north coast & cascades science days

February 13–15, 2024 | *Virtual Format*

Agenda

TUESDAY, FEBRUARY 13

Plenary	10am–12pm	Restoring Relationships
Concurrent A	1–3:40pm	Wildlife Focus
Concurrent B	1–3:40pm	Shakes & Lakes: Geologic History Written in the Landscape

WEDNESDAY, FEBRUARY 14

Plenary	10am–12pm	From Snowpack to Salmon
Concurrent A	1–3:40pm	Seismology & Sediments in Flux
Concurrent B	1–3:40pm	Insect Insights: Monitoring Meadows and Waters

THURSDAY, FEBRUARY 15

Plenary	10am–12pm	Tough Questions: Using Science for Stewardship
Concurrent A	1–3:40pm	Past is Present
Concurrent B	1–3:40pm	Coastal Concerns

Restoring Relationships

Facilitator: **Jalyn Cummings** | Program Manager, North Coast and Cascades Inventory and Monitoring Network

10:00 Welcome Session

10:25 Establishment of terrestrial mammals on former reservoir beds following large dam removal on the Elwha River, Olympic National Park

Dr. Rebecca McCaffery
US Geological Survey, Forest and Rangeland Ecosystem Science Center, Olympic Field Station

Kim Sager-Fradkin
Lower Elwha Klallam Tribe

Terrestrial wildlife species are important and often overlooked taxa in the recovery of ecosystems following dam removal. Their presence can shape ecosystem recovery, signal restoration of ecosystem function, and influence food

web dynamics. We describe distribution and seasonal use of the mammalian community on former reservoir beds following the removal of two large dams on the Elwha River. We examined presence of medium and large mammals using camera traps placed in the two reservoir beds as well as in an upstream reference reach. For certain taxa, we compared current species use to data collected prior to dam removal. Camera traps revealed use by at least fifteen mammal species, including but not limited to bear, deer, elk, cougars, coyotes, bobcats, and snowshoe hares. We did not see major differences in species composition between the restoration areas and the upstream reference reach, though number of detections differed for most species. Black bears were observed across all seasons, a shift from research findings prior to dam removal which documented greater use of the floodplain by bears in the spring. Full restoration of the terrestrial wildlife community will take decades to unfold, but early patterns demonstrate rapid establishment of wildlife on new riparian surfaces.

10:45 Grass-roots salmon recovery project

Jonathan Scordino
Makah Tribe

Lake Ozette in Olympic National Park is home to a unique population of sockeye salmon that is listed as threatened under the ESA. It is not known for sure why the population crashed, but it is thought that habitat degradation due to logging played a critical role. A 2009 analysis identified the quality of beach spawning habitat within Lake Ozette as a major limiting factor to the recovery of the population. In 2021, the Makah Tribe and Olympic National Park teamed up to propose restoration work at Olsen's Beach to restore beach spawning habitat. The goal of the project is to remove vegetation that has encroached on the beach spawning site and is now holding fine sediment and silt, causing degradation of spawning habitat.

In 2022, a team of 27 volunteers contributed 39 work-days over a two-day coordinated effort to remove vegetation. In 2023, we had 50 volunteers who contributed 81 work-days over a three-day coordinated effort to remove vegetation. The coordinated effort transformed 35 meters of shoreline in 2022 and an additional 100+ meters in 2023 from a dense stand of sweet gale with an understory of mixed sedges to a fully exposed naked beach ready to be cleaned by waves during winter storms. Salmon surveys this winter documented spawning sockeye using the restoration site. We plan to continue this work until we have cleared the vegetation from Olsen's Beach; anyone interested in volunteering is encouraged to email jonathan.scordino@makah.com to help us save the Lake Ozette sockeye salmon.

11:05 Break

11:15 S'Klallam Prairies

ƛ̓əw'cən Mackenzie Grinnell
Jamestown S'Klallam Tribe Traditional Foods Gathering Coordinator

Join us in listening to ƛ̓əw'cen Mackenzie as they share their perspective on what it means to belong to this land and community. Prairies are one of the oldest ecosystems here in the Pacific Northwest and the S'Klallam people have been a part of that ecosystem from the beginning. Through weeding, transplanting, and burning prairies have been maintained. However, with less than 1% of prairies left in the Dungeness valley Jamestown S'Klallam Tribe first must restore prairies before continuing these vital practices of prairie management. ƛ̓əw'cen Mackenzie will be discussing the path that the Tribe is taking to restore these prairies and the traditional practices that surround them.

11:35 Managing islands within islands: Lessons learned from using fire to restore coastal meadows and woodlands on Jones Island, WA

Samantha Martin, R. Adam Martin
Ecostudies Institute

Coastal meadows and oak and Douglas-fir woodlands are important and highly at-risk eco-cultural island landscapes within the Salish Sea of Washington State. Since European settlement, fire suppression, introduced species, increased herbivore density, and tree encroachment have fragmented and reduced these open habitats. In 2019, Ecostudies Institute and Washington State Parks initiated a restoration project on Jones Island to assess how fire, thinning, seeding, and invasive species control could help restore coastal meadows and woodland.

This restoration effort is a perfect case study, highlighting the unique challenges of managing islands. While we conducted two successful prescribed burns, follow-up treatments are challenging due to limited weather windows and the logistical challenges of working on a remote island. Likewise, while native plant species were able to establish initially, both extreme summer droughts and deer herbivory significantly impacted longer-term establishment. Areas with some shade from oaks or Douglas-fir had strong native grass establishment, and native forbs seeding has been successful inside of deer exclosures. In the future, we suggest managing south aspects for woodlands instead of meadows and prioritizing restoration on islands without deer or with highly managed deer populations.

Wildlife Focus

Facilitator: **Miranda Terwilliger** | Wildlife Biologist, Olympic National Park

1:00 Muckleshoot Indian Tribe elk, deer, and cougar studies: summer use of Mount Rainier National Park

David J. Vales
Muckleshoot Indian Tribe Wildlife Program

The Muckleshoot Indian Tribe has been studying movement, survival, and population status of radio-marked female elk collared in the White River during winter north of Mount Rainier National Park since 1998. We began using GPS collars in 2004 to intensively track migration routes and movements. For this presentation I summarize general movements and migrations of marked elk, deer, and cougar into the Park, cases of elk mortality that have occurred in the Park, and estimates of the proportions of the White River elk herd that winters in Game Management Unit 653 that use MRNP in summer. The Tribe's radio-marked elk were used to develop a sightability model for NPS use to estimate elk numbers on summer range in the Park, but those cooperative surveys with WDFW, Muckleshoot, and Puyallup Tribe of Indians were discontinued in 2017. Muckleshoot, however, has continued to survey elk in the Park during fall because we view fall herd composition to be an important component of management data. I present survey trend data to reflect the results from Muckleshoot's continued effort.

1:20 Drosophilids of the Northwest: Taking a research lab into the wilderness

Dr. Thomas Werner
Michigan Technological University

Dr. Thomas Werner is the author of "The Encyclopedia of North American Drosophilids," which currently includes two open-access volumes, "Drosophilids of the Midwest and Northeast (Volume 1)" and "Drosophilids of the Southeast (Volume 2)." To expand this encyclopedia's coverage to the Northwest, Dr. Werner embarked on a road trip with a mobile fruit fly lab equipped for publication-quality imaging in 2022 and 2023. During his journey, one of his collection stops was Olympic National Park, where he spent time at Mora Campground in 2022 and Fairholme Campground in 2023, collecting fruit flies. The advanced imaging equipment was essential because many of these species cannot be kept alive in captivity for extended periods. In Olympic National Park alone, he collected approximately 10 fruit fly species, immediately imaging several for his upcoming book. Dr. Werner's presentation will showcase the unique fly species he collected during these trips and offer a virtual tour of his mobile lab. While previous scientists conducted significant fruit fly collection trips over the past century, Dr. Werner's innovative approach of bringing a functional lab on the road sets his journeys apart. In addition to Olympic National Park, he collected and imaged fruit flies in Montana, Idaho, Oregon, California, and Colorado, covering over 12,000 miles and amassing 6,000 fruit flies from nearly 25 species, many of which will be featured in the next volume focusing on the Northwest.

1:35 Sentinels of the montane biome: Status and food habits of endangered Cascade red fox and wolverine at Mount Rainier National Park

Dr. Jocelyn Akins
Cascades Carnivore Project

Mount Rainier National Park is one of the last strongholds of the Cascade red fox and contains a portion of Washington's recolonizing wolverine population. Cascades Carnivore Project is collaborating with Mount Rainier National Park to monitor these rare carnivores' populations and determine their status throughout the South Cascades. Cascades Carnivore Project has deployed non-invasive survey techniques including scat searches and DNA sampling, multispecies camera stations, and wolverine integrated monitoring stations to detect individuals and collect samples for genetic analyses. In addition, the organization has a long-running community science program for volunteers to participate in carnivore research, which has been highly successful.

