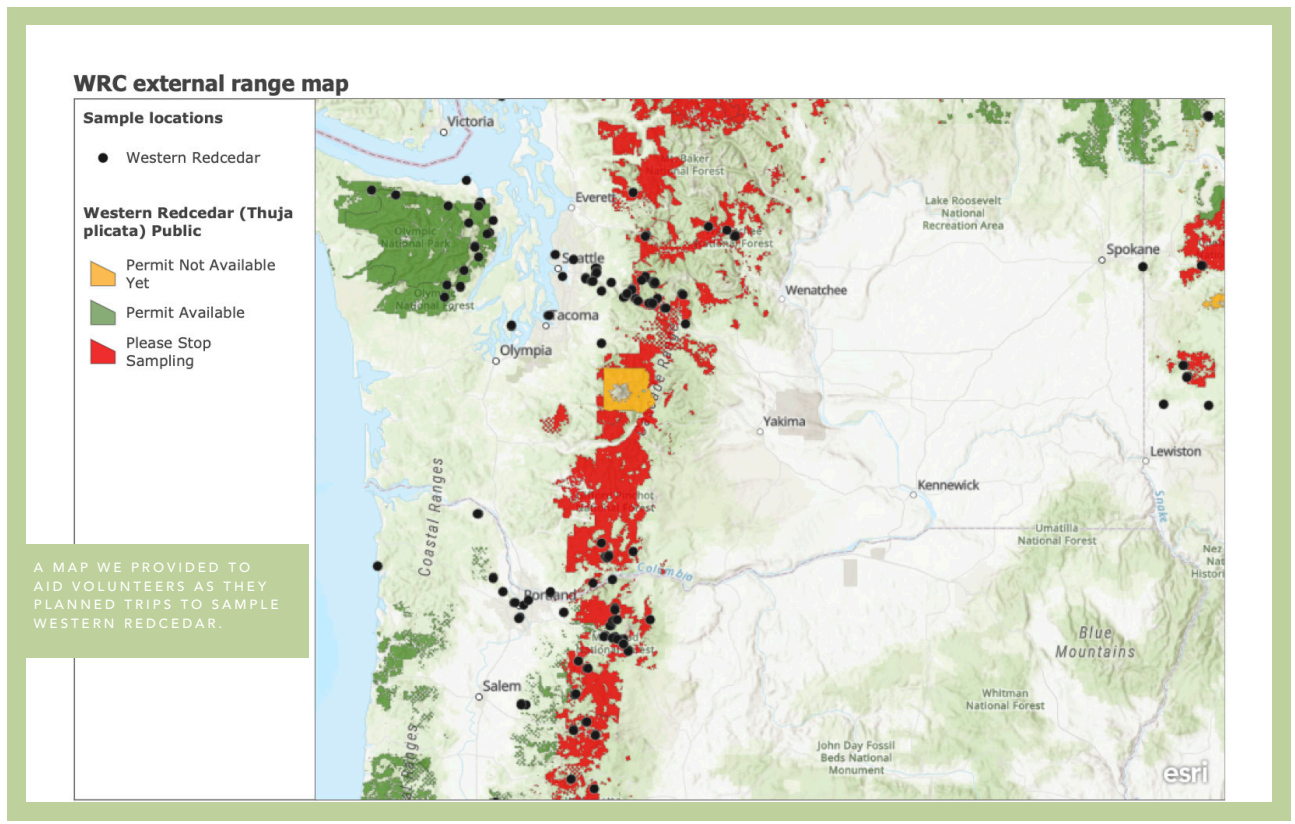
FIELD PROTOCOLS

Adventure Scientists adapted the original bigleaf maple project protocol created in collaboration with Dr. Brook Milligan (NMSU), Dr. David Erickson (DNA4 Technologies), and Meaghan Parker-Forney (World Resources Institute) so that it was appropriate for western redcedar, Alaska yellow-cedar, and coast redwood. To do this, we worked closely with Rich Cronn (USFS) and Kristen Shive (Save The Redwoods League) to determine sample number, types of samples needed, sampling locations, spacing between sample trees, transport and preservation techniques, etc. This process resulted in three

protocols, one for each tree species. Protocols for Alaska yellow-cedar and western redcedar include a detailed procedure for the collection of leaf segment, cone, and tree core samples. The protocol for coast redwood includes a simpler procedure for the collection of basal sprouts.

