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OSU is Oregon's largest public research university with more than \$231 million in research funding in FY2008. 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 natural resources, earth dynamics and sustainability, life sciences, entrepreneurship and the arts and sciences.

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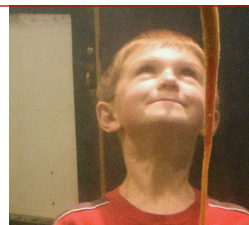
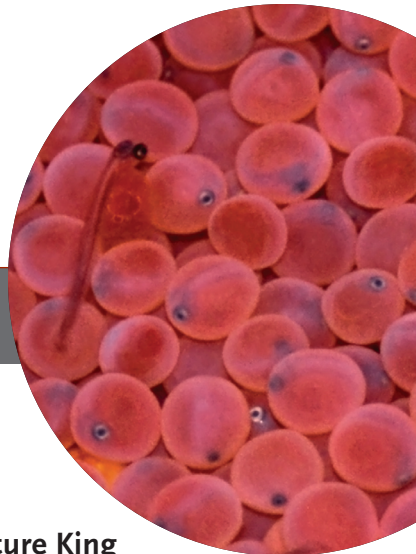
The risk of falling rises as we get older, but researchers and fitness instructors have a prescription: Better Bones and Balance. Even if you're 88 years old, there's a class for you.

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When Jerry and Diane Plante went to the Hatfield Marine Science Center in Newport, Oregon, they discovered more than they bargained for. They became part of a movement that is breaking new ground in science education.

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It took a potato launcher, a canoe and a helium-filled balloon to propel a high-tech scientific enterprise during an international workshop at the H.J. Andrews Experimental Forest.



# Wired Watershed

## Fiberoptics bring new precision to ecosystem sensing

By Lee Sherman

*Advanced fiberoptic cable captures finely detailed data, revealing the complexities of forests and watersheds. (Photo: John Selker)*



**H**igh-tech science got a lift last summer from a curiously low-tech device: a potato launcher.

Puzzling over the best way to string fiberoptic cable through dense, old-growth canopy, OSU scientists devised a “canon” with an air-compression gun and fishing line weighted by a starchy tuber. From a 100-foot research tower in Oregon’s H.J. Andrews Experimental Forest, a research assistant spent an afternoon in June launching lengths of Swiss-made cable through towering boughs of Douglas fir and big-leaf maple.

“We needed a projectile with a mass sufficient to place the line, something that would not be hazardous and would not light the forest on fire,” explains OSU researcher John Selker. “We tried everything — bows and arrows, slingshots. In the end, we were shooting organic, biodegradable potatoes around the forest.”

### Transformative Science

Selker, a professor in the Department of Biological and Ecological Engineering, is taking ecosystem sensing to new heights with an advanced generation of high-tech cable. Today’s fiberoptics use glass strands so pure that pulses of light zip along the line with little resistance. By detecting the tiny amount of light that scatters back from the source, scientists can measure the temperature of the glass. What that means for monitoring the

infinite complexities of ecosystems such as watersheds and ancient forests is an exponential increase in precision, down to hundredths of a degree. Scientists can now take measurements more frequently (every three seconds) at closer increments (every meter) across longer distances (up to five or six miles), capturing spatial structure in three dimensions. The result is an infinitely more nuanced — and thus more accurate — depiction of the natural world.

“With fiberoptics, we’re getting about 10,000 times more data than we did with traditional sensors,” says Selker, a hydrologist who studies stream dynamics. “We’ve added a whole bunch of zeroes to the precision of our measurements. This is transformative science. It’s changing how we see the world.”

Getting finer data about the temperature, relative humidity and evaporation of a stream will vastly improve resource management, Selker predicts. Indeed, warming is one of the greatest dangers threatening watersheds. That’s because fish thrive in narrow spectra of water temperature. A few degrees warmer can mean less oxygen, more pathogens and greater stress on aquatic animals. Strategies for stream protection and restoration can be more effective if based on truer readings and better models.

But for its promise to be fully realized, the novel technology needs rigorous field testing. “There are a





Researchers lay cable at Blue Lake Reservoir in Oregon's Cascades for an experiment measuring relative humidity during an OSU-led summer workshop. (Photo: Lina DiGregorio)

whole lot of practical problems to be overcome,” Selker says. The sensors need to be carefully calibrated, for example, to correct for things like weld joints in the wires, “jitter” caused by stream flow and albedo (light reflection). “The history of science is littered with great measurement techniques that fizzled because of poorly run experiments,” says Selker. “We need to seed the science community with people who know how to do this.”

