terra

A world of research & creativity at Oregon State University • Winter 2010

CAPTURING CARBON

How much can Northwest forests absorb?

ALSO IN THIS ISSUE

SWEET SPOT FOR CARBON

Tropical rain forests capture our imaginations with their breathtaking beauty and diversity. But acre for acre, when it comes to absorbing and storing carbon from the air, they can't beat the old-growth forests of the Pacific Northwest. At a time when landowners are beginning to see cash for carbon, that means opportunity.

As our cover story explains, the science of carbon sequestration — the process of absorbing carbon and keeping it out of the atmosphere for long periods of time — is young. OSU scientists Beverly Law and Mark Harmon are among the leaders in that field, but how their work translates into policy is still a matter of hot debate.

Meanwhile, if you want a stake in this arena, you have options. You can support The Climate Trust, the Portland-based nonprofit that is investing in forest-based carbon storage in Deschutes County, the state of Washington and elsewhere. Through the Pacific Forest Trust, Green Mountain Energy will sell you carbon credits for $19.95 a ton, based on a 100-year plan for the Van Eck forest in Northern California (payments for 185,000 metric tons of carbon credits have reached nearly $2 million, according to Christine Harrison, PFT communications director). And if you are a family-forest landowner, you can learn more about Woodlands Carbon of Salem, one of two pilot projects supported by the American Forest Foundation to assemble and sell carbon credits.

OSU researchers and Extension foresters are in the thick of the emerging science. They run monitoring programs and develop computer models. They assist Woodlands Carbon by calculating carbon uptake and conducting workshops on forest planning. They take leading roles in national and international public policy studies for the U.S. Forest Service, the State Department and the United Nations. They focus on economics, land use and carbon monitoring. Their work could contribute to a comprehensive carbon accounting system, which will be a crucial part of an international program known as REDD, Reducing Emissions From Deforestation and Forest Degradation, the most successful outcome of the recent climate talks in Copenhagen.

The forest carbon story wouldn't be complete without wood products and their role in reducing the carbon footprint of industrial economies. As OSU Professor Jim Wilson and his colleagues have demonstrated, wood takes less energy to produce than concrete, plastic or steel. They have shown that over their life cycle, products from sustainably managed forests will be part of a comprehensive solution to climate change.

— Nick Houtman

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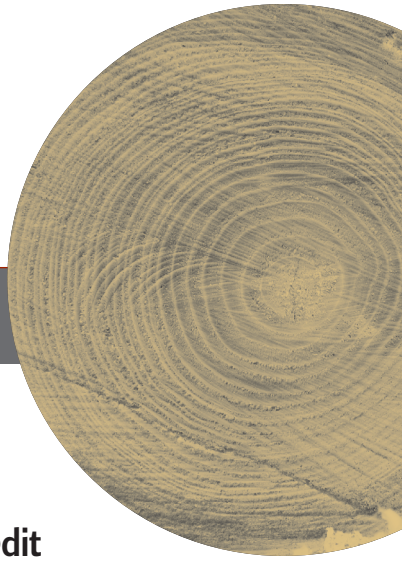

OSU is a leading public research university with more than $252 million in research funding in FY2009. Classified by the Carnegie Foundation for the Advancement of Teaching in its top category (very high research activity), OSU is one of only two American universities to hold the Land-, Sea-, Sun- and Space-Grant designations. OSU comprises 11 academic colleges with strengths in Earth systems, health, entrepreneurship and the arts and sciences.

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Technology Meets Culture Join OSU anthropologist Sunil Khanna for a personal look at a small village in India
Credit for Carbon Listen to OSU Extension forester Rick Fletcher describe how landowners can prepare for carbon credit markets
Renewing the Range Take a video tour of two Central Oregon watersheds

Features

LIVING ON CREDIT

Forest landowners are beginning to turn carbon to cash

By Nick Houtman

(Photo: Eppic Photography)

In Brief

THE ISSUE Paying forest landowners to maximize carbon uptake in their woodlands could mitigate global warming and provide an incentive to keep forests from being developed for other land uses. However, scientists are still learning how to measure carbon flows, monitor carbon storage and determine the most effective carbon management strategies.

OSU LEADERSHIP OSU researchers have made important strides in monitoring and understanding the carbon cycle in old-growth and young forests. They testify before congressional committees, lead national and international carbon research programs and help family-forest owners to qualify for emerging carbon credit markets.

Ken Faulk hopes carbon credit payments can slow the conversion of woodlands to non-forest land uses. (Photo: Nick Houtman)

As Arctic ice thins, sea levels rise and glaciers recede, Ken Faulk takes stock of his trees in the Oregon Coast Range. Last summer, he began measuring his stands of Douglas fir and white oak by pounding plastic pipes into the ground to mark the centers of circles nearly 30 feet across.

Working steadily in the soft twilight under the forest canopy, he recorded the height and diameter of every tree in each circle. It took him five days to cover 40 acres, but Faulk didn't mind. He regards trees with the experienced eye of a man who loves the woods. "I saw old friends I hadn't seen in a long time, trees I remembered, that I had taken an interest in. It was of value to me for that alone," he says.

He sent his data to Oregon State University forest modeler Greg Latta, who analyzes carbon offset policies for the U.S. Environmental Protection Agency. Latta calculated that Faulk's Douglas firs, planted in 1980 by a previous owner, were growing fast enough to absorb more than five tons of carbon per acre annually, an amount equivalent to that generated by a car driving more than 35,000 miles.

Faulk's forest isn't unusual. The process, known as carbon sequestration, occurs everywhere that plants grow. As they absorb carbon dioxide from the air during photosynthesis, trees store part of that carbon in branches, stems and roots. Not all species are alike. The oaks come in a poor second to the firs, and on Faulk's land, they absorb only about one ton per acre.

An OSU College of Forestry alumnus and the son of a Tacoma millworker, Faulk has seen the woods from every angle — independent logging contractor, Weyerhaeuser forester, Oregon Department of Forestry inspector and now president of the Oregon Small Woodlands Association. The nonprofit organization's 3,000 members own about 16 percent of Oregon's 30.5 million forested acres.

With help from OSU Extension, the American Forest Foundation and other organizations, OSWA has created a company, Woodlands Carbon of Salem, Oregon, to create access to carbon sequestration markets.

By the end of December, Woodlands Carbon had signed up 11 landowners who agreed, like Faulk, to tally the tons of carbon being sequestered by their woodlands. More importantly, according to OSWA' s Mike Gaudern, it had assembled nearly 20,000 tons of carbon credits and was seeking buyers for them. Unlike with other commodities — two-by-fours or bags of wheat — you can't take a ton of carbon home and put it in the garage. But by paying landowners to lock carbon away in the woods for a period of time, buyers can offset their own carbon emissions.

The hope is that carbon credits can provide a boost to financially struggling landowners who are facing growing pressure to convert their lands to other uses. If Gaudern and Faulk succeed, they won't be the first. Such deals have already been struck in California, Michigan and elsewhere in the Pacific Northwest.

An Appetite for Carbon

Oregon has long been the nation's mother lode for softwood lumber, but if carbon sequestration is the goal, Faulk and other forest landowners are in the right place. OSU researchers have determined that forests here are among the best in the world for absorbing carbon dioxide, the gas linked to global warming. Old-growth stands in the Coast Range and west side of the Cascades store as much or more carbon than tropical rain forests, according to studies by OSU forest scientists Mark Harmon, Beverly Law and their students. Moreover, Law and her team have found that there is enough capacity to theoretically double the amount of carbon currently stored in forests stretching from San Francisco to the Columbia River.

"Many of the mature and old forests are on public lands, so they are uniquely positioned to act as carbon reserves," Law told a U.S. Senate subcommittee chaired by Oregon Senator Ron Wyden last November.

To Faulk, more capacity for carbon means opportunity. "Scientists are telling us we need to draw the carbon dioxide level down as quickly as we can," he says. "And that's what we're aiming to do here. Whether we can find some buyers who will accept that concept is our next challenge."

It is just one of many hurdles confronting forest owners and scientists who are still coming to grips with what it might mean to put a price on forest carbon. At present there is little consensus. While professional forestry groups develop standards for inventorying carbon, economists are highly skeptical that, without national carbon emissions limits, carbon-credit markets can work. Forest ecologists are evaluating the carbon consequences of forest management practices and have barely begun to consider the influence of a changing climate. And forest products engineers have shown that wood can both store carbon for long periods and reduce carbon emissions by replacing other energy-intensive building materials such as concrete and steel.

Regenerating forests continue to pump carbon into the atmosphere for 15 years or more, according to studies by Mark Harmon, Bev Law and their colleagues. (Photo: Kelly James)

"We need to look for ways forest resources can mitigate or ameliorate undesired climate change."

— **Hal Salwasser, Dean**
College of Forestry

Global Accounting

"If you're going to make policy decisions to reduce carbon emissions and to mitigate by picking up carbon on the land, you need to measure these processes and ask, 'Are we even coming close to what we think is going on?'" says Law, a Professor of Global Change Forest Science. "'What is the ultimate effect on the atmosphere across the globe?' That's a big task."

Law seems undaunted by big tasks. In 1996, she joined scientists planning a new national network that monitors the exchange of carbon dioxide between forests, shrublands and other biomes, with the atmosphere. The goal was to track carbon flows across the country — from the maple, spruce and fir of New England, to the Ponderosa pine and aspen of the West. She suggested that sensors needed to be standardized and calibrated regularly so that data could be compared and analyzed nationally. "I spoke a little too much and became the science lead," she says, a position she holds today for the international AmeriFlux network. Law also advises climate science programs run by the federal government and the United Nations.

Closer to home, she and her OSU colleagues manage three AmeriFlux sites in Oregon — two west of Sisters and another on land owned by Starker Forests Inc. along the Marys River near Philomath. They complement atmospheric carbon dioxide concentration measurements at three other locations — Newport, Marys Peak and Burns — that capture changes as air flows from the coast to the Great Basin.

Hardly a molecule moves at AmeriFlux sites without being detected. Instruments monitor weather, sunlight, heat and moisture. They track carbon in the soil, water, atmosphere and even water flowing through tree sap. Data flow every half-hour via cell-phone networks to Law's lab on the Corvallis campus where she and her team monitor the instruments. They use the data to calibrate computer models that evaluate how carbon dioxide flows in and out of the forest and how carbon remaining in the forest changes at local, regional and national scales. Scientists will need such models to achieve the most ambitious result of the recent climate talks in Copenhagen: a program to cut carbon dioxide emissions in half by 2050 and to reduce carbon emissions from deforestation and forest degradation, particularly in tropical rain forests.

