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Yvonne Worden
Western Washington University

Huxley College of the Environment, Western Washington University

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DEAR READER,

The term “resilience” has two crucial components; experiencing challenges and overcoming them. When both occur, incredible stories emerge.

I once saw resilience in a 70-year-old man named Timoteo. He is an elder of the Bri-Bri tribe living in Costa Rica’s Talamanca Mountains. He led a group of travelers on a river hike in the pouring rain. The terrain was hilly and slippery, but this Bri-Bri elder was more sure-footed than anyone else in our group of 20-somethings. Timoteo’s strength was impressive.

This quarter, The Planet staff sought more resilience stories. We met people who attended the 21st Conference of Parties in Paris, aiming to minimize human-caused climate change. We met people living on Washington state’s Olympic coast who will have to relocate due to increased storms, flooding and sea level rise. U.S. veterans told us how gardening is helping them recover after their service.

Some stories were less human-centric. We encountered sea stars decimated by disease. We met scientists studying microbes deep in the ocean — minuscule beings capable of surviving extreme temperatures and volcanic eruptions. Astronomers showed us how much debris is trapped in our atmosphere from space exploration, the consequences of this “space junk” and efforts to clean it up.

Our video staff investigated how scientists and engineers in the Pacific Northwest are preparing for the next big earthquake and how the community of Darrington, Washington is working to revive itself after the Oso mudslide in 2014.

When reading this issue, contemplate the earth and its inhabitants’ capacity for adaptation and survival.

May these stories intrigue and inspire you.

Keep on keepin’ on,

Yvonne Worden
Editor-in-Chief

In the Fall 2015 innovation issue, the article “Anthropocene Dilemma” contained errors. The pull quote on page 15 was incorrectly attributed to Alex Trembath. The quote actually belonged to Ted Nordhaus. Alex Trembath’s accurate job title is Breakthrough Institute communications director, not senior energy analyst. These errors have been corrected in the digital version of the issue, located on our website. Visit www.theplanetmagazine.net/issues to see the full corrections.

THE PLANET MAGAZINE is the quarterly student publication of Western Washington University’s Huxley College of the Environment. We are dedicated to environmental advocacy through responsible journalism.

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STORIES on Resilience

HIDDEN WORLD
by Tyler Cohen

Microbes feeding off toxic chemical soup from underwater volcanoes and deep sea hydrothermal vents may provide the key to the Earth’s past, present and future.

SEEDS OF CHANGE
by Kamea Black

A Bellingham, Washington woman hopes to help bring the millennium-old tradition of saving seeds to Whatcom County, despite legal barriers.

PICKING UP THE PIECES
by Morgan Doyischer

The Senate passed the Microbead-Free Waters Act of 2015 with a unanimous vote, but scientists say the legislation addresses only a small part of plastic pollution.

BRACING FOR CHANGE
by Sarah Climaco & Evan Keen

Residents of Taholah, Washington and members of the Quinault Indian Nation confront floods and rising sea levels. Now they must relocate the town or risk losing their homes to climate change.

ROOTS OF RECOVERY
by Simon Bakke

After three deployments in the Middle East, a U.S. Air Force veteran and Western Washington University alumnus turns to organic farming to heal from the scars of war.

CHIPPED AND COMPACTED
by Sam Chanen

Cornwall Park in Bellingham, Washington, is a popular place to play disc golf, but the sport may be causing unintentional damage to the natural landscape.

MYSTERY MALADY
by Monet Curnutt & Rebekah Way

Scientists are investigating the causes of sea star wasting disease and whether or not several species can make a comeback.

POWER OF PARIS
by Maddle Gavigan Martin

Our Planet correspondent reflects on her time at the U.N. COP21 Climate Conference in Paris.

STUCK IN ORBIT
by Erik Faburrieta

Years after humankind’s initial ventures into space, our entryway into the final frontier is littered with debris that may make future space travel dangerous and difficult.

ON THE COVER

Micah Hasten, Quinault Indian Nation member, gave me a personal tour of Taholah, Washington, showing the impact of natural damage on the land. He showed me the places he holds close to his heart, from the coastline spotted with tide pools, to his grandfather’s fishing spot lined with nets and boats. I felt his love for their land during a time of transition.

-Sarah Climaco
On April 20, 2015, about 90 scientists gathered in Seattle to discuss Axial Seamount — the most active undersea volcano on the Juan de Fuca Ridge. After eruptions in 1998 and 2011, the next was imminent. Researchers were filled with anticipation, eager to catch the exact moment of the eruption. It wasn’t until several days after the conference ended that Deborah Kelley received an urgent email from her colleague. Axial was erupting, and although they were nearly 500 kilometers away, they had never seen it like this.
"What the microbes do is they really modulate the extremes. They help make the planet more habitable, and they always have."

CRAIG MOYER
PROFESSOR OF BIOLOGY
WESTERN WASHINGTON UNIVERSITY

OFF THE COAST of Oregon, a few thousand meters underwater, lies the spreading center of the Juan de Fuca Ridge. It's a hostile scene — deep sea volcanoes erupt in darkness, covering any life in its path with hot, goopy lava. Nearby hydrothermal vents spew heated seawater mixed with toxic chemicals, including methane and hydrogen sulfide, at temperatures up to 402 degrees Celsius. And yet, these apocalyptic zones are crucial to the survival of our planet, and may have been the starting grounds for life itself. The unlikely heroes? Microbes. Billions and billions of microbes.

Microbes are tiny single-celled organisms, and they're everywhere.

It's been estimated that all the biomass on land doesn't rival the biomass of microbes living in the subseafloor, that dwell in the fissures filled with seawater, heated by underlying magma. Microbes also live within the hydrothermal vents themselves, where they convert toxic gases to the most basic source of energy for any nearby life daring to live in the absence of the sun.

"Almost anything that would kill us, they've figured out how to utilize," said Deborah Kelley, an oceanography professor at the University of Washington.

Kelley is also the associate director of the Ocean Observatories Initiative's Regional Scale Nodes, an initiative to lay roughly 900 kilometers of fiber optic cables on the seafloor just off the coast of Washington and Oregon.

The cables represent a huge leap in deep sea research, as they relay power and instruction to instruments that can conduct tests in the place of researchers, ranging from temperature collection to DNA analysis. The data is sent via the cables to the shore station in Pacific City, Oregon, then to Rutgers University before making it online to be accessed by researchers across the globe. An high-definition camera at the summit of the Axial Volcano also streams live video eight times a day.

The system went live in 2014, in time to catch the eruption of Axial. According to Kelley, data coming in from the cable array showed that over 8,000 low-intensity earthquakes had occurred in that day alone.
It was clear — Axial was erupting. For the first time, scientists were able to collect data as the eruption progressed without even being there.

“We were all really excited, because you wait a lifetime for something like that,” Kelley said.

Soon, billions of microbes would be expelled from the seafloor. Most of the microbes forming deep sea microbial communities are forced up through fissures in the Earth’s crust. Others might be expelled through megaplumes — an ash-cloud-like burst of heated seawater and chemicals that occurs after an undersea volcanic eruption.

Nearby vents termed “snow blowers” might also release microbes entangled in their own exopolysaccharide gunk, forming thin, slimy layers called “microbial mats” upon the cooling lava. As the name suggests, it makes the abysmal scene look like an underwater snow storm.

“We aren’t there, hardly ever, at the right time. We can see the vents afterwards, but not right when they’re forming,” Kelley said. “[The megaplumes] entrain microbes from deep beneath the seafloor, so they let us have a window into that biosphere we don’t get to see very often.”

Kelley took part in an old-school expedition to Axial several months later to observe changes following the eruption. As she slowly descended into the ocean’s depths from within the three-person, deep-sea research vessel called Alvin, Kelley peered through the porthole at the apocalyptic scene.