Little is known regarding how the food habits of Cascade red foxes and wolverines are being affected by climate change at Mount Rainier National Park. These two carnivores occupy the alpine and subalpine zones of the South Cascades landscape where food resources are especially limited during the winter when many summer prey species either hibernate or move downslope where conditions are less harsh. Identifying key food resources is critical to improving our understanding of the long-term survival of these species at Mount Rainier and make informed predictions about their future. Understanding the seasonal movements of these rare carnivores within and beyond the park can help inform conservation strategies, and outreach campaigns to improve support for carnivore conservation.

1:50 Relating rocky talus slopes characteristics to habitat use by vulnerable alpine mammals in a changing climate

Ana Ferreira
Washington State University

Rocky talus slopes are vital habitat for thousands of species worldwide, including the American pika (Ochotona princeps), an iconic species of the North Cascades. In a warming climate, the talus interstitial spaces are critical to these sensitive mammals, buffering the effects of climate extremes. However, little is known about how the talus morphology affects subsurface temperature, in part because current techniques for measuring rock characteristics at the relevant scale are rudimentary. One aim of our research is to explore the long-term surface and subsurface temperature patterns in North Cascades National Park Service Complex (NOCA) and evaluate how talus characteristics influence them. The second aim of our research is to determine the rock characteristics pikas select for their haypiles. Pikas do not hibernate, spending most of the winter close to the haypiles they build during the summer. Haypiles are their main forage source during the winter when vegetation is scarce. To address these objectives, we developed a method using hand-held photogrammetry to map rocky habitats at a fine resolution (0.7mm-1.1mm) from which we can measure fine-scale characteristics of rock shape and size. This study will provide a method for continuous talus slopes characterization and a better understanding of pika habitat use, identifying what rock characteristics are most likely to maintain populations in the future.

2:05 Break

2:15 Breakout Discussions

2:35 The transition of methods for northern spotted owl population monitoring in Washington

Dr. Damon Lesmeister
USFS Pacific Northwest Research Station

Wildlife monitoring programs designed to inform forest management and conservation decisions benefit from long-term datasets with consistent methodology. However, modern methods that leverage emerging technologies can improve population trend tracking and expand the number of target populations, increase spatial scale, and reduce long-term costs. Integrated models strengthen the capacity to adapt long-term monitoring programs to next generation methods. Here we present a case study of northern spotted owl (Strix occidentalis caurina) population monitoring that has undergone a transition in methods. The first monitoring phase focused on territory occupancy and mark-resighting individual owls, which became less viable for long-term monitoring due to rapidly declining populations and increasing costs. The second phase uses passive acoustic monitoring, which is effective for detecting

spotted owl presence, estimating occupancy rates, distinguishing sex, detecting population trends, and monitoring many additional species. A key component to the transition was the development of machine learning models to automate species detections that enable rapid and effective data processing and analysis workflows. Combining broadscale passive acoustic monitoring networks, machine learning, remote sensing vegetation and disturbance data, and modern analytical methods provide powerful tools for predicting forest change impacts on wildlife populations and identify winners and losers in dynamic landscapes. The second monitoring phase will leverage new technologies, expand the scope of inference to all federal lands within the species' geographic range, link forest inventory and remote sensing datasets, and transition this iconic program to biodiversity monitoring that informs decision making in dynamic landscapes.

2:50 Fall phenology, movement, and roost use of little brown bats (*Myotis lucifugus*) and California myotis (*Myotis californicus*) at Mount Rainier National Park

Michael Hansen
Department of Fisheries, Wildlife, and Conservation Sciences, Oregon State University

Little is known about the fall and winter ecology of hibernating bats in western North America. Filling knowledge gaps for these populations has become more urgent with the westward spread of the white-nose syndrome, a disease that infects bats during hibernation. We used radiotelemetry to track little brown bats (*Myotis lucifugus*) and California myotis (*Myotis californicus*) from late-August to mid-December in 2021 and 2022 at Mount Rainier National Park to gather information on fall and winter phenology, movement, and roost use. Telemetry signals were lost in mid-to-late fall for all *M. lucifugus*, likely because they transitioned from fall roosts to subterranean hibernation sites that attenuated telemetry signals. *M. lucifugus* captured at an all-male roost left their fall roosting area an average of 29 days later than individuals captured at a maternity colony, suggesting site-level differences in hibernation phenology. All *M. californicus* remained in the study area, suggesting they over-winter locally. We observed a two-tiered pattern in the duration of roost use for *M. californicus* in late fall, with short-term roost use (2–6 days) punctuating bouts of long-term roost use (12–20 days). *M. californicus* were still moving between roosts through the end of telemetry effort in mid-December.

3:05 A genetically distinct native northern flying squirrel population in San Juan Island National Historical Park

Madrona Murphy, Russel Barsch
Kwiáht

Northern Flying Squirrels (*Glaucomys sabrinus*) were observed and collected adjacent to San Juan Island National Historical Park's Mount Young unit 15 years ago, the only occurrence of this species in the San Juan Islands. More recently, bioacoustics and acorn-caching indicated seasonal activity within the park as well. Genetically, specimens collected near the park appear to be more closely related to NFS populations in the upper Fraser River watershed of British Columbia than NFS populations in mainland western Washington. The evidence suggests that NFS colonized San Juan Island by rafting down the Fraser River in relatively early post-glacial times and continue to be genetically unique and isolated. This study offers clues to the post-glacial recolonization of the San Juan Islands that may be pursued for other small mammals and reptiles. It also suggests the usefulness of bioacoustics for detecting and monitoring nocturnal and cryptic small mammals; and the potential keystone role of a single small mammal species in distributing Garry Oaks within insular habitats.

3:20 Common sharp-tailed snake (*Contia tenuis*)

Christian Oldham
Kwiáht

The first verified observations of Common Sharp-tailed Snakes (*Contia tenuis*) within the San Juan Island National Historical Park were reported from Young Hill in 2016. This snake is considered to be a species of concern in the state of Washington, due to the small number of known populations in the state, as well as a relative lack of available data. Washington lists the species as a Species of Greatest Conservation Need under the State Wildlife Action Plan, as well as a Priority Species under the Washington Department of Fish and Wildlife's Priority Habitat and Species Program. Sharp-tailed Snakes are rare in Western Washington, with just five known occupancy sites. In 2018, artificial cover

object arrays were placed at Young Hill. Between 2018 and 2023, these arrays were surveyed for Sharp-tailed Snakes. Data collected provide insight into seasonal activity and habitat use within the San Juan Island NHP.

Shakes & Lakes: Geologic History Written in the Landscape

Facilitator: **Scott Beason** | Geologist, Mount Rainier National Park

1:00 Cascadia earthquakes recorded in prehistoric sediments beneath Ozette Lake, Washington

Dr. Daniel Brothers
US Geological Survey, Pacific Coastal and Marine Science Center

Ozette Lake is a ~100 m deep lake located along the outer coast of the Olympic Peninsula; it is ideally situated above the locked portion of the northern Cascadia megathrust, which is the tectonic plate boundary fault capable of generating massive earthquakes. Here we present a suite of geophysical and geological evidence for earthquake-triggered underwater landslides in Ozette Lake since the end of the last ice age (~14,000 years). In 2019 and 2021 the USGS collected high-resolution bathymetry data, sub-bottom seismic profiles, and sediment cores. With these new data, we discovered stacked sequences of landslide deposits along the steep flanks of the lake; these deposits are distinct from the intervening mud and clay sediments that continuously accumulate along the lake bottom. A total of 30-34 of these deposits are observed in the post-glacial record and are inferred to be caused by intense shaking and failure of lake sediment during megathrust earthquakes. Radiometric dating was used to reconstruct a detailed sedimentation history and develop an age model for all of these earthquake deposits, yielding an average recurrence estimate of approximately 400 years. Thus, Ozette Lake contains one of the longest and most robust records of megathrust earthquake shaking along the entire Cascadia subduction zone.

1:20 A late Holocene sedimentary record of earthquakes and hydroclimate from coastal Lake Ozette, Olympic National Park, Washington

Dr. Lonnie Leithold
North Carolina State University

Lake Ozette, located on the far western part of the Olympic Peninsula, Washington, is ideally situated to provide a sedimentary record of past Cascadia subduction zone earthquakes. The sediments accumulating in the lake are punctuated by event layers known as turbidites, with characteristics typical of those triggered by earthquake shaking in other lakes around the world. Moreover, sediments deposited in Lake Ozette over the past 1,200 years show decadal-scale variations in color, magnetic susceptibility, clay content, density, and organic carbon content. These patterns correlate well to local and regional instrumental and proxy cool-season (Nov-Mar) precipitation records. We infer that these decadal-scale variations in Lake Ozette's sediments are a faithful recorder of pre-historic stream discharge into the lake and lake level fluctuations. Placement of the turbidites within the Lake Ozette hydroclimate record yields dates with narrow uncertainties for the past four Cascadia subduction earthquakes consistent and independent from radiocarbon estimates for these past earthquakes. In addition, Lake Ozette's long hydro-climatically-sensitive sedimentary record may provide a useful framework for understanding the impacts of natural climate variability on the terrestrial (stream and lake) component of the anadromous salmonid life cycle and deciphering the signals of land use practices in the lake's recent history.