Meanwhile, the OSU professor and her collaborators have produced groundbreaking studies of Pacific Northwest forests. Some of their findings:

- Fires produce less carbon emissions than previously thought. Even in a high severity fire, only about 10 percent of above-ground live carbon stocks are burned. About 60 percent of burned carbon comes from litter on the forest floor, underlying duff and mineral soil, and most of the rest comes from snags and other dead material. Less than 1 to 3 percent comes from the trunks of live trees, somewhat lower than the fraction commonly used by scientists who produce national estimates of fire emissions.
- Like all living systems, forests constantly send carbon dioxide back to the atmosphere, but most of it, about 70 percent on average, comes from the soil (roots and microorganisms), not tree stems and foliage.
- Still, most forest carbon is stored in the soil, and 15 to 25 percent of soil carbon is long-lasting fire-produced char.

Disturbance

When it comes to carbon, Mark Harmon describes the forest as a leaky bucket. As carbon pours into the bucket through photosynthesis, it constantly leaks out through other

processes, mostly decomposition and respiring plants and microbes.

It's no different, he adds, than a bucket of water. "People tend to think that a leaky bucket can't hold water. Well, that's not true at all. It can, and it does. As long as there's something coming into the bucket and the leaks aren't mammoth, some water will accumulate. The more you pour in, the higher it will rise. The more holes you have, or leaks, the more it will go down."

The holder of the Richardson Chair in forestry has specialized in two parts of forest carbon cycle: dead wood and the disturbances that produce it. Logging typically leaves large amounts of branches and other unsaleable material on the forest floor. In past years, much of this so-called slash was burned to "clean" the site. Harmon's research has showed that as this wood decays, it fertilizes the regenerating forest. Leaving slash on the ground not only benefits young trees, it saves money by eliminating unnecessary work.

However, decomposition sends carbon back into the atmosphere. Harmon and Law have shown that for 15 years or more, the amount leaving a harvested site outpaces what young trees can absorb. Eventually, rapidly growing trees catch up and reverse the flow, resulting in the high rate of carbon sequestration that is occurring in Ken Faulk's forest. But, says Harmon, forests must go through a massive carbon release before they reach that stage. "You just can't get to the mountain peak without going through a valley," he adds.

Harmon and colleagues demonstrated this process in a landmark study published in the journal *Science* in 1990. In the late 1980s, some scientists had proposed replacing old-growth forests, thought then to be stagnant, with carbon-hungry youngsters that would take more carbon out of the atmosphere. Together with OSU colleague William Ferrell and Jerry Franklin of the U.S. Forest Service, Harmon reported that replacing old-growth with young stands would in fact pump more carbon into the atmosphere, even accounting for the carbon stored in wood products. It could take at least 200 years, they concluded, for the regenerating forest to store as much carbon as the old-growth.

"You look at a tiny young forest and a massive old forest and ask which one stores more carbon. It doesn't take much to figure this out, although it's taken some people a really long time," Harmon says. It's an argument that continues to the present day and has continued to motivate research by Harmon and his students on tree mortality, decomposition and the carbon consequences of harvesting systems.

Green Wood

The carbon story doesn't begin and end in the forest. In fact, the benefit of wood as a "green" building material goes beyond its ability to sequester carbon. It also serves as an alternative to more fossil fuel-intensive products such as aluminum, steel, concrete and plastic. "If you don't look at what it's displacing, you miss a big part of the story," says Jim Wilson. "You have to look at the whole life cycle."

For the last decade, the OSU wood scientist has worked with a national organization, the Consortium for Research on Renewable Industrial Materials, or CORRIM, to follow the carbon trail for wood and other industrial materials from cradle to grave. With public and private funding, CORRIM has conducted life-cycle analyses of wood products industries across the country, from softwood lumber and plywood in the Pacific Northwest and South to hardwoods in the Northeast. It has analyzed wood flooring, particle board, laminated timbers and even the adhesive resins used in engineered wood products.

Bleeding Edge

Last fall, in a class created with support from the American Forest Foundation, OSU students led by forestry professor John Bliss and colleagues Sally Duncan and James Johnston from OSU's Institute for Natural Resources delved into the carbon credits issue. They talked with scientists and economists and surveyed 30 OSWA members and chapter presidents. Bliss told his students they were watching the science unfold before their eyes.

"This is the bleeding edge," says Bliss, holder of the Starker Chair in Private and Family Forestry at OSU. "Everybody thinks this is important stuff, that figuring this out is worth the time and effort. Very few think we're anywhere near getting there."

It can take 200 years or more for regenerating forests to replace the carbon stored in old-growth stands. (Photo: University Marketing)

Leaves and needles are the engines of carbon sequestration. The international AmeriFlux network measures carbon flows at more than 100 locations. (Photo: Ulrike Hammerich)

A 2009 CORRIM report, *Maximizing Forest Contributions to Carbon Mitigation*, notes that harvesting trees more slowly to increase carbon storage in forests would be counterproductive. That's because a smaller supply of wood products would lead builders to substitute materials that require more energy to produce, thus leading to larger carbon emissions from fossil fuels. Over time, according to the CORRIM model, the use of wood to displace other building materials keeps more carbon out of the atmosphere than would be solely stored in the forest ecosystem itself if no harvesting was done.

To reach that conclusion, Wilson and his colleagues compared typical wood-frame houses to homes built with steel framing and concrete blocks. They also assumed that wood would come from "sustainably managed" forests, not old-growth. "If they aren't sustainable, it's not going to work," Wilson adds.

"The CORRIM study suggests that when we take a comprehensive look at building materials, including total energy consumption, global warming, air and water emissions and solid waste disposal, wood turns out to perform better in most categories," Wilson says in a 2009 report, *Building to Benefit the Environment*, by the Oregon Forest Resources Institute.

Pork Bellies

Andrea Tuttle, board member for the nonprofit Pacific Forest Trust (PFT), put it bluntly in a recent public radio interview: "Anything you can do with a pork belly, you can do with forest carbon, in terms of cash sales, derivatives, hedge funds, portfolio mixes. It's a legitimate product now." The trust has arranged to sell carbon credits from a mixed redwood and Douglas-fir forest in northern California to politicians (Governor Arnold Schwarzenegger, Speaker of the House Nancy Pelosi), utilities and even commodities traders. It predicts that the Van Eck Forest in Humboldt County will store an additional 500,000 tons of carbon over the next century. Spurred by California's climate change program, buyers have already paid nearly $2 million for 185,000 tons of carbon credits, according to Christine Harrison, PFT communications director. In December 2009, national energy supplier Green Mountain Energy was selling Van Eck carbon credits for $19.95 per ton.

Despite this success, economists find the idea of a carbon market hard to swallow unless there is a government policy imposing emissions limits. "Carbon is not like pork bellies," says Andrew Plantinga, OSU professor of Agricultural and Resource Economics. "Since people

RESEARCHER PROFILES

Beverly Law

In addition to her work at OSU, Beverly Law leads carbon research programs for the AmeriFlux network and for the United Nations. She leads a regional project on the carbon balance of Washington, Oregon and California, and how it is affected by disturbance and climate. She is helping to develop international protocols for forest carbon accounting and database design. A fellow of the Aldo Leopold Leadership Program at Stanford University, she has received funding for her research from the U.S. Department of Energy, NASA and NOAA, among other agencies.

Mark Harmon

Holder of the Richardson Chair in Forest Science and the former lead scientist at the H.J. Andrews Experimental Forest, Mark Harmon has specialized in nutrient cycling, decomposition and carbon dynamics. He has collaborated with researchers in the U.S. Forest Service and at universities in Washington, Colorado, Wisconsin and other states as well as OSU. He has received funding from the National Science Foundation, U.S. Environmental Protection Agency, NASA, U.S. Department of Energy and the Forest Service.

can derive the benefits from carbon sequestration without paying for carbon credits, there are powerful incentives for them to free-ride on other people's purchases. Unless there are restrictions on emissions, the incentives for anybody to buy carbon credits are weak."

Even with emissions limits, a market for forest carbon suffers from three major problems, he explains. The first, known as "additionality," stems from the fact that trees sequester carbon just by growing. Landowners need to demonstrate that their actions will cause the forest to store more carbon than it would have done on its own.

Second, he adds, carbon credits aren't permanent. If a contract ends and landowners are free to harvest their forest or convert their land to another use, much of that carbon can be released back into the atmosphere.

Third, carbon credits can reduce tree harvests in the short term and lead to less wood available for paper, construction and other uses. That may raise prices and give other landowners an incentive to harvest their trees earlier. This so-called "leakage" problem also puts carbon back into the air.

In an analysis for The Harvard Project on International Climate Agreements, Plantinga and Kenneth R. Richards of Indiana University suggest an alternative: an international treaty that places national limits on forest carbon emissions and requires regular accounting of carbon stocks across the globe. Such a system could avoid the pitfalls of a project-by-project approach, which was adopted in the Kyoto Protocol.

By substituting for more energy intensive products, wood can cut carbon emissions to the atmosphere, according to studies by Jim Wilson and his colleagues. (Photo: Nick Houtman)

"We need to look at forestry at as broad a scale as possible," says Plantinga. "We need to count everything. We should have a way of looking at all of the forests in the United States and relative to a (carbon) benchmark that we all agree on, determine if they go up or go down."

A national cap on carbon emissions could provide an incentive for utilities and other emitters to buy carbon credits, such as those offered by Woodlands Carbon and Green Mountain Energy. Plantinga is currently studying the potential for policies based on emissions caps to meet the problems posed by carbon markets. terra

Jim Wilson

Jim Wilson is a professor emeritus in the Department of Wood Science and Engineering. He has specialized in the life cycle of wood products and the environmental performance of wood building materials. He served as the vice president of the Consortium for Research on Renewable Industrial Materials and continues to conduct research with CORRIM with funding from the USDA Forest Service, U.S Department of Energy, contributing university members and the forest products industry.

Andrew Plantinga

As a professor in Agricultural and Resource Economics, Andrew Plantinga specializes in land use, climate change and forests. He uses econometric models to analyze policies promoting carbon sequestration, wildlife conservation, and other environmental outcomes. He has held positions with the U.S. Forest Service and Resources for the Future and has received research funding from the Forest Service, the National Science Foundation and other agencies.

