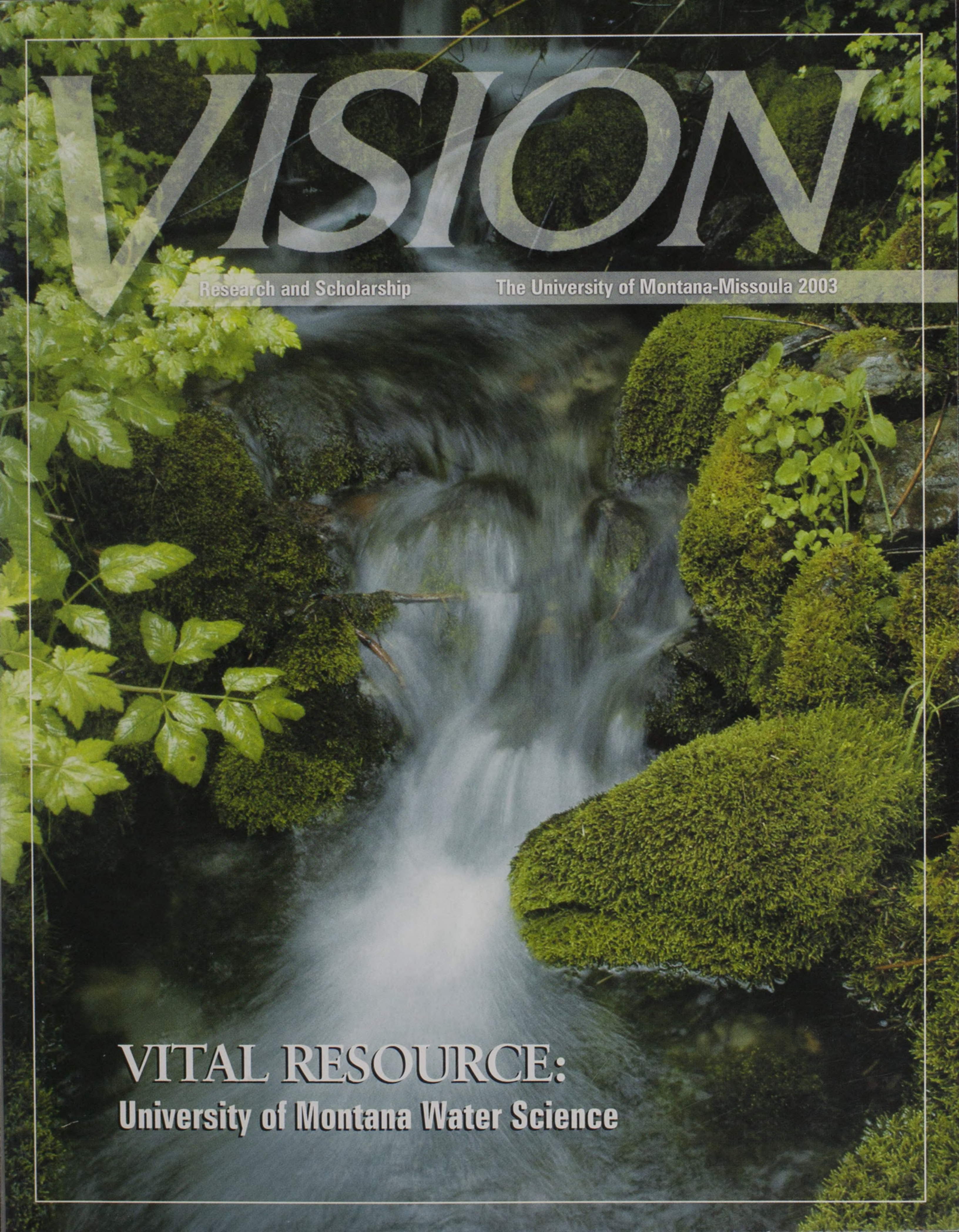
Vision 2003

VISION

Research and Scholarship

The University of Montana-Missoula 2003

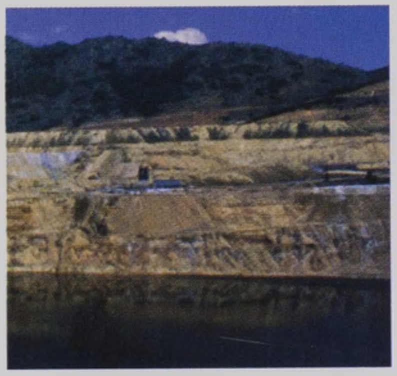


VITAL RESOURCE:

University of Montana Water Science

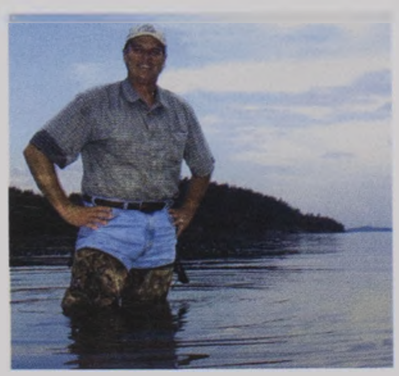
Inside

Autumn 2003 The University of Montana



4 THE ACID WATER OF BUTTE'S BERKELEY PIT

10 ARSENIC EFFECTS ON MICE



12 WATER EXPERT JACK STANFORD

18 THE AGING COTTONWOODS PUZZLE

"Eventually, all things merge into one, and a river runs through it." Norman Maclean

31 ALASKA EXPEDITION

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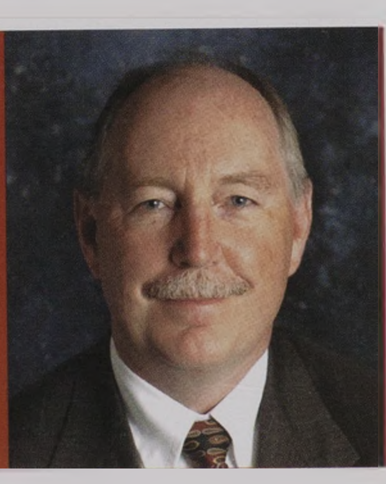
Vision is published annually by the UM Office of the Vice President for Research and Development and the office of University Relations.

Cover Photo by Todd Goodrich: Boulder Creek on the edge of Flathead Lake

message
From Vice President Dan Dwyer



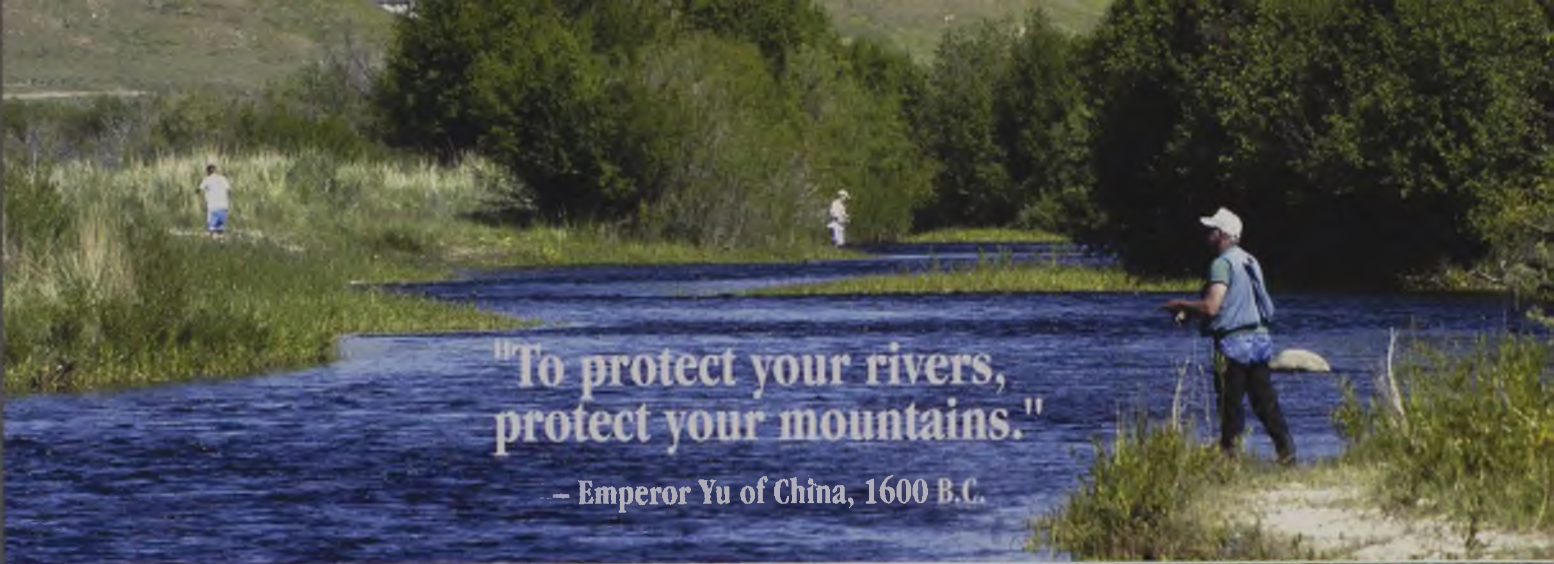
This issue of Vision is particularly significant to me: It is the first issue published under my tenure; and, secondly, as I am an avid fisherman, its theme of river and stream health is a topic of keen personal concern and interest.

Familiar with the West in general and having traveled over many years specifically to Montana to fish, my arrival in August at The University of Montana brought a sense of homecoming. With my return came a renewed acquaintance and understanding of the persevering pioneer spirit upon which this state — and later this University — was built. And this hard-working, no-holds-barred spirit is one of many attractive characteristics of our state, and one of the reasons The University of Montana has grown and, indeed, prospered. Determined teachers, dedicated researchers, visionaries all, have woven the individual threads of their expertise into the colorful and strong tapestry of this institution of higher education.

Today this tapestry reaches far beyond the borders of campus. Having surpassed $60 million in grant volume, the University's research enterprise is a significant economic development engine that stretches into all corners of the state and beyond. In this economic continuum, research endeavors support faculty, students, staff and independent contractors. As a result, individuals and programs gain national recognition and additional funding is received. Programs advance. Staff members are hired. Small businesses develop, spin out from the University and expand in the community. The economy grows.

