SPECIAL ISSUE: OREGON'S CLIMATE

terra

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Facing Climate Change

Oregon confronts the human and ecological risks

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FEATURES

DEPARTMENTS

Mt. Hood at sunrise. (Photo: Dudley Chelton, College of Earth, Ocean, and Atmospheric Sciences)

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OSU is a leading public research university with more than $262 million in research funding in FY2011. Classified by the Carnegie Foundation for the Advancement of Teaching in its top category (very high research activity), OSU is one of only two American universities to hold the Land-, Sea-, Sun- and Space-Grant designations. OSU comprises 11 academic colleges with strengths in Earth systems, health, entrepreneurship and the arts and sciences.

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On the cover
Matt Horning, forester with the USDA Forest Service, surveys trees burned in the 2003 B&B Complex fire. (Photo: Lynn Ketchum, Extension and Experiment Station Communications)

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CLIMATE ROULETTE

I am lousy at poker, but that doesn't keep me from participating in the worldwide gamble we call climate change. It's a game of chance with deadly consequences. With each passing year, we up the ante by adding more greenhouse gasses to the atmosphere and tipping the scales in favor of a drastically different future.

Some of the cards are already on the table: receding glaciers, rising sea levels, rampant forest pests, eroding coastlines, intense storms and spreading drought. By themselves, such trends are not the definitive signature of a changing climate. Taken together, however, they demonstrate that we are indeed living on a new planet, as author Bill McKibben argues. Here, the chances are diminishing that future generations will be able to grow enough food, keep people healthy, ensure public safety and enjoy our rich ecological heritage.

This issue of *Terra* shows what some Oregon scientists, foresters, farmers, public health officials and planners are doing to prepare. They face a moving target, because as they work, knowledge continues to evolve. Two recent examples from OSU suggest the scale of the challenge. A 2011 report in the journal *Science* by OSU professor Andreas Schmittner and colleagues concluded that the most drastic climate scenario posed by the Intergovernmental Panel on Climate Change (IPCC) is less unlikely than had previously been judged. Contrary to some criticism, they did not rule out major consequences from small changes in climate.

Earlier, Alan Mix, one of Schmittner's colleagues on the *Science* paper, co-authored a report in *Nature Geoscience* that throws cold water on a hypothesis involving the source of atmospheric carbon that ballooned after the last Ice Age. The evidence from a deep-ocean site about 70 miles off southwest Oregon was conclusive: The carbon came from some place other than the northeast Pacific, which scientists had considered the most likely location. The findings, said Mix, left them puzzled.

These might seem like arcane footnotes to arguments among specialists, but on them and other details rest our understanding of how the planet works. Much of that knowledge is in hand, but while scientists have reached wide agreement about the outlines of a changing climate, the picture is still coming into focus.

What do current trends mean for the rest of us? Here's a view from writers and scientists assembled last fall by OSU's Spring Creek Project for Ideas, Nature and the Written Word. In the Blue River Declaration, they wrote: "A truly adaptive civilization will align its ethics with the ways of the Earth. A civilization that ignores the deep constraints of its world will find itself in exactly the situation we face now, on the threshold of making the planet inhospitable to humankind and other species."

If you like to gamble, you might think that nature is bluffing or that we've got the rules all wrong and we can go on changing the chemistry of the atmosphere and the oceans. With every passing year, it appears that nature is serious. We might not have every rule nailed down yet, but this is a game in which the losers are likely to be our children.

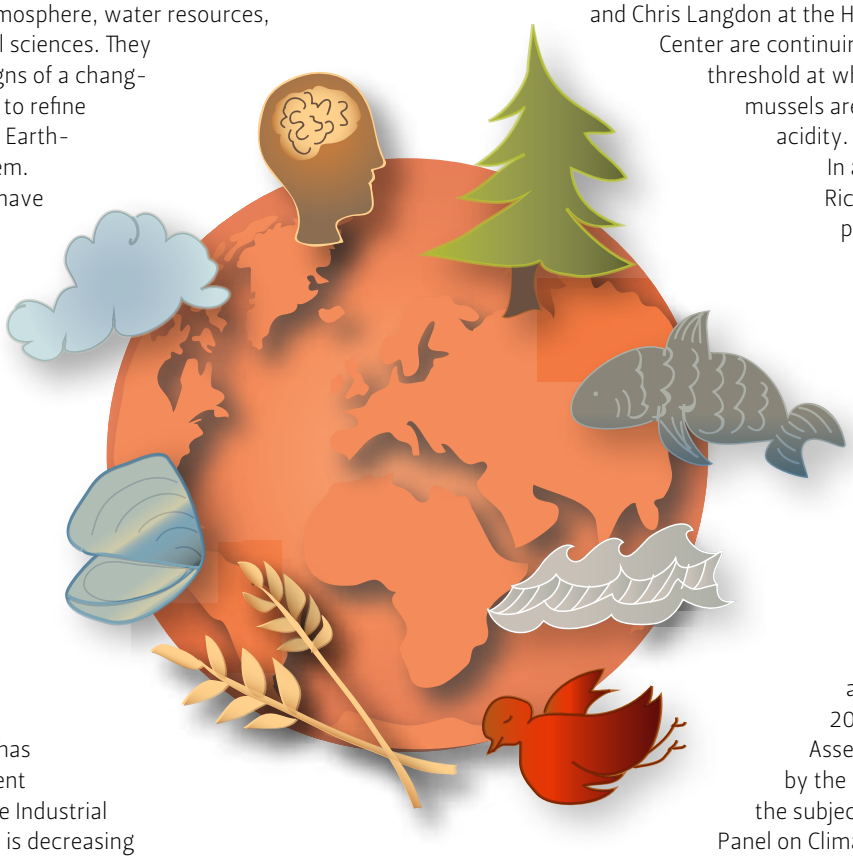
Editor

Reality Check on Climate

BY RICHARD SPINRAD, VICE PRESIDENT OF RESEARCH

WHEN BILL MCKIBBEN KICKED OFF Oregon State University's Discovery Lecture Series in November, the audience was savvy to his wake-up call regarding climate change. Nearly half of OSU research focuses on Earth systems science. Our scientists study the oceans, the atmosphere, water resources, agriculture and the social sciences. They have documented the signs of a changing climate and continue to refine our understanding of the Earth-ocean-atmosphere system.

McKibben's concerns have been shared by many in our scientific community. OSU research, which produced one of the earliest atmospheric circulation computer models in the 1980s, confirms that disturbing trends are under way today in our forests, the Cascades and off our coastline. Tree species are showing signs of severe declines across the West. Sea level and maximum wave heights are rising. Ocean acidity has increased about 30 percent since the beginning of the Industrial Revolution. Soil moisture is decreasing across much of the world's temperate food-growing regions.



To McKibben, founder of 350.org, a worldwide nonprofit focused on this issue, these changes are evidence of radical human behavior. Addressing them, he said, is an action that is conservative, based on the desire to conserve the planet as a place where human civilization has developed over thousands of years.

Practical Impacts

Our faculty are thinking creatively about how we can mitigate and adapt to these changes. When OSU researchers investigated the alarming decline of larval oyster production several years ago on the Oregon coast, they pinpointed ocean acidification as a causal factor. Their results helped two oyster-seed producers adapt by changing the way they pumped water into their tanks. Production rebounded. George Waldbusser, Burke Hales and Brian Haley in our College of Earth, Ocean, and Atmospheric Sciences and Chris Langdon at the Hatfield Marine Science Center are continuing to investigate the threshold at which oysters, clams and mussels are harmed by increased acidity.

In another example, Richard Waring, OSU professor emeritus, is leading an investigation of long-term forest trends. As tree species decline in their current locations, "connective corridors," he says, would help them migrate to new areas.

OSU scientists play leading roles internationally. Philip Mote and Peter Clark are lead authors of the 2013 Climate Change Assessment being developed by the pre-eminent body on the subject, the Intergovernmental Panel on Climate Change (IPCC). Mote directs the Oregon Climate Change Research Institute, and Clark, a geoscientist, studies ice sheets, glaciers and abrupt climate change. OSU economist John Antle was a lead and contributing author on the 2003 and 2007 IPCC reports (as was Mote in 2007). I expect the 2013 report to not only increase global awareness but also to influence policy.

Day-to-day, guided by OSU's new ***Research Agenda***, we are enhancing our support of faculty and student research to make discoveries that have a positive impact on the world. We take seriously our responsibility to investigate what is changing in our climate and are striving to become wise to what that can mean for the future — in our own backyard as well as around the globe.

Taking Stock of Wave Energy

Researchers make preparations for an emerging industry

BY NICK HOUTMAN

THESE ARE THE FORMATIVE YEARS of a West Coast wave energy industry, and scientists are working with businesses, communities and policymakers to gather environmental data, test new technologies and consider the options. Their work is coordinated through the Northwest National Marine Renewable Energy Center (NNMREC), a partnership between Oregon State University and the University of Washington.

Since its establishment in 2008, NNMREC has attracted nearly $20 million in private, state and federal support.

Just off the coast, not far from OSU's Hatfield Marine Science Center in Newport, a marine ecologist affiliated with NNMREC has been analyzing life on the seafloor. Working at depths of 60 to more than 400 feet, Sarah Henkel and a student team scoop sand and sediments to examine organisms and physical properties. They conduct beam trawls to gather bottom-dwelling fish. They use a remotely operated vehicle to survey rocky outcrops.

Henkel aims to anticipate the biological consequences of ocean wave energy on the Oregon coast. Her work complements studies of gray whale migrations conducted by OSU's Marine Mammal Institute (MMI). In a 2007-08 survey, a team led by MMI Director Bruce Mate followed 120 whales within about 10 nautical miles of the shore. "As expected," they reported, "the migration paths of some gray whales cross through areas of proposed wave energy development." Studies under way focus on acoustic techniques to help whales avoid wave energy arrays if the facilities are deemed to create problems for the animals in the future.

Meanwhile, OSU engineers are testing wave energy devices and working with AXYS Technologies, Inc., of Vancouver, British Columbia, to build a new offshore moored test buoy. A search for an additional test site connected to the nation's power grid is being led by Sean Moran, NNMREC ocean test facilities manager.

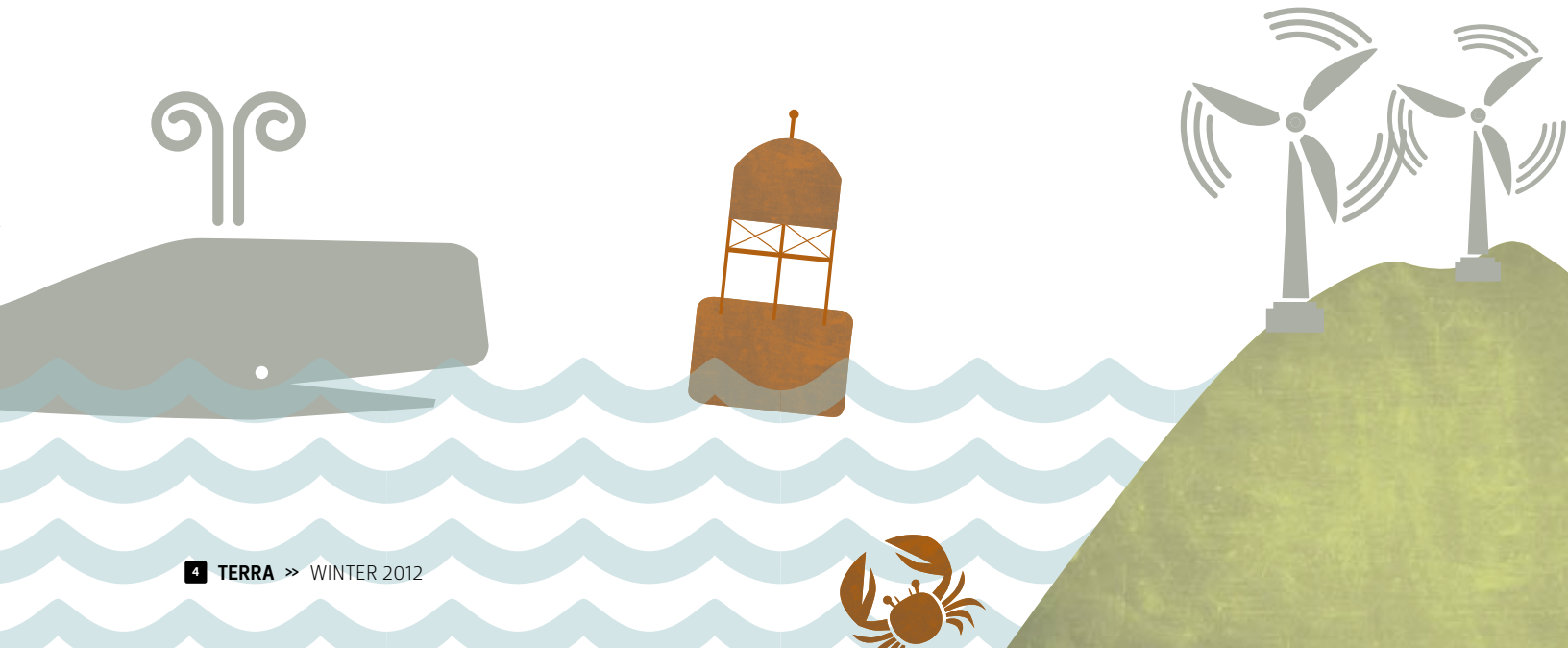
Testing the Wind

To add a new wrinkle to ocean energy, scientists are starting to investigate the potential to capture energy from sea winds. With a U.S. Department of Energy grant, Rob Suryan, a seabird expert at OSU, will lead another NNMREC project to develop remote monitoring technologies that can assess potential wind turbine impacts on seabirds and bats.

The goal is a thorough analysis of Oregon's wave energy potential. Engineered systems will need to survive extreme ocean conditions and minimize impact on the environment and traditional ocean uses. "We've got the technical side, the environmental side and the outreach to communities through Oregon Sea Grant. You don't have that everywhere," says Belinda Batten, director of NNMREC.

Plans are to deploy the NNMREC's test buoy in a site three nautical miles off the coast at Newport in 2012. The moored buoy will allow wave energy developers to place their devices in the ocean and monitor performance. "It can gather all the data we need about the devices: systems performance and power analysis. The developers will go out and moor alongside the buoy and connect through a cable," says Batten, a mechanical engineer.

Companies such as Columbia Power Technologies, Neptune Wave Power and Northwest Wave Energy Innovations have been discussing plans for testing prototypes in Oregon. A fourth company, Ocean Power Technologies, has already received permits for a small commercial-scale device near Reedsport.