The Stress Paradox

Coping with trauma can strengthen us over time

By Lee Sherman
Illustration by Santiago Uceda

Carolyn Aldwin has been privy to countless untold secrets, heartbreaking stories from war zones, hospital wards and prisoner-of-war camps. People from all walks of life have confided their everyday problems and their worst nightmares to her.

"I talked to someone who was a lawyer at the Nuremberg Trials," she says. "I've talked to people who've committed murder. I've talked to people who've lost children to cancer. I'm very humbled by the things people tell me."

Aldwin, a professor in OSU's Department of Human Development and Family Sciences, has interviewed thousands of people across the United States, many of them combat veterans, for longitudinal studies of aging. Her findings have shaken up conventional notions about stress and trauma across the lifespan.

"When I was in grad school in the '70s, old people were viewed as frail, lonely, depressed and beset by overwhelming stresses and losses," says Aldwin. "We've since learned that stress is fairly constant across the lifespan — that no stage is necessarily more or less stressful than another. What does change as we age is the way we view our troubles and the way we deal with them."

Events as horrifying as 9/11 or as threatening as today's tottering economy take on new perspective when seen through eyes that witnessed the Battle of the Bulge or the Great Depression. Aldwin continues to explore coping strategies through her research and to share what she learns with students. She currently teaches a University Honors College class, Coping with Stress.

Double Puzzle

At Leisure World, Carolyn Aldwin stuck out like a sore thumb. The blond, blue-jeaned 29-year-old researcher, crashing temporarily at her uncle's townhouse, was easy to spot among the silver-haired retirees.

But this newly minted Ph.D. in the field of aging and adult development was thrilled. For her, the sprawling retirement community in Irvine, California, was a big metaphorical petri dish. Eager to discover how elders cope with life's stressors, the young social scientist spent the next few months talking with her neighbors (average age: 78) about their struggles and worries. Scientists were just beginning to study stress-related health risks, both physical (high blood pressure, immune system suppression, heart disease) and mental (anxiety, depression). The impact of coping strategies on health and well-being was mainly theoretical at that point.

Certain puzzling patterns popped up early on. First, despite their seeming vulnerability to loss and illness, elders tend to report less stress in their lives. "If late life is supposed to be such a miserable time, why are old people reporting fewer stressors than younger people?" Aldwin wondered. This is Paradox One.

Second, most adults find positive aspects — the proverbial silver lining — in even the most wrenching events. This is Paradox Two.

"As a developmental psychologist, I believe events are connected, rather than being discrete, isolated episodes," Aldwin says. "I wanted to investigate the ways people draw upon earlier experiences, even traumatic ones, when coping with current problems or crises."

Teasing out the truths behind these two paradoxes has been Aldwin's driving motivation in the decades since Leisure World. How, she wanted to know, did a soldier whose buddies perished on the battlefield convert that searing trauma into psychosocial strength over time? How could watching one's child die of cancer mitigate the ill effects of daily stress down the road?

Ask the Right Questions

Aldwin turned up one crucial clue to the first paradox in her Leisure World study. Researchers, she discovered, were asking the wrong questions. The standard survey instrument for major life events was loaded with younger people's milestones and struggles — marriage, parenting, military service, divorce, unemployment, incarceration. By broadening the questioning, Aldwin found that elders face not fewer stressors, just different ones. It turns out that as people age, they fret less about themselves and more about loved ones. These indirect stressors — a grown child's job loss, a spouse's move to a nursing home, a sibling's struggle with Alzheimer's — Aldwin calls "network" stressors. She designed a new survey instrument, the Elders Life Stress Inventory, to account for them.

The new survey, however, failed to resolve the paradox. Instead, the question mark shifted from the amount of stress to the response to stress. With the new instrument, older subjects were reporting life stressors roughly equal in number to those of younger subjects. Yet still

In Brief

THE ISSUE Emotional stress has been linked to post-traumatic stress disorder among military veterans and increased health risks in the general population.

OSU LEADERSHIP In studies with veterans and the elderly, Carolyn Aldwin has found that successful coping strategies can mitigate stress-related health problems and help people respond to day-to-day events.

they claimed fewer worries. When prodded — "Certainly, you must have *some* problems"— one man parsed the wording for Aldwin. "I don't have problems," the octogenarian told her. "I have concerns." The biggest of these concerns was his 90-year-old sister suffering from dementia and living alone in New York City. She refused to move, despite his entreaties. So he settled into a philosophical stance ("There's nothing more I can do"), thereby keeping his emotional equilibrium. This ability to stave off stress derives from what Aldwin calls "perspective." Having survived the slings and arrows of life for 60, 70, 80 years, elders often are able to step back and assess new challenges with a steadier gaze. As one man told her, "Once you've watched your 20-year-old daughter die of cancer, it's hard to get really upset about other things."

Silver Linings

Aldwin and her adviser at the University of California, Irvine, Dan Stokols, both should have grown up to be drug-using dropouts — that is, if you believed the psychological research literature of the 1970s and 1980s. Each had lost a parent in childhood, and delinquency was the expected outcome for kids so bereft. Sitting together in Stokols' office one autumn afternoon, these two highly accomplished PhDs wondered aloud how they had defied expert predictions. Maybe, they speculated, those predictions were off-base. After all, it was known that geniuses often had older parents who died. Other emerging evidence suggested that remarkable resilience was not only possible, but actually common, in the wake of tragedy. Their curiosity evolved into a research thread.

"We started asking, 'Are there circumstances under which stress can have positive effects?'" she recalls. "This was a very radical notion at the time."

No formal, quantitative studies existed then. But the trauma literature from records of tragic events turned up promising leads for further research. In tragedy's aftermath, many victims reported closer community ties, increased mastery and heightened altruism. The extraordinary lives of many Holocaust survivors, such as Nobel laureates Elie Wiesel and Daniel Kahneman, also seemed to refute the view of trauma as inevitably and irretrievably damaging to the psyche.

To explore this intriguing phenomenon, Aldwin added one question to the 1,000-subject Normative Aging Study then under way in Boston: Was there anything in your earlier life that was useful in helping you deal with a current problem? She was stunned by the response — not so much because 80 percent of the respondents said yes, but because they identified serious, even horrific, occurrences as teachable moments. Battlefield traumas came up often for this population of men, who were mostly veterans of the Korean and Second World wars.

"One guy said, 'I was shot down at Midway in the Pacific,'" Aldwin recalls. "'I spent three days bobbing in a lifeboat while the battled raged around me. I thought, if I can survive this, I can survive anything.'" Midway became the yardstick against which he measured every tough spot he faced in later years.

Another veteran said he watched three commanders die on the European frontlines. Being next in rank, he was promoted on the battlefield. He managed to lead his men to safety. Ever after, he gauged life's challenges against that life-or-death test of his mettle.

Over and over, Aldwin heard this story. Even the fiercest conflict in a boardroom or a courtroom is manageable after you've faced down death on the battlefield, the old soldiers said. Psychologists call the phenomenon post-traumatic growth or stress-related growth. "This is not to suggest that combat is good — not at all," says Aldwin, who has taken flak from colleagues for suggesting that anything positive could come out of the horrors of war. "Trauma has long-term effects. But the guys who were able to find benefits in their military service — whether it was unit cohesion or believing in the mission — were much less likely to exhibit symptoms of post-traumatic stress disorder."

Aldwin found similar results in another Boston study, the Health and Personality Style Survey. A majority of subjects, 70 percent, reported that trauma led to positive outcomes including closer family ties, better coping skills, more positive values and deeper spirituality.

Observes Aldwin: "Older people understand that problems are finite, that grief is time-limited. They also know that letting yourself get upset when you have a chronic illness like hypertension can trigger a cascade of harmful physiological responses." terra

See more about Aldwin's research at *oregonstate.edu/terra*

RESEARCHER PROFILE

Carolyn Aldwin studies the interplay between physical and mental health. She investigates the ways in which personality and coping moderate the effects of stress on health, especially in older adults. She also examines the positive effect of stress on adult development. The author of *Stress, Coping and Development: An Integrative Perspective* (2007), she received a FIRST award from the National Institute on Aging (NIA) early in her career. Additional funding sources have included private foundations, the Department of Veterans Affairs and the National Institute of Alcohol Abuse and Alcoholism.

Singing of Science

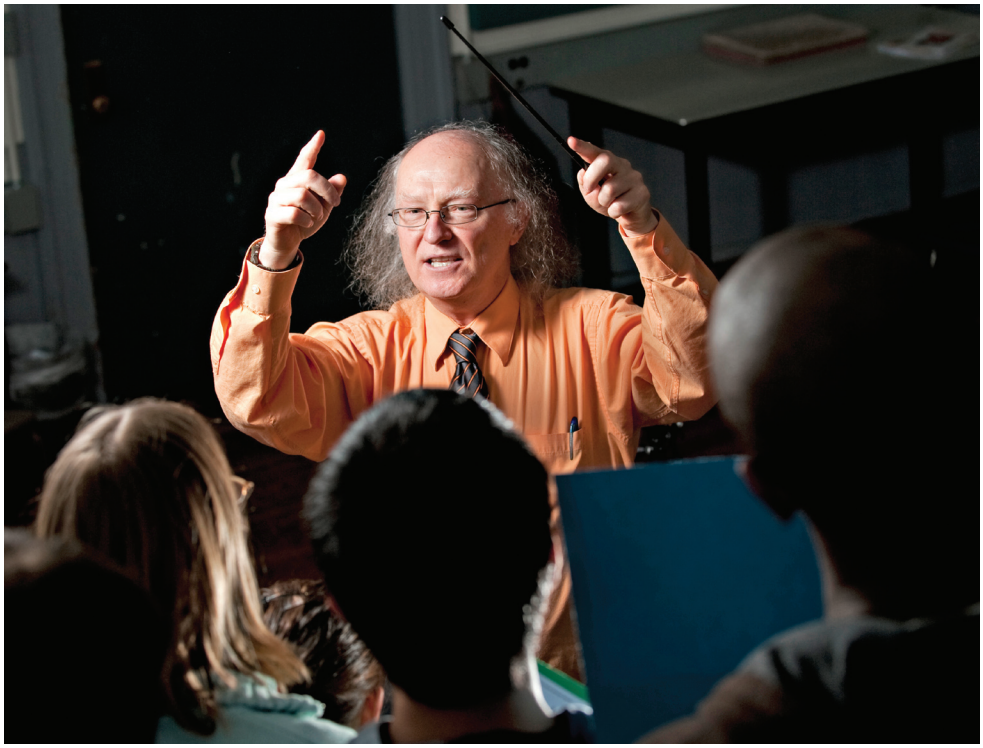
Kevin Ahern's lyrics help students learn about biochemistry

Like most teachers, Kevin Ahern savors the smile on his students' faces when they suddenly get it. He remembers having those bright "ah-ha" moments in school only too well.