Thoughtful investment, concentrated attention and orchestrated cultivation have contributed to the current health and strength of The University of Montana's research enterprise. It is healthy and strong, and just as research teams study river and stream health, I intend to work as part of the existing team to diligently monitor and nurture the University's research and scholarship so that future generations will benefit from our stewardship. I'm delighted to be here and look forward to the journey.

Dan Dwyer
Vice President for Research and Development
The University of Montana



The Clark Fork Basin
From Butte to Missoula

Top and left photos: Anglers fish the Clark Fork where it emerges from Warm Springs Ponds.

This Clark Fork Basin view is a Landsat 7 satellite image courtesy of UM's Earth Observing System Education Project.

To learn more about issues facing western Montana's largest waterway, turn the page ...

River Rescuers

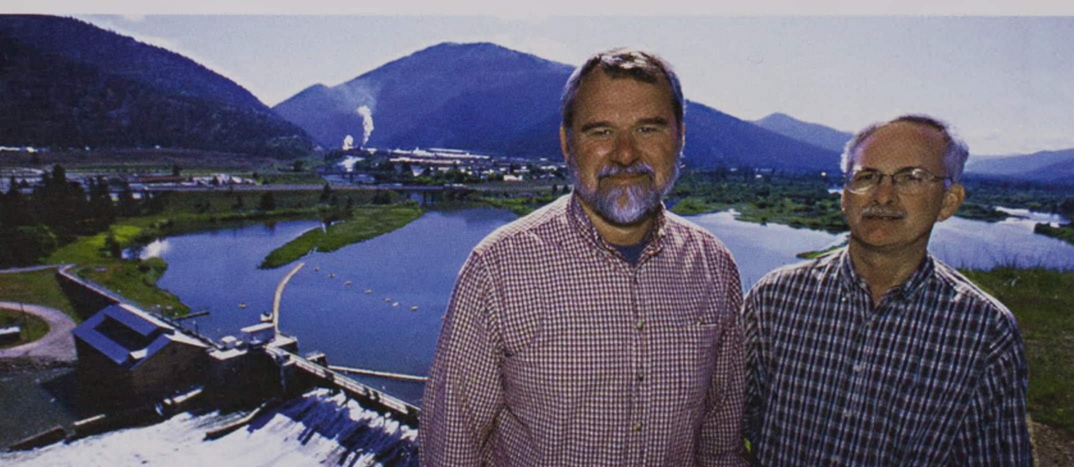
UM Center Studies Damaged Waterways

By CARY SHIMEK
VISION EDITOR

Photographs by TODD GOODRICH

February 1982 found young University of Montana scientists Bill Woessner and Johnnie Moore cold, wet and miserable. Accompanied by two graduate students — one a shivering hot-climate kid from India — they had skied onto the frozen Milltown Dam reservoir pulling a sled piled with science gear. It was 10 degrees and the Hellgate Canyon winds were whipping.

Using a $20 grant from the geology department to rent a chainsaw, they cut four 2-foot-wide holes in the ice. But they could only afford a short-bladed chainsaw, and the reservoir ice was about 24 inches thick, so they had to finish their holes by hammering with metal poles.



"It was cold," Moore recalls. "We were just covered with ice and cold water and the wind was blowing. It was totally miserable."

Punching through the ice, they used a grab sampler — which has two scoops that come together like jaws — to gather mud from the bottom of the reservoir. They sampled near shore and in deeper areas where the water was up to15 feet.

Why do this at such a hostile time of year? The science team was on the ice to solve a mystery — one that could affect the entire Clark Fork River system and the future of western Montana.

The Missoula County Health Department had discovered arsenic in tap water at nearby Milltown, a community five miles east of Missoula, and 35 families had been advised not to use their well water for drinking or cooking. Locals thought the contamination resulted from the nearby plywood plant. Other possible culprits included an old dump site, which contained some industrial waste, or perhaps a natural source of arsenic welling up from the fault that underlies the river valley.

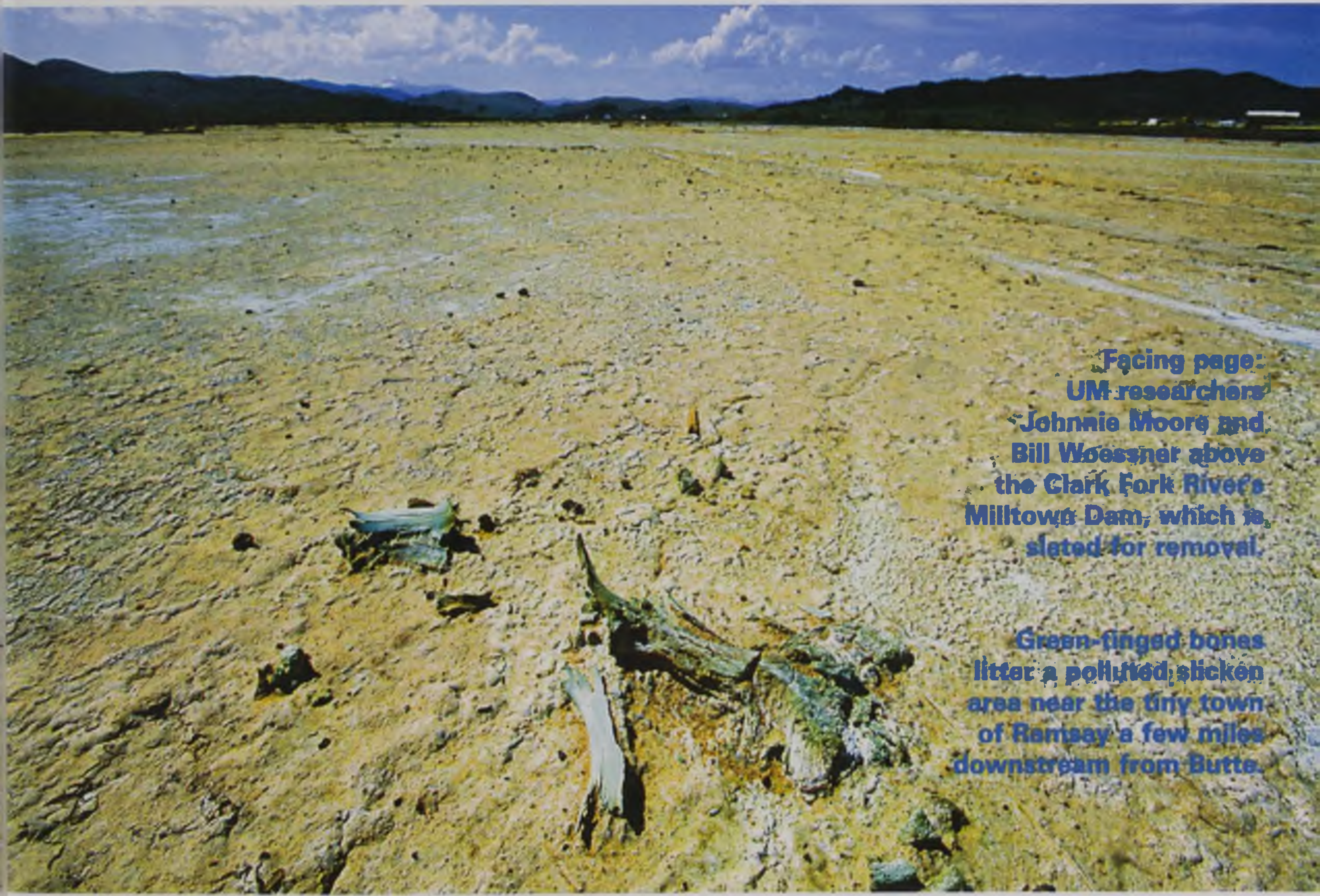
But the frigid researchers knew that a 1975 study by a UM chemistry student had found elevated levels of copper, zinc and lead in crayfish living in the Milltown Reservoir — the pond formed behind Milltown Dam, which straddles the confluence of the Clark Fork River and the Blackfoot River of "A River Runs Through It" fame.

The student had discovered elevated metals but had never tested for arsenic. When Woessner and Moore finally found some money to get their samples tested in June 1982, arsenic levels ranged as high as 155 parts per million — six times greater than sediments already targeted for cleanup in Lake Michigan.

Mystery solved

"We did the original work and identified the reservoir sediments as the source contaminating the groundwater that flowed to the affected wells and houses," Woessner says.

As a hydrogeologist, he also mapped the water table under Milltown and suggested a new well site to resupply the townspeople with clean water. By



Facing page: UM researchers Johnnie Moore and Bill Woessner above the Clark Fork River's Milltown Dam, which is slated for removal.

Green-tinged bones litter a polluted slicken area near the tiny town of Ramsay a few miles downstream from Butte.

1984 Milltown homes had arsenic-free tap water.

But that frozen February day started a snowball of ramifications that are still being felt. It led to the Milltown Reservoir being named a Superfund site, and other sites on or near the damaged Clark Fork River followed — a smelter site in Anaconda, the Montana Pole site in Butte and the entire river and flood plain between Warm Springs and Milltown Reservoir. All these areas became collectively known as the Clark Fork River Superfund Site, the nation's largest.

And now steps are being taken to improve the function of the Clark Fork, which has been hammered by a century-plus of mining and smelting contamination, municipal waste and more. Superfund cleanup efforts are ongoing in the Butte area, and in April 2003 the U.S. Environmental Protection Agency and Montana Department of Environmental Quality recommended removing Milltown Dam and the contaminated sediment behind it.

River Science Center

Montana has 177,000 miles of rivers, with 8,900 miles in poor condition and 1,300 directly impacted by mining. UM has a prime example, the Clark Fork River, flowing right beside campus. People want to fix such polluted waterways, but river restoration is a new and tricky business.

Now middle-aged, Woessner and Moore tossed around ideas for 15 years about how to get the University more involved in what was happening in the Clark Fork Superfund Site. For after they helped find clean drinking water for Milltown, private consulting groups and Atlantic Richfield Co. — the company responsible for Clark Fork environmental cleanup — took over the Milltown research and data collections going on in the river basin.