Forests on the Move

Drought, insects, disease and climate are teaming up to change the face of western forests, scientists concluded in a recent study. Richard Waring, professor emeritus of forestry at Oregon State University, said that changes are already under way.

"We can't predict exactly which tree (species) will die or which one will take its place, but we can see the long-term trends and probabilities," Waring said. "The forests of our future are going to look quite different."

In some cases, once-common species such as lodgepole pine will be replaced by other trees, perhaps ponderosa pine or Douglas fir. Other areas may shift completely out of forest into grass savannah or sagebrush desert.

With support from NASA, scientists used satellite data to survey 15 coniferous tree species in 34 eco-regions across Canada and the United States. They reported their results in two journals, *Ecological Modeling* and *Remote Sensing of the Environment*.

Bisbal Named Northwest Climate Science Center Director

Gustavo "Gus" Bisbal, a science and policy expert with the U.S. Department of State, has been named director of the Northwest Climate Science Center based at Oregon State University.

Bisbal established his career in the Pacific Northwest, spending four years in the Portland office of the U.S. Fish and Wildlife Service, where he managed the Columbia River Basin and water development program for the agency. He also spent eight years with the Northwest Power and Conservation Council in Portland.

The Department of the Interior established the Northwest Climate Science Center in 2010. The consortium of three universities — OSU, University of Washington and University of Idaho — has its administrative home at OSU and advises federal agencies on policy decisions, especially those relating to climate change.

Ocean Observing Network Ready to Launch

A new network of moored observing platforms and a fleet of autonomous gliders will start sensing the seas from top to bottom in the next two years. Oregon State University will launch a fleet of undersea gliders in 2012 and deploy the platforms the following year as part of the $386 million Ocean Observatories Initiative (OOI).

The National Science Foundation funded the ambitious observation network. A significant piece of the OOI's "Endurance Array" will be located off the coast at Newport, which increasingly has been under scientific scrutiny because of issues ranging from hypoxia and "dead zones" to climate-change impacts.

Researchers in OSU's College of Earth, Ocean, and Atmospheric Sciences helped to develop the national OOI program and are collaborating locally with their peers at the University of Washington.

Jeff Pietro (left) and Chris Holm attach the electro-mechanical stretch hose to the universal joint. (Photo: Craig Risien, Oregon State University)

Learning To Think Like a Planet

True adaptation will require a radical redefinition of human goodness

BY LEE SHERMAN

"In the face of what we have unintentionally done to Earth's ecology, who shall we become?"
– Allen Thompson, OSU philosopher

Like a bunch of teens left unsupervised, humans have been running amuck ever since crude oil first gushed forth on a Pennsylvania farm in the 1800s. Our 200-year-long "fossil-fuel party" has made modern life possible but has fouled the environment and ignited catastrophic changes in Earth's climate.

"We're like juveniles throwing a big party," says OSU's Allen Thompson, an assistant professor in the Department of Philosophy. "The house is a mess, the goldfish are dying, the plants haven't been watered. We've screwed up everything."

As we awaken to the sobering consequences of unfettered consumption, we can take several tacks, Thompson argues. We can give in to despair or denial. We can continue trying to mitigate damage by cutting carbon emissions. Or we can begin adapting to our radically altered world.

Thompson doesn't suggest for a minute that we shouldn't do everything in our power, personally and politically, to curb greenhouse gas emissions. But, as he notes in a rueful tone, international mitigation efforts have so far failed to slow the trajectory of worldwide warming. Even if nations suddenly clamp down, there's enough carbon dioxide already wrapping the planet to alter conditions for thousands of years.

Choosing Optimism

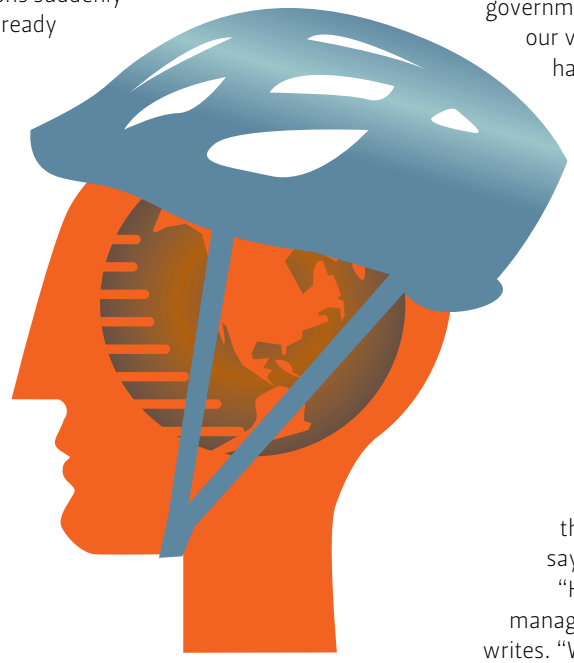
Thompson admits to bouts of anxiety about where we're headed. As an undergrad at The Evergreen State College, where he was part of a "very liberal, environmentally minded, progressive set of young nouveau-hippies," he first read *The End of Nature*, Bill McKibben's now-classic book on global warming. It has haunted him ever since. But rather than succumb to hopelessness, he set about constructing a philosophical framework for at least a limited form of optimism.

Our best chance for bequeathing to our children an intact planet and an ethical society — a "life worthy of human dignity" — is adaptation, Thompson has concluded. When he talks about adaptation, however, he's not talking about girding seaside towns against storm surges or planting drought-resistant crops (although those kinds of measures certainly are needed). Rather, he's talking about nothing less than a radical transformation of our humanity. Our current idea of adapting to climate change is too limited for a ravaged world; it's more akin to "coping" or only reducing vulnerability, he says. Besides, the strategies we typically put forward — exporting new energy technologies, for example, or sending money to poor nations for desalination plants — while helpful, too often are also effective at preserving or extending the very economic framework and consumer culture that created the climate crisis in the first place.

So if we hope to flourish in this human-dominated geologic era (which scientists like Nobel Prize winner Paul Crutzen are calling the "Anthropocene"), we must reinvent ourselves, Thompson argues in *Ethical Adaptation to Climate Change: Human Virtues of the Future*, a new book of essays from The MIT Press that he co-edited with Jeremy Bendik-Keymer of Case Western Reserve University. We must redefine what it means to be a good human, both individually and collectively.

Ecological Identity

"Adapting to new conditions really means changing yourself," Thompson says. "The scale of change we're facing with global warming is unprecedented in human history. It will put a tremendous strain on our social orders and our governmental patterns. It will threaten our very mode of civilization. We have to start rethinking not only our individual character traits but also our institutions so we can move toward a new global ecology. It is crucial that we think of human excellence ecologically."



In a few short millennia, the human species has altered its mother planet irrevocably. Just as we are the only animals capable of such profound impact, so we are the only ones capable of reparation and restoration. In this fact lies our greatest duty, says Thompson.

"Humanity now has the role of managing the global biosphere," he writes. "We were neither designed nor destined for this; only the contingent course of history has made it so. ... Human beings are now managers of the planet in the sense that collectively our actions determine the basic conditions for the existence of all life on Earth."

Communicating About Climate Change

It takes more than facts to reach agreement

BY JOE CONE, ASSISTANT DIRECTOR AND COMMUNICATIONS LEADER, OREGON SEA GRANT

I REMEMBER WHEN I FELT that the climate change workshop would go well. After a period of planning and preparation, our Oregon Sea Grant team arrived in Port Orford not knowing how the diverse community group would respond to the issue of a changing local climate when we were all actually face to face. So, after introductions and a brief discussion of overall goals, our team explained why and how to make a "concept map" — each individual's simple diagram of how he or she perceived a particular idea — in this case, the local effects that participants were concerned about and that they thought might be linked to a changing climate.

For about 10 minutes, the participants worked on their own concept maps and then put their Post-its next to each other on sheets of poster paper. As we all took a look at the array, the 10 community members — a schoolteacher, fisherman, mayor, city manager, environmental leader and others — saw that they held both a number of concerns in common and some that were individually distinct. Through discussion, we rearranged the Post-its into clusters until everyone was satisfied with the way their concerns had been sorted.

The group reflected on what they had done: "Everyone's ideas are up there" — "no one's excluded" — "we're beginning to see an overall picture." Bingo. With contentious issues such as climate change, a good place to begin is to have each voice be heard.

This isn't the end-point, of course, but it does highlight what's often missing from national discussions of climate change and what can happen in a small-group context in a workshop. Actual two-way communication: listening respectfully, contributing respectfully.

We started listening long before the face-to-face meeting. Like other professional communicators and similar OSU climate programs, including those of the Oregon Climate Change Research Institute, my Extension, education and research colleagues and I use methods such as surveys, focus groups and interviews with target populations before we start engaging them on the substantive issues — what a particular community may want to do around climate change. From our 2008 surveys of coastal decision makers in Oregon and coastal property owners in Maine, for example, we learned about not only what information related to climate effects they thought they needed, but also what personal attitudes and other behavioral factors they held that were influencing their actions and intentions to act on information. Without understanding those attitudes and beliefs, we wouldn't really know what information might be directly useful or how best to present it. In both states, one communication tool we used was short videos that specifically addressed concerns the intended viewers had. (Follow-up surveys confirmed their value.)

Focusing on the decisions that individuals and communities feel they need to make to address a recognized problem yields a much more constructive conversation than does focusing on global warming itself, we find. No surprise there, really: If coastal residents are concerned about flooding, that's tangible and relevant to them. Whether humans caused it by increasing use of fossil fuels that led to global warming is, for most, an abstraction — and an invitation to argument.

We recognize that the American public continues to be sharply divided over the reality of global warming, its causes and potential remedies. Is the division a function of our science education, our news media, our divisive politics? Perhaps all contribute, but consider that what all of us believe is influenced by our values. So, if today's fact appears to undercut other deep-seated value beliefs that are far more important to us than the *fact du jour*, what do we do? We tend to discount the "fact" — all of us. So don't expect doubtful Americans to suddenly believe the science of global warming.

On the other hand, helping individuals and communities adapt to climate effects on places important to them might open a different kind of conversation and, over time, move us together into a changing world.

Read a more thorough discussion of this issue at **oregonstate.edu/terra**. And listen to Oregon Sea Grant's Communicating About Climate Change podcasts, **blogs.oregonstate.edu/communicatingclimatechange/**.

ADVOCATE for the Planet

Bill McKibben travels the Earth to save it

Bill McKibben, called the "**planet's best green journalist**" by *Time* magazine, drew more than 750 people to OSU's inaugural Discovery Lecture in the CH2M HILL Alumni Center in November. The renowned author's "exquisite style includes technical insight with the spice of unique historical perspectives," said Rick Spinrad, OSU's vice president for research, in his introduction.

McKibben described the grassroots climate campaign 350.org, which he started in 2009 with seven students at Vermont's Middlebury College, where he is a distinguished scholar. The campaign has coordinated more than 15,000 rallies in nearly 190 countries. He also told of circling the White House with thousands of fellow activists and spending three nights in a Washington, D.C., jail to protest the Keystone XL tar sands pipeline.

Between this and other events on campus — including a workshop sponsored by OSU's Spring Creek Project and a local-foods breakfast prepared by Gathering Together Farm — McKibben sat down with *Terra* magazine's Nick Houtman and Lee Sherman to talk about the urgency of climate action worldwide. Below is an excerpt from that conversation. Read the full interview on *Terra's* website, **oregonstate.edu/terra**

Terra: From your perspective, how does Occupy Wall Street intersect with climate-change action as a people's movement pushing back against corporate interests?

McKibben: I went down to Occupy Wall Street very early and got to speak through the grand human microphone. And the thing I said was: "I'm very glad you're here. Wall Street's been occupying our atmosphere for the last 30 years. It's about time we returned the favor." You know, we can't get anything done on climate change because enormous corporate power blocks action, time after time after time.

Terra: What is the role of research universities in advancing the agenda for environmental clarity and stability?

McKibben: It's been really important that hard science has been applied to climate change in a huge, serious, sustained way. Probably more human intelligence has been directed at trying to understand this than just about any other scientific question. Thanks to research at universities above all, and for the work of federal government agencies like NASA, we've managed to understand this problem. In a short period of time it's crunched difficult problems in atmospheric chemistry and physics. It's given us a workable consensus on what's going on. That's an enormous triumph. The scientific method has worked remarkably well.

The part that hasn't worked is the political method. Where we've failed as educators, as citizens, is in taking what we know and turning it into public policy. All the economists and policy people and everybody else have been saying the right thing to politicians, explaining the many ways that they could be working on this. It just hasn't happened very much, especially at a federal level, because the power of the fossil-fuel industry is so great. So, that's really our work — our responsibility as citizens — to take care of that. Outside of the classroom, we've got to build a movement big enough to make these guys do it. And that's what we're trying to do.

Terra: OSU's Spring Creek Project is dedicated to bringing scientists together with poets, writers and musicians to talk about issues like climate change across disciplines in order to reach different segments of the population. The idea is that not everyone responds to science.

McKibben: You know, 350.org is this huge campaign that takes its name from scientific data, so we're not at all afraid of science. In general, I find no problem with people anywhere in the world understanding the basics of the science. I think we sometimes overstate how difficult or complex it is.

On the other hand, environmentalists have done much better appealing to the left side of the brain — the half that likes bar graphs and stuff — and not so well appealing to the side that deals well with art and music and things like that. That's why we've made a big effort to incorporate tons of that stuff into 350.org. Much of our work is based around images — these beautiful images of thousands of rallies and demonstrations around the world. We did this giant art project last November with 20 pieces of art so big you have to look at them from satellites to really understand them. It involved thousands of people. Just yesterday we released a song in five or six African languages for this project called Radio Wave — bringing in one radio station at a time, north to south across Africa, to arrive in Durban, South Africa, right when the big UN Climate Conference is kicking off there.

Terra: Here in Oregon, people who are addressing environmental change in their communities tend to ask very practical questions — you know, sea level rise in a beachfront community that is causing waves to crash through their front windows. Most people don't see climate change as the source, or global warming as the issue to address. They want to protect their property from erosion, period.

McKibben: Yeah, of course. It's always easiest to think about things just locally, and that's good. But what we've come to understand in recent years is the scale of change and the pace of change that we're now kicking off. We're not going to be able to adapt past a certain point. So people better start thinking further upstream and figuring out that we've got to stop putting carbon into the atmosphere. If we don't, then we're out of luck. terra

State of

Oregon confronts a climate in flux

BY LEE SHERMAN | PHOTOS BY LYNN KETCHUM

Change

Editor's note: In the capital city of Salem, lawmakers are tapping the expertise of the Oregon Climate Change Research Institute to help communities adapt to the state's changing climatic landscape. To learn how Oregon is coping with this issue, *Terra* magazine's Lee Sherman and OSU Extension photographer Lynn Ketchum traveled across the state talking to stakeholders in seven sectors identified in the *Oregon Climate Assessment Report*.