Over 120 meters of lava — over half the height of the Space Needle — had solidified over the once vibrant hydrothermal vent systems.

First to colonize the scene, microbes spread out over hectares of cooling lava. This microbial buffet could soon start a whole new community for deep sea organisms to thrive on, until the next eruption, of course.

The resilience of these communities may be a clue to how life began. Since the late 1980s scientists have speculated life originated with microbes in hydrothermal vents. German chemist Gunter Wächtershauser published a series of papers on this theory, which he called the Iron Sulfur World Hypothesis.

According to David Butterfield, a senior research scientist at the University of Washington’s Joint Institute for the Study of the Atmosphere and Ocean, the energy and nutrients existing in hydrothermal vents makes the site a good candidate for life’s starting grounds.

“It’s hard to think of another place, another type of environment on earth, that would be better for getting the starting conditions for life,” Butterfield said. “How you actually go from water and rocks and reactions to producing the complicated organic molecules and then producing DNA and replicating life, nobody has that figured out. But if you look at the DNA tree of life for earth, the microbes that you find in these systems are the most ancient things that we see.”

It’s enough to make us multicellular creatures feel small. Not only were deep sea microbes potentially essential to life’s beginnings, they may also be essential to our survival.

Craig Moyer is a professor of biology at Western Washington University who studies the microbial ecology of hydrothermal vent systems. The door and wall outside his office are adorned with stickers, research papers, and scientific posters, all pertaining to his deep life research, including a bumper sticker that reads “Volcanos Rule” (undersea volcanos, presumably).

Moyer said he had always been interested in marine microbiology, and thought working on chemosynthetic systems — which rely on energy from chemicals, as opposed to sunlight — would be easier than researching photosynthetic systems higher up in the water column. At this time, deep sea microbial life was thought to be fairly simple.
It’s hard to think of another place, another type of environment on earth, that would be better for getting the starting conditions for life.”

DAVID BUTTERFIELD
PRINCIPAL RESEARCH SCIENTIST
JOINT INSTITUTE FOR THE STUDY OF THE ATMOSPHERE AND OCEANS
UNIVERSITY OF WASHINGTON

“Since then I’ve found that boy, that assumption was wrong,” Moyer said. “There’s all kinds of stuff going on down there that we didn’t even imagine way back when.”

Take for example, a microbe’s role in climate change. One single-celled organism may not make much of a difference, but their collective impact is significant, Moyer said. Together, they sequester from the oceans, noteworthy amounts of carbon dioxide and methane, both leading greenhouse gases, that could otherwise be emitted into the atmosphere.

Through the process of chemosynthesis, microbes take in carbon dioxide and toxic gases from hydrothermal vents, like methane or hydrogen sulfide. They use this “food” to produce energy and to grow, incorporating carbon dioxide into their biomass by converting it into organic carbon. A microbe will eventually die and become buried in the sediment, thus locking up that carbon in the ocean floor and keeping it far away from our atmosphere, Moyer said.

Moyer said if deep sea microbes weren’t feasting on these chemicals, the presence of greenhouse gases in our atmosphere would increase dramatically, causing climate change to occur at a much faster rate.

Scientists like Moyer are now studying whether or not deep sea microbes could help counteract what we’ve done, in terms of increasing carbon dioxide concentrations in the atmosphere.

“What the microbes do is they really modulate the extremes. They help make the planet more habitable, and they always have,” Moyer said. “It was microorganisms that made [Earth] a nice place to live to begin with, and now we’re going to rely on them even more to basically save us from ourselves.”

TYLER COHEN is a Western Washington University senior studying environmental science. She enjoys exploring the mysteries of the ocean, and hopes to one day attempt free diving.

JESSE NICHOLS is a visual journalism major hailing from a small town on Washington’s Kitsap Peninsula. He loves finding stories in science, data and the human experience.

Heat loving single-celled life forms live in the walls of hydrothermal vents. When an eruption occurs, clumps of bacterial colonies from inside the vents fall like snow across the ocean floor.

The resulting layers of microbes, sometimes called “microbial mats,” become the bottom of the food chain in deeper, lightless parts of the ocean. Very small crustaceans feed on the microbes directly. Larger and larger animals can then feed on the crustaceans.
A simple barrette restrained long wispy silver hair from falling into the eyes of Heather Ktahdn as she wandered through the eighth annual Heirloom Seed Swap in Bellingham, Washington. She made her way through the room to observe a crowd of more than 300 people who had lined up outside in the chilly January air to attend her event.

INSIDE, ESTABLISHED SEED savers displayed educational materials and carefully labeled packets of seeds. Novice seed savers offered seeds preserved from their home gardens in small jars and nondescript envelopes. There were about 30 seed savers in all, each with their own story to share and each a participant in a growing global push for seed independence. This push is known as the seed sovereignty movement.

"We have inherent rights to grow our food," Ktahdn said.

Ktahdn is a longtime seed saver and one of a group of four individuals who started the seed swap in 2008 after reading the book "Food Not Lawns," which encourages people to take surplus resources, such as seeds, and share them with their communities to increase food security.

Since the beginning of agriculture, saving and sharing seeds from crops has been essential to food production worldwide. This shared indigenous practice faced little restriction until the 20th century when intellectual property rights were granted to the developers of new strains of seeds. These rights allow patent holders to be the sole proprietors of a product, excluding others from selling it. This resulted in the illegalization of saving and sharing the seeds of many crops.

As a result, many farmers are dependent on corporations. Monsanto Co. in particular holds a large library of seed and chemical patents that are widely used in conventional agriculture throughout the world, according to an article by Vandana Shiva, an environmental scholar and activist.
"Women are making more money selling seeds. Instead of a huge bundle of tomatoes, which might rot in transport, you can sell the seed, which is more valuable."

NORMA MALDONADO
CO-CHAIR
THE PEOPLE'S COALITION ON FOOD SOVEREIGNTY

Dependency occurs when a farmer has to continuously purchase seeds in order to grow valuable crop varieties year after year. Additionally, farmers must purchase applicable certificate fees, royalties and the product's associated chemicals that ensure a crop's productivity, according to Shiva's article.

The same year the Heirloom Seed Swap began, Krista Rome, owner of Whatcom County's Resilient Seeds Company, started conducting trials in Everson, Washington on beans and grains. Initially, the experiments were a simple effort to fill her pantry with locally grown staple crops. But by 2011, she was selling them.

Rome chooses to only produce open-source seeds her customers can buy and save to replant. Rome's customers owe her no royalties and are not required to purchase any additional products to be successful; they are encouraged to save the seed and use it again.

"It is really empowering to show people how [to save seeds]," Rome said.

Even in her line of work with open-source seeds, Rome has faced intellectual property rights barriers. She spent years growing a specific quinoa variety but a crop breeder in Europe had already registered it. Ultimately, fees and inspections caused her to drop the project.

"There is a very revolutionary act to have your own seeds and to have your own food," Maldonado said.
At Post Point Wastewater Treatment Plant, all solids in the wastewater from Bellingham, Washington, seem to be getting separated out efficiently. In the preliminary treatment room, a giant, mechanical rake pulls aside large solids. Larry Bateman, the operations manager, shows how solids such as larger plastics are removed from the wastewater. Beyond the heavier solids, the plant is designed to remove organic particulates from the water. After the complex process of solid removal, diffusion and chemical treatment, the water is returned to the ecosystem a half-kilometer offshore in Bellingham Bay.