UM did have some formal involvement. Moore conducted a 1984 EPA study that tracked the source of the metal

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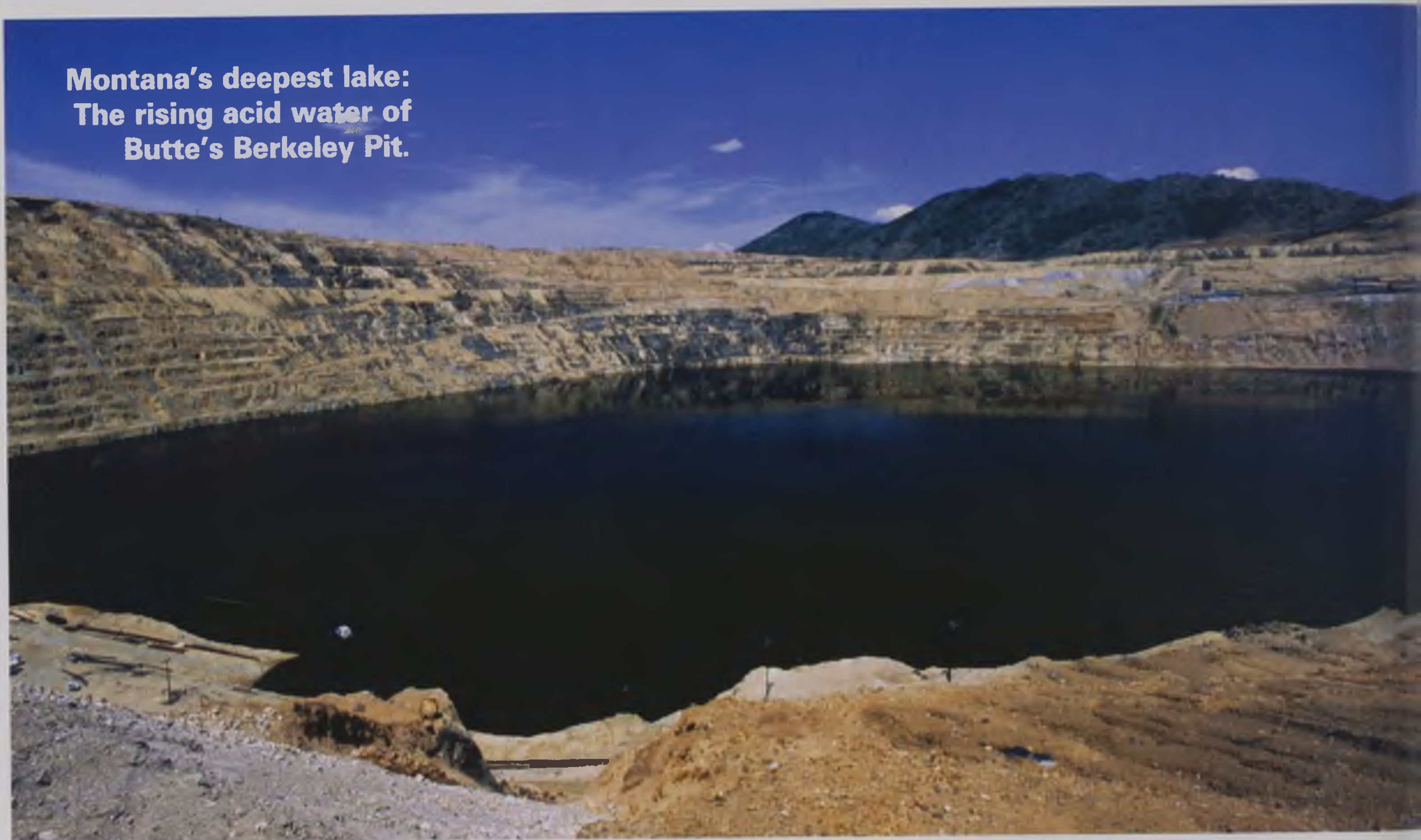


contaminates in the Milltown Reservoir 120 miles upstream to the Butte-Anaconda mining area.

"Nobody at that time considered that it was reasonable you could get contamination so far away," Moore says. "We sampled soils and cutbanks all along the Clark Fork River from Milltown to the Deer Lodge Valley. Concentrations of contaminates got higher as you moved upstream. You could see (mine) tailings in the banks all the way downstream nearly to the Drummond area."

Moore also kept graduate students working on research projects involving the Clark Fork, but there was no focus for University science studying the Superfund site. So in November 2002 Woessner and Moore got state Board of Regents approval for the UM-based Center for Riverine Science and Stream Re-naturalization. The University then approved a one-time grant of $65,000 to fund a half-time director and assistant to get the center rolling. The river organization is headquartered in UM's geology department, and must find its own resources for future funding.

Woessner, the center director, says the new organization acts as a nucleus to focus interdisciplinary teaching and research on natural and impacted streams. The center will research and assess stream modification projects, as well as develop creative ways to physically, geochemically and biologically restore function to damaged river systems.

"This is an area where The University of Montana can be a leader," Woessner says. "We already have very good people in multiple departments and units working on this at the national and international level, and by building on our strengths we can make a major contribution to this field."

The center is designed to link the efforts of scientists across the UM system doing water-related research. Initial partners are located at the main Missoula campus, the Flathead Lake Biological Station, Montana Tech in Butte and the Montana Bureau of Mines and Geology in Butte. New partners will be brought on board as the center grows.

"There are millions of dollars being spent in Montana and across the country on what we call stream restoration," Woessner says, "but very little of that goes into assessment; most goes into dirt moving. Over $80 million is committed to re-naturalization of mining-impacted streams in western Montana, and state and federal land management and fishery projects spend over $2 million annually. The center could become a draw for this research funding."

He says river restoration projects often create a channel that looks like a stream, acts like a stream, but doesn't function like a stream when it's all finished. It doesn't restore the groundwater-surface water interactions; it doesn't restore the chemical fluxes from the surface and groundwater. It may be an engineered structure that looks right — one that carries enough water and has the right number of curves. Those are all important, but does it create the right fish or riparian habitat?

Moore, an environmental geochemist, says it's critical to have a wide spectrum of experts from many disciplines involved in river restoration because rivers are incredibly important and complex — often the drivers of biodiversity in landscapes.

"You want to be able to fix more than one aspect of a river," he says. "Let's say you make it transport water easily. So what? You can make a concrete ditch that transports water easily — and people have done that in California and all over the place — but you have destroyed a river in the process."

Moore says a key goal of the center's research is trying to find ways to manipulate rivers to improve their function. But he says most rivers realistically will never be restored to pre-European-settlement conditions. They have too many demands on them, such as irrigation, hydro-power and municipal uses. But he believes some function can be restored.

While the Clark Fork River provides the center with an excellent natural laboratory for stream restoration right in its backyard, the UM researchers say their work will have applications across the nation and around the world. In the United States alone, 235,000 river miles have been channelized, 25,000 miles have been dredged and more than 600,000 miles are impounded behind dams. There are Clark Forks everywhere.

Woessner says millions of dollars are available for river restoration work, and he would like the center to develop substantial funding to help with such projects. If someone wants to develop a five-mile section of stream to improve bull trout habitat, for example, the center would partner with the people designing the restoration work and monitor the physical, chemical and geologic aspects of the project before and after.

"We'll be able to assess afterwards what was accomplished," he says. "Then we'll use that information to plan the next project. So we basically learn from these assessments and incorporate that into being better stewards of our river resources."

Moore says, "Our hope is that this center is the beginning of something that can start addressing really complex problems relating to rivers."

The river center could become an economic boon for Montana, Woessner says, as it helps put people to work doing river restoration in the state and elsewhere. He says UM students will receive training and funding for river restoration work through the center. Hopefully jobs also would be created for average Montana citizens living near impacted streams.

More information about the riverine science center is available online at www.umt.edu/rivercenter. The center hosted its first River Center Workshop Sept. 25-26. It was titled "Assessing and Re-naturalizing Streams Impacted by Mining."

Bringing Down the Dam

The newest restoration project planned for the Clark Fork is the proposed removal of Milltown Dam. Area bumper stickers proclaim "Remove the Dam, Restore the River," and everyone from the Missoula County Commission to Montana Gov. Judy Martz is advocating that the dam come down. (ARCO company representatives, however, are concerned about the cost, and some Milltown residents worry about potential disruption to their community.)

The EPA and Montana DEQ in April recommended removing 2.6 million cubic yards of contaminated sediment behind the dam and placing it in a lined repository less than a mile downstream from the dam, which would be torn down. The work would begin in 2006 and take about three years at an estimated cost of $95 million. The plan would return the confluence of the Clark Fork and Blackfoot rivers to a free-flowing state with unrestricted fish passage.

"Nothing like this has ever been done before," Woessner says. "I don't care what people tell you, but no one has removed a dam of this size with contaminated sediments behind it. This isn't a small river — during runoff it has 20,000 cubic feet per second running through it. There are a lot of unanswered questions about how this should happen."

Both Moore and Woessner have concerns about the dam-removal process. They believe the cart may be in front of the horse since more scientific appraisal of the complex Milltown site wasn't done before the decision was made to remove the dam.

Woessner says whatever is done should be intensely evaluated and assessed so river restorers can do adaptive management — adjusting their plans as new data comes in and they learn from the process.

He says the Milltown Dam shelters Missoula and other areas somewhat from arsenic and heavy metals coming down the river.

"We have to do things so the water supply of Missoula is not impacted by this operation," he says. "The river water recharges our groundwater system here. What happens if we change the chemistry in the Clark Fork with the dam removal and (pollution) concentrations in wells climb above drinking-water standards? What is our contingency plan? Under what conditions would this happen? We have to make sure we don't perturb this system and suddenly things get a lot worse."

Moore contends that the initial dam removal plan might not go far enough, since it calls for removing only 2.9 million cubic yards of about 8 million cubic yards of contaminated sediment actually sequestered behind the dam. He also describes the initial plan of moving the sediments a few hundred yards downstream to a depository on the river flood plain as "crazy."