The signs may be subtle so far, but the science is conclusive: Climate change is upon us. Even in the Pacific Northwest — this mythologized place of swirling ocean mists, moss-soft rainforests, crystalline rivers jumping with trout, reedy lakes teeming with waterfowl, juniper-perfumed grasslands bounding with pronghorns, shining cities wedded to sustainability — elevated levels of carbon dioxide are altering natural ecosystems and affecting human well-being year by year.

Globally, the science has been mounting for decades. A panel of more than 1,300 scientists worldwide has forecast a temperature rise of 2.5 to 10 degrees Fahrenheit over the next century. The effects on individual regions will vary over time, according to the Intergovernmental Panel on Climate Change (IPCC).

To better understand those effects on Oregon, the Legislature charged the Oregon Climate Change Research Institute (OCCRI) in 2007 with making a biological, physical and sociological survey of existing climate-change research from Oregon's coastal oceans to the Cascade Mountains to the high desert. The evidence was unequivocal.

"We are already experiencing the impacts of climate change in Oregon," concludes the *Oregon Climate Assessment Report* (OCAR), edited by OSU researcher Kathie Dello and OCCRI Director Philip Mote, and presented to the Legislature in December 2010.

Since 1920, Oregon's average temperature has gone up 1.5 degrees Fahrenheit, says OCCRI, a network of more than 100 researchers across the Oregon University System, housed at OSU's College of Earth, Ocean, and Atmospheric Sciences (formerly COAS). That may not sound like much. But for ecosystems and organisms that have adapted to distinct niches over countless millennia, it can be huge.

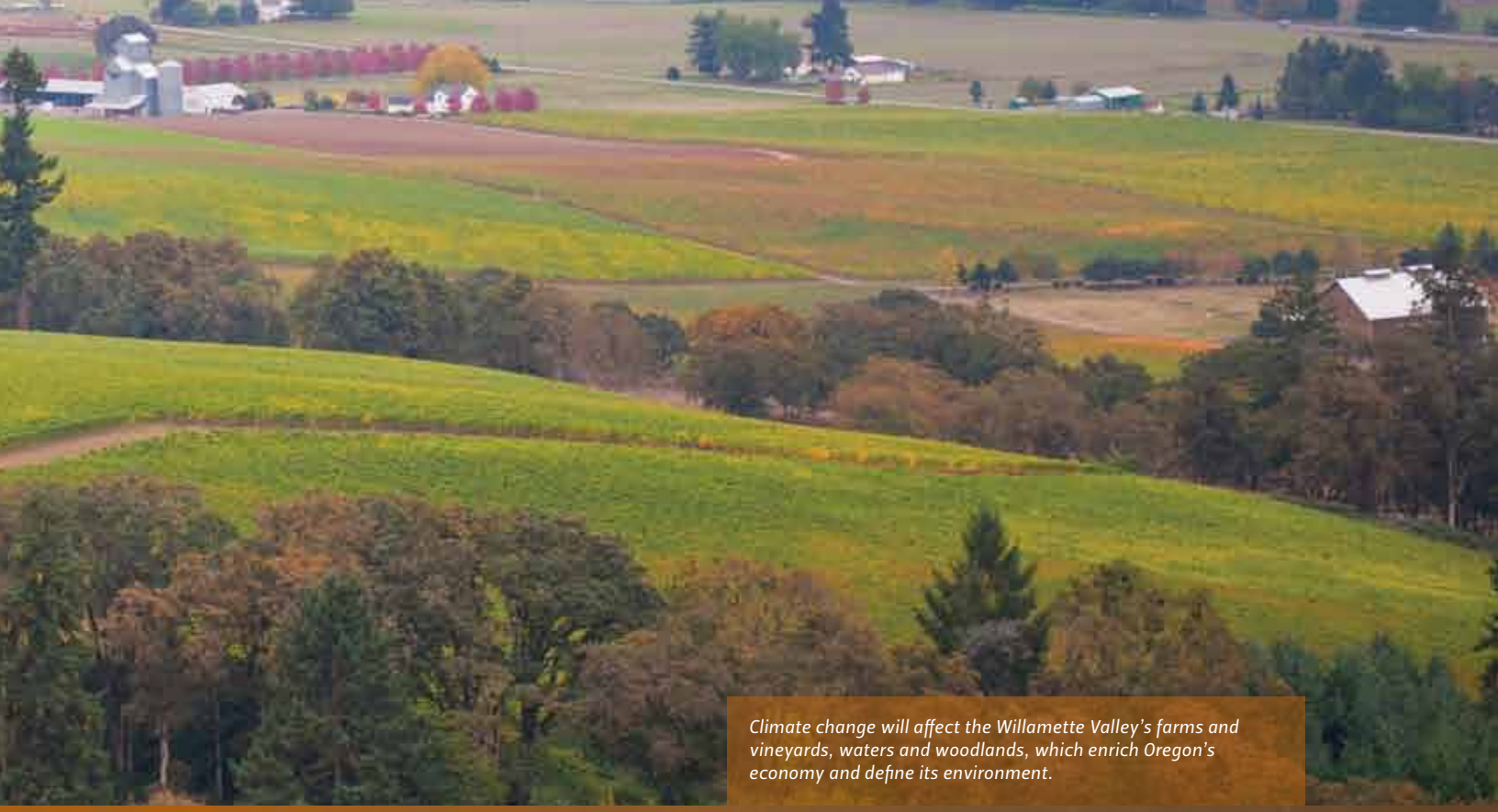
"Small changes in temperature correspond to enormous changes in the environment," explains NASA on its climate change website. "For example, at the end of the last Ice Age, when the Northeast United States was covered by more than 3,000 feet of ice, average temperatures were only 5 to 9 degrees cooler than today."

And temperatures will keep rising through the end of the century — faster if carbon emissions continue unabated, slower if significant cutbacks are made, the researchers say. As the thermometer climbs, summers will get hotter and drier, snowpack will shrink, wildfires will spark up, rising seas and coastal floods will speed erosion. Plant and animal populations will shift across the landscape as they struggle to adjust. Pathogens will find new niches. Novel diseases will emerge.

Regions and communities that take active measures to adapt will fare best, the IPCC counsels.

Hearts and Minds

The iconic image of global climate change is a polar bear poised on a shrinking scrap of ice. This symbol of Earth's fragility and life's vulnerability — a floe adrift in the ocean, disintegrating under great white paws — works because it embodies a maddening complexity in a single, searing picture. You can wrap your heart around it, as well as your mind. It helps, too, that the basic science is easy: Heat melts ice. You



Climate change will affect the Willamette Valley's farms and vineyards, waters and woodlands, which enrich Oregon's economy and define its environment.

don't need a physics degree to grasp cause and effect.

Unfortunately for the scientists and environmentalists sounding the alarm for climate change, clear-cut images are hard to find. That's because threats to human survival suggested by long-term data and projected by computer models are as complex as the systems they attempt to characterize. Rarely can they be reduced to a picture as stark, or as haunting.

Neither can clarity be found in America's popular media. Images with the power to persuade — say, villagers being inundated by seawater in low-lying places like Madagascar and the Maldives Islands — rarely make the evening news. And when catastrophes of nature are reported, coverage lurches from natural disaster to natural disaster, offering little insight into the forces that connect and drive them. Monstrous storms crush small towns in Hurricane Alley. Heat waves sizzle across the Rust Belt. Wildfires blacken homes in California and the Southwest. Drought bakes the ranches and rangelands of Texas. People who rely on cable or network news for their information may perceive such events as random and unrelated — as short-term weather dynamics rather than long-term climate indicators.

Early Adapters

In the Pacific Northwest — this temperate corner of the country where extremes of heat, cold, wind, flood and fire are uncommon — the signs of change are less evident than in some other regions. Oregon's relatively benign climate presents a predicament for planners and policymakers, according to public health expert Kari Lyons-Eubanks.

"We're not in Chicago, where people are dying from heat," notes Lyons-Eubanks, a policy analyst for the Multnomah County Health Department. "We're not in Florida, where people are suffering from dengue fever. When dengue is happening, people pay attention to the issue.

"In Oregon, we don't have a destructive hazard that's causing a big problem right now. With slow, creeping climate change, it's a little bit more challenging."

But it also presents an opening — if communities have the foresight to walk through it.

"We're lucky in the Pacific Northwest because we have more time to figure this out," she says. "We have an opportunity to do this really well if we add some urgency to it. We can adapt if we pay attention now."

All over Oregon, government agencies and private companies are doing just that. Using scientific data from OCCRI and elsewhere to craft policies and create plans to help people and ecosystems adapt to climatic shifts now and in the future.

"Prudent measures to adapt should be taken now," Dello and Mote caution. "Resilience needs to be built into human communities and fostered in natural communities to deal with the adverse impacts of climate change."

In the pages that follow, stakeholders in a range of economic and environmental sectors tell their stories. You will meet a wheat farmer in Eastern Oregon, a public-health professional and a green-construction expert in Portland, a sustainability official in Salem, an ornithologist in Ashland, a city planner in Florence and a forest geneticist in Bend.

Seedlings for Evergreens

Oregon's future forests depend on matching species to sites

"Adaptive management strategies may assist plants in adapting to future climate changes, but will be challenged by the long life-cycles of many Oregon tree species."
– Oregon Climate Assessment Report

Matt Horning

VEGETATION

BEND, Oregon – The seedlings are barely visible among the tufts of lupine, balsamroot and bunchgrass dominating the study plot in the Deschutes National Forest. Matt Horning tramps over the uneven ground, naming each tiny tree as he goes — Douglas fir, Ponderosa pine and a dozen other species whose survival rates, growth patterns and genetic makeup are under scrutiny for a joint study by Canadian and American scientists.

Out beyond the Cyclone fence enclosing the hilltop site, acres of charred forest march across the landscape, thousands of blackened trunks etched eerily against the Three Sisters peaks. "We're still replanting from the B&B Complex fire of 2003 because the burned area was so huge," notes Horning, a geneticist for the U.S. Forest Service. "Seedlings not only have to be adapted to the local climate, they also have to compete with existing vegetation and withstand nibbling by deer and other browsers. Replanting on some of the units has not been as successful as it has on others."

Understanding the optimal growing conditions for trees and other vegetation helps foresters ensure good outcomes when they replant burned-out, pest-infested or logged-over stands of timber. "My role is to help identify the most appropriate plant materials that will be used in reforestation and revegetation," says Horning, who has studied genetic diversity and adaptation of flora and fauna ranging from the American robin to a threatened prairie lily. "So if there's a big fire or some other disturbance, and the Forest Service decides to revegetate the area, land managers will be able to use the best plant materials to create a healthy, sustainable forest."

Ancient Giants

Scientists with the Forest Service and OSU's College of Forestry have collected legions of data on Northwest species over the decades. They have mapped which plants thrive in each local mix of geography, elevation and climate. These maps are called "seed-zone" maps — they pinpoint places where each seed type is best suited.

But the climate defining those zones is shifting fast. As forests get wetter or drier, warmer or cooler, vegetation migrates in response. For short-lived plants, the shifts are quick. Grasses can adapt nearly overnight. But for the giants of the Northwest's boreal and temperate forests, which take decades to mature, a rapidly changing climate can be catastrophic. A seedling that takes root during one climatic period may suffer stress or die in another. Its genetic code, written over eons of evolutionary adaptation, no longer matches the world it lives in.

"Some species can migrate more readily than others," says Horning, who collaborates not only with OSU forestry researchers but also with crop and soil scientists on rangeland studies. "Species that are generalists, like western red cedar or bluebunch wheatgrass, are more broadly adapt-

able. Species that are specialists, like whitebark pine, are more susceptible to climate change."

In fact, more than half of the evergreen species across northwestern Canada and the U.S. already are losing their competitive edge, according to a new study led by Richard Waring, an emeritus professor in the OSU College of Forestry. "Some of these changes are already happening, pretty fast and in some huge areas," says Waring.

Seeding the Future

That's why the Forest Service and OSU recently created a Seedlot Selection Tool — a public website built with GIS mapping technology and climate modeling software — to help land managers adapt to change. (A "seedlot" refers to seeds of a certain plant collected at one time and likely to have similar germination rates and other traits.) Horning's Forest Service colleague Brad St. Clair at the Pacific Northwest Research Station in Corvallis and OSU tree geneticist Glenn Howe led the project with funding from the U.S. Forest Service's Global Change Research Program.

"Because forest trees are genetically adapted to their local climates, local seed sources are generally recommended for reforestation," St. Clair, Howe and their colleagues explain. "These recommendations, however, assume that climates are stable over the long term, an assumption that we now know is unlikely."

The Seedlot Selection Tool is one of several projects undertaken in recent years by OSU's Taskforce on Adapting Forests to Climate Change, whose mission is to provide science-based management options for public and private forest landowners. At a genetics workshop for researchers in 2010, Horning highlighted the user-friendly tool during a presentation on seed-transfer guidelines. "We sat down in Corvallis — the genetics community in the Forest Service along with a lot of researchers from OSU and elsewhere — and said: 'What sort of management recommendations can we make to folks to help mitigate climate change?'"

Matching seeds with sites is one key strategy. To get the free, online tool into the hands of stakeholders, the OSU taskforce brought potential users together in 2010 for a workshop. Among the attendees were members of OSU's Tree Improvement Research Cooperative, which includes Starker Forests, Stimpson Lumber Co., Weyerhauser Co. and a dozen other private firms and public agencies.

With a few clicks on the computer, users can try out various seedlots on a selected planting site (or they can map various planting sites onto a selected seedlot) under a range of climate scenarios. In places where precipitation has dropped and temperatures have risen, for instance, they might discover that drought-tolerant Ponderosa pine is a better fit than moisture-craving Douglas fir. "The best way to learn about the tool," notes Howe, "is to try it."

"The changing climate will likely have significant impacts along the coast and estuarine shorelines of Oregon. Changes associated with global climate change include rising sea levels, storminess, rising water temperatures and ocean acidification."
– Oregon Climate Assessment Report

Sandra Belson

FLORENCE, Oregon – Several dozen people cluster under the Siuslaw River Bridge, colorfully zipped into fleece and Gore-Tex against the damp marine air. As a bitter wind tugs at their hats and mufflers, they listen to local planning officials tell stories of this place called Siuslaw Estuary. Once upon a time, these waters were home to millions of Coho salmon. That was before intensive fishing, farming and logging severely stressed the fragile ecosystem. Today, only a few thousand of the prized fish return each year to spawn in the streams and creeks draining the watershed.