1:35 An 8000-year-long record of earthquake shaking from Lake Crescent, Olympic National Park, Washington

Dr. Karl Wegmann
North Carolina State University

Western Washington experiences earthquakes from various sources, including the Cascadia subduction zone offshore and faults on land in the overriding North American Plate. Sediments at the bottom of Lake Crescent in Olympic

National Park serve as recorders of past earthquakes, providing insight into their recurrence and impacts. Sediment cores collected in 2022 sample 25 m below the current lake floor, revealing evidence for at least 24 earthquake events over the past 8,000 years, at intervals of about 300 years. During these events, multiple above and below-water landslides are triggered around the lake, forming distinctive layers of sediment on the lake floor. The most dramatic effects followed earthquakes sourced to the Lake Creek-Boundary Creek Fault that trends directly beneath the lake. Shaking during these events caused large rockslides on the surrounding slopes to enter the lake and caused large displacement (tsunami) waves. We have identified evidence for four of these events in the lake's history, the last around 3,100 years ago. The penultimate earthquake–rockslide event, about 4,000 years ago, likely separated Lakes Crescent and Sutherland. Cascadia subduction zone earthquakes, the last of which occurred in 1700 CE, occur more frequently yet result in lesser impacts on the lake.

1:50 Lacustrine paleoseismic investigation in the North Washington Cascade Range: Geophysical and sedimentological observations from Lake Chelan

Boe Derosier, Dr. Daniel Brothers, Peter Dartnell, Drake Singleton
US Geological Survey, Pacific Coastal and Marine Science Center

Dr. Brian Sherrod
US Geological Survey, Earthquake Science Center

Dr. Phil Long
Lake Chelan Research Institute

Lacustrine paleoseismic proxies observed within the Northern Cascade Range (WA, USA) may provide insights into the Late Pleistocene through the Holocene earthquake record of the Pacific Northwest. Multibeam bathymetry, sub-bottom CHIRP, and sediment core data recently collected from Lake Chelan comprise an ideal dataset to investigate the spatial and temporal distribution of significant (>MMI V-V1/2) strong ground motion events that have impacted the region. Eighteen percussion-driven gravity cores and 26 mini-piston cores provide ground-truthing to event horizons in the upper ~3.5m of lake sediment. Based on core-to-seismic correlations and deposit geometries, the mapped horizons are associated with sandy turbidite beds, volcanic tephra, fires, floods, and other environmental changes within the watersheds. Our qualitative and quantitative approach relies on the distribution of dated paleoseismic proxies within Lake Chelan to describe historical earthquakes' relative distribution and magnitude. Understanding how large megathrusts and shallower crustal earthquakes are recorded in lacustrine environments is a field of research now coming into sharp focus; the goal of our work is to build on the existing lacustrine paleoseismic observations and techniques as well as to refine the earthquake catalog for the Pacific Northwest.

2:05 Break

2:15 Breakout Discussions

2:35 Exploration of underwater landslide scarps in Lake Chelan with a Remotely Operated Vehicle (ROV)

Dr. Phil Long, Ken Gordon, Ben Brownfield, Tim Sullivan
Lake Chelan Research Institute

Boe Derosier, Dr. Daniel Brothers
US Geological Survey, Pacific Coastal and Marine Science Center

Joe Heinlen
Lake Chelan Adventures

Newly collected bathymetric data for Lake Chelan (spatial resolution 3X3m, USGS) reveals multiple underwater landslides that commonly exhibit scarps where the landslide pulled away from undisturbed sediments. These scarps expose underwater outcrops that have been directly observed with an ROV (spatial resolution of cm to mm), greatly enhancing our understanding of these features. The bathymetric data thus provide "dive targets" that enable us to focus on landslide scarps among other bottom features. ROV dives have yielded detailed information on the lithology of the youngest sediments in the lake, landslide failure mechanisms based on the morphology of the scarps, and the possibility that the scarps provide habitat for one of the native fish species in the lake, Burbot (L. Iota). Recently we observed Burbot in the vicinity of a landslide scarp, supporting the hypothesis that holes and tunnels (30 to 40 cm in

diameter) in soft sediments exposed in scarps are created by Burbot for spawning and protection of offspring. Exploration of Lake Chelan with an ROV is just getting started. Thanks to both bathymetry and sub-bottom sediment profiles, we now can fine-tune the scientific objectives for our future ROV dives.

2:50 Tracking the tectonic history of an ancient subduction zone, the North Cascades, Washington

Dr. Stacia Gordon
University of Nevada, Reno

Dr. Michael Eddy
Purdue University

Dr. Robert Miller
San Jose State University

The region within the North Cascades National Park represents the exhumed deep roots of a volcanic arc system that was active from 90 to 45 million years ago (Ma). The addition of magma to this area was unsteady during this time. Our research group has National Science Foundation funding to map, date, and collect geochemical data from the rocks within the park to determine when large additions of magma occurred. Our results indicate that there were major additions of magma from ~96–89 Ma, ~78–65 Ma, and ~50–45 Ma. Each pulse of magmatism introduced large amounts of heat into the crust, which can significantly weaken rocks and cause them to flow. This weakening is further enhanced if the arc's lower crust is composed of sedimentary rocks that have been transferred to great depths through tectonic processes, which is the case for the North Cascades. Our current research aims to track how the emplacement of large volumes of magma into the crust ultimately affects crustal thickness and strength. Changes to these parameters will ultimately affect how the mountain range evolved through time.

3:05 Evidence for subduction processes in the exhumed Olympic Subduction Complex, Washington

Anna Ledeczi
University of Washington

Subduction zones, convergent plate tectonic boundaries where oceanic lithosphere is overridden by continental lithosphere, are the only places on Earth capable of hosting great (magnitude > 8.5) earthquakes. Stretching from northern California to Vancouver Island, the Cascadia Subduction Zone, where the Juan de Fuca plate is subducting under the North American Plate, poses a serious seismic and tsunami hazard to populations along the coast of North America. The rocks that make up this extensive subduction zone are exposed at the surface only in the central-western Olympic Mountains within Olympic National Park. Here, a record of subduction is preserved in outcrops of mélange, highly chaotic and jumbled masses of sedimentary rock. These rocks formed in a three-stage process of initial subduction to a depth of 15-20 kilometers beneath the Cascadia plate boundary; transfer to the base of the North American plate accretionary wedge through underplating as new faults formed; and uplift and exhumation to the surface over millions of years. The geology of the region surrounding Mt Olympus and Mt Tom preserves evidence of these key processes, and we hypothesize that it specifically preserves examples of prominent subduction faults from depths relevant to great earthquakes. We conducted geologic mapping and extensive sampling of outcrops in the Lake of the Gods region in summer of 2023. We present initial evidence that these rocks document subduction zone processes through analysis of microscopic structures, mineral composition, and chemistry of rock samples.

From Snowpack to Salmon

Facilitator: **Jalyn Cummings** | Program Manager, North Coast and Cascades Inventory and Monitoring Network

10:00 Snow darkening in the North Cascades due to smoke deposition and snow algae growth

Dr. Alia Khan
Western Washington University

Snow is an incredibly valuable resource in the North Cascade mountains. Along with nourishing the mass balance of glaciers and regulating the regional energy balance, snowmelt is an important contribution to regional watersheds. As

the high elevation snow melts from Spring to Summer, it darkens, often resulting in positive feedback on albedo reduction due to increasing snow grain growth and snowpack thinning. However, another reason for snow darkening is due to the presence of light absorbing particles, such as from the deposition of wildfire-derived black carbon, as well as the growth of biological constituents, like snow algae, which are both ubiquitous in the Pacific Northwest summer. Here, we combine ground measurements of light absorbing particles like snow algae, black carbon and dust, with satellite remote sensing imagery, to document the seasonal evolution of darkening of snow in the North Cascades. We show that the snow across the stratovolcanoes of the pacific northwest (PNW) darkens each summer through a seasonal evolution that often leaves the end of summer snow/ice surface even darker than the summer before. Comparison to smoke-derived black carbon deposition output from the Navy Aerosol Analysis Prediction System (NAAPS) model shows there is a also a relationship between peaks in snow darkening and the deposition of smoke from wildfires, a trend that will likely only continue as the climate warms.