TARGETS FOR SAMPLING

Between May of 2019 and December 2020, we will collect samples across each species' entire range. More specifically, we set a goal to collect leaf segments and cones from 1000 western redcedars, 900 Alaska yellow-cedars, as well as core samples from 360



A MAP WE PROVIDED TO AID VOLUNTEERS AS THEY PLANNED TRIPS TO SAMPLE WESTERN REDCEDAR.

trees of each species. We will also collect basal root sprouts from 1,100 coast redwood trees, with two basal sprouts collected from each tree—1,100 of these samples will be analyzed by federal agency partners, 1,100 by SRL. We establish target areas for sampling by first comparing existing maps and geospatial datasets to create a species range map using the best available information.

SITE SELECTION AND PERMITTING

For western redcedar and Alaska yellow-cedar, Adventure Scientists developed maps for each species broken down by 12 zones throughout the ranges. Rather than pre-determining thousands of potential field sites, Adventure Scientists empowered volunteers to identify their own field sites based on their local expertise as well as regional habitat guidelines and online geospatial resources such as land ownership layers and botanical databases. Adventure Scientists' staff updated sample locations on maps and closed off sections to volunteers once the target number of samples was reached in each zone.

To collect samples throughout the coast redwood range, SRL created a map of 12 zones. Adventure Scientists used this map as a planning tool to ensure that volunteers collected samples from 92 trees in each zone, spread out through at least three California State Parks. Volunteers committed to sampling from two or more California State Parks, which ensured that volunteers weren't duplicating sampling.

Adventure Scientists pursued permits and permission from land management agencies to provide volunteers access to as many potential field sites as possible. In total, the project secured sampling permits in 30 National Forests, 7 National Parks, state/provincial park agencies in 4 states/provinces, State Forests in 2 states, 4 Bureau of Land Management state/district offices, and 1 regional open space district. In addition, we secured permission to sample on unencumbered Crown lands in British Columbia, on Washington State Department of Natural Resources Land, and within several county and regional parks.

JULIA LICHTBLAU COLLECTS COAST REDWOOD SAMPLES

LEIF ESTES

JULIA LICHTBLAU HIKES THROUGH A FOREST SEARCHING FOR COAST REDWOOD

LEIF ESTES

JESSIE KAY PLACES A COAST REDWOOD SPROUT IN A SAMPLING ENVELOPE

VOLUNTEER MANAGEMENT

Adventure Scientists began recruiting for the Timber Tracking Project in March 2019 with social media posts and newsletter announcements to our existing network. Thirty-one volunteers from 2018 returned to collect samples in 2019. We continued geographically-targeted recruiting throughout the summer months, relying heavily on sponsored social media posts and direct inquiries made with organizations, companies, and community groups based within the three species ranges. In total, we received applications from 312 volunteers and accepted 301 volunteers to the

project. We saw a 74.8% follow-through of volunteer commitment as 225 volunteers collected samples.

We required all volunteers to complete online training modules prior to data collection, and we tailored training to each of the three species. We included background information on timber theft and climate change issues, a walkthrough of the technology required for data collection, and step-by-step videos and photos of proper implementation of the protocol. All volunteers passed the post-training quiz with 100% accuracy, as required, and they were given unlimited attempts to do so.

Data collection on conifers isn't limited by seasonal growth, so we managed volunteers by "sample periods" approximately 8 weeks in length. We required volunteers to complete training and sample collection at three locations within this short window of time to ensure adequate field equipment availability for other volunteers. Before each sample period, Adventure Scientists' Project Management Team led a volunteer information webinar to provide project updates and give volunteers the opportunity to interact with staff and ask questions. On average 25% of volunteers attended these webinars. Those who were unable to attend were sent the recorded version of the webinar.