"An estuary is where saltwater mixes with freshwater," explains one of the guides, city engineer Dan Graber, as he gestures at the rain-swollen river racing toward the breakers just beyond the bridge. "It's very important rearing habitat for the ocean-going salmonids."

Sandra Belson, the city's director of community development, elaborates. "It's the nursery for all the sea creatures — not only for salmon, but for crabs and clams and for birdlife, too. Because of the mixing of seawater and freshwater, the estuarine ecosystem is very diverse."

Partners in Protection

Just as biological diversity ensures productive habitat, so human diversity ensures productive environmental action. Belson and Graber, who led the fleece-bundled visitors that blustery day on the estuary, are members of the Siuslaw Estuary Partnership, a team representing nearly 20 government agencies, nonprofits, tribes and consulting firms wrapped under the mantle of watershed protection and restoration. In 2009, they won a grant from the U.S. Environmental Protection Agency to regenerate the watershed where the endangered Coho are struggling to survive.

"We had some contentious issues locally," says Belson. "We realized that the driving force behind all of those issues was water: storm water, surface water, groundwater, seawater, freshwater. It's all connected. Through this project, we've been able to get everybody together — to find common ground on a scientific basis."

The estuary field trip was a highlight of the annual Heceta Head Coastal Conference, which the partnership co-sponsored with Oregon Sea Grant in October. Another of the partnership's recent initiatives was a comprehensive climate change study. A thick report issued by the City of Florence in April traces the science of estuaries and posits the likely effects of planetary warming on Oregon's coastal ecosystems and communities. The document draws heavily on the *Oregon Climate Assessment Report*, citing it more than 50 times.

At an open house in April, locals gathered to hear OCCRI scientists describe how global warming could alter Flor-

Nursery of the Sea

Coastal planners protect the productive waters of Siuslaw Estuary

ence's beaches, threaten its drinking water, damage its wetlands and tip the delicate balance of sea life in the already-troubled estuary. Getting out ahead of climate impacts is the community's best hedge against ecological and economic adversity, the OCCRI experts counseled.

Stormy Weather

One mist-shrouded morning, Belson and Mike Miller, director of public works, sit in her City Hall office on Highway 101, where traffic kicks up a steady spray of rainwater. "To me, the biggest threat to our community is the frequency and intensity of storms," says Belson, who first tackled climate issues as a Peace Corps volunteer in Samoa. "Bigger storms will mean stronger wave action and heavier runoff. Those forces will speed coastal erosion."

Miller came to Florence from Bend, where the looming climate worry was dwindling snowpack. "The estuary is vulnerable because it's so dynamic," he says. "Changes in the ocean — whether it be El Niño or La Niña or higher temperatures or acidification — affect the estuary, along with changes on the land, from erosion to rainfall to contaminants. The estuary gets impacts from both sides. That's what makes it particularly fragile."

Rising sea level is another concern on the community's horizon. As polar ice and glaciers melt, seas are getting higher along with waves and tides. Higher tides carry saltwater farther inland, where it can intrude on freshwater systems. The aquifer that supplies Florence's drinking water could be at risk for inundation. Oregon's only federally designated "sole-source aquifer," this pristine reservoir holds millions of gallons of rainwater that has filtered through Florence's famous sand dunes.

Despite Florence's status as a forward-looking town whose environmental leadership is perhaps unmatched on the Oregon coast, the topic of climate change still raises hackles for some, according to Belson. In July when the city council considered the Siuslaw Estuary Partnership's Climate Change Report, the councilors "decided to not set policy regarding climate change at the current time," the minutes show.

Meanwhile, the partnership is moving ahead with wetlands restoration and water monitoring. Going straight for solutions while sidestepping the contentious public debate seems to Belson like a pragmatic approach — at least for now. "One of our county commissioners told us we shouldn't discuss whether climate change is or isn't happening, but to focus instead on the strategies for dealing with whatever environmental stresses may come about," she says. "That way we can be resilient and adaptable to anything that may happen, whether it's a tsunami or an invasive species or human-caused climate change."

Against the Grain

Eastern Oregon wheat growers ask tough questions about climate study

"Agriculture is considered one of the sectors most adaptable to changes in climate. Typically, agriculture producers are an adaptable group; however, increased heat and water stress, changes in pest and disease pressures, and weather extremes will pose adaptation challenges for many crop and livestock production systems."
– Oregon Climate Assessment Report

Walter Powell

PENDLETON, Oregon – Technology rules. Oregon's wheat country is no exception. Today's farmers use precision electronics for site-specific applications of seed, fertilizer and pesticides. Many of the advances are geared toward ecosystem protection. But farmers are nothing if not pragmatic. Few would invest in the expensive, environmentally friendly equipment if it didn't pencil out on their balance sheets.

So says Walter Powell, vice president of the Oregon Wheat Growers League. On his farm, which rambles across 380 acres in the hamlet of Condon, tractors are fitted with the latest in electronic sensors and GPS software. His "auto-steer" and "auto-boom" devices are fine-tuned to prevent over-use of chemicals.

Powell is more than happy to give nature a break. But in his day-to-day operations, new technologies have to make sense economically. Turns out, they do. Adopting precision equipment has saved Powell significant costs on fuel and "inputs" — materials that growers add to soils and crops to boost yields, repel pests and block weeds.

That's what he told Oregon Sen. Jeff Merkley when they sat face to face in Merkley's Washington, D.C., office last spring. With the new Farm Bill making its way through Congress, Powell was lobbying for continued government support for EQIP, the U.S. Department of Agriculture (USDA) Environmental Quality Incentives Program, which he regards as a life-support system for precision agriculture.

"Sen. Merkley is a tech guy," Powell says. "He got really interested when I started telling him about the impact of precision technology for cutting down on pesticide residue and nitrate leaching. All of a sudden, this grower from Eastern Oregon and the senator from Portland were speaking the same language."

On climate change, Powell is equally forward-looking. "I'm less skeptical about climate change than most growers," he says. Off the top of his head, he cites recent climate studies by the International Energy Agency and "ex-skeptic" Richard Muller of the University of California, Berkeley. Then he chuckles. "Farmers do read, you know."

Any Other Name

Steve Petrie has worked with Powell and other growers for decades. A soil scientist and director of OSU's Columbia Basin Agricultural Research Center, which has experimental farms at Pendleton and Moro, Petrie knows wheat like the back of his sun-browned hand. He also understands the staunchly conservative community that produces that wheat, which in Oregon grossed $354 million in 2010. On climate change, he reports, their attitudes range from "full acceptance to healthy skepticism to outright rejection."

But the range of views doesn't worry him. Even though growers are key participants in a $20 million USDA-funded study of climate impacts on cereal crops in the Pacific Northwest, they don't have to buy into the science or terminology of global warming in their role as stakeholder advisers, argues Petrie, who served on the Agricultural Technical Committee of the Oregon Global Warming Commission. After all, adapting to nature's fluctuations is what farmers do every day to survive. It's in their DNA.

"We're doing research into better farming practices under changing conditions," says Petrie, one of the managers for the Oregon portion of the three-state study. "If some of our stakeholders are skeptical about it, that's OK because they'll still benefit from the practices that are developed through this research."

Stephen Machado agrees. "The term 'climate change' has been so politicized," says the OSU agronomist and crop physiologist who grew up in Zimbabwe. "Growers have been adapting to changing conditions all along. Right now we just have a fancy name for it."

The growers on the stakeholders advisory committee aren't shy about challenging the scientists. "The stakeholders come to our meetings and ask really tough questions," says Petrie. "It helps ground us. In our world of science, sometimes we forget about the practicality of things. For the growers, everything is really down to earth."

Oregon State's

Amber Waves

The Palouse is an ancient landscape of ice-carved hummocks and hollows rippling across northeastern Oregon, southeastern Washington and north-central Idaho. In all but a few spots, native grasses long ago gave way to fields of wheat, along with some dry peas, lentils and alfalfa.

For 80 years, OSU has studied wheat from every angle. Disease resistance, yield potential, milling and baking qualities, soil erosion and pesticide use are just a few. Now, along with neighboring land grants Washington State and the University of Idaho, OSU is expanding those experiments to look at how grain crops will fare under future climate conditions. By feeding their data into WSU-designed computer models, the researchers will generate a range of possible scenarios.

Petrie anticipates that growers could wind up with more invasive plants, more destructive pests and new disease outbreaks as winters become warmer and summers become wetter.

"We can begin to make inroads in our understanding with this five-year study," says Petrie. "But we really have to look at this as part of a 50-year process or, actually, a forever process — always adapting our cropping practices to fit the world in which we're growing crops, whether the conditions are due to climate change or some other factor."

Oregon State's critical mass for climate science

CLIMATE CHANGE MODELING AND ANALYSIS

COLLEGE OF EARTH, OCEAN, AND ATMOSPHERIC SCIENCES (CEOAS)

- Mark Abbott
  Co-chair
  Oregon Global Warming Commission
- Philip Mote
  Director
  Oregon Climate Change Research Institute (OCCRI)
- Kathie Dello
  Deputy Director
  Oregon Climate Service
- Andreas Schmittner
  Associate professor
  Climate change and ocean circulation
- Christoph Thomas
  Assistant professor
  Biomicrometerology and sensor networks
- Karen Shell
  Assistant professor
  Climate modeling
- Peter Clark
  Professor
  Paleoclimatology, glaciers and ice sheets
- Ed Brook
  Professor
  Paleoclimatology, ice core records
- Chris Daly
  Associate Director
  National Alliance for Computational Science and Engineering
- Gustavo Bisbal
  Director
  Northwest Climate Science Center
- Alan Mix
  Professor
  Paleoclimatology, paleooceanography

SOCIAL AND ECONOMIC POLICY

COLLEGE OF LIBERAL ARTS

- Denise Lach
  Professor
  Environmental policy, conflict resolution

COLLEGE OF AGRICULTURAL SCIENCES

- Richard Adams
  Professor emeritus
  Climate change and agriculture, economics of pollution
- Andrew Plantinga
  Professor
  Economics of land use, climate change and forests
- Susan Capalbo
  Professor
  Economics of carbon sequestration, greenhouse gas mitigation
- John Antle
  Professor
  Economics of agricultural systems, climate change adaptation

CEOAS

- Mary Santelmann
  Associate professor
  Wetlands ecology, biogeography

OUTREACH

FORESTRY EXTENSION

- Kari O'Connell
  Project coordinator
  Teachers as Researchers
- Viviane Simon-Brown
  Associate professor
  Coordinator
  Sustainable Living Project

SEA GRANT EXTENSION

- Sam Chan
  Assistant professor
  Watershed health, invasive species

OCCRI

- John Stevenson
  Faculty research assistant
  Regional extension climate specialist

ETHICS

COLLEGE OF LIBERAL ARTS

- Kathleen Dean Moore
  Distinguished Professor of Philosophy
  Moral, spiritual and cultural relationships to the natural world
- Allen Thompson
  Assistant professor
  Environmental philosophy, ethics

FRESHWATER

COLLEGE OF ENGINEERING

- John Bolte
  Professor
  Alternative futures analysis

CEOAS

- Anne Nolin
  Associate professor
  Mountain hydroclimatology
- Gordon Grant
  Courtesy professor
  Geohydrology, watershed analysis

PUBLIC HEALTH

COLLEGE OF PUBLIC HEALTH AND HUMAN SCIENCES

- Anna Harding
  Professor
  Environmental risk analysis
- Jeffrey Bethel
  Assistant professor
  Epidemiology

AGRICULTURE

COLLEGE OF AGRICULTURAL SCIENCES

- Steve Petrie
  Director
  Columbia Basin Agricultural Research Center
- Steven Machado
  Associate professor
  Dryland cropping systems
- Leonard Coop
  Assistant professor
  Climate and plant diseases
- Todd Mockler
  Associate professor
  Plant genetics and climate change

INFRASTRUCTURE

COLLEGE OF ENGINEERING

- David Hill
  Associate professor
  Fluid mechanics, near-shore processes
- Desirée Tullos
  Associate professor
  River engineering, ecohydrology
- Annette Von Jouanne
  Professor
  Ocean wave energy, power electronics
- Ted Brekken
  Assistant professor
  Direct-drive energy conversion

COASTS AND ESTUARIES

CEOAS

- Rob Wheatcroft
  Professor
  Benthic ecology, sedimentation
- Peter Ruggiero
  Associate professor
  Geomorphology, coastal hazards

COLLEGE OF AGRICULTURAL SCIENCES

- Jessica Miller
  Assistant professor
  Fish ecology, larval transport

VEGETATION

COLLEGE OF FORESTRY

- Dick Waring
  Emeritus professor
  Forest landscape analysis
- Beverly Law
  Professor
  Global Change Forest Science
  Science Chair
  Ameriflux Network
- Mark Harmon
  Professor
  Richardson Chair of Forest Science
  Forest growth and decomposition
- David Turner
  Professor
  Carbon cycling and satellite sensing

HATFIELD MARINE SCIENCE CENTER

- Bryan Black
  Assistant professor
  Dendrochronology, climate change analysis

FISH AND WILDLIFE

COLLEGE OF SCIENCE

- Mark Hixon
  Professor
  Marine ecology, conservation biology

COLLEGE OF AGRICULTURAL SCIENCES

- Stan Gregory
  Professor
  Aquatic ecology
- Tiffany Sacra Garcia
  Assistant professor
  Aquatic ecology, animal behavior

COLLEGE OF FORESTRY

- Matthew Betts
  Assistant professor
  Forest landscape analysis

IMPACT

From the blue Pacific to expansive western forests, OSU scientists and their colleagues are gathering evidence of a climate in transition. Here are some of OSU's climate experts.

Lifeblood of a Region

The Willamette River gets an infusion of climate-science scrutiny

"Understanding the complex interactions among climate systems, terrestrial systems, and human systems is essential to predicting future changes in water resources and implementing sustainable water resource management in Oregon."
–Oregon Climate Assessment Report

SALEM, Oregon – The on-screen image looks like a network of arteries, veins and capillaries. Down the middle of the page snakes a thick, bluish cord. Flanking it is a twisting web of red threads.

The illustration posted on OSU's Oregon Explorer (www.oregonexplorer.info/) is indeed a picture about human health. But it's not about blood circulation. Rather, it's about the lifeblood of a region: the Willamette River. The bluish cord represents the river as it looks today, straight and tamed. The red threads show the intricate braid of channels, wild and rambling, that once flowed from the main stem. That was in 1850 before settlers and developers began draining and diking and damming to make way for human activities.