10:25 Extraction of snow disappearance from high resolution Planet imagery in alpine meadows

Dr. Aji John
University of Washington

Climate plays a pivotal role in determining the distribution and abundance of species, and this influence extends to alpine meadows. These high-altitude ecosystems are particularly sensitive to climate variations, and the rapid changes driven by climate change are causing shifts in species ranges, both in terms of elevation and latitude. One crucial factor in alpine meadows is the date of snow disappearance, which significantly influences the timing of meadow phenological events. Recent years have witnessed increased variability in this disappearance date due to a higher frequency of heatwaves and early springs, particularly in alpine regions. Traditionally, the snow disappearance date has been collected through in-situ sensors or interpolated from data gathered by weather stations. While these in-situ observations are invaluable for studying specific areas, they fall short when it comes to capturing the intricate and fine-scale patterns of snow cover heterogeneity across larger landscapes. To address this limitation, we employed higher-resolution satellite imagery to estimate snow disappearance in alpine meadows within Mount Rainier National Park, located in Washington State, USA. Our methodology aimed to enhance the accuracy of snow disappearance estimation compared to ground-based sensors, which were part of the MeadoWatch program, a volunteer-driven initiative dedicated to studying the impact of climate change on meadows. Our findings highlighted the influence of topographic complexity on snow cover estimation. As expected, we observed that sites at higher elevations exhibited later snow disappearance dates compared to those in depressions or more open and exposed areas. These variations in snow cover over short distances offer valuable insights into the intricate dynamics of species range shifts and can help identify specific areas that serve as buffers, protecting species from the adverse effects of climate change. In summary, our research underscores the critical role of snow disappearance in alpine meadows, especially in the context of a changing climate. By leveraging advanced satellite imagery, we enhance our ability to monitor and understand the impacts of climate change on these ecosystems and the species they support.

10:45 Trends in ice-cover duration in the mountain lakes of the North Coast & Cascades Network

Dr. Steven Fradkin
Olympic National Park

Bill Baccus
Olympic National Park

Mountain lakes are ecologically important and charismatic features of the high country of the national parks of the North Coast and Cascades Network (Olympic, Mount Rainier, North Cascades). These lakes are ice-free approximately 5 months of the year. The remainder of the year they are locked under a thick blanket of ice and snow that limits the amount of light, atmospheric gas exchange, nutrient dynamics, and the pace of biological activity. As the global climate changes due to warming, the duration of winter ice cover is expected to decrease with potentially profound changes to these fragile ecosystems. We present a long-term dataset (up to 16 years) of ice duration from 21 NCCN lakes. This period of record illustrates changes in ice duration and includes examples of conditions expected a near-future warmed world.

11:05 Break

11:15 Thermal profile and cold-water anomalies in the Hoh River watershed

Kim Bray*, Julie Ann Koehlinger
Hoh Indian Tribe

Mousa Diabat*
NV5 Geospatial

Nicole Rasmussen, Betsy Krier
Wild Salmon Center

The Hoh River watershed, located on the Olympic Peninsula in western Washington, supports Pacific salmon and steelhead populations, of which the Hoh Tribe retains treaty-reserved rights to harvest. Due to predicted glacial extinction and declines in snowmelt associated with increasing temperatures, the Hoh River is expected to warm considerably in the coming decades. Cold-water refugia, which salmonids rely on to survive the summer and fall low flow period, will likely diminish. To mitigate the expected warming of the Hoh River and its tributaries, it is necessary to locate cold-water areas in need of protection, and potential sites for future habitat restoration projects that promote the formation of cold-water refugia. In this study, our objectives are to identify the thermal profile and cold-water anomalies in the Hoh River watershed. To do so, a helicopter with a mounted cooled-technology thermal infrared sensor (FLIR SC6000, longwave 8-9.2um) flew 86 kilometers of the Hoh and South Fork Hoh Rivers during the early afternoon hours in August 2023. The results from this project will inform future restoration efforts that seek to maximize cold water features in the Hoh and South Fork Hoh Rivers.

11:35 Glacial loss and threatened fish: The future of Mount Rainier's cold-water bull trout habitats

Katie Ewen
Mount Rainier National Park

Glaciers play a key ecological role in the river systems that they support. Cold-water reaches supplied by glacial ice serve as critical habitats for species, such as federally threatened bull trout (Salvelinus confluentus), that rely on specific thermal ranges to survive. However, decreased glacial extent brought on by climate change could result in warmer stream temperatures and diminished cold-water habitats. This issue is particularly relevant to Mount Rainier, where glaciers support critical bull trout spawning habitat. To simulate future climate change impacts in Mount Rainier's cold-water habitats, I fit spatial stream network models to glacially-fed watersheds based on hourly stream temperature data. I then adjusted the models to predict stream temperature in both mid and late-century scenarios of air temperature rise, coupled with 20%, 40%, and 80% declines in glacial extent. My models predicted increased stream temperatures in both watersheds by late-century, as well as significant declines in thermally viable habitat for bull trout spawning. However, site-specific predictions found that a few streams may provide cold-water habitats in the coming decades. These results can be utilized to strategically protect enduring bull trout habitats. Similar predictive efforts can be applied throughout NCCN rivers, highlighting the importance of stream temperature monitoring data.

Seismology & Sediments in Flux

Facilitator: **Scott Beason** | Geologist, Mount Rainier National Park

1:00 Analyzing seismic data recorded from a debris flow at Mount Rainier National Park

Avery Conner
University of Oregon

Debris flows are some of the most dangerous volcanic hazards and may occur at any time, even during periods of volcanic rest. Often called lahars at volcanoes, debris flows are water-saturated landslides that move rapidly and can travel large distances. Debris flows often occur in remote locations and are difficult to predict, making it challenging

to study and collect data on the events. Efforts are being made to collect data with instruments such as seismometers to better understand debris flow dynamics, estimate hazard, and provide warning when communities are threatened. Tahoma Creek, a stream on the southwestern slopes of Mount Rainier, is prone to small debris flows and provides an excellent location to study flow processes. We deployed monitoring equipment including temporary seismometers along Tahoma Creek drainage and recorded a small debris flow on 15 August 2023. We plan to use the collected data to model the debris flow and attempt to link the data to properties of the event, such as velocity or volume. The ability to interpret aspects of a debris flow from recorded seismic data would allow warning systems to better inform threatened communities about the hazard represented by individual events.

1:20 Constraining Variability in Sediment Size, Strength, Density and Abrasion Potential among Volcanic Mass Wasting Deposits in the Pacific Northwest

Brian Pinke*, Dr. Allison Pfeiffer
Western Washington University

In the Pacific Northwest, more than half of catastrophic rock avalanches have occurred on volcanic slopes. As such, these volcanic landscapes serve as major contributors of sediment to river valleys downstream. Despite decades of research on mass wasting event mechanics and hazards, we lack a strong predictive framework for how mass wasting sediment will pass downstream and what the impact will be on the river. The grain size distribution (GSD) and clast abrasion rate can place strong controls on the downstream fate of these sediment pulses. Prior work completed at Glacier Peak, a stratovolcano in Washington State, constrained the GSD, lithology, and abrasion variability of a volcanic mass wasting deposit and demonstrated that much of the coarse material abrades to fines in the first 10s of km of transport. We build on this effort by quantifying the sediment characteristics of four other large volcanic mass wasting deposits in the region: Mt. Adams, Little Tahoma, Kautz Creek, and Mt. Meager. Initial results show sediment size and strength is highly variable within and between each measured deposit. These data on debris flow deposit sediment characteristics will provide constraints for future modeling work exploring the downstream hazards associated with volcanic mass wasting events.

1:35 An Expanded Rainier Lahar Detection System for Mount Rainier National Park and Surrounding Communities

Rebecca Kramer*, Benjamin Pauk, Dr. Wes Thelen, Dr. Seth Moran, Dr. Alex Iezzi
US Geological Survey, Cascades Volcano Observatory

Mount Rainier is an active stratovolcano with four major eruptive periods in the Holocene and a known history of large, far-reaching lahars (volcanic mudflows.) Of all the volcanic hazards at Mt. Rainier, lahars pose the greatest risk to communities downstream. The U.S. Geological Survey Cascades Volcano Observatory (USGS CVO) monitors Mount Rainier for signs of unrest. USGS CVO recently expanded continuous geophysical monitoring capabilities in Mount Rainier National Park (MORA) and the surrounding areas west of the park as part of a Congressionally funded initiative to upgrade the Rainier Lahar Detection System (RLDS). Since 2016 USGS CVO has installed 13 telemetered broadband seismic and infrasound (seismoacoustic) monitoring stations outside MORA along the Carbon, Mowich, and Puyallup drainages. Additionally, since 2020, USGS CVO has permitted and installed 12 new lahar monitoring stations within MORA boundaries and completed equipment upgrades at existing monitoring sites. The new stations and upgrades will significantly improve lahar detection capabilities on the Kautz and Tahoma Creek drainages. Five additional installations are planned along the White River, Northeast of MORA. Engagement and close coordination with partners from Pierce County, the Washington Emergency Management Division, South Sound 911, the National Park Service, and city-based emergency managers form Orting and Puyallup have been a critical component of this work.

1:50 Using Internet Infrastructure for Geological Hazards Monitoring: Distributed Acoustic Sensing (DAS) in Mount Rainier National Park.

Dr. Brad Lipovsky, Dr. Marine Denollek, Veronica Gaete Elgueta, Manuela Koefpli, Akash Kharita
University of Washington

Dr. Weston Thelen
US Geological Survey, Cascades Volcano Observatory

Mount Rainier is a seismically active glaciated stratovolcano in the Cascades Volcanic Arc that has the potential to host a wide range of geological hazards including earthquakes, far-reaching lahars, outburst floods, and debris flows. As one of the most seismically active regions in the Pacific Northwest, tracking seismicity is a primary tool used to monitor these hazards by the Cascades Volcano Observatory (CVO) and the Pacific Northwest Seismic Network (PNSN). Here, we report on progress using a new technology called Distributed Acoustic Sensing (DAS) that enables the use of existing telecommunications optical fibers as virtual seismic networks. We show that using DAS at Mount Rainier, we are able to detect previously undetected microseismicity in the West Rainier Seismic Zone. Our study lays the groundwork for the efficient augmentation of existing seismic networks with DAS with an eye towards both improved scientific understanding and operational systems.