We housed all volunteer resources (training, permits, sample mailing instructions, etc.) on a password-protected volunteer website so that volunteers could easily

find relevant information in one place. In 2019, we provided FedEx shipping codes to volunteers for equipment return, rather than reimbursemening shipping costs.

Adventure Scientists provided project equipment and printed field protocols to volunteers. This included sample envelopes, silica desiccant, and a tape measure. For Alaska yellow-cedar and western redcedar equipment, we provided an increment borer for tree cores, a saw toss tool to collect leaf samples, and an alcohol cleaning kit for tool cleaning between sample collection on different trees. We required volunteers to print out permitting documentation and provide their own smartphone for data collection.

Our project protocols emphasized data quality, environmental precautions, and volunteer safety. These documents provided detailed instructions on how to prepare for field visits, species identification, how to collect high quality samples and metadata, disinfect equipment, and successfully transfer data and samples to Adventure Scientists upon leaving the field. Ninety-six percent of volunteers who responded to our end-of-season survey indicated that they were "provided with the necessary materials and training resources to be successful as a volunteer" (54% strongly agree and 42% agree).

Once samples were shipped back to Adventure Scientists' headquarters, we verified species identification and quality of the samples. We found less than 1% misidentification of species and less than 1% of samples were damaged/unusable.

We communicated with volunteers via email, phone calls, and text messages. In addition, we sent out monthly newsletters to keep volunteers informed of progress and engaged throughout the field season. We rewarded our volunteers with Adventure Scientists merchandise, donated products, and pro-deal codes from our corporate partners. In the fall, we hosted an event in Missoula to celebrate volunteers across multiple projects by providing dinner and prize give-aways.

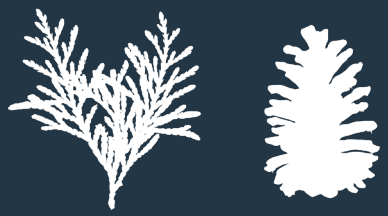
VOLUNTEER TIM PACIFIC COLLECTS SAMPLES FROM WESTERN REDCEDAR CHRISTY CAROVILLANO

ALASKA YELLOW-CEDAR BARK FLAKES OFF IN SMALL STRIPS

DATA COLLECTION & RESULTS

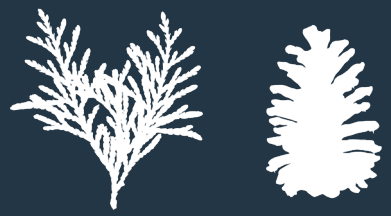
In 2019, Adventure Scientists' volunteers collected 712 leaf samples, 363 cones, and 80 tree cores from 712 total western redcedar trees. For Alaska yellow-cedar (*Cupressus nootkatensis*), they collected 262 leaf segments, 98 cones, and 42 tree cores from 262 total trees. For coast redwood (*Sequoia sempervirens*), they collected 2,282 basal sprout samples from 1,141 trees. In total, volunteers collected samples from 6 states in the US (Alaska, Washington, Oregon, Idaho, Montana, and California) and one Canadian province (British Columbia).

WESTERN REDCEDAR



1,155
samples

YELLOW-CEDAR



402
samples

COAST REDWOOD

2,282
samples

In 2019 we implemented Survey123 (Esri) as a data collection app due to challenges with the former data collections app, Magpi+. Survey123 provided the same functionality as Magpi+ with regard to offline use and barcode scanning. Survey123 provides more design options for the survey, combined with more robust conditional logic providing a fluid user experience. The information captured by the surveys communicates with Adventure Scientists' Esri Hub account.

This system updates data visualization tools and maps in real time. Before the switch to Survey123, data had to be exported and uploaded to separate mapping tools.