**BY ALL ACCOUNTS, this water is clean.** Immediately after treatment, it may be even cleaner than tap water.

However, the Post Point treatment plant and others like it miss one vital but tiny piece of pollution that may be causing harm — microplastics. These tiny pieces of plastic vary in size but are less than five millimeters in diameter. Microplastics were recently brought into the public eye by a flurry of stories surrounding the Microbead-Free Water Act of 2015, which banned microbeads, a specific type of microplastic.

Microplastics are specific classes of tiny plastic waste, said Joel Baker, science director for the Center for Urban Waters and an environmental science professor at the University of Washington, Tacoma.

Primary microplastics are deliberately manufactured as small pieces of plastic.

Secondary microplastics start as larger pieces, such as water bottles or grocery bags, and break down into smaller pieces over time.

Microbeads are pieces of primary microplastics. They are commonly found in cosmetic products and flushed into natural waterways, such as the Puget Sound, through toilets, sinks and bathtubs.

Microbeads act as abrasive exfoliants in products such as facial scrubs and toothpastes. In many products they also serve an aesthetic purpose.

In gels, they float suspended like a sea of stars; in toothpastes, they appear as shards of blue or white crystal.

Microbeads are a small section of the total microplastic pollution, dwarfed by the secondary microplastics which break down from general plastic pollution, and are much harder to quantify, Baker said.

Products containing microbeads will only be permitted on store shelves until July 2018, when the Microbead-Free Water Act of 2015 goes into effect.

Interest groups and researchers initially brought microbeads to the attention of the legislature because of the potential that they may be causing environmental harm. The bill had wide corporate support, and a host of cosmetics manufacturers had already begun to implement changes before the bill became law.
"Most environmental regulations only happen when the industry agrees."

JOEL BAKER
SCIENCE DIRECTOR
THE CENTER FOR URBAN WATERS

When companies like Procter & Gamble Co. and Unilever were initially confronted about their use of microbeads, they responded not because of environmental or health risks, but because of possible damage to public perception, Baker said.

Because many cosmetic corporations were on board with ending the use of microbeads in their products, it was easier for lawmakers to pass the ban. Far easier than eliminating the use of larger pieces of plastic, such as plastic grocery bags, which have only been successfully banned in a handful of cities in each state.

"Most environmental regulations only happen when the industry agrees," Baker said.

Beyond the public outcry, not enough is known to solidly condemn microbeads as a highly harmful form of pollution because most microplastics found in environmental samples are secondary microplastics, not microbeads.

"We know that some organisms can ingest the microplastics," Baker said, who explained that in some studies, the observed oysters and fish didn’t have access to foods they would normally eat.

Baker also said mussels have been known to accumulate microplastics, evident in the occasional piece of microplastic found in supermarket shellfish.

Oysters suffer from stunted growth and reproduction rates, and reduced offspring survival after ingesting microplastics, according to a study in The Proceedings of the National Academy of Sciences.

"Plastic is pretty inert stuff [without] any acute toxicity," Baker said. Plastic debris are most dangerous when large enough to choke or strangle marine life.

RIGHT: Larger pieces of plastic that end up on beaches often break down over time into microplastics less than five millimeters in diameter. These pieces tend to concentrate on coastlines and in the center of ocean currents.

OPPOSITE PAGE: Microbeads are small plastic particles in personal care products between 100 nanometers and 5 millimeters wide. In December 2015, President Obama signed a bill into law banning the production of cosmetics containing microbeads beginning July 2017. Photo Illustration.

LEFT: Larry Bateman, operations supervisor at Post Point Wastewater Treatment Plant, walks across a bridge on a settling tank where bacteria in the water form clumps and settle out. Traditional wastewater treatment can remove some microplastics, but not all.
“If I’m thinking about ocean ecosystems globally, there are a few things that are more urgent than plastics.”

BROOKE LOVE
ASSISTANT PROFESSOR OF ENVIRONMENTAL SCIENCE
WESTERN WASHINGTON UNIVERSITY

There are other possible problems beyond consumption by animals. Ongoing research is asking whether microplastics, because of their longevity in ocean ecosystems, are allowing viruses and bacteria to migrate to new areas, Baker said.

When microbes hitch a ride on particles, it’s advantageous for the pathogens if the particles never decompose, Baker said.

Microbeads can move up the food chain, from prey to predator, harming fish, humans and other large animals through a process called biomagnification. In the process, many harmful chemical pollutants, such as PCBs and DDT, increase in concentration as they move through trophic levels.

It’s a challenge to study microplastics smaller than a few tenths of a millimeter. Microplastics on the nanoparticle scale cannot always be measured, which leaves blind spots in understanding their potential impacts, Baker said.

“A lot of this consumer stuff is probably in that size range,” Baker said.

If these suggested problems with microplastics are reality, the ban may be a proactive solution, but public concern regarding the abundance of microbeads in the water is disproportionately large compared to other threats, such as climate change or potential oil spills in the Puget Sound.

“Microplastics, for reasons, some of which I don’t understand, are really overhyped as an environmental concern,” Baker said. “I can get an article a week in the local paper about microplastics.”

For all the potential harm microbeads have, experts like Baker and Brooke Love, assistant professor of environmental science at Western Washington University, agree they are a small part of a larger problem.

Baker said it’s possible that the Microbead-Free Waters Act of 2015 is solving problems yet to be discovered.

This legislation has increased public concern about the oceans, Baker said, which may pave the way for addressing larger threats to marine ecosystems.

“If I’m thinking about ocean ecosystems globally, there are a few things that are more urgent than plastics,” Love said. “Climate change, ocean acidification, and overfishing all come to mind as having larger and more immediate impacts.”
Standing near his front yard in Taholah, Washington, Micah Masten reflects on what it’s like to have the ocean invade his home. “During November and December we had to evacuate a couple of times,” he says. The only thing separating homes from the sea waves is a pile of boulders lining people’s backyards.
THE QUINAULT INDIAN NATION, which has about 3,000 enrolled members, is located on the Olympic Peninsula in Washington state. They are composed of the Quinault and Queets tribes, as well as descendants of the Quileute, Hoh, Chehalis, Chinook and Cowlitz tribes. About 840 members of the Quinault Indian Nation live in Taholah.

Residents of the lower part of Taholah are being threatened by the sea. As a result, they are relocating to higher land — a price tag of $65 million. As floods become more frequent, locals are trying to reconcile with leaving their homes.

According to the Taholah Village Relocation Master Plan, 660 people in the lower village are going to have to move almost a kilometer uphill. This move requires the relocation of 175 homes, the post office, the K-12 school and vital community programs.

Many have already begun to relocate and houses have started being built on higher ground. The Quinault Indian Nation has been building new housing on the plateau since the 1980s because of space restrictions in the lower village, according to Larry Workman, the centralized communications manager for Quinault Indian Nation.

Taholah’s seawall, built in the 1970s, is over 304 meters long and about 3 meters high. The wall is formed with large rocks and stretches across the edge of Taholah. In March 2014, this seawall was breached by the ocean, flooding most of the lower part of Taholah.

The U.S. Army Corps of Engineers responded to the breach by repairing over 200 meters of the wall, but this is a temporary fix.

The National Oceanic and Atmospheric Administration has linked two different mechanisms affecting sea level rise: sea water expanding as ocean temperature increases, and melting ice from glaciers adding water to the ocean.

Average temperatures in Washington state are predicted to increase from 3 to 9 degrees Celsius in the next century, according to a 2015 report from The Union of Concerned Scientists.

Storm surges and wave heights are also increasing, causing coastal flooding, according to a report published by the Weather Underground.

“This has major impacts on places where it’s not very high above sea level,” said Dargan Frierson, a professor of atmospheric sciences at the University of Washington. “The ocean level has not yet caught up with the amount of warming that’s happened already. Even if greenhouse gases were no longer being produced, glaciers will continue melting and the water will still expand.”