2:05 Break

2:15 Breakout Discussions

2:35 Carbon Sequestration, Storage, and Greenhouse Gas Emissions in Pacific Northwest Coastal Wetlands

Dr. Christopher Janousek
Oregon State University

Tidal wetlands are productive, ecologically valuable, and threatened coastal ecosystems. One of their important ecosystem services is high rates of organic carbon accumulation and storage, termed "blue carbon". Some tidal wetlands also emit methane, a powerful greenhouse gas, which can offset some of the benefits of carbon sequestration. The Pacific Northwest Blue Carbon Working Group has been studying tidal wetlands in the Pacific Northwest (PNW) to better understand how wetland type and estuarine environmental conditions such as groundwater and salinity affect different aspects of blue carbon. Recent research by the Working Group on carbon stocks shows that forested tidal swamps – though much diminished from their historic extent – store very high levels of organic carbon, followed closely by tidal marshes. Study of methane fluxes from coastal wetlands, including at Lewis and Clark National Historic Park, suggests that factors like low salinity, lower wetland elevation, and high groundwater levels can lead to higher methane emissions. Regional work to determine carbon sequestration rates from PNW tidal wetlands using radioisotopes is on-going. These blue carbon data will help coastal managers better protect carbon-rich estuarine wetlands and understand how coastal restoration can affect carbon sequestration and methane emissions.

2:50 Don't forget to look up!: How canopy soils contribute to old-growth tree resiliency and ecosystem function

Dr. Korena Mafune
University of Washington

Dr. Jen Kane
West Virginia University

Canopy soils occur on tree branches throughout the temperate rainforests of the Pacific Northwest Coast and are recognized as a defining characteristic of these ecosystems. Certain tree species extend roots from their branches into these canopy soil environments. Yet, research on canopy root-associated fungi remains limited. Our study used microscopy to compare fungal colonization intensity between canopy and forest floor roots of old-growth bigleaf maple trees. Then, we explored the spatial and seasonal variation of root-associated fungal diversity between the two soil environments. We found that canopy and forest floor roots had similar fungal establishment and were associating with a diversity of mutualistic fungi. Soil type and seasonality affected root-associated fungal community composition,

and several fungal species were indicative of the canopy soil environment. In Washington State's temperate old-growth rainforests, these canopy soil environments host a unique suite of root-associated fungi. The presence of arbuscular mycorrhizae provides further evidence that adventitious roots form fungal associations to exploit canopy soils for resources, and there may be novel relationships forming with other fungi. These soils may be providing a redundancy compartment (i.e., 'nutrient reserve') imparting a resiliency to disturbances for certain old-growth trees.

3:05 Soil Survey of Olympic National Park

Abby Field
USDA, Natural Resource Conservation Service

Staff from the Olympia, Washington soil survey office are working on the initial soil survey of Olympic National Park. The project is funded via a five-year interagency agreement between the National Park Service and the United States Department of Agriculture's Natural Resources Conservation Service. The goal of the project is to produce a complete soil survey and associated Ecological Site Descriptions (ESDs). Staff members are utilizing geospatial resources to identify and delineate areas with predictably similar groupings and patterns of soils and vegetation communities. Abiotic and biotic site characteristics are then sampled and inventoried in the field. Field work involves multi-day landscape traverses and documentation of site and soil properties using in-situ methods. These observations are then used to develop and refine soil component and map unit concepts. Additionally, vegetation plot data is collected for the purpose of developing ESDs which characterize landscape, soil, climate, hydrology, and vegetative patterns across the landscape. The ESDs also describe the maturation and succession of vegetative groupings based on the abiotic factors under various natural disturbance regimes. To date, field mapping has been completed for the entirety of the project and focus is now shifting towards data development and preparation for publication.

Insect Insights: Monitoring Meadows and Waters

Facilitator: **Beth Fallon** | Ecologist, Mount Rainier National Park

1:00 From water to wildlife: Quantifying changes in meadow extent from 1984 to present day for Mount Rainier and Olympic National Parks

Dr. Meghan Halabisky
University of Washington

Meadows represent integral plant and wildlife habitats in the northwest that are disproportionately affected by climate change, especially in montane systems. Yet we do not have a good understanding of which meadow habitats are most vulnerable, what hydroclimatic factors may be driving changes, and how wildlife will be impacted, which hampers development of management plans to mitigate climate effects. A warming climate, dwindling snowpack, and earlier snowmelt have led to tree encroachment into meadows as well as meadow expansion at higher elevations in Mt Rainier and Olympic National Parks. This project aims to quantify the change in meadow extent across both parks, including loss of canopy gaps and forest densification. We compared Landsat satellite imagery for two time periods in 1984 and 2023 to quantify change in meadow area. Spectral signatures that represent four types of land cover were used to model the fractional cover of each land category for every Landsat pixel (i.e., meadow, tree, bare earth, water/shade), which provides more accurate area estimates than previous methods. Our results provide estimates of meadow gain and loss for every catchment showing strong climatic spatial patterns. We compare these changes to other environmental variables and wildlife population surveys (e.g., marmots in Olympic National Park).

1:20 Effect of tree encroachment on meadow plants and pollinators at Mount Rainier National Park

Madeleine Strait
University of Washington

Subalpine meadows are important habitats that host unique biodiversity and provide many ecosystem services. Mountain ecosystems are vulnerable to climate change because shifts in temperature and precipitation can have large effects on snowpack dynamics, influencing water availability and season length. Global warming has increased the climatic suitability of subalpine meadows for tree establishment, and trees have begun invading higher elevation areas previously dominated by herbaceous plants. While previous research has explored ongoing and future tree encroachment, there is little knowledge on the impacts of such encroachment to subalpine flowering plant-pollinator dynamics. I will be conducting a project at Mount Rainier National Park (MRNP) during the summer that will measure the impact of tree encroachment on plant-pollinator communities, and potentially test the feasibility of tree sapling removal as a method for meadow habitat conservation. Specifically, I will monitor plant-pollinator dynamics in meadows with no tree establishment and meadows with ongoing tree encroachment. If approved by MRNP, I will also monitor plant-pollinator dynamics in meadows where I will experimentally remove all small tree saplings. This project has the potential to provide park management with an actionable framework for maintaining the diversity of plants and pollinators in important meadow ecosystems.

1:35 MeadoWatch: Utilizing community science to monitor wildflower phenology at Mount Rainier National Park

Dr. Berry Brosi, Manogya Chandar
University of Washington

Dr. Janneke Hille Ris Lambers
ETH Zurich

Understanding how plant phenology—the timing of life history events—is changing in response to climate is imperative given rapidly shifting environmental conditions. This is especially relevant for montane plants which often rely on snowmelt as a key indicator to determine flowering time.

"MeadoWatch" is a citizen science program for monitoring wildflower phenology at Mount Rainier National Park. This program, initiated in 2013, includes the timing of key reproductive stages (budding, flowering, fruiting, and seed release) for 17 wildflower species, as well as climate data (e.g. soil temperature and snow cover). The community/citizen science approach allows MeadoWatch to collect data at scale, while boosting public participation in scientific research. This citizen science approach is ideal for processes like flowering that turn over rapidly and require frequent sampling.

Plant-pollinator interactions may also be impacted by shifting plant phenology. Different abiotic cues drive plant flowering vs. pollinator overwintering emergence, creating the potential for timing mismatches that could have detrimental effects on pollination and subsequent plant reproduction. We are proposing an expansion of MeadoWatch that will incorporate citizen collection of pollinator visitation data, allowing us to better understand the potential for plant-pollinator mismatches and simultaneously increasing public engagement with pollinators.

1:50 Flower phenology and bumble bee foraging in mountain meadows of the North Cascades

James Davis
Shuksan Conservancy

We conducted a five-year study of flower phenology and bumble bee pollination in Heather Meadows in the northern portion of the North Cascades. Seventy species of flowering plants were recorded from seven transects at elevations ranging from 1,260 to 1,582 meters. Heathers and huckleberries dominated the flowering plant community. Sixty-seven percent of pollinator visits to flowering plants were by bumble bees. In a typical year, there was continuity of floral resources within each transect and across the elevation gradient, for the duration of the growing season. We found that tree islands were critically important in the spring for early season establishment of bumble bee nests and queen foraging for pollen and nectar. Study results indicated that bumble bees were responsible for nearly all huckleberry pollination in North Cascades meadows and are thus keystone species for sustaining the overall meadow ecosystem (including bears and other huckleberry foragers). Bombus melanopygus (shown in other research to be highly susceptible to heat stress) was the most important huckleberry pollinator (76% of bumble bees observed).