"I would argue that if you do anything with Milltown, it needs to go upstream to the big repositories already there (near Anaconda and Butte)," he says. "It will cost more, but if you dig up a bunch of sediment and put it on the Clark Fork River terrace a quarter mile away, someday that metal is going back into the river. It's too unstable next to the river."

Both Moore and Woessner agree that researchers in UM's river center will learn a lot from what happens with the Milltown Dam. With about 80,000 dams scattered across the United States — some ripe for removal — Milltown could

(Continued next page)



First two photos courtesy of Johnnie Moore.

become the template for how to safely remove a dam with contaminated sediment behind it and how to restore river functions. Time will tell.

The Alchemy of Healthy Rivers

The science of river restoration and remediation is so new that Moore and Woessner were stumped when asked to give a good example of a place where people have dramatically improved the function of a river impacted by mining. (Moore now is developing a river restoration course with colleague Jack Schmidt of Utah State University.)

Moore finally brought up Spain's Guadimar River, where in April 1998 a large tailings dam ruptured near the Aznalcollar mine, impacting a 40-mile stretch of river and polluting 11,500 acres in the area.

"It was a major disaster," Moore says. "The entire flood plain was polluted, and large numbers of fish were killed."

He says the Spanish government came in and took control of the contaminated areas in a way that would be highly unlikely in the United States, since most of the impacted areas in Spain were privately owned. Most of the contaminated sediment was removed, and the government cleared out all orchards and crops — which were contaminated — paid off area farmers and created what they call a "green corridor" in the river's riparian zone. The Spaniards also are planting natural vegetation and trying to bring natural habitat back in the corridor.

"Here we try to work with landowners and aren't going to change our land-use practices," Moore says. "But their approach will probably go a long way toward restoring the river. But even with everything they've done, it's difficult to get all the contaminants out."

He says actions now being taken at Montana's Silver Bow Creek, a Clark Fork headwater, are likely the largest river restoration project in the world right now from the standpoint of removing mining wastes and trying to remediate the pollutants.

"Along with the bulldozers and backhoes, if you do a lot of good science, we'll know a lot more about how to deal with rivers all over the world," he says.

Moore also is involved with the CALFED project in California — an effort to restore function to the Sacramento-

Bad Stuff Runs Through It ...

Western Montana's largest river springs from the Continental Divide near Butte and gushes 320 miles northwest to Lake Pend Oreille in Idaho, knifing through spectacular mountain scenery along the way. Salish Indians fished all along the river, which the Corps of Discovery dubbed the Clark Fork, and pioneers found one of its headwaters so glittery and appealing they named it Silver Bow Creek.

But the ebb of history changed the Clark Fork Basin, and the pristine river system known to Indian ancestors is long gone, perhaps never to return. Western settlement brought mining, irrigation, rechannelization, town waste, farm runoff and four dams. As recently as the 1960s the Clark Fork ran red with mine waste, and today the river supports one-tenth the trout it should. Silver Bow Creek now flows through a moonscape of mine tailings.

The river started its transformation in the 1860s when gold and silver mining and smelting started near its headwaters. Hard-rock mining of these ores climaxed in the raucous mining community of Butte in 1887, when 450 metric tons per day were processed at nearby mills. After 1892, copper production rose to the forefront inside Butte's "Richest Hill on Earth."

Butte was honeycombed by 10,000 miles of underground mines that produced one-sixth of the world's copper supply until the middle of the 20th century. Fortunes were made, and businessmen such as William Clark, Marcus Daly and F.A. Heinze became Wall Street powers. Mining kept food on the table for thousands of Montana families, and Butte's powerful Anaconda Copper Mining Co. dominated the state's economic and political life for decades.

But this prosperity had a price. Old West Montana had no environmental laws, and by the 1880s great heaps of gray waste rock dominated Butte's landscape, while cobalt blue clouds rose from smelters to shroud the city. Trees and vegetation withered, and pets and farm animals drinking from area puddles died. One 1880s writer describes arriving in the mining Mecca to find 'stifling sulphur' fumes so thick he couldn't see across the street, and a policeman 'with a sponge over his mouth and nose to protect him from the fumes' guided him to his hotel.

Another account said arsenic in the smelter smoke could bleach skin, and mothers back East would send their daughters to Butte to help them attain that alabaster, porcelain complexion so sought after at the time.

The mine tailings — as well as flue dust and slag from the smelters — contain toxic levels of arsenic, cadmium, copper, lead and zinc. When the giant Anaconda smelter 20 miles west of Butte started work in 1902, contamination followed. One ranch 12 miles downwind lost 1,000 cattle, 800 sheep and 20 horses during the first year of smelting.

Much of the pollution from area smelters wound up in Silver Bow, Warm Springs, Willow and Mill creeks and from there flowed into the Clark Fork. Through the 1930s, '40s and '50s there were no fish in the river's entire upper basin. Occasional storms or other high-runoff events would stir up sediment and send reddish, toxic pulses of heavy metals

Left to right: 1960s state worker studies how long Clark Fork trout will last when exposed to a toxic pulse of reddish mine waste. (A few minutes.) Discovery of arsenic in 1982. A slicken area. Efforts progress this summer to restore Silver Bow Creek. New life: A restored portion of Silver Bow Creek.

San Joaquin Delta, which has been heavily impacted by gold mining and mercury contamination. A major goal there is salmon recovery.

Moore would like to see Montana emulate California somewhat when it comes to river restoration work, because in that state a certain percentage of all restoration funds must be used for scientific evaluations of the projects.

"Every project has to have mandated science done to discover whether it is working or not working," Moore says. "In the long run this will save you money and from redoing the project."

He says that while the Clark Fork River is confronted with tough environmental issues, it's far from the worst example on the planet. In Russia, for example, there are rivers and lakes that are radioactive — places where human birthrates are negative because of contamination. Moore knows of a Russian scientist who toured the Clark Fork drainage a few years ago and basically said, "What's wrong with you guys? You have way too much money if this is where you are putting it." He thought there wasn't a problem.

The researchers hope UM's new river science center can help improve function of the Clark Fork, but they say the river never will return to the pristine condition of pre-European-settlement times. A century-plus of mining has changed the river forever. The removal of Milltown Dam should help — as should ongoing and planned river restoration efforts — but unknown levels of arsenic and heavy metals will continue sluicing down the Clark Fork as natural stream processes continue.

Moore said rivers can cleanse themselves over the centuries. In fact, he had a graduate student who did one aspect of his master's thesis on how long it would take the Clark Fork to erode all the contaminated material that has been deposited in the Deer Lodge Valley, if the river were allowed by humankind to rechannel itself naturally and crisscross the flood plain. He found that under ideal conditions all the contaminants would be eroded once in 1,000 years, which still wouldn't completely clean the river. The river would need tens of thousands of years to clean itself naturally.

"So we're never going to get it back," Moore says, "but it's not naive, with the right science, to think that we can make it better." ■

downstream, killing aquatic life for many meandering miles.

The pollution also created 'slickens' downstream from Butte and Anaconda. Not much grows in these riverside dead zones but crusted deposits ranging in color from gray to blue or bright green. Most slickens were formed by sediment deposited by large floods in 1908 and 1910. Some areas contain so much copper that the bones of cattle that died there are stained a vivid green.

Eventually realizing the environmental damage being done, the Anaconda Co. built the 2,400-acre Warm Springs Ponds in the Deer Lodge Valley between 1911 and 1959 in an attempt to trap the tailings before they entered the Clark Fork. (Work on the ponds continues to this day.) The ponds did stop most heavy metals from reaching the river — except during heavy runoff events — but they failed to completely stop passage of arsenic. The four Clark Fork dams also seem to contain downstream contamination somewhat, but UM researchers suspect some pollutants may travel 300 miles or more — all the way to Lake Pend Oreille.

By the early 1910s the Anaconda smelter was processing 11,500 metric tons of ore per day, and by the time depressed prices shut the smelter down in 1980, more than 1 billion metric tons of waste rock had been produced in the Butte area.

Underground mining in Butte sputtered in 1976, but by then the Anaconda company was turning the Richest Hill on Earth into the 900-foot-deep Berkeley Pit, which gobbled up part of the town as it gaped wider. The pit grew from 1955 until 1983, when pumps that kept groundwater from flooding it were shut off. Since then the pit has slowly filled with water so acidic that 342 snow geese died after landing there in 1995.

The Anaconda company sold its holdings to Atlantic Richfield Co., the oil giant, in 1978. After that with the diggings unprofitable, ARCO, now part of BP, closed its Montana mines and now faces nearly $1 billion in inherited cleanup costs. One ARCO plan is to build a treatment plant for the Berkeley Pit water so it never reaches drinking aquifers. The acidic water will have to be treated forever.

The heyday of Butte-area mining has now passed, with one active mine scheduled to reopen this fall. The mining is largely gone but its legacy remains. Mining areas typically have elevated disease death rates, and a 1979 study found the death rate in Butte from disease was among the highest in the nation between 1949 and 1971.

Western Montana's biggest river also is now part of the nation's largest Superfund cleanup site. Much work already has been done on the river, significantly improving its water quality, but much work remains to be done. The two largest contaminated areas within the site are the Milltown Reservoir near Missoula and a 120-mile stretch of river, which starts at Warm Springs Ponds and extends downstream.

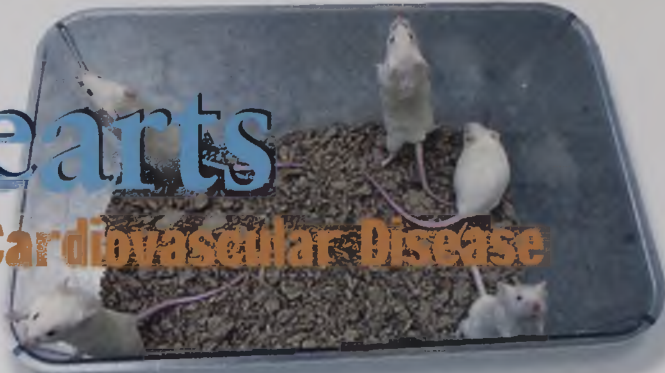
The Environmental Protection Agency, the state of Montana and industry partners are continuing work to restore more function in the river, including the proposed removal of Milltown Dam, which has millions of yards of contaminated sediment sequestered behind it. Public comment is now being taken about how the restoration should be done.