Sea level rise in Taholah has already damaged and flooded properties. Masten, a member of Quinault Indian Nation, lives in a trailer roughly 15 meters from the ocean. Separating his trailer from the ocean is the sea wall.

PREVIOUS PAGE: Quinault Indian Nation member Micah Masten walks along the tide flats near his hometown of Taholah, Washington. “I am from here,” Masten says. “My creation story is from here.”

ABOVE: A 304-meter-long seawall of boulders stands between the coastal village of Taholah and the Pacific Ocean. The ocean breached the wall and flooded the village during a storm in March 2014.

NEXT PAGE, LEFT: Masten looks out at the Pacific Ocean from a grove of trees near Taholah.

NEXT PAGE, RIGHT: Masten digs for horse clams on the coastline of Taholah.

“it is painful for people to leave the land they have called home for so long — that is the biggest impact of the move on our people.”

FAWN SHARP EXECUTIVE DIRECTOR QUINAULT INDIAN NATION

“The worst I’ve heard is one trailer got lifted up about 10 to 15 feet when the waves broke over,” Masten said, sharing what it’s like when storms hit their homes. “[The trailer] was pulled off its foundation.”

While pointing out the damages along residents’ homes, Masten explained how the landscape of the reservation is constantly changing.

When the lower part of Taholah is flooded, residents’ belongings left outside are swept out to sea, leaving the beach littered with garbage, furniture and household appliances. Further down the beach, erosion can be seen on the cliffside. Trees that once lined the cliff now lay uprooted on the shore.

Executive Director of the Quinault Indian Nation and President of the Quinault Tribal Council, Fawn Sharp, is at the center of the tribe’s efforts to protect homes belonging to members of the Quinault Indian Nation.

If there were an alternative to leaving Taholah, the Tribal Council would have considered it, Sharp said in an email. Because of sea level rise, intensified storms and floods, staying in the lower part of Taholah seriously endangers residents, she said.

“We will not leave our children, our elders or any of our people in harm’s way,” Sharp said in an email.
Other Washington state tribes have chosen moving as a way to avoid floods. In 2012, the Quileute Nation from La Push, Washington received a land grant expand their reservation into land that was part of Olympic National Park. The transfer allocated about 300 hectares to the Quileute Nation so they could move out of the tsunami zone. In return, the tribe granted public access to coastal beaches reached by trails through tribal lands.

Sharp has been working with Washington Sen. Maria Cantwell, Sen. Patty Murray and Rep. Derek Kilmer on a climate adaptation and mitigation strategy since 2014. The relocation has five components: land acquisition, master planning for upper village development and lower village reclamation, infrastructure development, engineering and architectural planning, and workforce development and construction. The master planning phase for the Taholah proposal is projected for completion in 2016.

While the Taholah Master Plan is well underway, some residents in the lower Taholah village would rather not move.

"The water doesn’t stop anymore. It doesn’t stop at the seawall," said Tracy Lewis, a member of the Quinault tribe.

Lewis is a caretaker for 98-year-old tribal elder Clifford Corwin, who doesn’t plan on relocating, Lewis said.

"It doesn’t matter if the ocean came over [the wall] and swallowed half his house," Lewis said. "He will not move."

Although the situation in Taholah is dire, Masten chooses to look beyond the obvious by embracing the beauty radiating from their land. He shared memories full of fishing, hunting and foraging throughout the area. As he walked down the beach, he pointed to different spots of Taholah that are important to him.

While digging for horse clams, Masten explained why he is reluctant to relocate. He took off his shirt and jacket, and then scanned the sand to find evidence of clams. One finally showed itself with a spurt of water escaping the sand. Digging for his prize, Masten realized he was not fast enough and lost it. He said he plans to stay in the Taholah area because of his love for the land, from the sea to the sand and the river through the forest. This is his home.

"I am from here," Masten said. "My creation story is from here."

This is why Masten has not left yet. He plans to relocate when the time comes, but for now he’ll stay in his trailer near the seawall.

Sharp said the Quinault Indian Nation’s history and connection to the land in Taholah will make relocation a difficult transition.

"The land, the ocean, the rivers, the fish and wildlife are far more meaningful to us than any amount of money," Sharp said. "It is painful for people to leave the land they have called home for so long — that is the biggest impact of the move on our people."

SARAH CLIMACO, from Marysville, Washington, is a public relations senior in the journalism department at Western Washington University. She reports and photographs stories and operates Stihl and Honda power equipment. EVAN KEEN is Western Washington University senior majoring in public relations. He spent winter quarter learning about climate change.
ROOTS
of recovery

STORY AND PHOTOS BY | SIMON BAKKE
Sean Dalgarn, a U.S. Air Force veteran and Western Washington University alumnus, spread gravel onto the paths of a Mount Vernon, Washington farm on Martin Luther King Jr. Day. With a reddish beard and full-sleeve tattoos, he leads over a dozen veteran and civilian volunteers to mend the roads connecting the farm’s six buildings. The nearest building was once a clinic for traumatic brain injury patients run by a Vietnam War veteran. When the nonprofit, Growing Veterans, leased this 16-hectare farm, they transformed the building into a rec room with a wood stove, pool table and full kitchen.

LEFT: Sean Dalgarn (right) and Joel Swenson burn some old wood to clean up the original Growing Veterans farm in Lynden, Washington. This one-hectare farm was previously owned by the Bellingham Food Bank.
"This is showing them how to fix those wounds in the long run. It’s empowering you. It’s showing that you have the ability to move beyond the tough issues you may have faced during your military service."

SEAN DALGARN
VOLUNTEER COORDINATOR
GROWING VETERANS

Dalgarn is far from alone in dealing with post-traumatic stress disorder. Anywhere from 11 to 20 percent of veterans who served in Operations Iraqi Freedom and Enduring Freedom experience PTSD. An estimated 22 veterans died from suicide every day of 2009 and 2010, according to a report from the U.S. Department of Veterans Affairs.
"[The work] puts you in touch with the one thing we can count on, and that's the Earth."

SEAN DALGARN
VOLUNTEER COORDINATOR
GROWING VETERANS

Once back at school when his enlistment ended, Dalgarn worked in the Whatcom Community College Veterans Services Office. He learned how to use the services available to veterans from a mentor, a U.S. Marines veteran, who helped Dalgarn better understand his resources and opportunities.

Dalgarn jumped on the opportunity to use his experiences to help other veterans. He connected with Chris Brown in the human services program at Western Washington University. Brown is co-founder of Growing Veterans, where Dalgarn got involved after graduating.

But why organic farming? Brown sprouted the idea after finding himself stuck with physical and psychological injuries from three combat deployments with the U.S. Marines. His counselor suggested gardening, and as his garden grew, Brown said he saw himself growing and healing as well. He started thinking about how to make this applicable to his job at the WWU Veteran Services Office.

“There was something to working with plants,” Brown said.
Being out on the farm helps veterans fight depression and PTSD, and has a range of related benefits, said Chris Wolf, operations manager and co-founder of Growing Veterans.

“If you take any human being and you give them more physical exercise, a purpose they believe in, a team of other people who care about them and they see on a regular basis, a healthier diet, more vitamin D and contact with dirt, they almost have to be happier,” Wolf said. “It's all the factors that lead to human wellness.”

For Dalgarn, after working with Growing Veterans for over seven months, he feels better more frequently. His symptoms have lessened over time, and though he still struggles with nightmares sometimes, Dalgarn said he can sleep like a baby now.

“[The work] puts you in touch with the one thing we can count on, and that's the Earth,” Dalgarn said.