But Ahern, who teaches introductory and advanced biochemistry classes to many of Oregon State University's pre-med students, has another reason for wanting to drive science into his students' minds. "These kids will be treating me sometime. I don't want to have one of them as my physician and think, 'Oh man, you got a D in my biochemistry class.'"

Ahern's own expertise is in viruses, and he holds a patent for a laboratory technique called "boomerang DNA amplification." He has written regular columns for *Science* magazine and other publications and directs OSU's annual Howard Hughes Medical Institute summer research program. But it's his unusual teaching style that has earned him a reputation among students at OSU and even among distance-learners in Europe and Asia.

Despite admitting that he can't carry a tune, he sings his own "metabolic melodies" to make a memorable point. At the end of class or in the middle of a lecture, Ahern will break into songs like "B-DNA" (to "YMCA"), "Glucagon is Coming Around" (to "Santa Claus is Coming to Town") and "When Acids are Synthesized" (to "When Johnny Comes Marching Home").



Kevin Ahern writes one or two new "metabolic melodies" every term. He has inspired comments from students as far away as Ukraine and Croatia. (Photo: Karl Maasdam)

Posted on YouTube

His copyrighted compositions have been recorded by students and professional singers, including Corvallis musicians Neal and Barbara Gladstone. Versions have been posted on YouTube and are available free at www.davincipress.com/metab-melodies.html.

A self-described ham who loves melodies, Ahern can break into a slightly off-key number at unexpected times in his classroom. And the reaction from his students? "You just saw this look that went across the crowd, 'Look, he's gone nuts,'" he says. But they laugh and applaud and have told him later that the catchy tunes help them to remember arcane facts.

Whether his students go on to the Oregon Health & Sciences University in Portland (where OSU contributes a large share of entering classes) or hold policy-making positions in state or federal agencies, Ahern wants them to be well-equipped. It's not just for technical proficiency. Inevitably, whether as physicians, administrators or policymakers, they will have to deal with controversial topics such as genetic engineering, animal cloning or nanomedicine. He wants their opinions to be grounded in facts.

These topics may generate varying points of view among students, but Ahern gives his graduates the ability to do more than work in a laboratory. "They need to talk the talk, and they need to understand the language," he says. "I think my songs tap a musical part of the brain and help them do that."

For his source of inspiration, Ahern credits a gifted math teacher in Fowler, Illinois (population 200), where he grew up. To hear him tell it, young Kevin had gotten in with the wrong crowd at school. He wasn't doing the work he was capable of, and his parents were exasperated. His math teacher did something that no one else had done: He explained the meaning of the equal sign. "It resonated with me in a way that is difficult to describe. I never had to study for another math class in my life."

— NICK HOUTMAN

On the Web: A list of Ahern's songs from "Biochemistry Pie" to "I'm a Little Mitochondrion," are at ***biochem.science.oregonstate.edu/people/kevin-ahern***

Depths of Discovery

A young oceanographer carries on a legacy of epic seafloor science

The colossal clamshells caught the young scientist's eye soon after he arrived at Oregon State University in the late 1970s. Giant bivalves the size of footballs were piled in the corners of offices and cradled in the arms of researchers walking the halls of the School of Oceanography.

"I realized pretty quickly that they weren't left over from a clambake," marine geologist Erwin Suess recalls wryly.

Far from being beach-party cuisine, the mega-shellfish evidenced one of the most stunning discoveries ever made in ocean science. Superheated water seeping from deep-sea volcanic rifts, discovered near the Galapagos Islands during a 1977 expedition led by OSU oceanographer Jack Corliss, jolted the fields of marine chemistry and geology. The implications for scientists' understanding of heat exchange and geochemical balance across the planet were profound. Even more startling was the host of outlandish creatures found thriving in the sulfurous, sunless depths. These mysterious species — the gargantuan clams, red-tipped tube worms, ghostly crabs and other weird residents of the ocean's hydrothermal vents — rocked biology to its core. Animals subsisting on gasses instead of sunlight had never been imagined, let alone witnessed from the portal of a manned submersible. These "chemosynthetic" organisms, scientists realized, could hold clues to life's very origins in Earth's ancient chemical soup.

On Their Shoulders

These discoveries underpin the work of a whole new generation of researchers in the College of Oceanic and Atmospheric Sciences (COAS). When Ph.D. candidate Brandon Briggs, for instance, hunkers over his microscope to study methane-making and methane-consuming microbes from the ocean's subsurface biosphere, he is carrying on the legacy of Corliss, Suess and dozens of other marine geologists, physicists, chemists and biologists who, over the program's 50-year history, have elevated COAS into one of the nation's top-three oceanographic research institutions (along with Scripps and Woods Hole).

"I was drawn to the interdisciplinary nature of the research here," says Briggs, whose passion for environmental microbiology took hold in his home state of Idaho. "You have to understand math, physics, chemistry and geology along with the microbiology. You have to be able to converse with people in all the different disciplines."

Briggs' research is anchored in a COAS discovery closely related to hydrothermal vents: ocean floor "cold seeps." First located in 1984 at the Cascadia Subduction Zone by Suess and Professor LaVern Kulm, the cold-water vent systems leak methane and other carbon-rich fluids from decaying life forms buried in subsurface sediments. The seeps support their own unique collections of "extremophiles" — organisms that exist in ecosystems devoid of light or oxygen. The gasses not only feed such oddities as the "seep tubeworm" (which can live 250 years) but also play a role in another deep-sea anomaly being studied by Briggs under the advisement of geomicrobiologist Rick Colwell: gas hydrates.

Caged in Ice

Methane in ocean sediments can, under certain conditions of temperature and pressure, become locked into a lattice of water molecules to form ice-like structures. Once thought to exist naturally only on Saturn's moons, hydrates have been found not only in ocean deposits around the globe but also in polar permafrost.

As a potential energy source, hydrates have gotten the attention of the U.S. Department of Energy, the agency funding Briggs' and Colwell's research. But the researchers warn that exploiting this resource must be approached with great caution. That's because methane is a potent greenhouse gas and hydrates are highly unstable; their gaseous "guest" molecules escape rapidly when the "host" latticework melts. This poses serious worries for environmental science, Briggs says. A runaway greenhouse effect could be triggered if hydrate fields were disturbed by earthquakes, rising ocean temperatures, changing sea levels, deep-sea oil drilling, melting permafrost or ocean-floor mining, releasing massive amounts of trapped methane, the researcher explains.

"When temperatures rise, hydrates release their methane," he adds. "There's evidence that methane from hydrates may have been released into the atmosphere the last time Earth was really hot, about 55 million years ago during the Paleocene-Eocene Thermal Maximum."

Examining core samples from Hydrate Ridge off the coast of Newport, Oregon, as well as from Canada's Vancouver Island and India's Bay of Bengal, Briggs is documenting microbial distribution using DNA analysis and studying biochemical pathways of microbes living in and around hydrates. Of special interest is the balance between microbes that *make* methane and those that *use* methane, the latter providing a brake on the accumulation of this gas in the environment. One central question is: If the rate of methane production were to speed up because of, say, rising temperatures, could the methane users keep up, or would they become overwhelmed and lose their buffering function?

"We're interested in the amount of methane produced in deep marine sediments, what controls the rate of methanogenesis, and how that biogenic methane factors into the global carbon cycle," says Colwell, a member of OSU's Subsurface Biosphere Initiative who came to the university in 2006 from the Idaho National Laboratory.

The answers may help scientists predict harmful off-gassing from melting hydrates. They may also guide decisions about carbon sequestration and energy exploitation in the ocean.

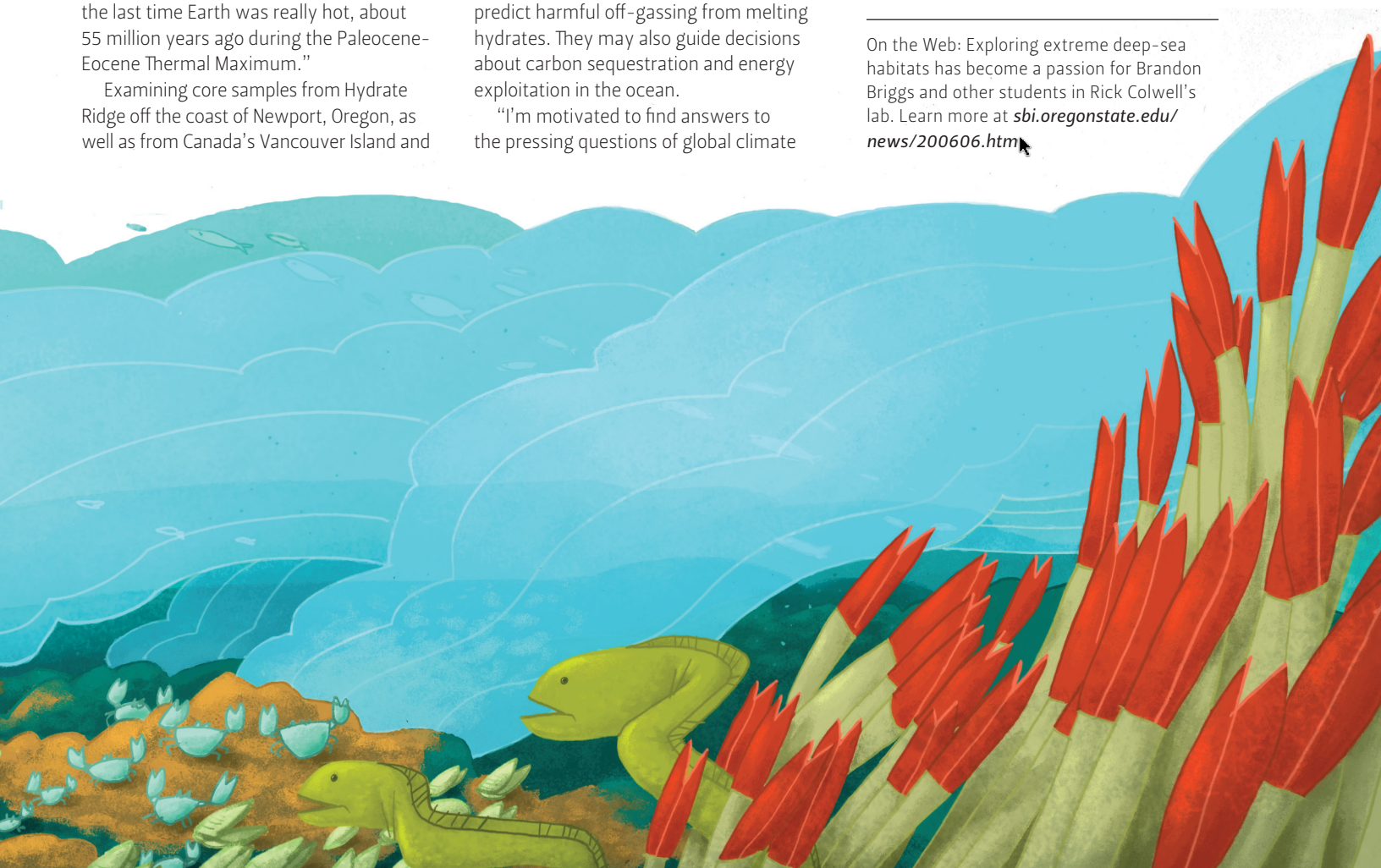
"I'm motivated to find answers to the pressing questions of global climate change," says Briggs.