ALASKA YELLOW-CEDAR LEAFLETS GROW IN CHARACTERISTIC FERN-LIKE SPRAYS

VOLUNTEER LIBBY O'SHEA-BETKER COLLECTING A TREE CORE FROM A WESTERN REDCEDAR CHARLIE KATERBA

DATA END-USE

Rich Cronn (USFS) will analyze DNA from 800-1000 leaf-segment samples using the single nucleotide polymorphism or (SNP) approach (Gupta et al. 2001). Ed Espinoza (USFWS) and Cady Lancaster (USFS) at the USFWS Forensics Lab will use tree cores to create a reference library of chemical fingerprints using the Direct Analysis in Real Time Mass Spectrometry (DART-TOFMS) approach (Cody et. al. 2005). Our agency partners are currently determining which analysis procedures and facilities they will use for coast redwood basal sprout samples, since the coast

redwood has a "mega-genome," with a large number of chromosomes, and that presents unique analysis challenges. In addition to contributing to their scientific fields, these collections will enable each of these researchers to establish new tools to support the successful prosecution of poachers and illegal traders of these valuable tree species in the future.

Our work with Save the Redwoods League will allow them to conduct a full-genome study of coast redwoods on a landscape scale. In previous phases of their Redwood Genome project, SRL developed technologies needed to genotype coast redwood trees. The data collected by Adventure Scientists, in conjunction with the genotyping technologies SRL previously developed, will allow them to link the genomic information of each tree to the variability of the environment where the tree grew. This allows researchers to determine which trees are well adapted in their particular regions, and are expected to do well under changing environmental conditions. The data generated by this project will ultimately be used by resource managers as they plan their conservation strategies.

TIM PACIFIC LOOKS FOR WESTERN REDCEDAR IN OREGON

CHRISTY CAROVILLANO

ADVENTURE SCIENTISTS STAFF MEMBERS MICHELLE TOSHACK AND JESSIE KAY MEET WITH SCIENTIFIC PARTNERS RICH CRONN, LAURA HAUCH, AND KRISTEN FINCH

VOLUNTEER EXPERIENCE

In total, our volunteers donated more than three years' worth of field days to this effort (1,248 days). Julia Litchtblau, a coast redwood volunteer, saw these trees with a new lens. She wrote, "I was really amazed to find such amazing redwood parks

> *"I was really amazed to find such amazing redwood parks in my own backyard. These hidden gems were completely unknown to me before this project and now they are some of our favorite parks."*
>
> JULIA LITCHTBLAU

"I have to admit that this project already has me seeing a species that I've ignored for years."

BRAD ANDERSON

"I had not known how valuable trees were and that poaching was so widespread. It surprised me, and so I talked about it with friends and family. Because of my experience with Adventure Scientists I now pay more attention to environmental news and causes for conservation."

BARRY FADNESS

in my own backyard. These hidden gems were completely unknown to me before this project and now they are some of our favorite parks." We were impressed by the dedication of volunteers to data collection, such as a long-time Adventure Scientists supporter who completed an epic road trip in coast redwood habitat, collecting samples from 150 trees for the project. His work filled out the data set in the areas where we had data gaps, contributing immensely to this project. Another volunteer, Claire Dibble, paddled a handmade kayak from the Columbia River source-to-sea, collecting western redcedar samples along the way. In our end-of-season volunteer survey, 72% of respondents indicated that the project increased their awareness and knowledge of the illegal timber trade and climate change impacts on forests, and 68% reported that they have undertaken conservation actions as a result of the project. Volunteer Barry Fadness commented,"I had not known how valuable trees were and that poaching was so widespread. It surprised me, and so I talked about it with friends and family. Because of my experience with Adventure Scientists I now pay more attention to environmental news and causes for conservation." 26% of respondents reported that they were more likely to pursue a career in conservation, for example, volunteer Brad Anderson shared that "I recently finished a degree in environmental science and I hope to make illegal timber a part of my career."

MICHELLE TOSHACK AND JESSIE KAY TEST WESTERN REDCEDAR PROTOCOLS IN THE FIELD

LESSONS LEARNED

PERMITTING

Due to lessons learned from 2018, we began obtaining permits much earlier. We also had a dedicated staff member work on permits rather than relying on our scientific partners to do so. For coast redwood sample collection, we experienced some difficulty with obtaining permits from California State Parks in a timely manner. In addition, we were unable to obtain a permit in wilderness areas (USFS)

for Alaska yellow-cedar, which covers a large portion of the species range. We will work with the USFS in securing this permit for 2020. British Columbia permits were delayed at provincial and regional offices and provided frustration for volunteers who were trained, equipped, and ready to volunteer. In many instances, these delays significantly shortened the window of opportunity for volunteers to get into the field.