So, as it has for the past 140 years, the Clark Fork flows toward an uncertain future. ■

Article material provided by Johnnie Moore and Bill Woessner.

Poisoned Hearts

Researchers Link Pollutant and Cardiovascular Disease



By GARY JAHRIG
VISION STAFF WRITER

Photographs by TODD GOODRICH

Mice drinking arsenic water are more likely to experience plaque buildup in heart arteries.

It didn't take Melisa Bunderson long to set her sights on a research project after arriving on the UM campus several years ago.

Bunderson, a graduate student in pharmaceutical sciences, already had earned a master's degree in toxicology from Utah State University. And concerns over the elevated levels of arsenic in the Clark Fork River at nearby Milltown Dam were at the top of the list of community concerns when she arrived in Missoula.

The idea of furthering her education by exploring a topic of great local interest appealed to Bunderson. So she put together a proposal to conduct a study of the effects of long-term exposure to arsenic in drinking water and its relation to cardiovascular disease.

"I became intrigued by looking through papers and seeing arsenic linked to cancer, but not much to cardiovascular disease," Bunderson says. "I was a little amazed there weren't many people trying to figure out that link."

Faculty members Doug Coffin (left) and Howard Beall have found that arsenic exposure increases risk factors for cardiovascular disease.

Bunderson approached UM Center for Environmental Health Sciences researchers Howard Beall and Doug Coffin with her idea. Beall, an associate professor of toxicology, and Coffin, an associate professor of molecular genetics, signed on to the project and the research was under way.

"This was Melisa's idea. It just happened to come up at the same time the Milltown situation became newsworthy," Beall says. "We began looking into the topic and found there is a relationship between drinking water with arsenic in it and cardiovascular disease."

Beall, the principal investigator on the project, says the topic was a natural one for the center — part of UM's School of Pharmacy and Allied Health Sciences — to take on. Under the direction of Andrij Holian, the center conducts research into a number of environmental health concerns.

In taking on the project, all three members of the research team — Beall, Coffin and Bunderson — brought different types of expertise to the research lab.

"Melisa was interested in metals. My general area of research is toxicology. Doug is in cardiovascular studies," Beall says. "We figured we would work well together on a project like this."

And work well they have.

The UM team's publication of its initial research findings — that arsenic exposure increases levels of specific factors that can cause cardiovascular disease — coincided with the U.S. Environmental Protection Agency's decision to tighten restrictions on arsenic in drinking water.

The EPA also issued warnings that too much arsenic intake can contribute to cardiovascular disease, cancer and other diseases.

"We're pleased the EPA made levels of arsenic in drinking water more strict," Beall says. "Since environmental arsenic is normally found in combination with metals, we also want to look at the effect of those combinations on cardiovascular disease."

Poison for the Heart

More than 60 million Americans suffer from some type of cardiovascular disease — the number No. 1 killer in the United States. Several well-known risk factors, such as smoking, high blood pressure, high cholesterol and inactive lifestyle, have been linked to cardiovascular disease.

Coffin, a five-year UM faculty member, says his team's research specifically focused on linking arsenic with atherosclerosis or coronary artery disease — the buildup of plaque within arteries connected to the heart.

"Atherosclerosis is the most important factor in the development of other heart diseases," says Coffin. "There are a lot of theories about how atherosclerosis happens. We wanted to find out if arsenic exposure is a risk factor like being overweight or smoking. We wanted to know if arsenic exposure should be treated as another risk factor."

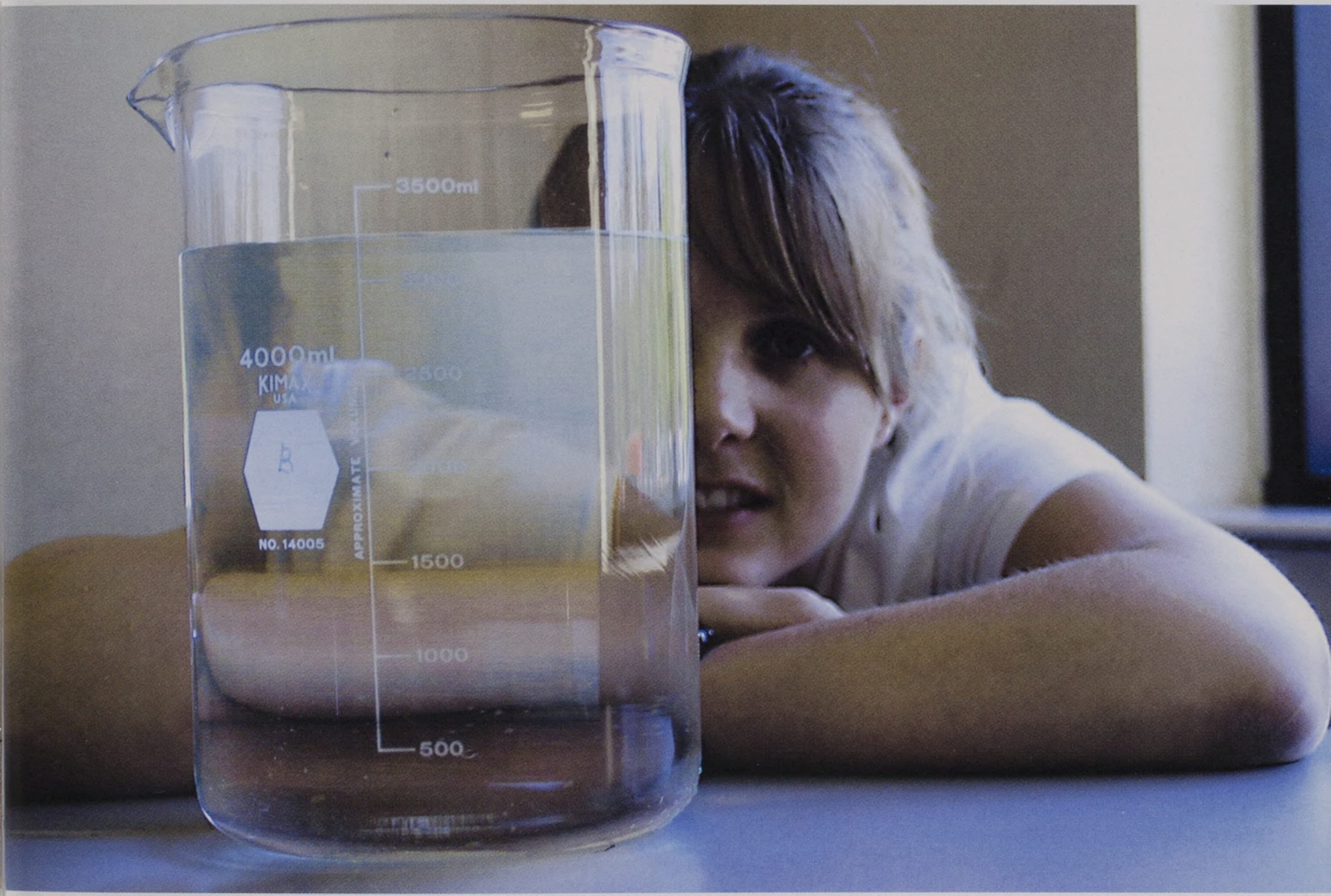
The first part of the study involved testing endothelial cells, which line the inside of blood vessels.

"We exposed the cells to arsenic," Beall says. "We looked for inflammatory markers — things that lead to inflammation. We found evidence of those markers."

The UM team then moved on to testing laboratory mice. Since mice don't get atherosclerosis, Beall says, their genes are altered to model human coronary artery disease.

"There are no human studies. We have to rely on animals," he says.

Some mice are continuously exposed to arsenic in drinking water at a level higher than humans generally are exposed. Others are not exposed at all. The researchers then compare



Melisa Bunderson studies the dangers of arsenic in drinking water.

the findings from the two groups.

"The main finding and most exciting is the size of the plaques in arsenic-treated mice is much more advanced than the size of the plaques in the control mice," Beall says. "This is the first controlled study showing that arsenic in drinking water in any animal model causes increases in atherosclerosis."

Coffin says data from the study will be used to look at how atherosclerosis affects overall cardiovascular fitness.

"We want to show that exposure to arsenic is likely to be a risk factor for heart disease," he says. "We want to show there are links between the cell study and animal study."

Grant Funds Human Health

To fund the project, the UM team earned a five-year grant from the National Institutes of Health. The funding is part of a larger grant received by the UM Center for Environmental Health Sciences under a program called Centers of Biomedical Research Excellence (COBRE).

"Our overall goal is health-related," Beall says."Our goal is to find a way to prevent and treat arsenic-induced cardiovascular problems."

Holian, who oversees the COBRE program at UM, says research such as that being conducted by Beall, Coffin and Bunderson is highly beneficial to UM and the general population at large.