As Ph.D. student Brandon Briggs studies the mysteries of methane hydrates, he follows a long OSU history of ocean-floor investigations.

Already, his research into the microbes' biochemical pathways is yielding intriguing findings. He has, for instance, identified microorganisms living in "biofilms" — "slimy, pinkish-orange" coatings of bacteria — feeding on methane 60 feet deep in Indian Ocean sediments. "To have that amount of biomass that deep in ocean sediments is surprising," Briggs says. "This hasn't been reported anywhere else."

— LEE SHERMAN
ILLUSTRATION BY WARD JENKINS

On the Web: Exploring extreme deep-sea habitats has become a passion for Brandon Briggs and other students in Rick Colwell's lab. Learn more at ***sbi.oregonstate.edu/news/200606.htm***



The Range Keepers

A perennial partnership of ecologists, hydrologists and ranchers is renewing Oregon's grasslands

By Lee Sherman

Winds gust lightly over the meadow, riffling the grasses and sage, carrying the sonorous tones of Angus, Hereford and Tarentaise mothers lowing at their calves. The tableau looks ripped from a TV commercial or a Hollywood set, all daubed with wildflowers and rimmed by junipered hills under cirrus skies.

The Hatfield and McCormack ranch families of Brothers, Oregon, have partnered with OSU for generations to improve rangeland ecology. (Photo: Mark Reed)

But this isn't the invention of a Madison Avenue ad agency, some "pastoral fantasy" spun by Big Agribusiness to fool consumers.

This is the real McCoy — or McCormack, actually.

The McCormack and Hatfield families of Central Oregon are known far and wide for their leadership in eco-friendly ranching. Patriarchs Doc Hatfield and Bill McCormack, whose ranches sprawl side-by-side across 100,000 acres near the one-pub town of Brothers, are charter members of a wildly successful company called Country Natural Beef. In just two decades, the co-op has grown from 14 Oregon families to 120 ranchers across the West and Hawaii. Their beef, pastured on grass and fattened in a feedlot on a pure vegetarian diet before slaughter, provides an alternative to factory-farm meat — the kind that's been pumped with antibiotics and plumped on growth hormones, as highlighted in *Food, Inc.*, the highly praised but controversial 2009 documentary on industrial food production.

The co-op, which posted sales of $50 million for 2008, isn't making the ranchers rich. Rather, it pays the bills and keeps the ranches solvent. And that's OK, because money isn't the true bottom line out on these semi-arid plains. It's respect for the life-sustaining land. For 30 and 50 years, respectively, Oregon State University has helped the Hatfields and McCormacks hone that ethic of respect through cooperative research. In return, scientists have been granted nearly unfettered access to vast watersheds and rangelands for study.

Catch and Release

One blistering morning in July, Doc Hatfield's black motorcycle kicks up a froth of dust along Bear Creek Road. He's on his way to meet a group of ecologists, activists, government agents and grad students touring a long-term research site on his acreage. While waiting for stragglers to arrive, Hatfield sets his silver helmet on the seat of the BMW and snaps a few photos of a cow-studded pasture. He's excited about its midsummer lushness. Clearly, science-based management strategies are making a difference.

"If you've got good native perennial grass cover on the upper slopes, the rain soaks into the ground where it drops instead of flowing off in a gully washer," he explains to the group gathered on the gravel road. "That stored water then flows subsurface, forming groundwater reservoirs and making the meadows wetter. That means it's still green on

In Brief

THE ISSUE Sustainable ranching means taking care of scarce water supplies and fragile desert grasses. Parched streams, erosion and invasive plants pose threats to ranchers' livelihoods and a productive ecosystem.

OSU LEADERSHIP For more than 30 years, OSU rangeland scientists have been working with Central Oregon ranchers to test the effects of removing juniper and managing grass and cattle. The results have contributed to a successful beef coop that has become an industry leader.

the 10th of July instead of just dry cheat grass."

This optimal water cycle is what OSU rangeland hydrologist John Buckhouse calls "capture, store and safe release." Buckhouse, one of the stalwarts in the multigenerational bond between the university and the Central Oregon ranching community, has spent much of his 35-year career investigating the impacts, both positive and negative, of cattle on high-desert ecosystems. One winter, with the mercury hitting 20 below, he sat on the ground at Bear Creek every day for a month, insulated in long johns and "lots of woolens," recording observations of streamside grazing behavior. Another early study asked the question, How many seasons should sown grass seed grow before you graze the pasture? Common wisdom said two years. The answer turned out to be much more complicated.

"We discovered that nothing is the same everywhere," says Buckhouse. "That has been our mantra ever since. You have to manage on a site-specific basis — what we call a prescription basis. If you come up with a prescription that works in Brothers, Oregon, and try to apply it in Missoula, Montana, you're probably going to be wrong."

From Tales to Data

Buckhouse's magnum opus is a longitudinal study devised to help Oregon ranchers catch, retain and put to use more of the region's scant precipitation. Key to the study is the western juniper, a native tree that, in the absence of natural fire, has encroached on millions of high-desert acres. Through its dense web of roots, the juniper takes up great gallons of water. The surrounding grasses die back. Rains rush over the bare earth, sweeping away tons of soil. Fifteen years ago, there was lots of local folklore about the rangeland's power to heal and regenerate after juniper was removed (stories like, "Gosh, I cut down a bunch of trees over at Salt Creek and a spring popped up the next year"). But there were no hard data on a watershed scale. So Buckhouse and his colleagues designed a "paired watershed" study to test the effects of a fire-mimicking treatment for halting juniper encroachment.

The experiment compares two 400-acre drainages at Camp Creek straddling the Hatfield High Desert Ranch and public lands overseen by the Bureau of Land Management. One parcel, Jensen Canyon, serves as the "control" site — that is, it has remained untouched by the researchers. The other parcel, Mays Canyon, is the "treatment" site for juniper removal. High-tech instruments, including ultrasonic sensors and devices for remote monitoring via satellite, were installed by then-graduate student Michael Fisher and Crook County Extension scientist Tim Deboodt. Data on groundwater levels, stream velocity, snow depth, rainfall and other indicators are collected around the clock.

After 12 years of baseline data collection, young juniper trees (those that took root after Europeans arrived in the mid-1800s) were cut from Mays' upper elevations. Downed branches were left on the slopes at diagonals to impede runoff of precipitation — a paltry 13 inches a year on average.

The results have stunned everyone. Four years after the cutting, streams that were ephemeral (flowing only after a storm) are now intermittent (flowing in tandem with recharged groundwater). Springs are gushing where once they were just gurgling. Erosion, as indicated by the depth of gullies and sediments, has slowed. And, judging by increased numbers of seed heads per clump of grass and reinvigorated species of native perennials, the improved water dynamic is translating to healthier forage. That, in turn, means more robust habitat for birds, deer, elk and other wildlife.

This ecosystem perspective is what Hatfield values most from his long-time association with OSU.

"Understanding the holistic watershed — how it all works together — has helped us improve our grazing strategy," says the 70-year-old rancher. "That's what sustainability is all about — it's land, people, dollars, and putting it all together."

Time Travel

Before you venture off Highway 20 onto the rangeland, you can grab a burger, a Bud Light and a fill-up at the weather-beaten Brothers Café. If you're hauling a horse, you can water it at Brothers Oasis, the equine-friendly rest stop right next door.

After you leave the crush of cars and commerce in Bend 40 minutes behind, the desert can at first be disorienting in its stillness — unnerving, even, in its seeming limitlessness. For an urbanite traveling this trackless landscape for the first time, the McCormack ranch house is a welcome sight when it rises up at road's end 20 miles from the highway.

The house, whose solid-juniper timbers once grew in the nearby hills and draws, was built a few years ago (30 friends and family framed it in one weekend) to replace the homestead where Bill moved with his parents and lived for seven decades. (Once when he was buying a pickup truck in Portland, the salesman got confused at McCormack's answer on the loan application to the question, How many years at your current address? "What does *this* mean?" the salesman demanded, pointing at Bill's penciled response, 68. "I guess he thought it was a joke," the rancher recalls with a chuckle. "He'd never heard of anyone living in one place for 68 years.")

Time has a different quality on the range. It stretches out long and slow, like the landscape, and curves beyond the visible horizon. Bill's dad, who bought the family's first 3,000 acres in 1943, counted time, not in months and years, but in seasons and generations. Among his descendants is 19-year-old Tyler. This fourth-generation McCormack, sitting beneath soaring pinewood beams with his cowboy hat poised on his knee, carries within him the

Patriarchs Doc Hatfield (top) and OSU alumnus Bill McCormack are passing on traditions to their progeny, including McCormack's grandson, OSU student Tyler McCormack (bottom), shown here on horseback moving cows from one pasture to another. (Photos: top, Mark Reed; Holli McCormack)

> That's what sustainability is all about — it's land, people, dollars, and putting it all together.
>
> **Doc Hatfield**

genes of an Oregon pioneer — his great grandfather, a homesteader who herded sheep across the state's south-central reaches.