Our gains from reshaping the river (flood control, transportation, agriculture) are being weighed against the losses (despoiled habitat, destroyed wetlands, degraded riparian zones) more acutely than ever, now that climate change is raising the stakes. For in those iconic waters, which touch more than 11,000 square miles of the state, shimmers a reflection of who Oregonians are and who they aspire to be. The Explorer website puts this notion eloquently: "The Willamette River is one of the defining features of the Valley; a sinuous thread which binds us together and readily reveals our civilization's successes and failures."

Another eloquent voice for the river is Lynn Peterson. "The social and economic impact of the river's health is priceless," says Peterson, Gov. John Kitzhaber's policy adviser on sustainable communities and transportation.

Her capitol-mall office sits just a few blocks from where the river flows, silvery and serene. Before coming to Salem, she worked in another place tightly bound to the river, Clackamas County, which bumps into I-5 and Portland on the west and wraps around Mt. Hood on the east. As chair of the county commission, Peterson wrestled with water over and over.

"Clackamas County is a microcosm of the state of Oregon," she observes. "On one hand, it has a vast forest and watershed ecosystem. On the other, it's part of the largest metro area in Oregon. So its water issues are very complex."

Water, Wheels and Rails

What do streetcars have to do with rivers? What do freeways have to do with fish? What does high-speed rail have to do with the ice cubes that tumble out of your fridge? Everything, says Peterson, who started her career as a highway engineer before shifting to transportation planning for Metro, TriMet and 1000 Friends of Oregon. More cars on Oregon's roads equal more stress on the state's watersheds, she says. More suburbs sprawling across the landscape create grave threats to the purity and quantity of groundwater. More dwellers crowding into cities mean spiraling

Lynn Peterson

demands on the snow-fed, fish-filled streams that symbolize what is best about the Pacific Northwest. "We know that the way we manage population growth, transportation and land use will influence the risk of water scarcity," Peterson notes. "But right now, we do not have the tools to plan for a future that is likely to be strongly affected by climate change."

Enter Envision, a new software system for looking into the future of the Willamette River Basin from all sorts of angles. Developed at OSU, Envision not only can create climate scenarios based on geography, hydrology, ecology, sociology and economics, it can toss all sorts of hypothetical human decisions into the mix and see how those might play out over time.

The pressing need for powerful predictive tools prompted Peterson to lend her voice to a multi-university project called Willamette Water 2100. Funded by the National Science Foundation (NSF) and managed by OSU's Institute for Water and Watersheds, the project uses Envision to capture the complexities of climate change, population growth and water availability in the river basin. Faculty at Portland State and the University of Oregon are collaborating with OSU's team, led by hydologist Jeff McDonnell and engineer John Bolte, creator of Envision.

"Envision is the best available tool for answering this question: How can we protect ecosystems and better manage and predict water availability for future generations given alterations to the water cycle caused by climate variability and change, and by human activity," McDonnell and Bolte assert.

Voicing the viewpoint of a local stakeholder in the researchers' funding proposal to NSF, Peterson argued for "workable tools to pave the way for adaptive planning." She says: "If you want a cleaner, greener Oregon, a computer model can help you play with the levers. But you need to run more than one model. You need to run a lot of different scenarios in order to weigh all the alternatives, to compare and contrast so that you get the best outcome — the one that's closest to your articulated goal. That's what Envision lets you do."

Ramping It Up

As Oregon's cities, counties and other jurisdictions seek climate adaptation strategies, its universities contribute what Peterson calls the "spirit and culture of experimentation." Toss in Oregon's status as the "planning mecca of the United States," she says, and you have a potent force for effective action.

"No state has pushed sustainability as far as Oregon has," Peterson asserts. "Oregon has been working on clean air and clean water for 35 years. Now, with global climate change, we've raised the goals higher. We know how to do it. We just need to ramp it up."

"The best means of fending off any changes for the worse due to climate change are similar to those already in place: ensuring that changes in disease patterns can be detected, investigating as needed, and mounting an appropriate public health response as soon as possible."
–Oregon Climate Assessment Report

Kari Lyons-Eubanks

PUBLIC HEALTH

PORTLAND, Oregon – Some time after paddling the pristine inlets of Vancouver Island in British Columbia, a kayaker came down with a severe headache. Within months the 45-year-old woman was blind and bedridden. She died of a massive brain infection in 2002.

Health workers traced her illness to a strain of deadly fungus called *Cryptococcus gattii*, once found only in hot spots like Australia, Asia and South America. When inhaled, *C. gattii*'s tiny spores can lodge in the lungs, attacking respiratory and neurological functions. Over the past dozen years, it has sickened nearly 200 people in the region and killed more than 40. One survivor, a robust Portland outdoorsman named Bob Lewis, told NPR that he's "one of the lucky ones," even though his heart, lungs and kidneys were permanently damaged when he was stricken by one of Oregon's earliest cases in 2007.

Experts point to climate change as a likely culprit for *C. gattii*'s emergence in the moist soils and decaying trees of the Northwest. As greenhouse gasses warm the region, scientists expect once-tropical fungi and other hot-weather pathogens to migrate northward. "The pathogen emerged as the cause of an outbreak on the east coast of Vancouver Island beginning in 1999," writes Oregon Public Health Division Director Mel Kohn in a recent article, "Climate Change and Communicable Diseases in the Northwest," in *Northwest Public Health*, a University of Washington publication. "Environmental sampling ... unveiled an ecological berth among several tree species there, notably our beloved Douglas fir. The researchers hypothesized that the establishment of the fungus in this area may have been due to climate changes."

Longer summers and hotter temperatures are giving a leg up to other communicable diseases, such as West Nile fever and Lyme disease, according to Kohn, who served with OSU's Mark Abbott on the Oregon Global Warming Commission and the Governor's Climate Change Integration Group. That's because many viruses, bacteria, protozoa, funguses and parasites can survive longer in warmer climates, shifting and expanding their ranges in response.

Heat Islands

Communicable diseases are just one health threat linked to climate change. Others include "heat islands" — patches of concrete and asphalt devoid of greenery — that concentrate solar energy and pollutants to create ground-level ozone. That's why city dwellers are especially vulnerable to asthma and other lung maladies. In small towns and woodland communities, wildfires can create physical and mental stress. Laborers who harvest crops in the blazing sun risk heat-related illnesses. Floods can contaminate drinking water and displace families.

The young, the old, the sick, the poor and the disabled suffer disproportionately during heat waves, storms and

A Capacity for Health

Tropical fungi, asthma and heat islands will challenge local agencies

other climate-related events. And linguistic and cultural minorities face extra obstacles. Kari Lyons-Eubanks ranks social justice as a top priority in her role as a policy analyst for Multnomah County Environmental Health Services. She likes to paraphrase the "father of environmental justice," Robert Bullard, saying: "Sustainability cannot be simply a green or environmental concern." So Lyons-Eubanks, who coordinates the public-health piece of the agency's local climate action plan, pays close attention to the full array of needs across the entire spectrum of neighborhoods — food, transportation, housing, heating, cooling, emergency preparedness — in short, anything that impinges on human health and well-being.

"We need to really engage the impacted communities," says Lyons-Eubanks, whose background includes HIV prevention work in Kenya, Zimbabwe and Portland's Somali-Bantu community.

Reaching Out

Making sure human health is folded into climate-change planning initiatives is taking on new urgency for the health division. "Public health has a huge role that often is overlooked," says Julie Early-Alberts, Office of Environmental Public Health. "It's important to have a public-health professional at the table, someone who has that lens."

Of eight states to receive climate-adaptation grants in 2010 from the Centers for Disease Control and Prevention, Oregon is one of four to get a "Category 2" grant for higher levels of implementation. That's because Oregon is a front-runner in building "climate-resilient communities," says Lauren Karam, former grant coordinator. "Some states are just getting started laying the groundwork," she says. "We already have a lot of the baseline data."

Early-Alberts and her colleagues have held "Ready for Change" workshops for public-health workers and emergency-preparedness personnel in Hillsboro, Newport, Bend and Grants Pass to gauge readiness for local climate impacts and help lay the groundwork for future planning. Also, five Oregon locales — Multnomah, Benton, Crook and Jackson counties, along with the north-central region of the state — have gotten "mini-grants" for two-year pilot projects. The idea is to raise awareness and build local capacity for keeping residents healthy during climate-related events.

Science — particularly science pertaining to Oregon's unique mix of ecological and climatic niches — underpins the division's outreach. For that reason, OCCRI's *Oregon Climate Assessment Report* is a key document informing the workshops. The report also is highlighted on the division's climate-change website. "We see OCCRI as a key partner," says epidemiologist Mandy Green. "As we work with local public health departments, the localized data collected by OCCRI will be essential for them."

Building Our Shells

Architects and engineers envision a triple-net-zero tower in the city

"The attitudes of Oregonians toward climate change are somewhat unknown, but small-scale surveys indicate that many residents of our state would consider it a problem worth attention by policymakers."
– Oregon Climate Assessment Report

INFRASTRUCTURE

PORTLAND, Oregon – Oysters and clams build their shells locally. Using only the most immediate minerals, chemicals and organic compounds to craft their shelters, the mulluscs are masters of waste-free, energy-efficient, life-sustaining construction.

A group of humans led in part by the Oregon University System has embarked on a similarly molluscan task: to construct a "living building" that taps directly into nature. Like a biological organism, the Oregon Sustainability Center in downtown Portland is designed to create energy from the sun, capture water from the sky and recycle outputs to the Earth. Workspaces will be alive with sensors giving continuous feedback to tenants on the fundamental questions driving the project: How are we protecting the planet? How can we do better?

"The built environment, as a form of both art and problem-solving, is a real, tangible expression of human connection to the Earth," notes Johanna Brickman, an expert in sustainable architecture and a key participant in the endeavor. "It's the shell that we build for ourselves."

The center's planned use of 100-percent local, eco-friendly materials is just the beginning. More broadly, its creators envision it as a crucible for innovation. A "triple-net-zero" building — one that emits no carbon, generates its own energy, and produces no waste — it could showcase the world's most advanced technologies in green construction.

The center is the serendipitous brainchild of the Oregon State Board of Higher Education, the City of Portland, the Oregon Environmental Council and Earth Advantage Institute, all of which were heading down the same built-environment path in 2008 when they bumped into each other and decided to join forces. The university researchers, architects, engineers, urban planners, environmentalists and entrepreneurs leading the project anticipate its role as an internationally recognized seedbed for life-sustaining technologies when it opens, possibly as early as 2013. But with a price tag of $62 million, it has hit a stumbling block: strapped state and city budgets. Financial support for the project will remain uncertain, *The Oregonian* reported in December 2011, until the Legislature votes in February and the Portland City Council votes in the spring.

Synergies of Energy

Johanna Brickman is all about the synergies of design, construction and adaptation to a rapidly changing environment. When she arrived in Portland in the late '90s, her resume featured degrees in studio art and environmental studies, four years of organic farming, and a stint as an artist for a Southern California architect. It all coalesced in a new position created for her at one of Portland's leading firms, Zimmer Gunsul Frasca Architects, to "inform their design from a sustainability perspective." She began

Johanna Brickman

digging into alternative materials. "Organic farming taught me a lot about systems thinking — the interconnectedness of things," she says. "In my work, I'm always looking at the intersection of culture and natural systems — anthropology, policy, biology — and how all of that merges with self-expression."

With LEED certification just emerging as the "industry's catapult" toward sustainability, Brickman grew her team at ZGF to eight before taking on her current challenge: speeding up commercialization of emerging technologies and spurring technical solutions to environmental problems by bringing university researchers and private businesses together. "If you push these two groups together as much as possible and force that interaction, you'd be surprised at what pops out," says Brickman.

Brickman manages the Sustainable Built Environment Program for Oregon BEST (Built Environment & Sustainable Technologies Center), a legislatively created research center that drives innovation in green building and renewable energy by connecting businesses with more than 200 researchers from Oregon State, Portland State, University of Oregon and Oregon Institute of Technology. Nearly half are from OSU. Rick Spinrad, OSU's vice president for research, sits on BEST's board of directors.

"Of the folks who have been involved in our research team, OSU has been disproportionately represented," Brickman says. "They've had a lot of interest and a lot of engagement. In terms of doing applied research, it's been really rewarding to work with the OSU folks."

Extending Resources

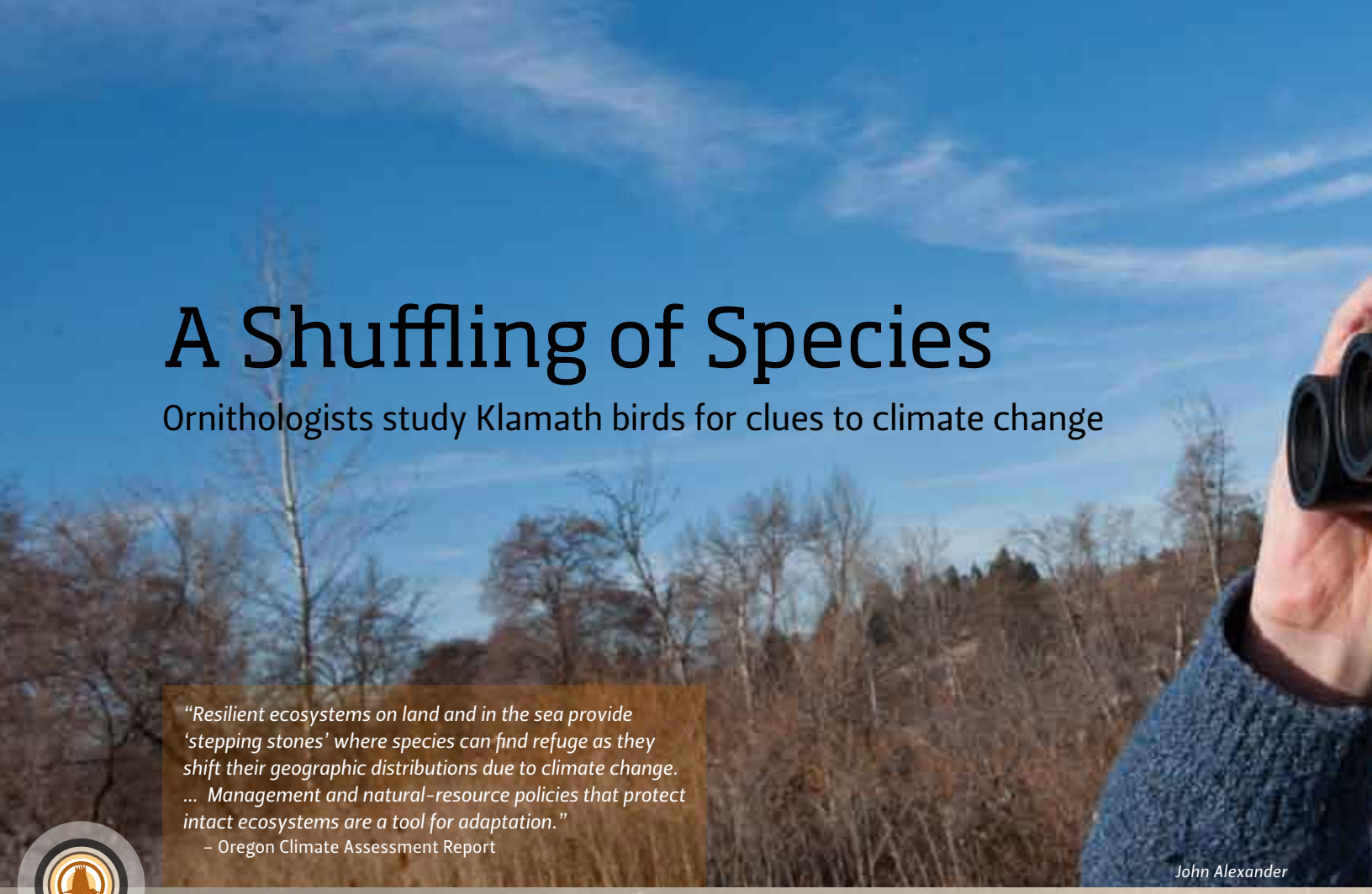
Scott Shull is Intel's liaison with Oregon BEST. "We're looking at closing the loop with the office worker, with the individuals who are in the building," says Shull, a director in Intel's Eco-Technology program and a member of Oregon BEST's university-industry research consortium. "Intel, having spent 30 years making computing personal said, 'Well, we can lead the way in making energy personal, too.'"