Using agriculture to help veterans reintegrate into civilian life is a growing field. The U.S. Department of Agriculture announced a grant program in 2014 to aid veteran and minority farmers. Organizations in other states, like the University of Nebraska program Combat Boots to Cowboy Boots, aim to make veterans self-sufficient farm owners.

There are now three Growing Veterans farms in northwest Washington — Mount Vernon, Auburn and the original Lynden property. A portion of the produce from the farms is sold at a market next to the Veterans Affairs Puget Sound Medical Center in Seattle. The rest is donated to food banks or goes home with volunteers.

At the market, Growing Veterans staff have an unwritten policy that if they notice someone outside the hospital who is looking at the produce but cannot afford it, they fill up a bag and send them home with food.

For the rest of the afternoon in Mount Vernon on MLK Day, everyone moved gravel and readied the farm for springtime. When they broke for lunch in the rec room — ham and potato soup with potatoes and garlic from the farm — the meal was laid out around the table’s centerpiece, a combat helmet with lavender and primrose planted inside. A veteran played a mandolin with another volunteer. Billiards clacked together over laughter from the other end of the room.

“Organic agriculture is a huge deal. Reducing the veteran suicide rate is a huge deal,” Dalgarn said. “[We are] showing people there is life after service and you can repurpose your life to help others or to help yourself.”

BELOW LEFT: Sean Dalgarn, Growing Veterans volunteer coordinator, stands in the office of their Lynden farm. Dalgarn served two deployments in Iraq and Kuwait before returning to get a human services degree from Western Washington University.
BELOW RIGHT: Volunteers for Growing Veterans serve lunch in the recreation room after working to prepare the 16-hectare farm in Mount Vernon, Washington for springtime. At the center of several tables in the room, inverted combat helmets hold plants and herbs.

SIMON BAKKE is a Huxley College senior studying environmental science. He didn't think he had it in him to be a photojournalist, but hey, he learns something every day.
The 9-hole disc golf course at Cornwall Park in Bellingham, Washington, is surrounded by towering Douglas-firs and western red cedar trees. It's before noon on a cold Tuesday and a man in a green plaid shirt and jeans is already playing disc golf. He throws a Frisbee-like disc toward the basket and eventually makes a shot.

**While the Course** brings many visitors to Cornwall Park, it also attracts disc golfers who put the health of the soil and trees at risk. Disc golf is the Frisbee version of regular golf, and its rules are similar. As its popularity grows park managers and enthusiasts must decide if disc golf can be played without scarring the natural landscape.

As the City of Bellingham Parks and Recreation Department Grounds Supervisor Steve Nordeen placed his hand on a Douglas-fir, he quickly identified how one side of the tree's bark had been chipped and discolored, while the other side appeared to be unharmed.

If a tree is physically damaged, then it becomes more susceptible to disease, Nordeen said. Because of disc golf damage, up to 10 trees have been removed from Cornwall Park.

Disc golf is one of the fastest growing sports in the world. Three thousand disc golf courses exist in the United States and 100 new courses are established each year, according to a 2014 study by researchers at Kansas State University.

Compared to Frisbees, the discs fly further and faster. However, their weight is similar to a Frisbee, weighing between 120 and 180 grams.

In addition to potentially harming the trees, the soil compaction from foot traffic at Cornwall Park resulted in the soil becoming cement-like.

When the soil is compacted and hard, it makes it difficult for new plants, such as native shrubs, to grow underneath the trees, Nordeen said.

The soil compaction can restrict root growth and lead to disease from limited drainage, according to a 2005 report from the Tree Associates Professional Consulting Arborists.

Soil compaction prevents the roots from accessing oxygen and water, causing the roots to die and trees to possibly fall over, said Brandon Brodie, certified arborist and owner of Earthworks Tree Service in Bellingham, Washington.

Brodie, a disc golf player himself, mentioned how underneath the bark is the most important part of the tree, because that’s where the bark cells and new wood cells are being produced.

"Once the bark gets penetrated then you’re going to start seeing rot,” Brodie said.

The discs hitting the trees can reach speeds of over 80 kilometers per hour, according to a 2015 study by researchers at Kansas State University.

"Once the bark gets penetrated then you’re going to start seeing rot.”

Brandon Brodie
Certified Arborist
Owner of Earthworks Tree Service

**Above Left:** Damaged trees are more likely to succumb to disease or pests.

**Above Right:** A disc golfer aims to get his disc into a chain-link basket in the fewest possible number of throws from a starting platform.

**Next Page, Right:** Steve Nordeen, Bellingham Parks and Recreation Department Grounds Supervisor brushes aside some compacted soil near one of the disc golf holes, which can prevent tree roots from getting air and water. Some disc golfers helped the park department keep the course’s soil healthy by spreading mulch to add organic matter and relieve soil compaction issues.
The trees are getting hit hard and while no exposed bark has been seen yet, it's close, Brodie said. "Even though I love disc golfing [at Cornwall Park] and I love the sport, it's definitely at the sacrifice of the trees," Brodie said. "They can handle a lot of abuse, but I think more care could be taken.

To protect the trees, the parks department will be attaching a rubber mesh-type material to the trees in play, Nordeen said.

Compared to traditional golf, disc golf doesn't require trees to be cut down to design the course or a chemically treated green, according to a 2011 study in the *International Journal of Sport Management, Recreation and Tourism*.

"You don't have to cut anything down, the course is a natural layout through the trees," said Colin Morris, an industrial maintenance mechanic and disc golfer. "It's the easiest sport to set up and play because you use the trees as natural fairways."

Morris played his first game of disc golf at Cornwall Park back in 2003. He went on to become a professional disc golf player and is the current steward of the course at Cornwall Park.

"It's crazy," Morris said.

In the past three to four years, the popularity of disc golf has grown at Cornwall Park. When he started playing, there were a few regulars, but now there are families, couples, kids and large groups going out and playing, Morris said.

To help relieve the pressure from the increased use, Morris got approval for a disc golf course at Van Wyck Park in Bellingham, and is waiting for a parking lot to be built for the course.

"Alleviating the pressure would be getting a new course," Morris said.

The parks department attempted to address soil compaction at Cornwall Park by delivering woodchip mulch throughout the year. Disc golfers have been working with the department to spread mulch piles, Nordeen said.

The woodchip mulch helps protect the soil from further compaction, said Andy Bach, an associate professor of geography at Western Washington University and an avid disc golfer.

Applying mulch increases the level of organic matter in soil areas that have been affected by foot traffic and lack of vegetation growth, according to a 2011 study in the *International Journal of Sport Management, Recreation and Tourism*.

As organic material such as woodchips decay it's going to turn into the organic materials that would normally be going into the soil, Bach said. Both tree health and soil compaction are equally important, because you need one to keep the other one healthy, Nordeen said.

Some people would say Cornwall Park is a good place to play disc golf and others would say it's not, Nordeen said.

As the man in the green plaid shirt throws his disc at the chained basket, the sound of the disc rattling the chains can be heard from quite a distance and accompanies the booming sound of Squalicum Creek's flowing water.

Arborists, disc golf players and volunteers will continue working together to accommodate outdoor recreation and limit disc golf damage at Cornwall Park.

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"Even though I love disc golfing [at Cornwall Park] and I love the sport, it's definitely at the sacrifice of the trees."

BRANDON BRODIE  
CERTIFIED ARBORIST  
OWNER OF EARTHWORKS TREE SERVICE

SAVY CHANEN is a Western Washington University junior studying public relations. As an Eagle Scout who has gone camping throughout Washington, he feels a strong connection to the great outdoors.

SIMON BAKKE is a Huxley College senior studying environmental science. He didn't think he had it in him to be a photojournalist, but hey, he learns something every day.
Western Washington University biology professor Benjamin Miner walked into the all-white room and shook his head. On a table to his left, there were three tanks; two tanks of clear seawater and purple sea stars, and one tank of dirty brown seawater full of disintegrating sea stars, capped with bubbles made of the same proteins that once held the stars together.