The McCormacks' intergenerational ties extend even to the family alma mater. Tyler is a Beaver, like father Jeff, grandparents Bill and Donna, and both great grandparents (class of 1923). It was Tyler's grandfather who first welcomed OSU scientists onto his creek beds and pasturelands for study. Since then, the ranch has been a living lab for investigations on everything from watershed contamination to sage grouse habitat. The McCormacks' ranch, like the Hatfields', is also an open-air classroom during field trips for rangeland ecology majors.

Tyler, an agribusiness major, got his initiation into Country Natural Beef last summer when he conducted an "in-store" at a Whole Foods Market, the co-op's biggest customer. Next to the meat counter, he fired up a hibachi and passed out samples to shoppers. "I sold a hotdog to a vegetarian," he boasts with a grin.

These product demos let customers not only taste natural beef, but also meet ranchers face-to-face. Each ranch in the co-op has "adopted" one or two stores. Some stores run videos of their adoptive ranch so that consumers can make a visual and, they hope, emotional connection to the source of their pot roast or T-bone.

"Whatever we have to do, whatever we have to learn to keep the land sustainable for the next generation — that's top priority," says Tyler's mom, Runinda "Nin" McCormack. Her voice catches with emotion. "We realize that if we don't do it right, our kids won't have the opportunity to come home to the family ranch and participate in something so great.

"That's why we're here." terra

Trading on Trust

Businesses based on shared values benefit the bottom line

The search for sustainability is creating some strange bedfellows.

Take, for instance, Country Natural Beef. In the Oregon-based meat co-op, cattle ranchers — known for their fierce independence — have forged surprisingly strong alliances with other ranchers across the West. Even more improbably, these no-nonsense traditionalists are collaborating with progressive health-food aficionados, animal-rights advocates and environmental activists.

The unlikely partnering of 120 ranch families with the likes of national retailer Whole Foods Market (the co-op's biggest customer), Northwest restaurant chain Burgerville (whose slogan is "fresh, local, sustainable") and renowned animal-compassion expert Temple Grandin (a scientist at Colorado State University) represents a growing business trend, according to Oregon State University business professor Zhaohui Wu.

"Country Natural Beef is an example of a trust-based model where relationships are driven by shared values," say Wu, who specializes in sustainable business practices and supply-chain management. Notions like "trust" and "values" may sound a bit warm and fuzzy to the ears of a financier. But a growing body of research suggests they can effectively cut transaction costs and boost profits. Basing business dealings on close and "voice-based" relationships (that is, talking things over) rather than on written contracts is the alternative to the typical American "arms-length" transaction in a fragmented supply chain, says Wu.

In the mainstream beef market, business is determined by producer costs, but prices soar and sink erratically as commodity traders bet against future supply and demand. In contrast, Wu explains, consumer values provide stability for the natural-foods niche. This highly discerning customer base demands strict synchronicity with the shoppers' philosophical beliefs: holistic rangeland management, stress-free cows, connectedness to the land, fair labor practices and additive-free meat traceable to its source. They're willing to pay a premium for a product that reflects their deeply held beliefs.

Rancher Doc Hatfield (left) grills up a sampling of range-grazed, hormone-free beef for grocery store customers, a personal touch that helps to set Country Natural Beef apart from factory-farm meat and to build trust among consumers (Photo courtesy of Country Natural Beef)

Trust and collaboration among producers also make for more nimble decision-making, essential in a rapidly changing marketplace. Co-op members control beef supply cooperatively and negotiate stable pricing with buyers. The volatility and unpredictability that can devastate independent ranchers is minimized. Wu even has a term for cooperation among competitors: "co-opetition." He is the lead author on this topic in an upcoming issue of the *Journal of Operations Management*.

Wu and Professor Mellie Pullman of Portland State University studied 30 member ranches of the beef co-op's network, traveling to some of the range's most remote reaches, from Frenchglen to Hell's Canyon. They interviewed people at every link in the supply chain, from pasture to feedlot to slaughterhouse. They talked to the co-op's customers, as well, including New Seasons grocery stores and Bon Appetit Management Co.

They learned that sustainability practices flow like an unstoppable flood inside a values-based business model. Pressure from the co-op's customers in 2008 pushed distributor Fulton Provision company (owned by food-services giant Sysco) to undergo a third-party audit of waste management, worker conditions, water and energy conservation and transportation by the Food Alliance. The result: Fulton now runs its trucks on biodiesel, recycles packaging materials, salvages wood pallets, re-circulates water and uses more energy-efficient machines.

Values-based approaches can be the salvation for struggling mid-sized and family-owned operations, argues Wu. In the late 1980s when Country Natural Beef was launched as Oregon Country Beef, family ranches were endangered. "Many small ranchers were in dire straits under a combination of factors: mounting pressures from dieticians to eat less red meat, a popular perception of the abuse of public land by over-grazing, rising interest rates and wildly fluctuating commodity beef prices," the professors assert in their case study.

In the two decades since the co-op formed, it has "evolved into a key player in the natural beef industry," the researchers say. Country Natural Beef has the power to sustain not only the landowners but also the land for generations to come.

— BY LEE SHERMAN

Girl ~~Girl~~ Boy Boy

Women's stories reveal the dark side of an age-old tradition

BY CELENE CARILLO

At the "Shahargaon" community clinic near Delhi in 2008, Sunil Khanna worked with doctors and community workers to learn about women's reproductive heath-care needs and their views on son preference. Khanna's interviews helped him develop community-based intervention programs. (Photo: Lakshman Anand)

The problem became clear to Sunil Khanna one hot, humid day in 1993 in a northern Indian village near Delhi. He was sitting in Dr. Mahavir Singh's office, preparing to interview the local physician, when someone interrupted them.

It was a man, frantic, looking for someone to perform an ultrasound on his wife.

"Ultrasound is not available at this clinic," Singh told the man. "But I can refer you to a nearby specialty diagnostic clinic that has ultrasound. Tell me, when would you like your appointment?"

"As soon as possible," the man said. "The other doctor already said it was too late."

"Is it so? How late is it?" Singh asked.

"It's my wife's fourth month," he said.

"I don't think it's too late. I will speak to a doctor next door. You can come at 10 in the morning. We will take care of your problem," said Singh.

"How long does the procedure take?" he asked.

"It will only take an hour," the doctor told him.

"And if we need to get an abortion?" he asked.

"That will also be an hour," the doctor said.

The man's tone — and Singh's — indicated that the procedures were routine. As the discussion unfolded, Khanna felt a growing sense of unease.

In fact, the man next told Singh he already had two daughters. And if this child was to be a third, they would almost certainly abort her. Once the prices were settled (about $36 for the ultrasound,

$24 for the abortion), the man left, and Singh turned to Khanna to resume their interview, as if nothing momentous had taken place.

Later, as he was interviewing parents and measuring boys and girls at the village school, Khanna started hearing shadowy suggestions that female-selective abortion was happening in the village. Occasionally, women mentioned village girls who had been born — and ones who hadn't. Or they mentioned "other women" who had undergone abortions. But never had the practice been revealed so frankly as it was that day in Singh's office.

In Brief

THE ISSUE In some parts of Asia, a cultural practice known as "son preference" creates barriers for women and leads to gender typing and female abortions.

OSU LEADERSHIP OSU anthropologist Sunil Khanna grew up in India and, in collaboration with an Indian nonprofit organization, is leading efforts to raise the status of women by revealing the power of tradition and modern technology.

Son Preference

This story appears in Khanna's book, *Fetal/Fatal Knowledge: New Reproductive Technologies and Family-Building Strategies in India* (2009, Wadsworth Publishing Co.). Before he interviewed Singh, he spent two months in Shahargaon (a pseudonym he created to protect the identity of his subjects) studying how the cultural practice of son preference affected child growth and development. Son preference, he says, reflects a patriarchal system that "ensures the inheritance of family name, property and decision-making power in the male line."

What occurred in the village was a turning point for Khanna, now an associate professor of anthropology at Oregon State University. The stories he heard set him on a path to confront practices ingrained through centuries of tradition. Today he specializes in the cultural circumstances that affect women's health.

By 1995, Khanna turned his attention entirely to the practice of using sex-selective screening and abortion as family-planning tools. And he found significant evidence that it was widespread, not only in Shahargaon, but nationally. From 1993 to 2003, Khanna collected census data among the dominant Jat ethnic group in Shahargaon. He found not only an imbalance among males and females in the village but a declining trend in sex ratios of females to males, even as the Jat population was increasing.

He also found that families in both rural and urban areas were less inclined to care about the sex of their first child, but if that child was a girl, they would test the second pregnancy. One of the major differences between educated urban parents and uneducated rural parents was access to contraception. Women in rural areas were more likely to have more children, as well as more abortions, to reach the desired number of boys and girls.

Tradition and modern technology often clash, Khanna points out in his book, but in this case, they are complementary. "What I found is that traditions of son preference are being realized through technology. And technology is being used to perpetuate that tradition," says Khanna.

A Growing Disparity

Although abortion has been legal in India since 1971, the use of prenatal screening to determine the sex of a fetus has been illegal since 1996. Still, the sex ratio in the northern Indian state of Haryana, surrounding Shahargaon, is 861 females per 1,000 males.

"Imagine the complication of implementing a law that makes female sex selective abortion illegal in a country where abortion is legal," says Khanna. "Doctors have to be on board not to use ultrasonography to identify the sex of the fetus. Ultrasonography machine sellers must be on board to not sell machines without registering with an agency. And parentts must be on board that they will not seek this kind of information."

Girls, says Khanna, are often seen by families as economic liabilities. Even though dowries have been illegal in India since 1961, the practice is still widespread nationally. And doctors have their own coded language when it comes to sexing babies. Often doctors will tell parents they are very lucky if the baby is a boy — and to start saving money if the child is a girl.

Shahargaon was the perfect place for Khanna to perform his study. Over the past 20 years, the ancient village of about 1,400 has been engulfed by the city of Delhi and its approximately 15 million people. The village has retained its autonomy and rural ethos, only due to an archaic rule that protected its residential boundaries. Its narrow lanes, fragrant with charcoal smoke and crowded with old buildings, are evidence of that character.

Still, Delhi encroaches.

"This is a rural enclave stuck in the middle of this roaring metropolis where everything is happening, and where you can find Nike and Adidas shoe stores, McDonald's and open access to the Internet," Khanna says.