Foraging by introduced honey bees overlapped temporally with foraging by bumble bees, created competition on several flowering plant species, and provided a pathway for viral disease transmission to bumble bees.

2:05 Break

2:15 Breakout Discussions

2:35 The Cascades Butterfly Project: Monitoring subalpine butterflies as indicators of climate change

Dr. Regina M. Rochefort*
North Cascades National Park Service Complex

Dr. John McLaughlin
Western Washington University

Volunteers with the Cascades Butterfly Project (CBP) have conducted weekly butterfly surveys along 10 subalpine survey routes since 2011. The goal of the project is to document patterns of butterfly abundance and plant flowering as indicators of climate change in subalpine meadows. Study sites extend from Skyline Divide in Mount Baker-Snoqualmie NF through North Cascades NP and Okanagan-Wenatchee NF to and to Mount Rainier NP. Volunteers survey routes using the Pollard-Walk method to estimate relative abundance of butterflies and record the flowering phase of select plant species. Prior to our study, butterfly surveys had been conducted in Mount Rainier NP, but there was very little documentation of butterflies in North Cascades NP or the two adjacent forests. We have documented 59 butterfly species butterflies and inter-annual differences in abundance, dates of abundance peaks, and between species.

2:50 Butterfly and subalpine meadow responses to climate change in Mount Rainier National Park

Dr. John McLaughlin
Western Washington University

The Cascades Butterfly Project (CBP) monitors subalpine responses to climate change, with a focus on butterfly populations and plant phenology. The program relies on trained volunteers who conduct weekly surveys throughout the flight and growing season at ten monitoring sites, five each in the North Cascades and Mount Rainier National Park. I complement CBP sampling with annual spatially-extensive surveys in Mount Rainier National Park. My surveys attempt to coincide with peak bloom and butterfly abundances and include subalpine meadows throughout the park. Sampling included 52 meadows, although logistical constraints and weather conditions precluded butterfly surveys at some sites in some years. Over ten years, I detected 42 butterfly species, including all five families known to occur in the Park. Survey data reveal relationships between butterfly abundances, plant distributions, and meadow area. They provide a preliminary glimpse of butterfly population dynamics. For 49 meadows, I compared current subalpine meadow type with Henderson's (1973) classifications. Most (88%) matched Henderson's classifications, suggesting persistence under climate change to date. Four have become more lush, likely due to shallower snowpacks and longer growing seasons. Three meadows are transitioning to subalpine forest and likely will cease to function as subalpine butterfly habitat in coming decades.

3:05 Sampling dragonflies in the North Coast & Cascades Network: Protecting resources and inspiring stewardship

Colleen Flanagan Pritz, Katherine Ko
Air Resources Division, National Park Service

Colleen Emery, Dr. James Willacker, Dr. Collin Eagles-Smith
US Geological Survey, Forest and Rangeland Ecosystem Science Center

One of the most recognized citizen science projects across the National Park Service, the Dragonfly Mercury Project (DMP) is a decade-long, nationwide assessment that uses dragonfly larvae as indicators of mercury risk in national parks. Contributing to 80% of fish consumption advisories across the U.S., mercury (Hg) is a global pollutant that can harm human and wildlife health, and impact park visitors. Five North Coast & Cascades Network (NCCN) parks – Olympic NP, Mount Rainier NP, North Cascades NP, San Juan Island NHP, Lewis and Clark NHP – have been longtime participants in the DMP, some since as early as 2012. Findings across parks and years show that 58 percent of NCCN

site-year data fall in the moderate or higher impairment categories, suggesting top predator fish may exceed human consumption thresholds and wildlife may be at risk from elevated Hg levels. In addition to quantifying risk, long-term records from NCCN parks also contribute to spatial and temporal models of Hg across the U.S. and feed into our understanding of the effectiveness of Hg emission reductions. Various public participants have helped sample dragonflies in NCCN parks, fostering the connection between people and parks. Lewis and Clark NHP staff remarked, "it has been a favorite activity mentioned by interns every year," showcasing programmatic benefits for multiple end-users and underscoring the importance of continued participation.

3:20 Statewide watershed health monitoring: Using minimally impacted streams to create standards for Washington's overall stream & river status

Kristi Floyd
Washington State Department of Ecology

The Washington State Department of Ecology has fostered a statewide Watershed Health Monitoring Project since 2009. This project aims to provide a status and trends report on the state's streams and rivers. While the majority of the sites selected are randomly assigned, there are a handful of regionally representative baseline sites known as our 'reference sites'. There are 16 reference sites are visited annually, two of which are within National Park boundaries (Twin Creek in Olympic National Park and Laughingwater Creek in Mount Rainier National Park). At these sites a record of fish, periphyton and invertebrate assemblages, habitat measurements, and water chemistry are taken. These data help us maintain a standard for minimally impacted streams within the correlated Salmon Recovery regions of Washington State. The ability to regularly sample within National Parks for this survey gives us great data on how healthy streams should look based on current regional conditions.

Tough Questions: Using Science for Stewardship

Facilitator: **Carla Cole** | Resources Stewardship Program Lead, Lewis and Clark National Historical Park

10:00 Mapping wilderness character degradation in the Stephen Mather Wilderness of North Cascades National Park Service Complex

Andrew Giacomelli
North Cascades National Park
Western Washington University

Using spatial analysis, GIS modeling techniques, and raster calculations, more than 40 measures of degradation were included to map threats to the five qualities of wilderness character in the Stephen Mather Wilderness of the North Cascades National Park Complex (NOCA), Washington. The five qualities of wilderness character outlined by the Wilderness Act of 1964 for preservation in Federal wilderness areas under the National Wilderness Preservation System include the degree to which the wilderness area is untrammeled by modern humans, natural, undeveloped, opportunities for solitude and unconfined or primitive recreation, and features of value specific to each wilderness. The results of this study found that much of the untrammeled, natural, undeveloped and features of value qualities specific to NOCA were well preserved, but opportunities for solitude and unconfined recreation showed the highest levels of impact due to elevated wilderness visitation rates, park restrictions on visitor behavior, and recreational facilities that decrease self-reliance in the wilderness. The results of this study are intended to provide a spatial baseline of wilderness character degradation at NOCA and assist wilderness managers and park staff improve stewardship activities and policy.

10:25 Assessing ecological integrity and recreation impacts in Washington's state parks

Dr. Andrea S. Thorpe
Washington State Parks and Recreation Commission

Washington State Parks manages over 120,000 acres, which are managed to provide for recreation as well as natural and cultural resource protection. While state parks include some of the state's most popular recreation areas, they also support a high proportion of rare and high quality ecosystems, rare species, and important cultural resources. For example, more than 40% of park landscapes have plant associations classified as being at moderate risk or higher, within Washington state or globally. There is concern that higher rates of recreational use are having increasingly negative impacts on natural and cultural resources. This presentation will summarize recent efforts by State Parks to quantify the ecological integrity of its natural systems and the impacts of recreation on wildlife, and how these data will be used to inform management and restoration. The intent is to share information to help encourage cross-boundary collaboration on recreation and resource management.

10:45 Level and extent of human waste-related disturbance on two beaches in Olympic National Park

Dr. Lara Jacobs
Michigan State University

In Olympic National Park (OLYM), Washington, many Indigenous Nations (e.g., the Quileute Tribe) have subsistence and cultural Treaty rights to their ancestral territories. Outdoor recreation behaviors on two popular beach destinations in OLYM have created a human fecal matter issue that has concerned the Quileute Tribe. This is important because the Tribe uses both beaches for subsistence and cultural purposes. This presentation reports on research examining the impacts of human fecal matter throughout the marine ecosystems on Second and Third Beaches in OLYM using spatial, cellular, and molecular methods. Specifically, we mapped locations of human fecal matter over time, measured the presence and concentration of E. coli and Total Coliforms, quantified antibiotic resistance and virulence of the E. coli isolates, and identified human genetic markers associated with our samples. We found that the presence of human waste was associated with increasing use levels. We also found a strong presence of human genetic markers and evidence of antibiotic resistance and virulence factors on both beaches. Overall, this study suggests that human wastes in marine environments in OLYM may be leading to pathogenic impacts which have both health and ecological implications.

11:05 Break

11:15 Learning groups in natural resource management: collaboration on the Olympic Peninsula, Washington

Courtney Bobsin
University of Washington's Olympic Natural Resources Center

Collaboration in natural resource management has been growing over the last 30 years. Though these groups often work to accomplish projects together, they rarely have a focus on learning. When land managers, researchers, stakeholders, and tribes experiment with innovation together, there is a potential to enrich scientific ideas, build trust, and change governance structures while learning together. We explore a social learning-based approach used to develop and run a new large-scale adaptive management experiment on the Olympic Peninsula, WA. I will describe a new application of social learning, referred to as learning groups, which bring together people of different backgrounds and interests to address specific portions of the study. In this presentation, I discuss methodologies to enact learning groups, assessment of learning group categories, elements of success from the first year after implementation, and constraints to this approach to help others embarking on collaborative work that seeks to inform management.