ELEVATION DATA

We trained volunteers to enter elevation measurements in meters, but realized that some people were entering data in feet. To remedy this, we researched ways to calculate elevation based on the GPS coordinates. We developed a system to automatically add elevation to our database without requiring volunteers to enter data. This eliminated errors with elevation and required one less piece of data for volunteers to collect. We implemented this system for 2020. To clean the data from 2019, we cross-referenced GIS layers with data collection GPS points to accurately determine the elevation at the location that the sample was taken. We removed all volunteer-entered elevation data from the database.

A VOLUNTEER GETS READY TO SAMPLE WESTERN REDCEDAR

CHRISTY CAROVILLANO

TECHNOLOGY

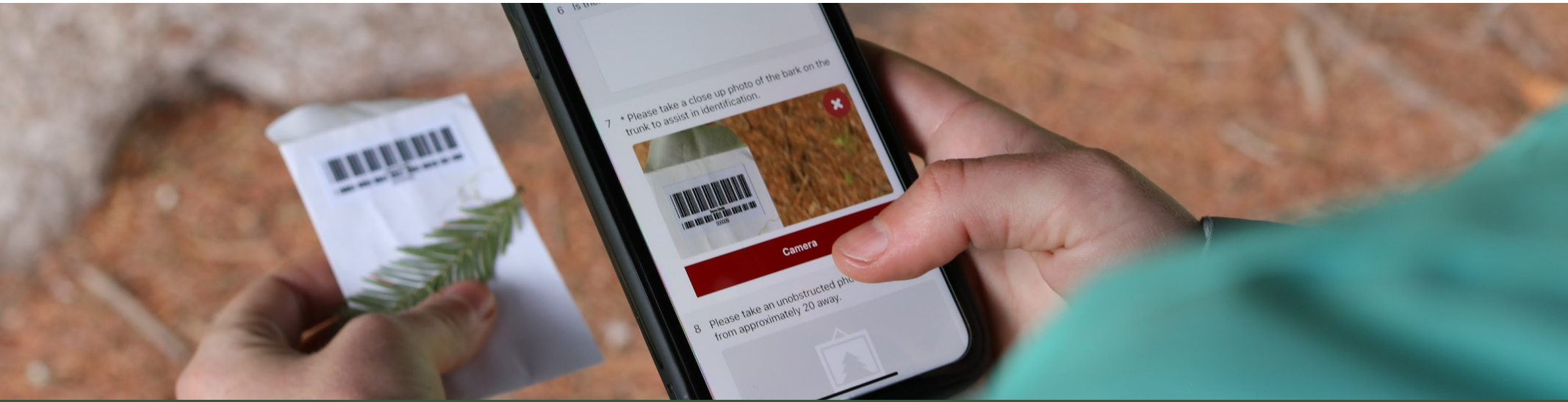
We applied many lessons from the 2018 Timber Tracking Project to improve volunteer management in 2019. We changed the data collection app due to continuing issues with Magpi+, and we now use Survey123 and are able to customize the survey form for our project. We made this decision to ensure high data quality and ease of use for volunteers. In 2019, we used Magpi+ for part of the year and then switched over to Survey123 for the remainder of the year. Magpi+ often crashed in the field, preventing volunteers from collecting data. There were significantly fewer challenges using Survey123. Two problems were notable. Volunteers reported that using both Survey123 and GaiaGPS for navigation drained battery life. In some cases, GaiaGPS reported a negative elevation reading—another reason we decided to auto-calculate elevation based on GPS location.

MULTI-SPECIES PROJECT CONSIDERATIONS

During project design, we envisioned a single project with a consistent protocol, training, and equipment. However, we soon realized that each species needed to be treated as its own project. We therefore designed three protocols, three different online training modules, and three equipment lists: one set for each tree species. Managing volunteers for each species across a large geographic area

increased the complexity of the project and required a large time commitment for management.