You can also find clinics where ultrasound technology is available. It was this intersection between old and new that intrigued Khanna. Shahargaon's size, too, meant that Khanna could understand everything that was going on in the community. But what really clinched the deal for him was how receptive Shahargaon's leaders were to his

being there. "They were very inquisitive to what I was doing and why I was there," Khanna says. "But at the same time they were open to it."

Over time, Khanna won the trust of villagers as well. But it did not come easily. During his first visit, his research assistant often had to conduct the interviews while Khanna waited outside villagers' homes. It wasn't until two years after his visit to Singh's office that Khanna felt comfortable bringing up the subject of female-selective abortion directly.

"It was terrifying to bring up this topic, risking that I would be thrown out of the community. It was only through establishing long-term, significant relationships that you begin to ask them," Khanna says.

Stories To Be Told

Later, though, women insisted on having him in the house. They would ask Khanna to make sure his tape recorder was working and asked him to play back portions of their interviews so they could be sure. They wanted to be heard.

Ultimately, Khanna's goal is to raise the status and role of women in Indian communities. "Khanna's work exemplifies one of the pioneering long-term community studies that go beyond just examining the contentious issues from an academic perspective," says Dr. Sunil Mehra, head of MAMTA Health Institute for Mother and Child, an Indian non-governmental organization. "Instead, his work involves building community-level opinions against this practice and developing meaningful linkages among key stakeholders in the community, government agencies and non-governmental organizations." MAMTA provides reproductive health care to impoverished women and, through Khanna, maintains a formal working relationship with OSU.

In Oregon, Khanna's research also finds its way into the classroom, where he relates his experiences in undergraduate anthropology courses on South Asia. His graduate students are studying access to abortion services in the state, in addition to son preference among Indian immigrants in the United States and Canada. And Khanna has completed several projects on the availability of health care to uninsured Oregonians.

Khanna collected reproductive histories from the two women behind him. He also learned about their views on son preference and the prevalence of ultrasonography for prenatal sex identification in Shahargaon. (Photo: Lakshman Anand)

"I continuously strive to produce knowledge that is meaningful and relevant to real people doing real things," Khanna says. "My research and teaching allow me to engage in a continuous and critical conversation between the 'theoretical' and the 'applied' contexts of my discipline."

Options for Women

In India, Khanna hopes to generate a community dialog that will help parents think differently about daughters. Such discussions, he adds, could influence policies on female-selective abortion.

Meanwhile, community leaders in Shaharagoan have encouraged people to talk openly about the reproductive and emotional consequences of female-selective abortion. They have highlighted the disproportionate sex ratios that result from the practice. Leaders have also been able to set up support for women experiencing domestic violence or intense pressure in their homes to have abortions. Khanna plans to implement this approach in both rural and urban areas.

"I want to develop programs, which are state or federally funded, but which are sustainable, so that people can look at their daughters not as financial liabilities, but as assets. And to think of them as equal to their sons in terms of ability and income potential," Khanna says. "This project has been one of the most challenging and fulfilling experiences of my life." terra

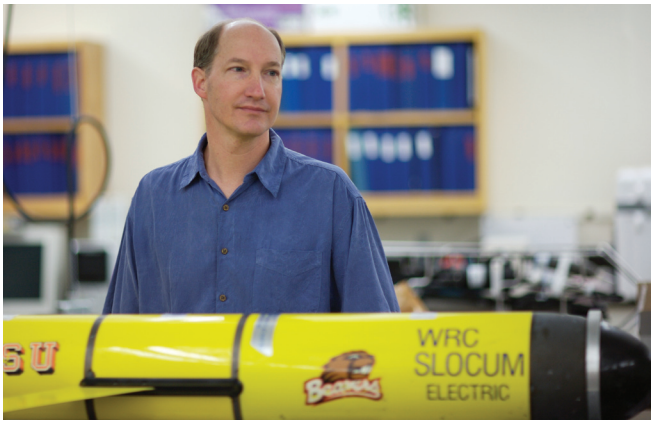
Stimulus Dollars Boost OSU Research

By Dec. 31, 2009, 54 OSU research projects in public health, climate change, math education and ocean science had received more than $23 million in federal stimulus dollars through the American Recovery and Reinvestment Act (ARRA) of 2009. The three projects sampled below together supported 21 jobs for undergraduate and graduate students, post-doctoral researchers, faculty and engineers. More information is on the Web at ***oregonstate.edu/research/ARRA/***.

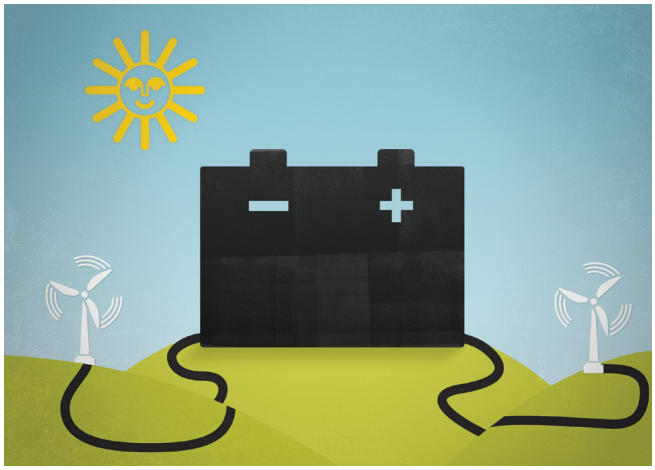
Sensing the Seas: New equipment will monitor coastal ecosystems

Ocean science is confronted with many unknowns about the intricate interplay of physics, chemistry and biology in Earth's vast oceans. In this era of climatic flux, better understanding of sensitive ocean systems has taken on new urgency.

OSU oceanographers Jack Barth and Murray Levine are refining and testing an innovative sensing system designed to track trends in temperature, current velocity, salinity, nitrates, dissolved oxygen, suspended particle load and chlorophyll concentration. Known as CAPABLE (Coastal Autonomous Profiling and Boundary Layer System), the gear, which is moored to the seafloor, must hold up to battering from ferocious seas as it collects data and monitors coastal oceans in real time. The $884,252 ARRA project includes mechanical and software upgrades along with four field tests over two years.



Jack Barth is a leader in ocean monitoring. (Photo: Jim Folts)



Girding the Grid: Engineers rethink power storage for wind

As wind turbines and solar arrays sprout up across the landscape, an urgent challenge arises: How to capture all that alternative energy for the electrical grid. Wind velocity and solar intensity vary wildly as weather changes and as seasons shift — fluctuations that are often out of sync with power demand.

With $399,973 in ARRA funding, OSU engineer Ted Brekken is tackling the problem by investigating scaled-up energy storage systems to even out the variability of wind energy generation. Such systems — which he likens to giant batteries — would "buffer the peaks and valleys in wind farm production," he says. Wind energy thus would become "more predictable, more forecastable."

Regulating Immunity: Toxicologists seek novel gene therapies

Dioxin, the chemical pollutant made infamous by Vietnam-era defoliant Agent Orange, has long been known to suppress immune function in humans and other animals. Surprisingly, this dangerous side effect has a scientific silver lining. While studying the toxin's health effects, researchers discovered the genetic pathway to immune system malfunction. For people who would actually benefit from suppressed immunity — those suffering from autoimmune and allergic diseases — this clue may lead to better therapies.

With $1.8 million in ARRA funding, OSU toxicologist Nancy Kerkvliet and colleague Siva Kolluri are investigating a genetic mechanism that turns immunity on and off — the aryl hydrocarbon (AHR) receptor — in search of a non-toxic compound that activates immune-cell regulation. If found, this compound could lead to a new generation of treatment options for victims of lupus, type-1 diabetes, multiple sclerosis and other diseases.

Nancy Kerkvliet and Sam Bradford use a flow cytometer to analyze cell response to chemical exposure. (Photo: Lynn Ketchum)

See Terra on the Web at Oregonstate.edu/terra

Renewing the Range

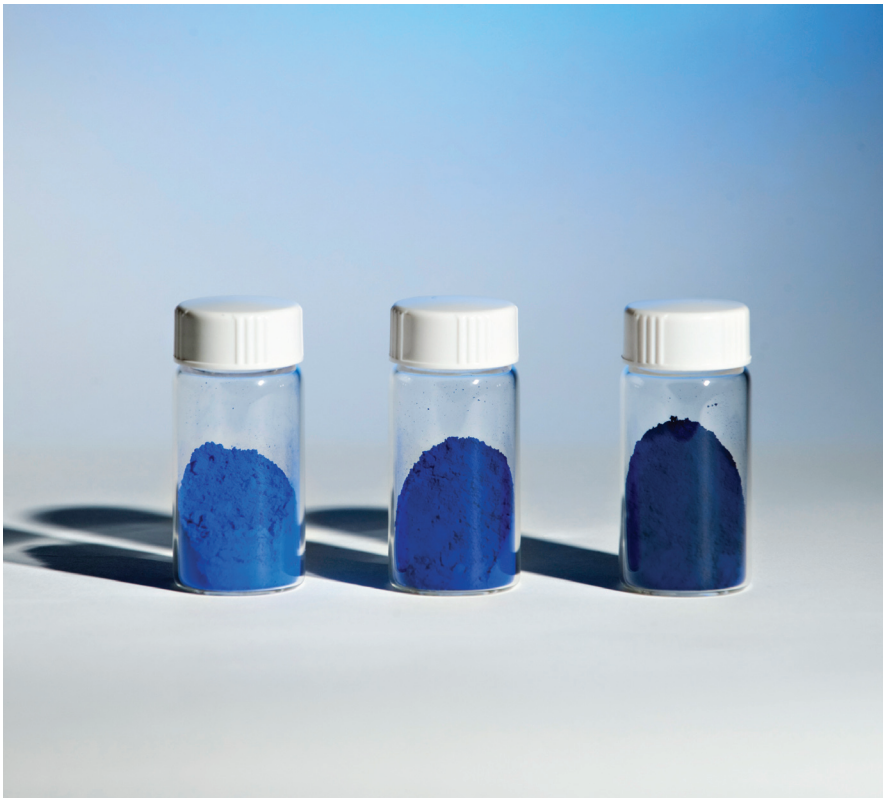
The Hatfield and McCormack ranch families of Brothers, Oregon, have partnered with OSU scientists, including John Buckhouse (above), for generations to improve rangeland ecology. One of the most far-reaching studies — a paired watershed experiment — is yielding exciting evidence of the power of science-based management to restore healthy ecosystems. See the results and hear the voices of scientists and ranchers.