"THEY WERE ALL ALIVE LAST WEEK," Benjamin Miner said.

Since fall 2013, sea star wasting disease has devastated the sea star population of the West Coast. Theories of its cause rang from a virus to changing oceanic conditions. Currently, Miner is researching the effects the loss of sea stars could have on their ecosystems and exploring ways to assist in their recovery.

One of the most devastated sea star species is the sunflower sea star, *Pycnopodia helianthoides*, characterized by its 20 or more arms.

"[The sunflower sea star] was super abundant. In some places, there were so many it was like a carpet. You couldn’t even see the bottom [of the sea floor] because there were so many of them," Benjamin Miner said. "It’s unbelievably rare for someone to see one of these individuals, an adult, anymore."

Melissa Miner, research associate at the University of California, Santa Cruz helped conduct biodiversity surveys along the coastline from Alaska to Mexico, and she has observed few sea stars surviving through their juvenile and adult life stages.

The decline in adults resulted in fewer available mating pairs, Benjamin Miner said. Sea stars free-spawn, a process where they shoot their eggs and sperm into the water with hope the two mix and fertilize. If there are not enough sea stars, the chance of successful free-spawning is slim.

Locations once full of adult sunflower sea stars have since been filled with the sunflower star’s meal of choice: green sea urchins, Benjamin Miner said. Now the larger adult urchins appear to have taken over what used to be the sunflower’s domain.

This result could have a cascading effect — increasing the sea urchin population lowers the presence of algae, their food of choice, and takes away the protection or habitat for smaller invertebrates and crustaceans in the Puget Sound, Benjamin Miner said.

Information on abundant species such as the ochre and sunflower sea stars makes it easier to compare what the populations were like before and after the recent rampage of wasting, Melissa Miner said. But it’s harder to say how rarer species are affected since less research has been done on them, she said.

In the San Juan Islands, an average loss of 70 percent of the most common sea star of the region, intertidal ochre sea stars, was observed during a mass mortality event in summer 2014, said Drew Harvell, a professor of ecology and evolutionary biology at Cornell University, in an email.
"There are definitely [environmental] stressors that might make sea stars more susceptible to whatever the cause of the disease is, but it's all speculation at this point, nobody knows for sure."

MELISSA MINER  
RESEARCH ASSOCIATE  
UNIVERSITY OF CALIFORNIA, SANTA CRUZ

"Some recovered in fall 2014, but then, unfortunately, about half of the remaining survivors continued to die in summer 2015," Harvell said. "The few survivors look OK now, but the real test will be how they are in the summer."

Scientists studying sea star wasting disease have identified a virus, sea star-associated densovirus, as a possible cause of the recent mass mortalities. The syndrome has also largely affected morning sun, mottled and giant pink sea stars, according to a University of Santa Cruz website run by researchers studying intertidal ecosystems.

However, some sea star species, including the Pacific blood and leather species, appear to be more resistant in the early stages of the syndrome, Harvell said.

Densovirus can also affect other members of the echinodermata phylum. Commonly known as echinoderms, these animals include sea stars, sea urchins and sand dollars. However, sea star wasting disease is the first recorded event where sea star-associated densovirus is singularly affecting sea stars, according to a study in the Proceedings of the National Academy of Sciences.

"There are definitely [environmental] stressors that might make sea stars more susceptible to whatever the cause of the disease is, but it's all speculation at this point," Melissa Miner said. "Nobody knows for sure."

Sea star wasting appears to progress more rapidly in warmer waters, Harvell said.

Mortality events, possibly of the same cause, have occurred in the past, Benjamin Miner said. Though these outbreaks appear to peak during El Niño years, isolated events have been noted during other years.

"But it has never been even remotely close to as extensive as it has been in the last three years," Benjamin Miner said.

Oceanic conditions shift during El Niño years — winds change the patterns of the current, carrying water from lower latitudes to more northern coastal areas in the Pacific Ocean and drastically changing weather patterns. Because of this, it's unclear whether this warmer, southern water is causing the syndrome or if it could be carrying an organism that is affecting the stars, Benjamin Miner said.

But Benjamin Miner has another idea. He says he wonders if the underlying cause of sea star wasting could be like HIV in that an infected person doesn't die of HIV, but it compromises their immune system so they can no longer fight off other diseases. In the case of sea stars, it would mean they are no longer able to defend themselves from a secondary invader, he said.

But recovery may be on the horizon. Melissa Miner has seen recovering populations of juvenile sea stars in nine of the 70 or 80 sites being observed.

"If they do survive, then I think the outlook for recovery is pretty good because these guys are broadcast spawners. If we start to see recovery in some areas, then those will likely help neighboring areas recover," Melissa Miner said. "But I think it's too early to say at this point."

MOINET CURNUTT is a native Seattleite and coffee lover, she is a Western Washington University junior and news journalism pre-major. She loves natural and environmental sciences, as well as sociology.

REBEKAH WAY is a Western Washington University sophomore studying journalism. She enjoys podcasting, playing jazz and learning about the world.

ERYNDAE THORVALDSEN is a Western Washington University sophomore studying urban planning and sustainable development. A Wisconsin native, her biggest passions in life are photography, food and playing in the snow.
PARIS — Still groggy from jet lag, my arm dangles from the top bunk while I chat with my roommate Alicia. She’s standing at the mirror of our Paris hostel, readying herself for another sleepless 48 hours. Despite being in the city of love and lights, this is no vacation.

JUST 10 KILOMETERS away from the hostel is Le Bourget, where delegates like Alicia are negotiating to protect the future of humanity. I and another hundred thousand-odd individuals from over 200 countries were inspired to travel to the 21st United Nations Conference of Parties to discuss climate change. The people here are united by a common cause, carrying a common burden, on a warming planet. Nearly everyone I meet is confronting climate change in their own way.

Touching down at the Aéroport Paris-Charles de Gaulle, I grip the arm rests, bracing myself as the wheels bounce on the tarmac. I first traveled to France when I was 16 on a summer exchange. I fell in love with my host family, their culture, and of course, the food. This time, it’s different. The month prior to my travels, terrorist attacks have devastated Paris and shaken the country.

On the train to the hostel I clutch a map in my hands, as if holding tighter will squeeze more information out of it. I’m admittedly nervous to be traveling alone, thinking of those who begged me not to travel to a country that had declared a state of emergency.

At the hostel, I drop my bags and clamber into a seat overlooking an overgrown courtyard. Too tired to whip out my minuscule French vocabulary, I order a veggie burger and fries in English, wondering what the next few days will bring.

When my room is ready, I take the elevator to the seventh floor, showing my keycard at three different checkpoints. No one else is in the room, but belongings of my roommates remain.

Hanging in plain sight is a shoulder bag with an emblem of a green leaf and the Eiffel Tower in its center. It says, “Ceci était un pull,” or “This was a sweater.” I’m relieved to see I won’t be alone anymore.

Later, I meet the owner of the bag. To me, she’s Alicia, a kind and gentle speaker who keeps odd hours. It is her sixth time at a COP meeting.

ABOVE: Paul Cheoketen Wagner (center) plays a flute in a demonstration during the U.N. climate conference in Paris. Cheoketen Wagner is part of a group of demonstrators carrying salmon flags, including members of indigenous nations of Washington state and British Columbia. Photo courtesy of Christine Castigliano
"We are moving too slowly, painfully slowly, given the urgency indicated by the science. We are well on track to warm the planet by far more than 2 degrees Celsius."