The "concept vehicle" Intel has developed is a PC equipped with light- and climate-sensing devices. "We call it POEM — personal office energy manager," says Shull. "It detects ambient conditions — What's the light? What's the temperature? What's the humidity? We'll be able to integrate all this information, report it to the user and coach them if they want to do better."

Oregon's preeminence in life-sustaining policies, especially in transportation and land-use planning, is unquestioned, Brickman says. "We're a state that has long relied on its natural resources for its success. Along with that comes an awareness of the need to preserve, to extend, to care for those resources — and an understanding of how that's tied to your own sustainability."

A Shuffling of Species

Ornithologists study Klamath birds for clues to climate change



"Resilient ecosystems on land and in the sea provide 'stepping stones' where species can find refuge as they shift their geographic distributions due to climate change. ... Management and natural-resource policies that protect intact ecosystems are a tool for adaptation."
– Oregon Climate Assessment Report

John Alexander

WILDLIFE

ASHLAND, Oregon – As he treads a footpath in the Bear Creek watershed, John Alexander is telling a story about the riparian zone's recent restoration when he stops abruptly. "There's a rail!" he whispers, pointing at a clump of cattails. His visitor whirls to see, but the bird has melted into the vegetation. "Just wait," he says softly. "It's coming out the other side!" Seconds later, the long-legged bird slips between the tall dry stalks and vanishes once again. "They're not called 'secretive marsh birds' for nothing," says Alexander, executive director of the Klamath Bird Observatory. "That's where the expression, 'skinny as a rail' comes from. When you look at them head-on, you can hardly see them."

The Virginia rail is one of the species Alexander and his fellow ornithologists monitor in the Klamath-Siskiyou bioregion, a biodiversity hot spot straddling the Oregon-California border. Spanning 10 million acres, the region is home to more than 400 resident and migratory avian species, 200 of which breed in the area. Some are abundant (song sparrows, Canada geese). Others are rare or threatened (rosy finches, marbled murrelets).

Whether common or scarce, each is an important indicator of ecosystem health. That's why Alexander's organization is committed to "all-bird" conservation, monitoring clusters or "suites" of species whose habitats mix or overlap. Scientists have discovered that a more accurate ecological picture emerges from monitoring suites of "focal species" rather than monitoring individual species.

"Instead of focusing on how one species responds to management, we take a community-composition approach," explains Alexander, who collaborates with OSU forest ecologist Matt Betts on modeling projects. "If you put all your eggs in one basket, so to speak, you can miss a lot of confounding factors. By looking at five or six associates, you diversify your understanding of what's happening on the landscape, whether it's an oak woodland, an old-growth forest or a wetland."

Heating Up

A birdcall pierces the wintry air. "Is it a hawk?" a visitor asks Alexander.

"It sounds like a red-tail," he says. "Then again, Steller's jays can mimic hawks to scare away competitors." Looking up, he scans the leafless branches. "There it is!" he points. At that moment, a winged form rises effortlessly above the treetops and disappears into the cold blue sky. "Yep, it's a red-tail."

This rich riparian habitat at Bear Creek is both a data source for scientists and a living lab for kids. The Klamath Bird Observatory shares space with the Willow Wind Community Learning Center, an old farmhouse that the local school district now runs as an educational facility.

At the top of a narrow staircase plastered with wildlife

posters, Alexander and his colleagues labor in a warren of shoebox-sized offices that belie the scope of their work. To the observatory's vast collection of bird data, the mother of all variables is soon to be added: climate change. As a partner in a mega-study on North Pacific birds, the Klamath group is working with two other conservation groups — PRBO Conservation Science and the American Bird Observatory — to create computer models of species distribution under three climate scenarios: low, medium and high temperatures for the Northwest. Ecologist Sam Veloz of PRBO drew on OCCRI's 2010 analysis in the lead-up to the study. "I used the *Oregon Climate Assessment Report* for background while preparing the grant proposal and for identifying data sets to use for our project," says Veloz.

Landscapes are holistic. They flow across Earth's surface, one into another, seamlessly. Boundaries of jurisdiction — county, state, nation — are human artifacts, irrelevant to the foraging, nesting and migrating of birds. Overcoming the artificial lines on the regional map is a main mission of the study's sponsor, the North Pacific Landscape Conservation Cooperative (one of 22 regional public-private cooperatives in the U.S. Department of Fish and Wildlife). Hosted by the OSU-based Northwest Climate Science Center, the cooperative represents yet another break from tradition in environmental science and management. By knocking down barriers between the usual silos — government agencies, NGOs, scientists, land managers, tribes, universities — conservation efforts can better address the urgent needs of species and ecosystems. "This partnership is helping to link science and management more tightly," Alexander says.

What If?

The study's endgame is a tool: an interactive, online program for land managers. It will help them better understand current conditions and also look into possible futures. Alexander calls them "what-if" scenarios.

"It will be a decision-support tool that ties our science directly to their challenges," says Alexander, who has devoted his career to what he calls the science-management interface. "They will be able to click on any pixel on the regional map and find out the probability that a number of different bird species will be there. It will help them make more informed broad-scale decisions that will benefit birds and people."

If current predictions are right, bird communities could shift dramatically as temperatures warm. Alexander warns of a potentially massive species re-shuffling that could upset the equilibrium of coexistence. The current project, he hopes, will help mitigate such challenges. "All-bird conservation is something that is going to benefit everybody. Birds are our tool for moving toward healthier landscapes," says Alexander. terra

SURF'S UP!

Scientists help coastal communities plan for an uncertain future

BY NICK HOUTMAN

Waves from a powerful storm crash into the seawall at Depoe Bay. (Photo: Erica Harris, Oregon State University)

If you love big surf, go to Depoe Bay on the Oregon coast during a winter storm. As swells rise and break offshore, winds whip spray high into the air, but the waves move inexorably toward the harbor (the "world's smallest navigable harbor," reads a road sign), channel through rocks and, with a resounding shudder, launch a geyser over Highway 101. Enthralled tourists standing along the seawall sometimes yelp as they get a cold shower.

It all makes for good fun, but the pounding water carries a warning. Data from offshore buoys indicate that the largest waves are getting bigger. Coupled with slowly rising sea levels and the occasional El Niño, when warm waters pile up along our shores (as much as 19 inches higher than normal, due to thermal expansion), storms are eroding West Coast beaches and undermining bluffs at an increasing rate.

Examples of damage aren't hard to find. In 2010, a series of El Niño storms "eroded the beaches to often unprecedented levels at sites throughout California and vulnerable sites in the Pacific Northwest," said coastal geologist Patrick Barnard in a U.S. Geological Survey news release. Damage to a highway lane south of San Francisco cost $5 million to repair.

In 2006, residents of Gleneden Beach found their homes tottering on the edge of a cliff when a weekend storm removed nearly 20 feet of shoreline. In nearby Oceanside, during the El Niño of 1997-98, a 32-home development at The Capes was threatened by collapse of the bluff on which it stood. In southern Oregon during that winter, a storm breached dunes and destroyed Port Orford's sewage treatment plant drain field. California coastal communities reported more than $100 million in property damage.

In the journal *Geophysical Research Letters*, Barnard and other West Coast researchers, including Peter Ruggiero of Oregon State University and Jonathan Allan of the Oregon Department of Geology and Mineral Industries (DOGAMI), raised the likelihood of increasing erosion risk in a changing climate and added: "If these trends continue, the combination of large waves and higher water levels, particularly when enhanced by El Niños, can be expected to be more frequent in the future, resulting in greater risk of coastal erosion, flooding and cliff failures."

While beaches wax and wane seasonally in a complex dance between land and sea, recent erosion losses have left some Oregon communities more vulnerable to the next storm. DOGAMI's beach monitoring program has shown that in Tillamook County, beaches have not recovered from the 1997-98 El Niño. They have eroded landward an average of 30 to 60 feet and, in some areas, up to 150 feet. Rockaway Beach alone has lost an estimated 2.5 million cubic yards of sand. At Neskowin, beach retreat has enabled storm waves to threaten homes, flood streets and undermine rock-reinforcement — aka "riprap" — in front of the dunes.

Wrestling with Risk

"Neskowin is at the head of the pin in terms of coastal erosion in Tillamook County. The community wishes to be proactive in addressing this problem," says Mark Labhart, chair of the Neskowin Coastal Hazards Committee and a Tillamook County commissioner. "OSU research papers and direct access to professors have been invaluable in providing factual data on what has been happening in

Maximum wave heights are increasing off the Pacific Northwest, according to a study by Oregon State University and the Oregon Department of Geology and Mineral Industries. (Photo: Erica Harris, Oregon State University)

the past and what we might expect in the future so the community, the county and the state can plan for the next steps."

At stake, he adds, are property values, roads, state park facilities and the relaxed quality of life for which the Oregon coast has become famous. Neskowin's quiet, family-oriented character has lured vacationers for more than a century. According to local historical documents, Sarah Page and her husband settled on what was known as Slab Creek in the 1880s. She opened the first post office and called it Neskowin after she heard a Nestucca Indian refer to the creek by that name, meaning it had plenty of fish.

> *The bottom line is that the waves have increased over the last several decades.*
>
> **Peter Ruggiero**

Today, the community has 408 homes (fewer than a quarter of which are occupied year-round), a golf course and a condominium development, the Proposal Rock Inn. Nestled against Cascade Head to the south, Neskowin mirrors much of coastal Tillamook County, which has the highest percentage of second homes of all the state's shoreline counties, according to the Oregon Coastal Zone Management Association (OCZMA).

Dedicated to protecting this idyllic enclave is a local group appointed by the county commission in 2009. The Neskowin Coastal Hazards Committee is composed of property owners and local and state officials and facilitated by Pat Corcoran, a coastal hazards specialist with Oregon Sea Grant. It has met with Ruggiero, Allan and other scientists. It has reviewed options (known as "Hazard Alleviation Techniques" or HATs) for reducing erosion hazards. With Corcoran's help, it identified emerging research and delved into erosion processes and trends.

Working with Mitch Rohse, a planning consultant from Salem, the committee published a proposed legal policy in 2011 for counties to deal with the mounting risks: *Adapting to Coastal Erosion Hazards in Tillamook County: A Framework Plan*. Local planners and the county planning commission must review the document before it goes for approval before the county commission. Concurrently, the committee has raised more than $27,000 from private contributors, the Neskowin Homeowners Association and the Oregon Department of Land Conservation and Development for an engineering analysis of options and costs to protect shoreline property.

A first for Oregon, the draft plan calls on the county to adopt policies that help communities reduce their vulnerability to storm damage and erosion. Reflecting current state and local regulations, it draws from a variety of scientific sources, including former OSU master's student Heather Baron's 2011 thesis, in which she focused on "coastal hazard zones." For her degree in Marine Resource Management, she evaluated the probability of erosion in each zone for 18 different climate-change scenarios. Each scenario reflects a combination of risk factors: sea level rise, extreme wave heights and El Niño frequency and intensity. Her work builds on research by Ruggiero, Allan and their colleagues, who have used beach, wave and landscape data to define such zones along the Oregon coast.

If the plan were approved, properties in each zone would be subject to standards that reflect their vulnerability to the risk of future storm damage. Neskowin committee members expect that idea to generate debate over issues from development rights to property values. "Any time you put colored lines on a map that potentially affect property values, you get people's attention in a hurry," says Labhart.

Coastal Change

The threat faced by Neskowin and other communities doesn't arise over night. It grows gradually from a series of seemingly harmless events, chief among them the construction of homes and condos and the seawalls that protect them. "A recent storm may have washed away a beach or destroyed homes lining the shore," wrote retired OSU coastal oceanographer Paul Komar in *The Sciences* in 2000, "but merely blaming the weather is simplistic. Almost always, subtle factors have been acting over time to weaken the coast and make it more susceptible; the storm, when it comes, simply delivers the coup de grâce."

Neskowin's case is puzzling, says Komar. When he started investigating erosion problems in the 1970s, Neskowin homeowners had

Waves crawl up against the lower level of a structure in Neskowin during a storm in January 2008. (Photo: Armand Thibault, Neskowin)

problems with sand increasing dune heights, blocking ocean views and even threatening to bury homes. "The change to erosion began with the 1982-83 El Niño and accelerated during the 'one-two punch' of the 1997-98 El Niño and storms of the following winter," he says. Today, he adds, the community is a "classic example of 'hot spot' El Niño erosion. Normally during the next few years following an El Niño winter, we expect the beach sand to be carried back to the south by the 'normal' waves, but this has not happened yet at Neskowin, and it's not clear why it hasn't."