Technology Meets Culture

For almost two decades, Sunil Khanna has interviewed people in a small Indian village. Homes, offices and narrow streets became the setting for his investigations of son preference and female selective abortion. See his photos from the community that maintains its ancient traditions in the midst of a modern city.

Credit for Carbon

What does it take for a family-forest landowner to qualify for carbon sequestration credits? Rick Fletcher (right), an Extension forester, has been conducting workshops and advising landowners on everything from Christmas trees and high-value timber to forest management plans. Fletcher collaborates with the Oregon Small Woodlands Association and Woodlands Carbon LLC.



New blue pigments developed in Mas Subramanian's chemistry lab have attracted commercial interest. (Photo: Karl Maasdam)

Blue Hue

An ancient quest for the perfect blue ended in a hot furnace in OSU's Department of Chemistry— totally by accident.

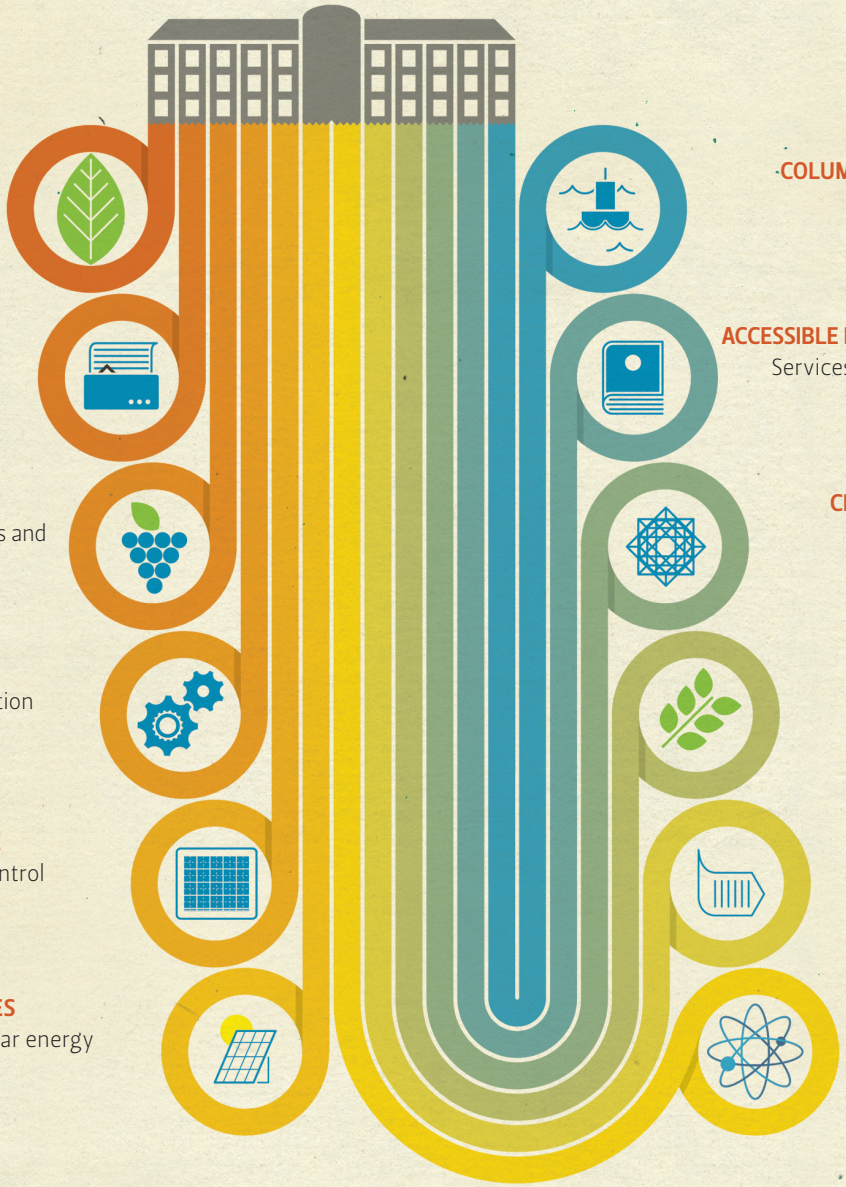
A blue pigment that is both safe and stable eluded the Egyptians, the Han Dynasty and the Mayans. The French developed cobalt blue in the 1800s, but it contains carcinogens. Prussian blue releases cyanide. Other pigments break down in hot or acidic conditions.

So when Professor Mas Subramanian walked through the materials science lab just as a student opened a white-hot furnace and laid eyes on manganese oxide samples being tested for electromagnetic properties, he stopped in his tracks. "They were blue—a very beautiful blue," says Subramanian. At nearly 2,000 degrees Fahrenheit, the manganese oxide ions restructure into an unusual "trigonal bipyramidal coordination."

The intense blue compound holds promise for a heat- and acid-resistant pigment free of toxins. Many of its potential applications — inkjets printers and automobiles, for example — could never have been imagined by those earliest seekers of the perfect blue.

Product Lines

These 12 biotechnology, energy and computer software companies account for about 300 jobs and $100 million in investment. They have spun off directly from or leveraged relationships with Oregon State University research.
(Source: OSU Office of Technology Transfer)



LIFE MICROSYSTEMS
Chlorophyll and bio-compounds
Corvallis, Oregon

INPRIA
Printed electronics
Corvallis, Oregon

FIZZY FRUIT
Carbonated strawberries and grapes
Portland, Oregon

STRANDS
Personal recommendation software
Corvallis, Oregon

REDROVER SOFTWARE
Spreadsheet quality control
Corvallis, Oregon

AZURAY TECHNOLOGIES
Semiconductors for solar energy
Tualatin, Oregon

COLUMBIA POWER TECHNOLOGIES
Ocean wave energy
Corvallis, Oregon

ACCESSIBLE INFORMATION MANAGEMENT
Services for persons with disabilities
Corvallis, Oregon

CLEAR SHAPE TECHNOLOGIES
Design-for-manufacture technologies
Santa Clara, California

PRECISION PLANT SYSTEMS
Optimized agricultural production
Corvallis, Oregon

SMART DESKTOP
Desktop usability recognition
Seattle, Washington

NUSCALE POWER
Nuclear energy
Corvallis, Oregon

SOME OF THE OTHER TECHNOLOGY COMPANIES WORKING WITH OSU

Apex Drive Laboratories Electric motor technologies Portland, Oregon
CSD Nano Thin-film technologies, Corvallis, Oregon
Home Dialysis Plus Kidney dialysis, Corvallis and Portland, Oregon
Mtek Energy Solutions Micro-channel reactors for biodiesel Corvallis, Oregon
Nanobits Nanotechnologies, Corvallis, Oregon
NWUAV Propulsion Systems Engines for unmanned vehicles], McMinnville, Oregon
Peregrin Power Electronics for extreme environments Wilsonville, Oregon
Ruminant Solutions Microbial products, Albuquerque, New Mexico
Transdigita Internet connectivity services, Corvallis, Oregon
Trillium Fiberfuels Wheat or grass straw for ethanol Corvallis, Oregon
Xtreme Energetics Solar energy, Livermore, California

A glossy ebony sculpture from East Africa — a gift from her students — symbolizes the values Ilene Kleinsorge nurtures and rewards: initiative, professionalism, innovation, discipline and, above all, the entrepreneurial spirit (Photo: Karl Maasdam)

Investing in the Best

Drive and dedication open doors for business students

"Do you know what this is?" the three students asked as they presented Ilene Kleinsorge with a smooth, black sculpture. She looked at the carved figure, a trio of human forms holding an orb aloft.

"Sure, it's ebony," replied Kleinsorge, dean of the OSU College of Business.

"It's us!" exclaimed the students, who had brought the gift from East Africa. "It's us, changing the world."

As she tells the story, Kleinsorge picks up the carving and holds it lovingly. "This," she says, "is why I get up in the morning."

As holder of the Sara Hart Kimball Dean's Chair, Kleinsorge's greatest satisfaction comes from investing in talented, motivated students like these members of OSU Students in Free Enterprise, a student organization that helps local and global communities through entrepreneurship education. Their trip to Arusha near Tanzania's Mt. Kilimanjaro to meet with founders of a micro-enterprise program arose from initiatives she has launched with funds from her endowed position and other discretionary dollars.

"I'm investing in students who want to invest in themselves," she explains. "I look for students who take initiative, who are professional and focused in a disciplined way. I leverage my social network and resources to help them."

Ranging widely in focus — from business models in developing nations to virtual project management in multinational companies — Kleinsorge's initiatives share one common denominator: the entrepreneurial spirit.

"Having access to discretionary dollars allows me to be entrepreneurial within the institution," she says. "It gives us the opportunity to dream and aspire to better things, even in this budget environment."

In an economy changing at lightning speed, driven by technologies that become obsolete almost as fast as firms can get them installed, the college must be agile, able to anticipate trends, pivot with the times, "explore and experiment"— words Kleinsorge uses frequently. In this hyper-dynamic world of global commerce, teams located all over the planet meet in cyberspace through "distributed workgroups." She's passionate about preparing OSU students to compete.

"In multinational corporations, projects move forward 24/7," she notes. "The project never sleeps. Our students have to be able to work in virtual environments."

Other initiatives she has funded with donors' support include: the annual ethics debate at the University of Arizona; the OSU student investment group's visit to New York City's financial district; time and tools for faculty to design and pilot new courses; virtual project management with students in India; and the Business Network, which brings women students and women professionals together for monthly meet-ups and mentoring.

"I'm purposefully diverse in what I've chosen to invest in," she says.

In everything, Kleinsorge is driven by a staunch commitment to quality, originality and accountability. Nothing less will suffice in today's competitive climate.

"I believe," she says, "that our national imperative is for creativity and innovation."

The Campaign for OSU
THIS AMAZING PLACE
THIS HISTORIC MOMENT

For more information about supporting the College of Business, visit *CampaignforOSU.org*, or call the Oregon State University Foundation, 800-354-7281.

Terra
416 Kerr Administration Building
Oregon State University
Corvallis, OR 97331

Tombo Navarro, Miller Timber Services, led a tree planting crew near Alsea in 2004. Decomposition sends more carbon back to the air from harvested sites than they absorb, but trees planted here are nearly 20 feet high today. Eventually, the forest will again become a carbon sink. See "Living on Credit," Page 2 (Photo: Lynn Ketchum)

Listen to OSU researchers, follow their stories and see more photos, at **oregonstate.edu/terra**