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**Daniel Price**

**Antarctic Climate Scientist**

She has already been here for more than a week, and her voice strains a bit over the stresses of negotiations to come as we talk. Alicia's barely slept since her arrival. Brushing back her dark, bobbed hair, we chat comfortably about the status of the Paris Agreement, this COP's primary negotiation.

Her belongings are meticulously organized, including a stack of chocolate at the head of her bed. To the Philippines, she is Dr. Ilaga, one of the most important people of their COP21 delegation, the lead negotiator for adaptation.

Adaptation recognizes it's impossible to fully halt the damages of climate change. In climate change policy, adaptation is used to anticipate how severe those damages will be.

The Paris Agreement explicitly states financial contributions will be needed to assist developing nations. The word "adaptation" is mentioned 85 times in the 31-page agreement.

This is of crucial importance to the Philippines.

In November 2013, Typhoon Haiyan, known as Super Typhoon Yolanda in the Philippines, killed thousands and caused billions of dollars in damage. When Yolanda hit the Philippines, Alicia was across the world at COP19 in Warsaw, Poland, just two years before COP21.

"My country is just reeling from another Category 5 typhoon and what we are counting are the dead; they are being buried, washed away by this abomination that is not our doing," Alicia said to the Warsaw media.

Alicia's country emitted just 0.3 percent of total greenhouse emissions in 2010, according to the World Resource Institute. Yet the Climate Vulnerable Forum considers the Philippines one of several nations most affected by climate change.

The international partnership, an alliance of 43 developing nations and small island states, campaigned for the Paris Agreement to aim for warming the planet by less than 1.5 degrees Celsius, an action the Climate Vulnerable Forum acknowledges is more ambitious than the standard set by the Paris Agreement.

Alicia said limiting temperature rise to 1.5 degrees Celsius or lower is important to the Philippines, being one of the most vulnerable countries to climate change.

"The Philippines, being located along the Pacific Ring of Fire, is susceptible to quite a number of risk factors," Alicia said in an email after the conference. "[They] include the rise in sea levels, extreme rainfall events, extreme heating events, increased ocean temperature, and other impacts such as landslides, flash floods, droughts, disturbed water budget and severe agricultural impacts."

The final agreement establishes global warming must be limited to "well-below" 2 degrees Celsius, an aim nations of the Climate Vulnerable Forum say is a risk to the survival of vulnerable nations.

Since 1880, the global temperature has warmed by nearly 1 degree already, which leaves only another available degree in the planet's global warming "budget" of 2 degrees total.

Alicia, a negotiator for her government, isn't the only one fighting for recognition for her country. Citizens are fighting for themselves, too.

In the Climate Generations area, known as the Green Zone at COP21, an open area for the public to visit, I meet two ambitious young scientists.

The two had arrived earlier that week, after collectively trekking 15,000 kilometers by foot and bike from the polar regions, a distance equivalent to more than 355 marathons.

Over half of the collective distance was biked by Daniel Price, a British scientist studying Antarctic climate. Leaving his research behind, he began cycling to Paris, determined to bring about climate change awareness.

"For years now I've felt like I'm the crazy guy in the room [when I talk about climate change]," Daniel said in an email. He tells me the hardest thing is overcoming the fear of what other people think when what you're talking about is not popular.

At their presentation, Daniel and his Arctic counterpart, Erlend Moster Knudsen, discuss climate change communication and swap tales from their trip to Paris in front of an enchanted audience.

Afterward, one audience member applauds them for using their charm and intelligence to advance their cause. Daniel and Erlend blush, embarrassed by the flattery.
Afterward, one audience member applauds them for using their charm and intelligence to advance their cause. Daniel and Erlend blush, embarrassed by the flattery.

Daniel reflects on the Paris Agreement as this yearlong journey comes to an end in the negotiations’ namesake, “We are moving too slowly, painfully slowly, given the urgency indicated by the science. We are well on track to warm the planet by far more than 2 degrees Celsius.”

At breakfast one morning I set my tray down across from a young woman who is unfazed by people’s disinterest in climate change action. From Atlanta, Georgia, Lauren Wiggins is a student of Tennessee State University and representative for the Historically Black Colleges and Universities Climate Change Consortium. Her university offers virtually no environmental programs or organizations for students she says. Lauren herself had only heard of climate change a few years ago, because of what Lauren says she believes is the general denial of climate change in the South.

We chat about what it’s like being in Paris, and Lauren laughs after every sentence, perhaps nervous for a press conference she is preparing for later this afternoon. I offer to listen to her speech, my face twisting at the bites of tart yogurt I take while she talks. Quick, yet confident, she rehearses her speech

She’s speaking on a Sierra Club panel to “award” the Renault-Nissan Alliance the inaugural Unjust Transition Award, calling out the company for not allowing workers to unionize in their Mississippi and Tennessee plants. These two plants have the highest percentage of African-American employees of all Renault-Nissan Alliance factories, Wiggins said.

Lauren recalled a story told at the conference about how the use of resources by settlers in the United States resulted in a belief they were more entitled to the land than its indigenous residents, creating a link between racism and environmental degradation.

“We’re seen as a white, middle class movement,” Lauren says of environmental activists. She tells me she is here to represent those who cannot speak for themselves, and are affected by environmental injustice or who may not have climate change action at the forefront of their mind.

“People of color are generally the first affected and the worst affected by climate change,” she says.

Lauren reflects on a Black Lives Matter action that was planned to occur the day before she left Paris, explaining their signs were confiscated by COP21 security. She says they were told the signs were removed because they were in English and could not be understood, but Lauren wonders if it was because they are African-American.

“We are human beings, your life matters no more than my life. So we deserve the same protections; we deserve the same freedoms,” Lauren says.

As I board the plane to leave Paris, I’m left wondering about the stories spoken for by Alicia, Daniel, and Lauren, and those whose stories remain untold. I consider the stories of those people, all from different corners of the earth, speaking a multitude of languages I’ll never comprehend, here for one cause.

Above the tarmac, settling into my seat, I look out the window and think through the last few weeks and how the different people I met are fighting environmental problems.

“There are so many, already ongoing implications of climate change,” Erlend later said, reflecting on his journey to COP21. “To me it’s an even stronger understanding of how important and urgent this is.”

MADDIE GAVIGAN MARTIN is a Western Washington University senior studying environmental education. An impassioned sustainability advocate for the past ten years, she enjoys admiring Ginkgo biloba trees and astronomical objects.
February 10, 2009: Communications satellite Iridium 33 and defunct Russian satellite Cosmos 2251 collide high above Earth. What bleeds from them is approximately 1,850 fragments that now travel in low Earth orbit at speeds of nearly 1,000 kilometers per hour, just shy of the speed of sound.
CURRENTLY, 7,000 METRIC tons of orbital debris reside in both the near-Earth space environment and low Earth orbit, the equivalent of over 4,000 midsized cars scattered around the area up to 2,000 kilometers above the Earth’s surface. An estimated 23,000 debris pieces occupy the same space as constellations of satellites and spacecrafts, which make modern life possible. Scientists who study orbital debris hope to prevent buildup of a satellite graveyard, which would confine us to our own atmosphere.

Satellites and spacecrafts, million-dollar machines, are the data collectors and signal senders that feed services including Google Maps, international phone calls and the Internet.

There are two elements to the debris problem: prevention and cure. Navigating in low Earth orbit is currently a manageable act even with looming debris clouds, which is why mitigation standards are being developed for spacefaring agencies. An international assault on space junk would be the ultimate cure for the debris problem.

As of October 2015, the International Space Station has performed 25 collision avoidance maneuvers in the last 17 years. The 24th maneuver was to avoid a debris fragment from Iridium 33.