Volunteers collected cones as part of the data quality control process, to ensure that they were sampling the correct tree species, since cones can easily distinguish between species. However, cones appear seasonally and volunteers were often unable to find cones growing directly on trees. As a result volunteers were either unable to find cones or they picked a cone up off the ground, which wasn't always from the tree that they were sampling. Based on correspondence from our partners, we decided that cone collection wasn't required from every tree. Rather, cones could provide a supplemental data quality check if volunteers were able to find a cone growing directly from the tree they were sampling. Photos of the bark provided confirmation of correct species ID and a reliable source of species verification across all seasons.



JESSIE KAY ENTERS DATA INTO A SMARTPHONE

A COLLECTION OF WESTERN REDCEDARS IN OREGON

CHRISTY CAROVILLANO

JESSIE KAY AND MICHELLE TOSHACK HIKE TO COLLECT WESTERN REDCEDAR SAMPLES

2020 AND BEYOND

We successfully collected basal root sprouts from 1,141 coast redwood trees in 2019, exceeding our goal of 1,100 trees. As such, we will not collect additional samples on this species. In 2020, the final year of the project, Adventure Scientists will continue collecting the remaining samples needed to reach our goal of leaf segments and cones from 1000 western redcedars and 900 Alaska yellow-cedars, as well as core samples from 360 trees of each species. We intend to make the final season of the project even more productive and successful by incorporating lessons and feedback from previous years. We look forward to sharing the publications that will result from the project with volunteers, land management agencies, and the general public.

ACKNOWLEDGMENTS

We are grateful for our volunteers — this research would not have happened without them. They invested their time and resources in this project and also provided us their valuable feedback. It's incredible to work with so many people who are driven by a desire to contribute directly to change in conservation.

Numerous land management agencies supported this project through their partnership in study design, on-the-ground logistics, and help securing permits and authorizations. We've listed them in Appendix 1.

We would like to thank Rich Cronn (USFS) and Meaghan Parker-Forney (WRI) for collaborating with us to design the study for meaningful impact on illegal timber trade. We were also fortunate to collaborate with David Erickson (DNA4 Technologies), Brook Milligan (NMSU), Cady Lancaster (USFS), and Ed Espinoza (USFWS).

Adventure Scientists' donor partners made the expansion of this project possible, as well as Adventure Scientists' other work. We are incredibly grateful for their

partnership and support. CLIF Bar generously supported this effort through donations of CLIF bars for volunteers, and through the CLIF Bar Family Foundation small grants program. GaiaGPS' in-kind donation waived subscription fees for all volunteers. **Outdoor Prolink, Sunski, Thule, Peak Design, SeaVees, and Croakies helped us award our volunteers with great prizes throughout the field season.**

In house, every member of the Adventure Scientists team contributed their optimism, creativity, and exemplary work ethic to help launch this project. Special thanks go to Projects Team Lead Katie Christianson, Technology Manager Ricky Jones, Content Specialist Jessie Kay, Project Coordinator Max Littlefield, Project Assistant Katya Koepsel, Project Coordinator Jordan Garrett, Director of Communications Andrew Howley, Director of Program Investments Marcus Pearson, and Executive Director Gregg Treinish.

BASAL SPROUTS GROW ON A COAST REDWOOD LEIF ESTES

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APPENDIX 1

Land management agencies that supported this project through help with study design, logistics, authorizations, etc.:

- California State Parks - Bay Area, North Coast Redwoods, Santa Cruz, Sonoma-Mendocino Coast
- Oregon State Parks
- Washington State Parks
- Region 1 of the United States Forest Service
- Region 6 of the United States Forest Service
- Six Rivers National Forest
- Klamath National Forest
- Tongass National Forest
- Redwood National Park
- Muir Woods National Park
- Olympic National Park
- North Cascades National Park
- Glacier National Park
- California Bureau of Land Management - Headwaters Forest Reserve
- Oregon Bureau of Land Management - Coos Bay, Roseberg, & Salem Districts
- Washington Department of Natural Resources
- Oregon Department of Forestry
- Midpeninsula Regional Open Space District

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