11:35 Predicting probabilities of late summer surface flow presence in streams flowing through Mount Rainier National Park

Dr. Kristin Jaeger
US Geological Survey, Washington Water Science Center

The 2015 snow drought in the western U.S. was one of the lowest annual snowpacks in Washington and corresponded with reduced surface-water flow in streams in Mount Rainier National Park. Reduction in surface-water flow presented water resource challenges to park infrastructures, which are all surface water-based supply systems. An empirical model was developed to predict streamflow permanence (late summer surface-flow presence) for Mount Rainier National Park and the surrounding mountainous area in western Washington, USA. The model was trained on newly collected, crowd-sourced flow/no flow observations. Model results indicate that approximately half of the streams (49%) within the Mount Rainier National Park boundary have a likelihood of going dry at some point during late summer. Modelled results may be used to prioritize which park facilities are either more or less vulnerable to limited water availability based on streamflow permanence probabilities of the associated streams on which the facility relies. Additionally, results can inform water availability for trail hikers with updated maps that identify streams predicted to have reliable late summer flow. Finally, results may be combined with other spatial datasets that describe instream conditions such as the water temperature to provide information on stability of instream habitats for stream-dwelling species.

Past is Present

Facilitator: **Meagan Huff** | Curator, Fort Vancouver National Historic Site

1:00 Fire, vegetation, climate, and humans: a paleoenvironmental reconstruction of the postglacial landscapes at Mount Rainier National Park, Washington (USA)

Dr. Megan Walsh
Central Washington University

Fire plays a significant role in the maintenance and alteration of many Pacific Northwest environments, including those at Mount Rainier National Park (MORA). The goal of this study was to reconstruct the paleoenvironmental history from six study sites located throughout the subalpine forest/meadow ecotone of the park for the past ~14,500 years using macroscopic charcoal and pollen analysis of lake sediment cores. Chronological control was established using 14C dating and the identification of dated tephra layers from Mount Rainier and other nearby volcanoes. The combined results show that fires were lowest during the early part of the postglacial period but were highest during the late Holocene when climates were cool and wet. The retreat of ice sheets and glaciers, changes in annual insolation, as well as increased interannual climate variability particularly in the middle to late Holocene, were likely responsible for changes in vegetation and fire activity during the postglacial period. However, abundant and increasing archaeological evidence from MORA suggests that humans also influenced the landscape at this time. This research provides the longest and most detailed records of postglacial fire activity at MORA and provides an opportunity to further examine pre-EuroAmerican human-environment relationships in subalpine landscapes.

1:20 Lake sedimentary DNA tracks plankton biodiversity in mountain lakes in the Western U.S. during the Anthropocene

Jordan Von Eggers
University of Wyoming

High elevation mountain lakes in the Western United States are naturally fishless, cold, possess few nutrients, and support a wide range of aquatic and terrestrial biodiversity. Despite being remote, human impacts transform lake ecosystems through the introduction of fish, climate change, and atmospheric nutrient pollution. Sediments accumulating on the lake bottom record past environments and biological communities, and recent advances allow us to recover DNA stored in sediment archives. In this study, we sequenced sedimentary DNA of phytoplankton and zooplankton and used proxies of temperature and atmospheric nitrogen deposition to track how anthropogenic

stressors influence aquatic biodiversity over the last few hundred years. We collected 15 sediment cores from lakes with and without fish introductions in Washington, California, and Wyoming to encompass a gradient of climate change and nitrogen deposition across the Western U.S.. Preliminary analysis indicates distinct geographic separation of plankton communities. Additionally, communities shifted in a similar manner over time regardless of whether fish were introduced, suggesting regional drivers - climate and nitrogen pollution - may drive major changes in plankton communities across the West. Revealing baseline conditions and recent shifts in biodiversity permit monitoring and thus preservation of sensitive mountain lake ecosystems.

1:35 The immensity of minutiae: utilizing bryophytes to detect an ice age refugium in the North Cascades

Miles Berkey
Western Washington University

Ice age refugia were ecologically stable areas that remained ice free during the Pleistocene glaciations. As a result, they offered a level of suitable conditions to host arctic and boreal species associated with the climate of that time. About 16,000 years ago, as the climate began to warm, the ice sheets in western North America began to recede, and these vestiges of the late Pleistocene became surrounded by the temperate ecosystems of today. Today, ice age refugia exist in part as biodiversity hotspots hosting relictual and endemic species of a late Pleistocene climate. This study takes a comparative bryophyte floristics approach to detect an ice age refugium in an area of the northern Cascade Mountains of Washington state – Barlow pass. Thus far, over 1,200 bryophyte specimens have been collected representing over 240 species some of which are ice age relicts for Barlow Pass, others rare or new to Washington State and the majority of which characterize the bryophyte flora of previously unsurveyed areas of the North Cascades. These results presented here deepen our understanding of the biogeographic significance of Barlow Pass and provide baseline data for future conservation strategies.

1:50 Mt. Rainier Bryophytes

David Kofranek
David Kofranek Botany, LLC

Recent bryophyte surveys of Mt. Rainier National Park are the first in about 60 years. Plot work, transects, and intuitive control meander were used in five premier locations of the park. Results were mixed in relocating the two-dozen rare species. A summary of species is provided, including relocated rare species, unexpected species, those missed, and suggestions as to how to find more.

2:05 Break

2:15 Breakout Discussions

2:35 Rare lichens of Mount Rainier National Park

John Villella
Siskiyou BioSurvey LLC

Lichens are an important component of terrestrial vegetation but are generally understudied when compared with vascular plants. Mount Rainier National Park contains diverse lichen communities, including species that are restricted to old-growth rainforests and species that are more common at higher latitudes, but are otherwise quite rare in the Pacific Northwest. Across the broader landscape these rare lichen species face threats from a changing climate and habitat loss. A recent study of visitor-use impacts on lichen communities that focused on both random and targeted locations revealed several new sites of these regionally rare lichens within the park. This presentation will summarize these results and suggest management considerations as well as identify general locations within the park that may yet host unknown locations of rare lichens.

2:50 Compositional analysis of glass beads from the Fort Vancouver Site

Dr. Alison Carter*
University of Oregon

Meagan Huff
Fort Vancouver National Historic Site

Dr. Laure Dussubieux
Field Museum, Chicago

The Fort Vancouver site is the location of the former Hudson's Bay Company (HBC) Western Headquarters (1824-1845), which supplied a variety of goods to outposts in the Pacific Northwest. Over 100,000 glass beads have been uncovered in excavations at the site, which were sold by the HBC as part of the fur trade. The beads were first studied and classified by Lester Ross (1990), with over 150 bead types identified. This was expanded into a reference guide in 2013 by Cromwell et al. In his investigations, Ross suggested that the beads may have originated from manufacturing centers in Venice, Bohemia, China, and possibly Great Britain, but to date none of the beads in the Fort Vancouver collection have undergone compositional analysis. Here we share the preliminary results of an ongoing collaborative study between the Fort Vancouver Site, the University of Oregon, and the Elemental Analysis Facility at the Field Museum, Chicago, which aims to provide compositional data for all the bead types identified in the Fort Vancouver bead guide. In doing so, we hope to create a reference for scholars studying the bead trade in the Pacific Northwest and beyond.

3:05 Archaeological investigations of Fort Clatsop: Ground Penetrating Radar (GPR), geospatial analysis and the good ol' college try

Dr. Colin Grier, Tyler Baley
Washington State University

Rachel Stokeld
Lewis and Clark National Historical Park

Glen Kirkpatrick
Lewis and Clark Heritage Trail Foundation

Starting in 2021, ground penetrating radar equipment from the Northwest Coast Archaeology Lab at WSU Vancouver has been utilized to survey additional areas of the Lewis and Clark National Historic Park (near Astoria, Oregon) that may contain the remains of structures related to the Corps of Discovery expedition in 1805-06. New GPR surveys to the northwest of the existing Fort Clatsop replica were completed, funded by the Lewis & Clark Trail Heritage Foundation. This work has been challenging, as the fort itself had a light footprint and past archaeological searches for the fort have generated subsurface disturbances that more readily catch GPR's eye. Additionally, work at the Canoe Landing on the nearby Lewis and Clark River was completed in summer 2023, which revealed interesting GPR reflections indicative of a structure potentially related to the use of this area by the Corps and/or Clatsop communities. This work has provided an impetus to georeference past maps and data, with the goal of providing a synthetic view of the research and results stemming from the long-standing search for Fort Clatsop.