"Prevention is always the best first defense against future [debris] population increase," said J.-C. Liou, NASA chief scientist for Orbital Debris. Liou’s department also provides annual debris updates and summaries of debris research activities to the Scientific and Technical Subcommittee of the U.N. Committee on the Peaceful Uses of Outer Space.

The Iridium-Cosmos collision was the very first time a fully operational spacecraft was completely destroyed by a piece of debris, underlining the potential of a debris domino effect, Liou said. But while the state of orbiting debris has yet to reach critical conditions, debris experts predict one collision involving a spacecraft every five to 10 years for the next 30 years.

The U.S. Air Force and Space Surveillance Network is able to track and catalog debris greater than 10 centimeters in size so that spacecrafts can be warned of debris in their paths. NASA’s ground-based radar and telescopes are monitoring the estimated 500,000 debris particles.

"Why do we care about debris that small? It is because of the high-impact speed in space," Liou said.

The average impact speed between two orbiting objects in low Earth orbit is about 10 kilometers per second, more than 10 times the speed of a bullet, Liou said.

"Why do we care about debris that small? It is because of the high-impact speed in space."

J.-C. LIOU
NASA CHIEF SCIENTIST FOR ORBITAL DEBRIS
SPACE WASTE

The U.S. Space Surveillance Network has spotted over 9,000 non-functional objects in orbit around the Earth. Of course, this is just what can be measured from the ground - there are thousands of times more particles and bits of broken hardware flying across the exosphere that can’t be seen. If junk continues to collect in orbit, future launches and satellite networks become increasingly more likely to be ruined by rogue pieces of space waste.

A boost from a “self-destruct” rocket at the end of a satellite’s lifetime can safely pull a dead satellite out of orbit. There are currently no regulations requiring satellites to have this type of self-removal plan, and manual removal efforts require whole missions to take down a single object.

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OBJECTS IN ORBIT

The cloud of debris is comparable to the early days of the Industrial Revolution, when pollution was everywhere, said Robert Winglee, a professor at the University of Washington Department of Earth and Space Sciences.

“We’re making pollution in space right now and no one’s actually spent a lot of time thinking about how to clean the mess up there,” Winglee said.

Winglee has been working on a magnetized-beam plasma propulsion device, referred to as a mag-beam, to assist with shortening the length of space travel. Instead of crafts depending solely on their fuel and orbits to propel them, an isolated device would help push them. A spin-off of the idea is now being considered as a potential debris removal operation.

The mag-beam device would target an area of low Earth orbit with lasers, push debris out of orbit and send them either outside of low Earth orbit or into Earth’s atmosphere where they would burn up upon reentry.

“You can start thinking about a single mission deorbiting, maybe, hundreds of thousands of objects as opposed to a few small objects,” Winglee said.

Mag-beam researchers attempted to demonstrate the technology would be able to deflect a piece of debris. However, investigations to figure out the optimal location for such a device are still needed.

Jonathan W. Campbell, astrophysicist and project manager for the NASA Advanced Projects Office, estimated that by using a laser propulsion method, one laser facility could remove all of the debris NASA is monitoring in three years or less.

Campbell estimated an effective ground-based laser facility operating near the equator would cost about $100 million to create, according to a 2000 report concerning the usage of lasers for orbital debris removal.

Graduate students at UW are creating a satellite to one day enter Low Earth Orbit. Paige Northway, a third-year graduate student, is one of the contributors to the development of the university’s CubeSat. CubeSats are privately funded, shoebox-sized satellites.

While CubeSats don’t have much protection, features such as a thin metal sheet might help.

“If it’s real small debris, like really, really tiny debris, that’ll probably stop it,” Northway said. “If it’s any bigger than that, nothing we can do is going to make a difference.”

The UW Earth and Space Sciences’ lab plans to equip their CubeSat with a pulse plasma thruster that would be able to change the orbit and velocity of their satellite. The thruster would demonstrate self-propulsion on a CubeSat, which normally are subject to the orbits they fall into.

“In the United States, for small satellites universities are launching, you’re actually required to make a good case your satellite will deorbit within 25 years,” Northway said.

Debris removal operations that serve no immediate advance of national security or assists in any data collection are not a funding priority, said Casey Dreier, space policy director at The Planetary Society. The Pasadena, California-based non-profit promotes space exploration.

“Who wants to pay for that, when at the moment, you can deal with existing in kind of a messy area,” Dreier said.

The U.S. government’s plan to lessen the amount of debris has become a widely accepted strategy within the space community. The proposal sets the idea that planned release of debris larger than five millimeters should either leave Earth’s orbit or be planned for removal within 25 years.
“It’s like getting everyone to eat their vegetables. It’s harder to do it, it costs more money to think about, it’s good for everybody. But, it’s a long-term benefit, not an immediate benefit.”

CASEY DREIER
SPACE POLICY DIRECTOR
THE PLANETARY SOCIETY

While the 25-year plan is an agreed upon industry standard, it’s not an international requirement. Enforcement only exists in the space programs that set aside the time and budget to self-regulate.

“It’s like getting everyone to eat their vegetables. It’s harder to do it, it costs more money to think about, it’s good for everybody,” Dreier said. “But, it’s a long-term benefit, not an immediate benefit.”

In December 2009, Liou’s program co-hosted an International Conference on Orbital Debris Removal with the Defense Advanced Research Projects Agency in Chantilly, Virginia. The conference showcased speakers from over 43 international agencies that gave presentations on orbital transfer and laser systems, capturing objects, and legal and economic issues.

International recognition of space debris protocol is a continuous goal for 13 of the major agencies from the conference. Liou was chairman for the multinational Inter-Agency Space Debris Coordination Committee. The committee was in charge of presenting an overview of its annual activities to the U.N. Committee on the Peaceful Uses of Outer Space.

From the guidelines presented, the U.N. committee developed a similar set of guidelines. These were adopted by the U.N. General Assembly in 2007, creating a step forward in international debris management.

“Right now we need to focus on mitigation,” Liou said. “But at the same time, we should encourage technology development for creative ideas, for cost-effective ways for potential remediation efforts we may need in the future to better manage the orbital debris problem.”

ABOVE: Casey Dreier, Director of Space Policy for The Planetary Society, works in his office space in Bellingham, Washington.
LEFT: Paige Northway, a University of Washington graduate student works in the Earth and Space Science lab there.

ERIK FABURRIETA studies environmental science and journalism at Western Washington University. He enjoys bridging the gap between the curious and scientists who dare to dream of uncovering the unknown.
ERYNDAE THORVALDSEN is a Western Washington University sophomore studying urban planning and sustainable development. A Wisconsin native, her biggest passions in life are photography, food and playing in the snow.
SEISMIC FORESIGHT

Researchers along the West Coast are developing an early earthquake warning system to detect earthquake waves before any major shaking begins. Harnessing this kind of information will give the ability to send out alerts that can offer seconds to minutes of earthquake preparation.

CURRICULUM FOR RECOVERY

Two years ago, the deadly Oso landslide rocked the nearby small town of Darrington, Washington. In an effort to revitalize the town, local and regional educators and policymakers are developing a cutting edge science and technology education program that capitalizes on the town's natural assets and experience.

RANDEE MATTHEWS is a passionate Western Washington University visual journalism student who finds joy in meeting new people and capturing the world's beauty.

JARED RUSK is a senior visual journalism major from Kingston, Washington. He has a passion for filmmaking, music and adventure.

THE METRIC SYSTEM

The Planet, an independent publication rooted in science, has switched to the metric measurement system because it is widely used in scientific literature. Constantly converting from the imperial system is difficult, so see our table of common references online at theplanetmagazine.net/metric-system.
“Although the world is full of suffering, it is full also of overcoming it.”

HELEN KELLER