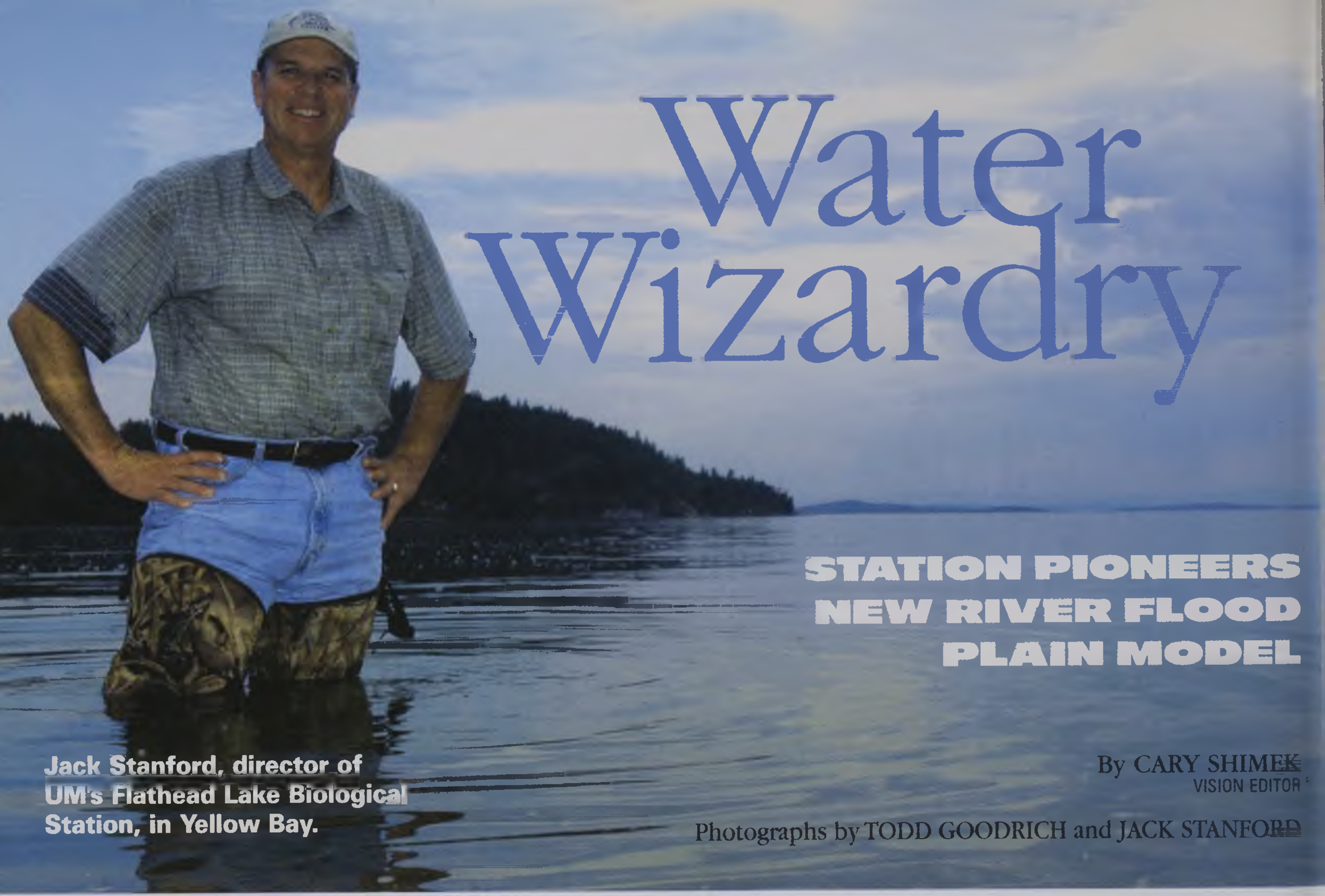
"First is the obvious health information that is highly relevant to all of us on the cardiovascular effects of arsenic in our waterways," Holian says. "Second is the resources that this project will bring in to the University community that has a positive impact for all.

"And third is the synergism that is created by all working on arsenic and related projects that will allow greater national recognition of the strong emphasis on research that this campus has developed."

Beall says the grant money is paying for a lab technician, two undergraduate students and two graduate students to work on the project.

And that's a plus for grad students like Bunderson who have the opportunity to work on cutting-edge research projects as part of their studies.

"This is a huge benefit to graduate students," Bunderson says. "This means we get to leave the program with some really strong research ties. That's very valuable."



Water Wizardry

STATION PIONEERS NEW RIVER FLOOD PLAIN MODEL

Jack Stanford, director of UM's Flathead Lake Biological Station, in Yellow Bay.

By CARY SHIMEK
VISION EDITOR

Photographs by TODD GOODRICH and JACK STANFORD

NO FLOOD PLAIN in the history of the world has been studied as thoroughly as one along the Middle Fork of the Flathead River, which forms the southwest boundary of Glacier National Park.

For the past two years, researchers organized by UM's Flathead Lake Biological Station have put a stretch of the river's flood plain under an intense microscope. They are studying the area's geology, chemistry, vegetation, aquatic organisms, stream flow and more in an effort to gain better understanding of the complex web of water and life — the "shifting habitat mosaic" — that makes up a healthy river ecosystem.

"This is a whole new way of looking at river ecosystems," says Jack Stanford, the biological station director and Bierman Professor of Ecology. "I think our project is absolutely fundamental to human well-being. It will teach us how to manage rivers better — to clean themselves naturally without having to spend tons of money on them."

Flood plains play major roles in controlling the natural purification of rivers and the distribution and abundance of plants and animals within river basins. Stanford contends that if these aquifers are unable to operate naturally, the river ecosystems slowly degenerate. He calls the interplay between life and river systems "biocomplexity."

Researchers are specifically studying the Nyack Flood Plain, a section along the Middle Fork 9 kilometers long and 3 kilometers wide. The flood plain biocomplexity project is funded by a three-year, $2.6 million grant from the National Science Foundation — one of the largest ecology grants ever awarded.

Traditionally, river research focuses on surface water. The biocomplexity model expands this view by diving underground to include surface and groundwater interactions and their ecological implications. Stanford says his model studies the river in four dimensions — laterally, longitudinally, vertically and over time — to gain the most complete snapshot ever of a river flood plain.

"When we first put this out there, it was brand new and changed the whole field of river ecology," he says. "It was revolutionary, but now people embrace it pretty well across the board on the scientific level."

Stanford, who has directed UM's biological research station since 1980, first made waves in the scientific community by discovering that areas beneath rivers actually are pretty happening places: home to stoneflies, salamanders and other unique critters that make up a complex food web. This led him and his colleagues to study how groundwater flows through saturated areas around rivers, especially the subsurface palechannels — areas of preferential flow where water flows faster underground, perhaps because a previous river channel had once been there.

"People don't realize that freshwater doesn't just exist in lakes, ponds and isolated aquifer systems," he says. "Much of it is below the surface, and water that penetrates at the top of the Continental Divide may flow underground for most of its pathway to the ocean."

This unseen part of river systems has been incorporated into the new river model, along with in-depth analysis of the river's erosion and deposition, course and speed, and water clarity.

Stanford says they chose the Nyack Flood Plain for the study because it functions well and is pristine — despite the presence of a railroad and highway running through it — and it's surrounded by wilderness on both sides. Named by railroad workers from Nyack, N.Y., the flood plain also is bounded distinctly by canyons at either end. In addition, most private property on the flood plain is owned by the John Dalimatta family, which has lived in the area for generations and has become a partner in the research effort.

Stanford says the river's virgin flow also is protected into perpetuity by federal reserve water rights that the biological station helped mediate several years ago — something that had never happened before in the United States. This means no dams, no water extraction or other tampering with the river. The Middle Fork should remain a template for what makes a good river forever.

Stanford says 23 researchers are working on the biocomplexity project right now — scientists from the biological station, the main UM campus in Missoula, Glacier National Park and Salish Kootenai College in Pablo. Five undergraduate students also are helping this year.

The fieldwork involves teams that fan out across the flood plain to measure everything from vegetation and animal density to sediment movement and water velocity. Their equipment includes a cabin, a trailer, a slew of sophisticated electronic devices, more than 50 sampling wells and six weather stations.

And new discoveries already have been made.

"We've learned new things about the life cycles of the organisms we knew were there," Stanford says. "They are more complex than we thought, with a lot more morphological variation than we realized — especially things in the groundwater like stoneflies."

They also found the zones of preferential flow in the groundwater are more complex and varied than expected, and that the valley fill, most likely alternating layers of clays and gravel, is deeper than they thought — nearly 150 feet of accumulation in some places.

One key research tool is a spectral-imaging, remote-sensing device that takes pictures of the flood plain from a plane using more than 100 bands. The images enhance what researchers are studying on the ground, and can graphically show changes in the flood plain over time and space.

"For example, we can remotely detect how deep the water is and how fast it's moving," Stanford says. "We also can see how vegetation is distributed across a landscape over time. In simple terms, we also can totally quantify habitat for any organism across the entire landscape of the river using this imagery."

He says the hyper-spectral imager assists with their integrated hydraulic modeling system, which uses geographic information system data to simulate surface and groundwater flows on alluvial flood plains in three dimensions. He says data from the modeling system can be plugged into new software that can create time-lapse movies of Nyack's shifting habitat mosaic.

"And even better, we will be able to fly you through it in three dimensions," Stanford says. "We'll fly you through the habitats, just like a plane, or even fly you through the subsurface palechannels."

He says their research plan calls for delving into precisely how the flood plain transforms and retains nitrogen, phosphorus and carbon. Researchers also will continue studying how rivers naturally cleanse themselves.

"That ability is missing on most of our rivers today because we have changed them so much," Stanford says. "So their natural capacity to clean themselves is compromised or gone, as well as their capacity to produce things such as healthy native fisheries. The main reason the water stays so clean around here is that groundwater circulates through the alluvial gravel in our flood plains. Without these flood plains, Flathead Lake [which the Flathead River flows into] would not be so beautifully clear and clean."

Lessons learned at Nyack about what makes a good river already are being applied around the globe. This spring Stanford took a trip to Norway to help experts there determine why their fishery is becoming depleted.

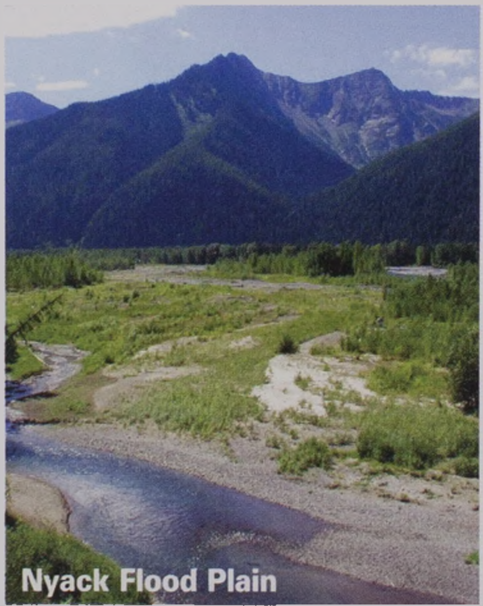
"They were overfishing," he says, "but they also were channeling water from the top of a mountain straight into their fishery, which had lowered the temperature by 10 degrees centigrade. That's a lot."