So Selker, along with colleagues at the University of Nevada, the Delft University of Technology in the Netherlands and the U.S. Geological Survey recently led two international workshops to test and troubleshoot fiberoptics and sensing instruments in real-life settings. The National Science Foundation’s Consortium of Universities for the Advancement of Hydrologic Science funded the sessions, which were part training, part joint problem-solving — what Selker calls “proof of concept” studies.

### Global Enterprise

In June, one of those workshops drew participants from five countries and 12 states to the 15,800-acre Andrews Forest in the western Cascades.

The nearly 40 industry-based engineers, university researchers, cable-manufacturer representatives and sensor makers hailed from Germany, Switzerland, the Netherlands, Spain, Quebec, and across the United States — a testament not only to the scientific promise of the new technology but also to its economic potential for cable and instrument manufacturers. In advance of the workshop, giant spools of fiber were flown in from Europe and Taiwan. A setback was narrowly averted when a FedEx driver, running late after losing his way on a logging road, pulled up just in time with his cargo — 360 pounds of high-resolution Swiss cable worth \$100,000.

Some of the cable shipped in for the workshops is unique, custom-

created just for eco-sensing.

“The cool thing is that we’ve got industrial participation from every major maker of these instruments — AP Sensing, Sensornet, Sensor-Tran,” Selker says. “Then the cable producers — Brugg Cables out of Switzerland, AFL Telecommunications from North Carolina — sent their teams out here to learn how their cables behave in the ecosystem. Our rigorous requirements demand completely new solutions.”

### Going With the Flow

On Day Two of the five-day workshop, the group breaks up for three experiments: one to measure relative humidity at Blue Lake Reservoir, a second to compare cable types at Andrews experimental watershed 3, and the third to measure stream dynamics and air flow at watershed 1.

As the morning mist dissolves, Selker leads a caravan of trucks and vans to the trailhead at watershed 1.



From there it's a short hike into the rainforest with spools of coiled cable, the researchers' hardhats of industrial yellow and red glaring against the organic greens of mosses and ferns. In the damp, dappled understory, the "stream team" unwinds the high-resolution cable — armored against the razor-sharp incisors of squirrels and muskrats by bright-blue plastic casing — and threads it through steel-eyed stakes driven into carpets of wood sorrel. Inside the blue casing, black and white strands of glass are twisted together to equalize the effect of sunlight absorption (black absorbs light, white reflects it).

Walkie-talkies link teammates wading downstream to those skirting steep ravines, their electronic *bleep! bleep! bleep!* shattering the silence of this place where Pacific giant salamanders can achieve 12 inches in length and some Douglas firs took root while Michelangelo painted the Sistine Chapel. The cable was installed on bedrock as well as on muddy banks to capture contrasts between groundwater and surface water temperatures. Readings will not only pinpoint groundwater upwellings but also detect how snow-pack levels affect stream dynamics from year to year. Ultimately, these powerful tools will help scientists monitor watershed health in the face of global climate change.

Meanwhile, Adam Kennedy, a research assistant in the College of Forestry, leads the "air team" from high in the 100-foot tower. Taking aim with the potato launcher, he shoots lengths of cable this way and that over the treetops into the waiting arms of a professional tree climber posted aloft. The zigzag in the canopy will monitor the ebb and flow of the forest's active airshed.

"We're seeing explosive changes in the field of ecosystem sensing," Selker says. "It's a challenging, opportunity-filled moment." **terra**

Watch researchers deploy a fiberoptic network at the Andrews Forest, [oregonstate.edu/terra](http://oregonstate.edu/terra)



An international group of engineers, scientists and cable experts teams up in the H.J. Andrews Experimental Forest in June, stringing cable along a stream and, with the help of a potato canon from a 100-foot tower, threading it through the old-growth canopy. (Photo: Lina DiGregorio)



**JOHN SELKER**, a professor in the Department of Biological and Ecological Engineering, uses fiberoptics and other sensing and communication technologies to study watershed hydrology. He specializes in tracing contaminant transport, using light-emitting microbes to track groundwater movement and sampling water in the area known as the unsaturated zone (the area between the top of the ground and the water table).

Funding for his research has come from numerous agencies, including the National Science Foundation, U.S. Geological Survey, Consortium of Universities for the Advancement of Hydrologic Sciences, state and federal departments of agriculture, U.S. Environmental Protection Agency and U.S. Department of Energy.