Over the last decade, with support from Oregon Sea Grant and agencies such as the National Oceanic and Atmospheric Administration, scientists have been zeroing in on those subtle factors. Basic questions motivate them: How do coastal systems work? How do currents carry sand onto and off a beach, piling it up in some years and draining it away in others? Is sand accumulating on the coast or moving permanently into the deep ocean?

Just as importantly, they are providing communities like Neskowin with the knowledge to reduce property risks in the future. "We're getting great data about the Oregon coast now. Compared to what we had 10 or 15 years ago, the observational data we have today are like night and day," says Onno Husing, executive director of the OCZMA.

Citizens, elected officials and policymakers can see those data at the click of a mouse. Researchers regularly profile beaches from Gold Beach to Astoria and publish charts that show present and past sand heights relative to mean low and high water levels (see "Beach and Shoreline Mapping" at www.nanoos.org). They monitor wave heights and wave "run-up" on beaches. They estimate future flood risks and how many homes, roads and businesses are in harm's way. And they meet with citizens to share the results.

Although the broad direction of these changes is clear, Ruggiero emphasizes that uncertainty casts a shadow over the likelihood that any home or community will suffer damage in the future. The range of estimates for climate change only adds to the difficulty of forecasting future risk.

Speaking of just one factor, increasing wave heights, he says: "Attributing it to climate change is very difficult. I don't do that, but the bottom line is that the waves have increased over the last several decades, and that could be for a variety reasons. Any time you look way out into the future, uncertainty is huge."

What is certain is that big waves will continue to hit the West Coast and attract sightseers to places like Neskowin, Rockaway and Depoe Bay. How coastal communities will adapt is an open question. terra

Clockwise from top left: Sarah Frey, Sihan Li, Lindsey Thurman and Seth Wiggins.

QUARTET for the Earth

Four students bring distinct perspectives to climate change research

BY LEE SHERMAN

One is a mountaineer investigating amphibians. Another is a world traveler studying birds. The third came from China to study ocean-atmosphere interactions, while the fourth is an elite athlete interested in the economics of rangelands.

What links these four students and their diverse scientific interests is climate change. Lindsey Thurman, Sarah Frey, Sihan Li and Seth Wiggins have been granted fellowships from the Northwest Climate Science Center, a program of the U.S. Department of the Interior hosted by the Oregon Climate Change Research Institute (OCCRI) at OSU.

"The purpose of the fellowships is to support promising graduate students whose research is relevant to the Climate Science Center," says Phil Mote, OCCRI director.

Their academic talents are exceeded only by the energy with which they engage the world. Here are their stories.

Little Nooks and Crannies

Her forest-green Toyota pickup was packed to the gills when Sarah Frey climbed in and steered toward I-90, trailer in tow. The Vermonter was in a bit of a daze. A chance encounter barely a month before had launched her on an unplanned journey across the United States, destination, Oregon.

It all started in 2008 at an American Ornithologists' Union conference in Portland, where Frey ran into OSU forest ecologist Matt Betts, an acquaintance from an earlier population-modeling workshop. After five years of tramping around the Americas and Pacific Islands doing fieldwork for conservation nonprofits — studying hawk migration in Nevada, banding owls in Michigan, investigating avian pox among forest birds in Hawaii, tracking tropical birds in Ecuador — she had recently finished her master's thesis at the University of Vermont on Bicknell's thrush, a rare, high-elevation species. She hadn't yet mapped out her next move. Then Betts sprung a fellowship offer.

"How about starting your Ph.D. next month?" he asked. A few weeks later, she was enrolled in the College of Forestry with a minor in Ecosystem Informatics.

For the next three field seasons, she monitored birds in the H.J. Andrews Experimental Forest. From mid-May through early July, she and other researchers climbed the rugged slopes, from creek bed to mountaintop, documenting behaviors and population densities of about 50 species. "We went out to 184 sites, stood, listened, and looked for 10 minutes at each site," she explains. "During 2011, we carried out fiberglass poles and PVC pipe to all of the points for installing temperature sensors."

Enduring the brutal conditions of fieldwork is an occupational hazard for Frey. Ever since the iconic behavioral ecologist Bernd Heinrich (*Mind of the Raven*) turned her on to birds during an ornithology field trip when Frey was an undergrad, she has thrown herself into more adventures than Indiana Jones. Braving the tropical forests of Queensland, Australia, for a study-abroad program was one. Another was her Bicknell's thrush study, which took her up and down a different Appalachian mountain every day for two breeding seasons. Her studies also have taken her to Switzerland where she recently spent two months working with a statistical modeler at the Swiss Ornithological Institute.

Frey's OCCRI-funded research challenges certain longstanding assumptions that underpin today's species-climate models. Typically, these models are based on "bioclimatic envelopes" — that is, the mix of temperatures, precipitation levels and other climate variables within which species thrive. She wants to know what other factors might be driving species extinctions and biodiversity in a time of shifting climate. How important is vegetation, for instance? What about competition among species? Where does predation fit in? How do microclimates help birds adapt to climate change?

One of the things she's investigating is the role of temperature in small-scale species distributions. The buffering capacity of "microclimatic refugia" (habitat havens she characterizes as "little nooks and crannies") in mountainous terrain could be critical as birds make adjustments to a fluctuating environment in nesting, breeding and foraging.

"I'm trying to tease apart the main drivers of where species occur," she says. "Most scientists think climate is the primary driver at large scales, while vegetation and other species are the main drivers at small scales."

To find out, she compared the influence of microclimate on distribution dynamics for three species with different migratory strategies: hermit warbler (a neotropical migrant), chestnut-backed chickadee (a resident) and Pacific wren (a partial migrant).

"There have been very few rigorous tests of these alternative hypotheses," Frey notes. "Uncovering the relative importance of different drivers of species distribution — climate, land cover, competitors, predators — is critical for both ecological theory and environmental policy."

Worldwide Weather Warriors

College student Sihan Li gazed in astonishment at the terracotta warriors, massed by the thousands on a silent, earthen battlefield near Xi'an in central China. Little did the Yunnan University undergrad know that soon she would be marshaling her own army from a computer lab in Oregon. But unlike Emperor Qin's clay troops, built to do battle in the afterlife, Sihan Li's flesh-and-blood legions are taking up arms against the here-and-now threat of climate

change. And instead of spears and swords, her climate warriors are wielding keyboards and barometers.

Li's army, enlisted by a global project called climateprediction.net, comprises more than 50,000 weather geeks. They have volunteered to collect information on local precipitation, temperature, humidity and other weather events and load it onto their home computers. Li's job is to analyze the data from the western United States — one of three regions being studied worldwide with funding from the U.S. Geological Survey. To do that, she is using BOINC (Berkeley Open Infrastructure for Network Computing), a software system for volunteer computing.

"Usually, communities feel removed from the research going on around them," notes Li, who goes by Meredith. "But volunteers for climateprediction.net become personally involved and committed to the project."

The experiment, characterized by Li as "unprecedented" in its scope and reach, is a perfect fit for this 23-year-old Ph.D. student in OSU's College of Earth, Ocean, and Atmospheric Sciences. To the young atmospheric scientist, only the colorful richness of humanity rivals topics like wind-ocean circulation dynamics and heat-flux transfer on the list of fascinating things to study and experience. As an undergraduate, Li explored the far corners of China with a train ticket and a backpack whenever she wasn't taking classes and working on regional climate modeling. The ancient city of Xi'an, home of the Terracotta Army, enchanted her with its palpable sense of history. "You can almost smell the culture in the air," she says.

Like humanity, climate is infinitely complex. So far, computer models designed to predict future climate scenarios have been hobbled by one of two problems: too broad a scope that glosses over the finer details of geography, or too narrow a range that fails to capture the larger context. The army of weather volunteers will remedy these deficiencies, Li says, by collecting data broadly and finely simultaneously. The result will be "super ensembles" — suites of large-scale simulations — for the western U.S., Europe and southern Africa.

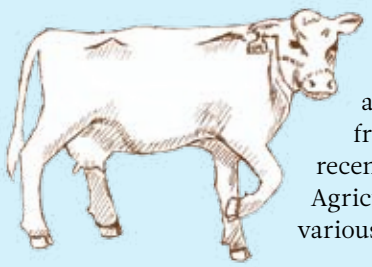
"This research," says Li, "is not only scientifically groundbreaking, but likely to provide the greatest value to date in assisting the western region as we attempt to cope with and plan for climate change."

Along with Oxford University, OCCRI's partner on the project, OSU is consulting closely with stakeholders, including the U.S. Bureau of Land Management, the California Department of Water Resources and the Water Utility Climate Alliance.

"Science is, in the end, to be of service to people — to make the world a better place for people to live in," says Li.

Carbon, Cattle and Costs

These days, Seth Wiggins spends long hours staring at a computer screen in his lab at OSU. But the master's student is not a natural habitue of chairs, swivel or otherwise. In 2009 his dead-accurate aim and rocket-fast arm won him a gold medal in Ultimate Frisbee at the World Games in Taiwan. The next year he pedaled his Giant OCR2 road bike from Seattle to New York, spinning 3,000 miles in six weeks, solo. The biggest challenge, he says, was getting enough calories. "I would go to these all-you-can-eat pancake places and eat them out of business," he reports. "My record was 23." Pancakes, that is. With butter and syrup.



Soon after his cross-country ride, Wiggins got serious about his other passion — saving the planet — and enrolled in graduate school. But instead of choosing a field like forest ecology or conservation biology, the 27-year-old from Corvallis is taking a less-usual path to planetary protection: economics.

"What I care about are environmental issues, specifically climate change," says Wiggins, who earned his bachelor's in econ and international studies at the University of Oregon. "But in this society, things don't happen unless money is attached."

Take CO_2 reduction, for example. Attaching a dollar figure to greenhouse gasses is the idea behind cap and trade, which lets companies exchange carbon credits on the free market. In Oregon, where rangelands comprise about one in nine acres, grasses soak up carbon dioxide by the ton. By capturing and holding ("sequestering") CO_2 from the atmosphere, Oregon's vast rangelands create a powerful sink for pollutants that would otherwise be warming the atmosphere. If policymakers were to offer economic incentives to ranchers, Wiggins suggests, the state could lock up significant quantities of emissions every year.

"This is an enormous land resource," says Wiggins. "Carbon sequestration on rangelands could potentially have a huge effect."

To test that potential in the Pacific Northwest, he is looking at ranching operations across Oregon, Washington and Idaho with at least 100 acres and cattle sales grossing $10,000. Using a statistical model designed by Professor John Antle in the Department of Agricultural and Resource Economics, Wiggins is analyzing data from the most recent Census of Agriculture to weigh various assumptions

— costs, returns, profits, and so on — that underlie the sequestration concept. The study's goal is to find the optimal price point where ranchers could be persuaded to join a sequestration program and improve their land management practices.

"Currently, much of the rangeland is overgrazed," says Wiggins. "It's cheaper for ranchers to add more cows than to maintain healthy grasslands."

Attractive economic incentives would encourage ranchers to adopt eco-friendly methods, such as rotational grazing or intensive pasturing — methods that allow soils to absorb carbon in the atmosphere, according to Wiggins. The way he sees it, practices that are affordable as well as environmentally sound allow people to align their actions with their values without taking a hit in the pocketbook.

"Right now there's a disconnect between our values and our actions," he says. "No one wants to leave a deteriorating environment to generations going forward, but many people act as if they do. Figuring out how to get people to act in accordance with their values seems incredibly interesting to me."

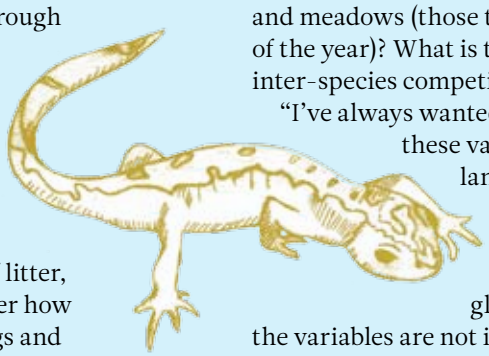
Blue Crabs to Cascades Frogs

The little girl with the sunburned nose and whorl of sun-bleached hair felt as much at home swimming and diving in Florida's Santa Rosa Sound as did the blue crabs she loved to trap. Since those carefree days on the Gulf Coast, Lindsey Thurman has stalked wildlife both cold-blooded and warm. She has monitored sea turtle nests from Pensacola to Alligator Point as an undergraduate at the University of Florida, Gainesville. Netted freshwater fish in Okefenokee National Wildlife Refuge for the Florida Museum of Natural History. Sampled tissues from snakes and other reptiles in Ocala National Forest for the U.S. Geological Survey. Tracked carnivores in California's Sierra Nevada range for a U.S. Forest Service study.

And she did all this before she was admitted to graduate school at OSU.

"I'm a field biologist at heart," says the Ph.D. student in the Department of Fisheries and Wildlife, which she chose because of its No. 1 national ranking. "I'm fascinated by phylogeny — how species are arranged on the tree of life. I like the challenge, physically and mentally. I like the serenity of being out there by myself."

These days, "being out there" means trekking through the Cascades, her backpack stuffed with topo maps and sampling kits for collecting live amphibians. In alpine ponds, creek beds and leaf litter, she seeks to discover how high-elevation frogs and salamanders are coping with climate change. With her yellow Lab, Sierra, loping merrily beside her, the 25-year-old is already blazing new trails in amphibian research. Her master's project, carried out under the guidance of Assistant Professor Tiffany Garcia, revealed that long-toed salamanders have modified their egg-laying behavior to protect their progeny from the interplay of mounting temperatures and UV (ultraviolet) radiation, which are dangerously strong in the upper reaches. Instead of laying masses of eggs at the water's surface, Thurman discovered, the salamanders are depositing their eggs singly under protective rocks or silt at high elevation.



For her new study, she's pondering a wider range of variables — what she calls the "litany of threats" to the survival of mountain-dwelling amphibians.

"The impacts of environmental stressors on amphibian populations typically have been studied independently," Thurman notes. "My study will contribute a broader analysis of climate change variables on multiple species across diverse, freshwater ecosystems."

Scientists know that amphibians' permeable skin and soft-shelled eggs make them hypersensitive to changes in temperature, moisture and UV rays. But there are all sorts of other questions demanding answers, Thurman says. For example, How do the animals' "plastic" (quickly adaptable) developmental traits mitigate climate stressors? What happens to animals living in ephemeral ponds and meadows (those that dry up part of the year)? What is the impact of inter-species competition?

"I've always wanted to look at these variables on a landscape scale," says Thurman. "Climate change is a global issue, and the variables are not independent. It's hard to tease them apart."