Stanford also recently used a Bureau of Reclamation grant to help determine how to restore a fishery on the Yakima River in Washington, where millions of dollars are being spent on the effort. He determined that agriculture was siphoning too much water from the stream.

"We showed them in quantitative terms what it would take," he says, "and, believe it or not, it would take a tunnel through the mountain to subsidize the Yakima with water from the Columbia River. It was very simple: If you want fish, you've got to spend money to bring water from the Columbia. And you mark my words, it's going to happen because it will work."

Stanford says biological station staff soon will hone their river model on another pristine river, this time in Kamchatka, Russia. Results there will be used to validate what they've learned at Nyack.

"Our overall goal," he says, "is to learn how to help rivers empower themselves." ■



Nyack Flood Plain

Studying Rivers That Time Forgot

Jack Stanford, director of UM's Flathead Lake Biological Station, says adventures abound in the Kamchatkan wilderness on Russia's Pacific Rim.

As an example, one night Stanford's wife, UM microbial ecologist Bonnie Ellis, woke him as they slept in their semi-permanent tent camp. "My bed just lifted up," she whispered. "Go see what's out there."

Stanford stuck his head outside and saw that a 1,000-pound grizzly had stepped on a floorboard outside the canvas tent wall, raising his wife off the ground. "Get out of here!" Stanford yelled at the behemoth. It only moved a few feet, so Stanford went outside and shouted again. The grizzly jumped in the nearby river, but it didn't leave. It just paddled around sniffing and snuffing at the unfamiliar human scent.

"He wound up living near us for a month," Stanford says. "We named him Clarence or something like that."

Kamchatka has a lot of bears, who live among some of the most pristine rivers remaining on Earth. It was the rivers and untouched fisheries that first lured Stanford to Kamchatka in 1999, and he's returned every year since, sometimes for two months at a time.

"I wanted to see functioning salmon rivers that had no roads, no harvest, no fishing pressure and had big giant flood plains with cottonwood galleries 10 to 100 times the size of what we have here," Stanford says. "And that's what we found."

During the Cold War, Kamchatka was a top-secret land, home to an excellent deep-water port at Petropavlovsk and Soviet nuclear submarines. The Soviets purposefully depopulated the Kamchatkan countryside, concentrating people in the port city, and jealously guarded their eastern peninsula. This had the unintended consequence of protecting an undisturbed wilderness laboratory for modern-day researchers.

Photo: Jack Stanford

UM microbial ecologist Bonnie Ellis holds a Kamchatka steelhead.

With partners such as Russia's Moscow State University and the Oregon-based Wild Salmon Center, Stanford's team is exploring an intact ecosystem teeming with salmon and steelhead trout. The research is funded partially by anglers who accompany the expeditions, paying $5,000 to $6,000 apiece to experience some of the best fishing on the planet. The scientists sample fish using the anglers, whose number has included Gordon Moore, chairman emeritus of Intel Corp.

"You can't imagine these salmon runs until you've seen them," Stanford says. "I've seen 35,000 red salmon on one gravel bar."

As part of the Kamchatka Salmon Biodiversity Project, Stanford and his team study rivers that could become templates for fishery restoration efforts around the globe. In the field they collect information about how juvenile salmon and steelhead interact with various habitats, and how these habitats shift around in time and space.

The work involves cruising across massive flood plains in jet boats or flying in a helicopter to the headwaters of a never-explored Kamchatkan river and rafting down it.

"We once landed in a place that made tears come down our faces, it was so beautiful," Stanford says. "There wasn't a single human footprint or indication there had been a human there, ever."

Of course all this wilderness work leads to all sorts of adventures. Stanford says they often follow bear paths and can encounter up to 20 half-ton grizzlies a day. The researchers also typically live off the land, but once they were stranded on a river without a salmon run and had to subsist on fish-head soup for several days. And he says most Americans look panicked when they first experience the old, Russian MI-8 helicopters they fly around in.

Working in such an intact environment — with its clean water and native species that have unobstructed access to the ocean — already has led biological station staff to discover that rainbow trout and large, seagoing steelhead are actually the same fish. It's just that in Montana, like most places in America, rainbows are prevented from

Photo: Jack Stanford

Unexplored vastness: The horizons of an eastern Russia flood plain.

journeying to the ocean and growing into their steelhead form.

"That's part of our research, studying what makes a steelhead vs. a rainbow," Stanford says. "We think that a rainbow living in the river who gets enough voles and salmon to eat is too lazy to go to the ocean, basically. He doesn't need the ocean. But in Kamchatka, competing against nine other species of fish, he might not get so fat and lazy, and this stimulates him to head for the ocean and get big."

Stanford says UM wants to be part of efforts that protect Kamchatkan rivers forever. To this end, the station recently landed a $2 million grant from the Gordon and Betty Moore Foundation that will allow study of 12 river systems in Kamchatka, Alaska and British Columbia using the UM model developed at Montana's Nyack Flood Plain.

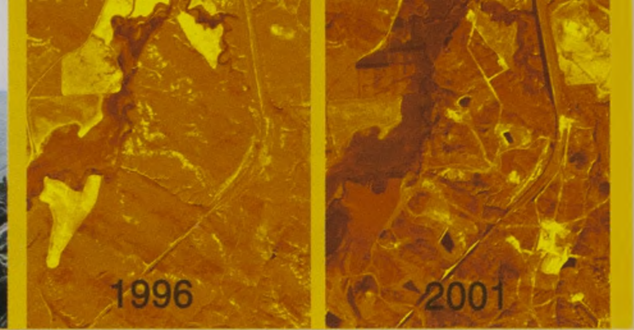
As part of the Kamchatka Salmon Biodiversity Project under the guidance of the Wild Salmon Center, Stanford says, some Kamchatka rivers also will become Pacific Salmon Observatories — places where researchers and students can experience firsthand a great salmon river swarming with fish. The goal is to learn how to restore fisheries and thus improve overall river health.

"There are a lot of places on our planet that don't have enough fresh water, and human suffering is increasing every day," Stanford says. "We are finding tools that will help to alleviate that by fully understanding these very pristine rivers."

By Cary Shimek

Sodium Solutions

Coalbed Methane Challenges Eastern Montana Rivers



Left to right: Professor Richard Hauer. Pair of images showing coalbed methane surface disruption near Decker on the Montana-Wyoming border.

Ranchers in the Powder River Basin of southeastern Montana have long known their drinking water sometimes comes with a kick. In fact, an unwary ranch hand who lights a match in the well house might accidentally blow the place sky high.

That's because domestic water wells in the area often tap into coal seams a few hundred to more than 1,000 feet deep. The water can be good quality — it has its own natural charcoal filter — but sometimes natural methane gas trapped in the coal seam comes up the pipe as well, which can create an explosive surprise.

New technology now makes it profitable for developers to go after the gas, which could mean big changes for the Powder and Tongue rivers, two of eastern Montana's most important waterways.

Professor Richard Hauer of UM's Flathead Lake Biological Station is an expert on lakes, wetlands and streams. He and station director Jack Stanford were asked by the state Legislature to provide an independent academic review of coalbed methane production on water quality and the river ecosystems that may be affected in eastern Montana.

"This is about as complex an issue as you could possibly find," Hauer says. "It's very dry in that area and water is a very precious resource. Water quality, fish, wildlife and other aquatic life of the rivers, plus the farmers who irrigate from the Tongue and Powder rivers, may all be affected by coalbed methane development and production. There are many things that we are uncertain about in all this. I certainly would tread very carefully out there."

According to a draft Environmental Impact Statement, about 20,000 wells would be needed to bring the Powder River Basin coal seams to full development, and production would then last about 30 years before the resource was depleted. Right now the only coalbed methane wells in Montana are concentrated near Decker, on the Tongue River close to the Wyoming border.

Coalbed methane fields generally contain a high density of wells — about three to five every 80 acres. The surface disruption includes a network of roads, well pads, pipelines, concentration stations and disposal ponds.

"We found the number of roads and other surface disturbances associated with development, such as the pipelines, rather disturbing," Hauer says. "It has been documented time and time again that large-scale disturbance to surface soils often results in modifications to water quality as it flows through and out a basin."

But the biggest conundrum is what to do with all the water produced by coalbed methane production. The water, typically high in sodium and other dissolved solids, is pumped out of the ground in order to release the trapped methane gas. Each well produces about 2.5 to 10 gallons of water per minute, which translates to about 110 to 450 cubic feet per second if the basin is brought to full production. It's a lot of water that has to go somewhere.

In Wyoming, which already is charging ahead with coalbed methane development in the basin, waste water generally is discharged directly into the Tongue and Powder rivers, which then flow north into Montana. This, however, might not be a good solution for water disposal in Montana. Based on the data, it appears that water coming from the coal-seams in Montana tends to be saltier than water in Wyoming. Hauer says that direct discharge of the higher sodium concentration coal-seam water in Montana could adversely affect the chemistry and biology of these rivers.

Stanford and Hauer's white paper specifically focused on the implications of development on water quality and river ecology. They evaluated several potential solutions to coal-seam water disposal with varying levels of risk and uncertainty. They reported that the least risky solution would be to re-inject the water back where it came from, but Hauer says most industry officials tell him that would be prohibitively expensive.

Another potential solution is holding ponds that allow the water to evaporate or drain back into the ground. But Hauer says evaporated coalbed water would leave a salted hardpan on the bottom of the ponds after the gas is depleted and production stops. A better option would be lined ponds, but once again these are expensive.

Other options include using the water for livestock, but cattle couldn't keep up with the volume they would be faced with. Or it could be used for irrigation, but there are limits to the amount of sodium water that can be applied to fields without permanently damaging them.

Hauer says direct discharge of coalbed methane water into the Tongue and Powder rivers carries the greatest uncertainties. The practice could change the rivers' chemistry to sufficient extent that use by native river species would be compromised and irrigated farmland could be impaired.