Coastal Concerns

Facilitator: **Dr. Steven Fradkin** | Coastal Ecologist, Olympic National Park

1:00 Cover classification analysis of intertidal Zostera marina (eelgrass) at 4th of July Beach

Kate Allhusen, Cathi Winings, Sean O'Connell, Erika Merto, Dr. Sandy Wyllie-Echeverria
University of Washington Friday Harbor Labs

Eelgrass (Zostera marina) is a marine flowering plant that has two mechanisms of reproduction: seed dispersal and vegetative propagation. Flowering shoots in the Salish Sea develop from perennial rhizomes in early spring (March-May) and reach their peak size in mid summer (July-August). As part of an ongoing eelgrass meadow restoration

project, we have collected flowering heads from Fourth of July Beach in the San Juan Island National Historical Park since 2020. Given that significant eelgrass loss has been documented in the islands, the project aims to restore meadows by planting seeds directly, rather than transplanting adult plants. The goal of our current study is to quantify the potential impact that harvesting flowering shoots may have on a well-established meadow. We examined trends in coverage of Z. marina at Fourth of July Beach over three years (2021-2023). We inventoried growth in 22 arbitrarily selected intertidal stations at this site defined by specific GPS coordinates. For each station, data was remotely classified from 0.25 m² quadrats to estimate percent cover of (1) foliage leaves, (2) flowering heads, (3) algae, and (4) other (bare sand, mud, etc.) at each station. Surveys were completed in summer, when seeds have fully developed.

1:20 Restoring eelgrass with dispenser injection seeding: a pilot experiment in San Juan Island National Historical Park

Adam Rogowski
University of Washington Friday Harbor Labs

The Eelgrass Restoration Team at Friday Harbor Labs initiated a novel technique to restore Zostera marina, as part of the efforts in Washington State to restore disappearing, declining and fragmenting populations. While we have engaged in ongoing efforts to restore eelgrass populations at Bell Point, on Northern San Juan Island, our study at 4th of July Beach, within the boundaries of San Juan Island National Historical Park, was part of a new effort to utilize a seeding technique developed by researchers at the University of Groningen, the Netherlands. The Dutch research team visited our sites to help pilot their seeding method in the Salish Sea.

The seeding method used at 4th of July beach utilized calibrated caulking guns filled with a combination of mud and seeds collected the previous year from flowering heads harvested in the summer of 2022 from within 50 miles of the restoration site. From 10-13 April 2023 seeds were injected directly into the substrate within marked plots located in the intertidal region. Seedling recruitment was monitored after injection in May, June, July and August. Our ongoing study is aimed at finding an efficient and reliable method for restoring critical Z. marina populations in the Salish Sea.

1:35 Sediment transport and bluff erosion along South Beach, San Juan Island National Historical Park

Amanda Hacking
Washington State Department of Ecology, Applied Coastal Research & Engineering Section (ACRE)

The Washington State Department of Ecology Coastal Monitoring & Analysis Program conducted two high-resolution mapping surveys of South Beach and the neighboring bluffs within the San Juan Island National Historical Park in 2016 and 2021. South Beach is mostly composed of sand and gravel, with cobbles and traces of boulders. The beach is bordered alongshore by bedrock outcrops and backed on the east end by eroding bluffs. The bluffs are mostly composed of recessional glacial deposits from the Frasier Glaciation overlaid on bedrock. Boat-based lidar data from the two surveys were used to measure the elevation change of the beach and recession rates and volume change of the bluffs. Over five years between 2016 and 2021, the beach exhibited an expected pattern of lowering on the updrift (west) end and raising on the downdrift (east) end. The bluffs lost 22,000 m3 of material, and the beach lost 4,500 m3. Bluff recession rates varied up to an average of 21 cm/yr at the toe and 15 cm/yr across the whole face. Alongshore patterns of bluff change suggest that the underlying geology plays a role in retreat rates and styles of erosion.

1:50 Using citizen science to track human impacts on the marine environment

Jackie Lindsey
Coastal Observation and Seabird Survey Team (COASST)
University of Washington

The Coastal Observation and Seabird Survey Team (COASST) has been monitoring the Washington/Oregon coastline for over two decades, working with community members to track patterns of marine bird and marine debris deposition on local beaches. Hands-on citizen science offers an opportunity to collect environmental data over stretches of space and time that no research lab could hope to attain on its own. It also provides the opportunity for program participants and partners to learn about their environment at multiple scales: from seasonal shifts in the distribution of local species to dramatic changes in the ecosystem. In this presentation we examine the impacts of

pollution on the outer coast of Washington/Oregon, including two historical oil spills and regional differences in marine debris deposition. We also look towards the future of energy production in this region, with a new project that will track the impacts of offshore wind farms on marine birds using the COASST beached bird baseline dataset.

2:05 Break

2:15 Breakout Discussions

2:35 Historical coastline change assessment at Cape Alava spanning the Ozette Reservation in the Olympic National Park to inform strategies for the protection of recreational and cultural resources

Hannah Drummond
Washington State Department of Ecology, Applied Coastal Research & Engineering Section (ACRE)

In support of the Makah Tribe, The Washington State Department of Ecology Coastal Monitoring & Analysis Program conducted a historical coastal change assessment along 7 km of coastline around Cape Alava. This coast has a wide wave-cut intertidal rocky platform with narrow beaches composed of thin deposits of sand, gravel, and cobble, which are backed by forested bluffs. Georeferenced historical photos, aerial imagery, and airborne lidar data were used to delineate shoreline features between 1977 and 2019. Oblique shoreline photos and Google Street View photos were leveraged to add qualitative context for the quantified change. Averaged over the entire study area, the shoreline retreated 0.06 m/yr between 1977 and 2019, and 0.77 m/yr between 2009 and 2019, with locally variable change rates corresponding to geomorphic complexity. Between 2009 and 2019 the coastline in the Ozette Reservation and the reach directly north was found to be eroding at a faster rates (~1.26 m/yr) than the region directly south (0.20 m/yr), including a locally high erosion rate of 1.73 m/yr for a 30-m reach at a backcountry campsite in the Olympic National Park. Results presented here may be used to inform management strategies to protect and maintain recreational and cultural resources.

2:50 Beach monitoring near Kalaloch in Olympic National Park for applications in nature-based coastal protection engineering designs

Heather Weiner
Washington State Department of Ecology, Applied Coastal Research & Engineering Section (ACRE)

In February 2019, the Washington State Department of Ecology Applied Coastal Research & Engineering team (ACRE) began monitoring a 0.55 km stretch of beach in the Kalaloch Area of Olympic National Park near the South Beach campground to study beach dynamics of a naturally occurring composite beach. South Beach has a sandy foreshore backed by a natural cobble berm which provides buffer for wave energy, protecting mature vegetation at the base of a bluff. ACRE conducts seasonal topographic monitoring of the beach and berm using RTK-GNSS receivers mounted on backpacks to collect cross-shore beach elevation profiles and map the position of the cobble berm toe. Digital photos are taken along the profiles to show qualitative changes of the cobble berm. In addition, RFID-tagged rocks were placed on the beach in October 2019 and are tracked annually to provide information on the rate and direction of cobble transport. Initial results show a seasonal lowering of the beach in the winter with cobbles exposed seaward on the beach compared to summer months. Results from monitoring South Beach may be used as a reference for nature-based shoreline protection measures that aim to mimic the natural function of a cobble berm.

3:05 Coastal bluff erosion at Kalaloch, Olympic National Park

Dr. Ian Miller
Washington Sea Grant

Dr. Steven Fradkin
Olympic National Park

The shoreline at Kalaloch is a broad, sandy, bluff-backed beach at the southern end of the coastal strip in Olympic National Park. The location of this distinctive notable shoreline along the coastal Highway 101 corridor, as well as its proximity to the popular Kalaloch Lodge and associated cabins and campground, make it one of the more valuable beach access points on the coast. The coastal bluffs at Kalaloch have been eroding at various rates since at least since

1974 based on available analyses of the site. Erosion at this site presents a variety of management problems, placing buildings and recreational infrastructure at risk. A variety of approaches have been employed to monitor and understand patterns of erosion of the bluffs at Kalaloch that will be summarized in this presentation, including ground surveys with GNSS, conducted at least twice annually, and often seasonally, since 2013. The results of those ground surveys can be coupled with available aerial lidar to provide insights about trends in morphology and position of coastal bluffs at Kalaloch between 2002 and the present. To complement the ground surveys, in October 2023 five Chronolog community-science photo monitoring stations were installed along the bluffs at Kalaloch. In addition to results associated with ground surveys, we will describe early insights provided by the first winter of photos submitted at those stations.

3:20 Utilizing San Juan National Historical Park intertidal zones for hands on marine science education

Adam Rogowski
University of Washington Friday Harbor Labs, Salish Sea Sciences

San Juan National Historical Park is used by several educational programs aimed at comprehensive Salish Sea ecosystem education. Utilization includes components of the Friday Harbor Labs K-12 Scientific Outreach Program, and local marine science program Salish Sea Sciences.

The FHL K-12 outreach program has used 4th of July beach as an important component of their 6th grade intertidal exploration program. This experience introduces invertebrate phylum to students before sending them to a rocky intertidal zone near the state park, and the soft sediment habitat at 4th of July Beach. Students learn to use transects, quadrats, and sieves to sample organisms from the habitat with the help of FHL scientists and learn about the complexity of soft sediment ecosystems.

High school students from across the country participating in Salish Sea Sciences used 4th of July Beach for a variety of field research and ecosystem comparison for their first real investigative project. Uses ranged from our introductory ecosystem exploration to taking transects of stretches of the beach to compare algal populations below forested or meadow littoral zones. Salish Sea Sciences students also assisted in seed collection for future eelgrass meadow restoration projects at 4th of July Beach.