To find out how amphibians respond to the synergies of climate and high elevation, her ambitious study has three parts: field work, lab experiments and theoretical modeling. In the field, she will document frog and salamander populations in three watersheds at elevations above 1,000 meters from southern Oregon to southern British Columbia. In the lab, she will run climate and population scenarios (wetter, drier, hotter, more animals per tank) on the Cascades frog, the western toad, the Pacific chorus frog and the long-toed salamander. In the computer lab, she will use models to predict climate-driven changes in ecology and species distribution.

"Mountain amphibians are losing suitable breeding habitat rapidly," Thurman says. "These species are going extinct at a disproportionate rate worldwide. With new baseline data, land managers will be able to fast-track conservation strategies for high-elevation freshwater ecosystems in time to make a difference."

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GREEN EVOLUTION

Economists evaluate options for farming in a warmer world

BY NICK HOUTMAN

In the Vihiga district of western Kenya, farms average little more than an acre. Corn is the dominant crop and source of sustenance, but most households run short six to 10 months of the year. They supplement with beans, groundnuts, bananas and vegetables and make money by selling milk, if they are lucky enough to own a cow. Throughout the country, corn production is declining, and researchers are urgently searching for drought-tolerant varieties to meet the needs of a growing population. For people already on the edge, adapting to climate change is a life-and-death matter.

In fact, scientists say, projections of a warmer, drier climate in East Africa could cut food production as it is currently practiced on 82 percent of the farms in Vihiga. This rural area doesn't have far to fall. More than half of its farm households already earn less than $1 per person per day.

John Antle sees a better future for the people of Vihiga. By shifting from corn to more drought-tolerant crops such as sweet potatoes, farmers could offset much if not all of the negative impacts of climate change. Moreover, since sweet potatoes are high in vitamin A and the vines make good livestock fodder, they could improve nutrition for their families, feed their cattle and maintain milk production.

For the Oregon State University professor of Agricultural and Resource Economics (AREc), Vihiga demonstrates the need for climate-change adaptation policies. "Until now, adaptation has been politically incorrect in the climate world," he says. "We see more and more evidence that real changes are happening, and we had better start thinking more about adapting."

With a grant from the German international development agency GTZ, Antle and a research team from Wageningen University in the Netherlands and international research centers are evaluating the impacts of climate change on agriculture and the potential benefits of alternative cropping systems in East Africa. The simulation models that Antle and collaborators have developed over the past two decades are now being used by researchers globally to assess impacts of climate and other environmental changes in agriculture.

In the Great Plains and Midwest, he and co-author Susan Capalbo, head of AREc, have used these tools to study the potential for cropland to store carbon under conservation and reduced tillage systems. They are partnering with colleagues at OSU, Washington State, the University of Idaho and the U.S. Department of Agriculture to evaluate wheat in the Pacific Northwest under a changing

John Antle received his Ph.D. from the University of Chicago in 1980. He is a University Fellow at Resources for the Future in Washington, D.C., and served as a senior staff economist for the President's Council of Economic Advisers in 1989–90. He was a lead and contributing author of the third and fourth climate change assessments organized by the Intergovernmental Panel on Climate Change (IPCC). He co-leads the economics team of the Agricultural Model Inter-Comparison and Improvement Project, whose goal is to characterize the risk of global hunger due to climate change and to enhance adaptation in developing and developed countries.

climate (see "Against the Grain," Page 18).

Global Food Supplies

"For about a 150 years, the real price of wheat has gone down," Antle says, even as global population has risen. "So why is that? Because supply has gone up faster than demand. That is the Green Revolution story, the scientific revolution that began after World War II and allowed agriculture to expand production. So the big question is, Are we now at a turning point where that's no longer going to be true?"

Two factors — increasing demand from larger, more affluent populations; flattening growth in food supplies, as the Green Revolution bumps into production limits — are contributing to higher food prices. In the short term, he adds, there is still plenty of arable land available, and farmers can shift crops from fiber and fuel to food. But rising incomes in developing countries are already adding to demand and are likely to continue to do so well into the future.

He points to China, which, despite increasing incomes for a portion of its people, still has massive poverty. "People think that China is now this rich country. That's wrong. There's a small proportion of people in China who are well-off now, but if you get away from the coast, there are still a billion really, really poor people. That's true for India and sub-Saharan Africa too."

Those countries will continue to transition to a higher standard of living, he says. "For a long time, people have said, when the rest of the world tries to have a lifestyle like ours, we'll be in trouble. Well, that's what's happening."

On top of that, climate change poses an additional threat. Somalia and other parts of East Africa are already in their 16th year of drought. In Kenya, which hosts refugees fleeing violence and famine in Somalia, crop failures are common, and the country has to import corn to meet growing demand.

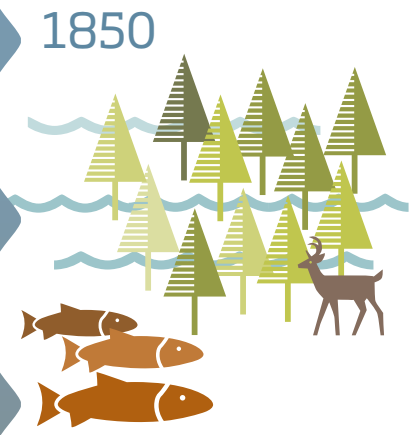
In their research, Antle and his colleagues combined available data on farm production in two Kenyan districts — Vihiga and Machakos — with the results of two climate models to estimate how new sweet potato varieties, milk, livestock and drought-tolerant corn might maintain food production and farm incomes in the future. Most previous studies of climate adaptation apply to large regions, such as whole countries. Their study was one of the first to compare the potential consequences of several climate change adaptation strategies for agriculture with this much detail.

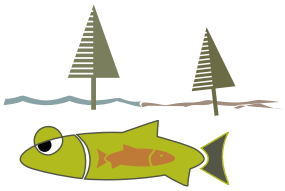
"We're trying to understand these systems, what characteristics make them work better or worse and what kinds of crop-breeding activities would work with changes in climate," says Antle. terra

River of Change

A resilient future for the Willamette River

BY STAN GREGORY, PROFESSOR OF FISHERIES AND WILDLIFE





A CHANGING CLIMATE IN THE PACIFIC NORTHWEST will challenge the Willamette River watershed. The river is lined with cities and towns that are home to more than two-thirds of Oregon's 3.8 million residents, and the valley's population is expected to double by 2050, bringing additional stress to a system that has already seen more than 160 years of land-use change.

The river that provided food and transportation to native people for more than 9,000 years and helped to propel Euro-American settlers in the 1800s has undergone a transformation:

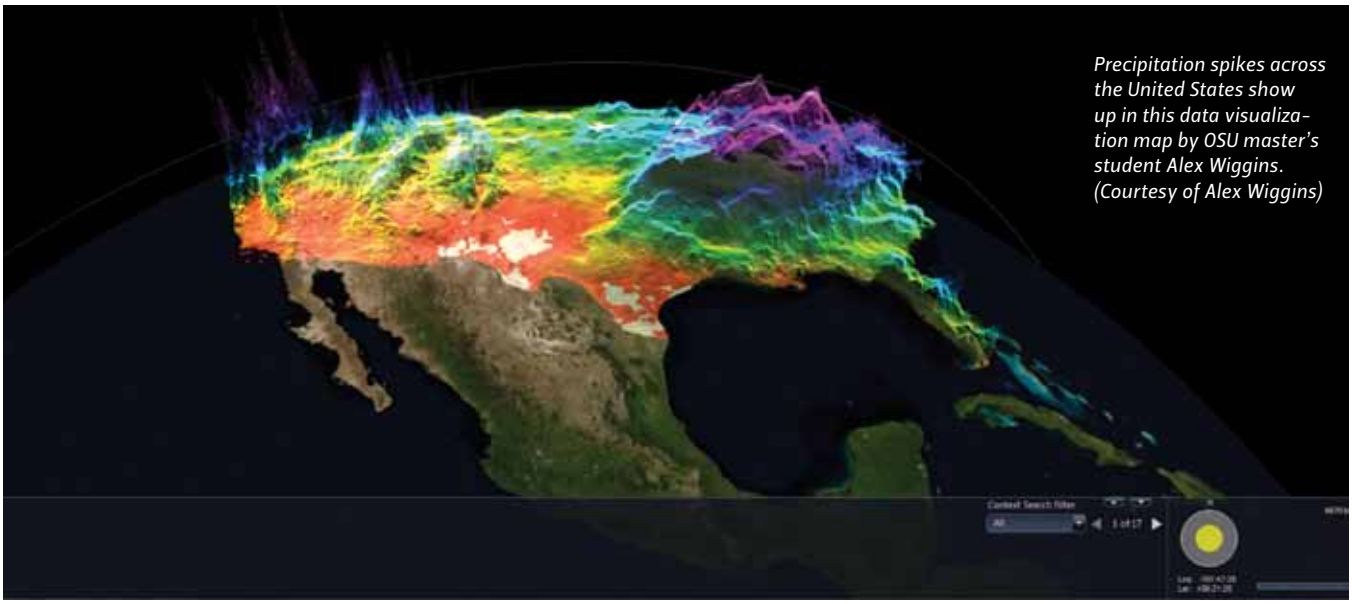
- Less than 40 percent of the river's length is forested today, compared to 87 percent in 1850. Length of river channels in the mainstem has decreased by 25 percent, and wetlands throughout the valley have decreased 95 percent.
- Cities, industries and farms withdraw an average of more than 37,000 cubic feet of water every day from the Willamette. More than 80 miles of small tributary streams that historically flowed year-round now go dry in a moderately dry summer.
- The Willamette basin supports 35 native fish species but now contains an additional 31 non-native species.
- The Pacific Northwest's climate is uncertain. Air surface temperatures are projected to increase by 0.2-1°F per decade, and precipitation timing and amounts may change, potentially leading to larger water withdrawals and increasing stress on some fish species.

While these trends seem dire, I and many other scientists have a vision of a restored, more resilient Willamette River. The rich and complex river channels witnessed by Lewis and Clark and other explorers in this region will not return, but rather, through deliberate design, we can see a more ecologically sound and livable future in the valley.

Getting there will require solid information about the distributions and habitats of native aquatic species, cold-water refuges, floodplain-inundation extents and opportunities for river and floodplain restoration. Researchers at Oregon State University, the University of Oregon, the Oregon Department of Fish and Wildlife and other agencies are providing the basis for the future.

Meanwhile, restoration initiatives are already under way. The Special Investments Partnership of the Oregon Watershed Enhancement Board and the Willamette River Initiative of the Meyer Memorial Trust have partnered to conserve and restore floodplain forests and channel complexity in the Willamette River mainstem. State and federal agencies are conserving habitats and restoring altered habitats in response to the Willamette River Biological Opinion, Wildlife Mitigation Agreement and other programs. Watershed councils are addressing ecological conditions along the mainstem and the smaller tributaries where their previous efforts have focused. The Willamette Partnership and Clean Water Services have developed systems for carbon-credit and thermal-credit trading that could involve reforestation of riparian areas and floodplains. Cities and industries are exploring options to mitigate for thermal effects of water use and treatment practices. A diverse array of citizens' groups, ranging from farmers to urban residents to industrial coalitions, are developing grass-roots programs to identify conservation opportunities and find ways to make them happen.

These programs build hope that the trends in resource loss observed in the Willamette River over the last 160 years may be reversed. The decisions we make today in our communities will shape the future of the Willamette River and the cities, farms and forests that depend on this river of change.



Precipitation spikes across the United States show up in this data visualization map by OSU master's student Alex Wiggins. (Courtesy of Alex Wiggins)

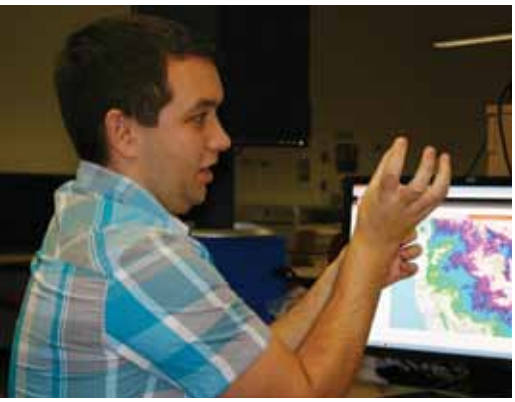
Mapmaker for the Climate

Student works with Microsoft Research to visualize climate data

BY NICK HOUTMAN

WITH THE SWEEP OF AN ARM, a TV weather announcer can set winds in motion like the master of ceremonies in a three-ring circus. We can sit back and watch clouds, rain and snow swirl over landscapes from local to continental.

Alex Wiggins would like to bring that kind of visual power to climate data. The native of Gresham is a master's student in computer science at Oregon State University and has been working with the Oregon Climate Service and Microsoft Research to create a new generation of online visual mapping tools.



The goal is to help the state climate service meet requests for information. People will need nothing more than their own Web browsers to place climate data on top of Microsoft's Bing maps and visualize differences in precipitation, temperature and other climate factors.

"Say you want to look at where there were lows for the month or highs for the month," says Wiggins. "You can put as many layers on the map as you want. You can play through it and see how it changes over the years."

While maps showing climate data and the results of modeling studies have been available for years, Wiggins' visualization tools will allow users to ask questions and to customize their own maps.

Microsoft Research and OSU have a history of collaboration, which reached a milestone in December when Mark Abbott, dean of the College of Earth, Ocean, and Atmospheric Sciences (CEAOS), received a national award from the company for his contributions to data-intensive computing.

Yan Xu, senior research program manager at Microsoft Research, says Wiggins' project engages those in the scientific and technology development communities. "That's the value I see in this kind of collaboration. Science scenarios challenge technology, and technology advances how scientists do science," she says.

The Oregon Climate Service (OCS) makes climate data available from a variety of sources, including the PRISM Climate Group at OSU, the Western Regional Climate Center, the Natural Resources Conservation Service and the Community Collaborative Rain, Hail and Snow Network.

"There's no limit when you have a system like this. The possibilities are endless," says Kathie Dello, deputy director of the OCS. Wiggins is working with Dello; Philip Mote, OCS director; and with Mike Bailey, professor in the School of Electrical Engineering and Computer Science. Mote and Dello are also affiliated with the Oregon Climate Change Research Institute.

Wiggins expects to complete his project next summer and enter a Ph.D. program in CEOAS to focus on signal processing from ocean observing systems.

Terra
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"You can either put your head in the sand or adjust," says Walter Powell, vice president of the Oregon Wheat Growers League. Powell, who keeps up on climate change research, describes himself as "less skeptical than most" growers. See "Against the Grain," Page 18. (Photo: Lynn Ketchum)