Eastern Montana is dry, and life clusters around the rivers there. One might assume that more water would be good, but he says that's not always the case.

"The ecosystem there may be very dependent on periodic drought. Native species may maintain their competitive edge against non-native species that might move in without drought," he says. "If we change that environment by adding more water, then you may select for organisms other than the ones that occur there as natives."

He says a "one-size-fits-all" method for dealing with the coal-seam water — while that may be easiest to legislate and regulate — may not be appropriate for Montana's Powder River Basin. He says the type of water produced from the coalbeds changes across the landscape, so if there is development, administration of the gas fields should vary between locations. Detailed water chemistries from each well should dictate the regulation and disposal of the water.

Hauer says eastern Montana could see an economic windfall from coalbed methane development. However, he adds that in Montana's past there have been various kinds of resource extraction with long-term ecological and sometimes human-health ramifications.

"Clearly, Montanans should want to be cautious about repeating past mistakes," he says. "Rushing into things oftentimes results in something you are really sorry for later."

To read Hauer and Stanford's paper, go online to www.umt.edu/biology/flbs/Research/More.htm.

By Cary Shimek

SCIENTISTS STUDY HEAVY METAL IMPACTS ON RIVER MICROBES

Not a rock band: (Left to right:) Matthias Rillig, Jim Gannon, Bill Holben, and Johnnie Moore.

By GARY JAHRIG
VISION STAFF WRITER

Photograph by TODD GOODRICH

WHEN A TEAM of University of Montana scientists decided they wanted to study how heavy metals affected life in the Clark Fork River, they opted to start at the bottom. The bottom of the food chain, that is.

"Basically there has been a lot of concern about metal contamination in rivers," says Johnnie Moore, a UM geology professor for the past 27 years. "There's been a lot of lab testing done on fish. We wanted to try something different."

Beginning in 2000, Moore, along with UM colleagues Bill Holben, a professor of microbial ecology; Jim Gannon, a professor of environmental microbiology; and Matthias Rillig, an assistant professor of microbial ecology, began overseeing a study on how metals in the Clark Fork affected the microbial community.

"We wanted to study a selection of metals, not just single elements like arsenic or cadmium or copper. We wanted to study them altogether as they are found in the environment," Moore says.

And they wanted to find a way to measure what effect the metals — from years of upstream mining — had on the river's ecosystem. So rather than study fish or the insects fish eat, the UM team set their focus on microbes — microscopic single-celled organisms found on rocks in the river.

"Basically it's the slime on the rocks you see in the river," Moore says. "Bacteria and other microbes are the base of the ecosystem. We decided we didn't want to work on organisms above bacteria in the ecosystem because we wanted to see how the foundation of the ecosystem was affected by metal contamination."

A RIVER'S LIFEBLOOD

Holben, who has been a faculty member in

UM's Division of Biological Sciences for the past eight years, says the team settled on microorganisms because they "are the true base of the food web" in the river.

"The basis of the food chain in the water and sediments is that bacteria consume organic carbon. Insects then consume the bacteria. And insects are then eaten by fish," Holben says.

To fund their research, the UM team secured two two-year grants from the U.S. Environmental Protection Agency, worth $140,000 per year. Based on the findings of the current research project, Holben says, the UM team hopes to secure additional funding from the National Science Foundation to continue the study.

Moore and Holben believe their research into river contamination is beneficial to UM because it gives both undergraduate and graduate students a chance to participate in a hands-on science project. So far, results from the research have been presented in a master's thesis and doctoral thesis for two students who have graduated from UM. Several other students currently are working on the evolving project.

And the subject of their study also could prove beneficial to residents of Montana, where fishing is a cherished pastime and water quality is an issue of intense interest.

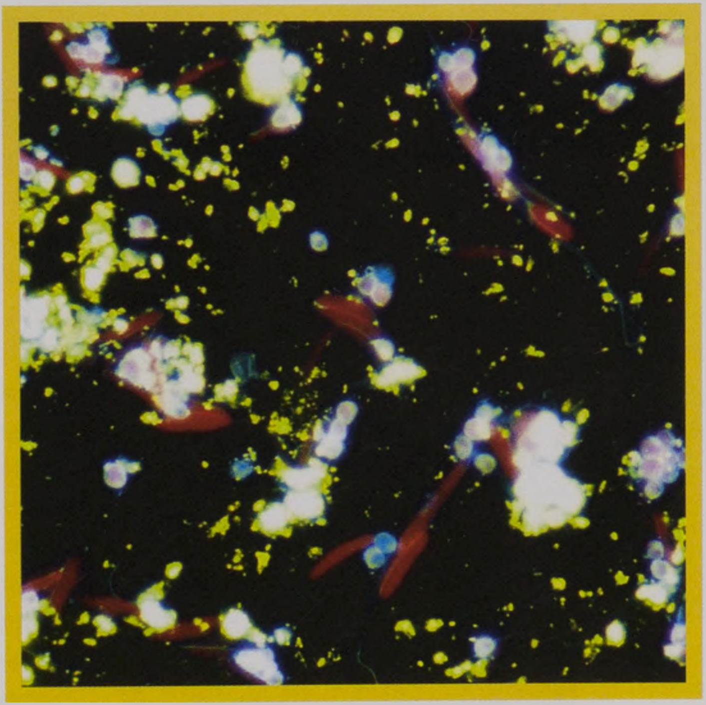
"One of our goals is to add new knowledge about the river system — additional knowledge of how ecosystems work and how humans affect them," Moore says. "Hopefully we can generate a better understanding of how contaminated rivers work and how to measure that contamination.

"And along the way, we're training scientists to solve these problems in other places and on other rivers."

A TALE OF SIX SITES

When research began three years ago, the UM team settled on six test sites on the Clark Fork — ranging from Silver Bow Creek, just west of Butte, to Rock Creek, just east of Missoula. What the scientists wanted to look at was the concentration of metals in the sediment in the Clark Fork. For years, mining operations in Butte and smelters in Anaconda dumped huge amounts of metals into the river.

Moore says researchers have found high concentrations of metals such as arsenic, cadmium, copper, lead and zinc, with different test sites yielding concentrations of different metals. The UM study's goal is to compare what kinds of microorganisms are found living in the presence of different concentrations of metals at various spots in the river.



Microorganisms such as these often are the only living things in metal-contaminated water.

Moore handles the geological testing for metals, while Holben, Gannon and Rillig oversee the biological research.

"We isolate the DNA from the organisms living on the sediments," Holben says. "We determine what kinds of bacteria are in the community. We compare samples from one contaminated site to others. We check to see if the same bacteria are present."

Holben says the team has created a "contamination index" to represent the total concentrations of different metals found along the river. He says the researchers found that different types of microorganisms thrive in areas contaminated with different amounts of metals.

"We test a bucket full at each site," Holben says. "We have found that the sediment is full of different things at different sites."

But that does not appear to have had an impact on the number of microorganisms living in the river.

"The idea is that the short-term response may impact numbers and the activity of the microorganisms there when the contamination first enters the stream. But over time, the community grows to have the same number of organisms as the uncontaminated sites. It's become a more metal-tolerant community," Holben says. "Some groups of bacteria are more apparent where there are heavy metal concentrations, while others are less abundant."

Holben says that since certain insects appear to prefer certain kinds of bacteria, affecting the makeup of the microbial community may in turn affect the insect community and ultimately the larger organisms such as fish.

Moore says the contamination in some areas of the river is great. "In some places there are 100 times more metal contamination than what would normally be there," he says. "So we see how the microorganisms have responded to the changes.

"The bacteria have built up their ability to deal with metals over a number of years. The environment appears to select certain organisms that can deal with metals."

Holben and Moore believe their research into microorganisms will prove to be an accurate indicator of the impacts of metals on aquatic life in the Clark Fork and other rivers.

"We want to establish the microbial community as a more sensitive indicator of toxic effects of heavy metals on rivers," Holben says.

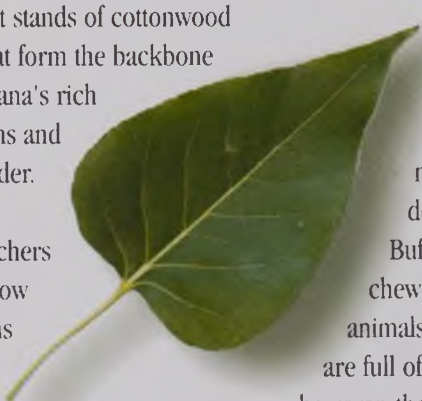
Adds Moore: "It's very difficult to get ecosystem data with insects or fish. With bacteria, you can monitor very small changes in the ecosystem very rapidly." ■

Cottonwood Conundrum

MONTANA'S FLOOD PLAIN TREES ARE LEAVING

By CAROLINE LUPFER KURTZ
VISION STAFF WRITER

Photographs by TODD GOODRICH and MIKE MERIGLIANO



There are still plenty of them, but the great stands of cottonwood trees that form the backbone of Montana's rich habitat along streams and rivers are getting older. Landowners, recreationists and researchers all would like to know why new generations of cottonwoods seem to be absent in many places.

Some of the blame can be attributed to dams or diversions, which change the natural flow of rivers, and to bank stabilization to protect roads, bridges and homes, all of which interfere with the conditions cottonwoods need to get started. But research from UM's College of Forestry and Conservation, among others, shows that is not the complete story.

In the spring, fluffy cottonwood seeds drift in the breeze and pile up against rocks and grass along stream banks. It seems miraculous that such big, beautiful trees — often the only trees to be found out on the hot, dry prairie — can grow from these insubstantial beginnings. Cottonwoods require bare, moist mineral soil to grow, primarily gravel bars that form on the inside of river bends. Controlling a river's natural flow or movement reduces the gravel bars deposited by the stream.

Buffeted by high water and chewed on by beavers and other animals, a cottonwood's early years are full of struggle. Once established, however, they anchor the stream edge, providing food and shelter for dozens of bird and mammal species.

Cottonwoods also have a well-understood relationship to stream dynamics, says Mike Merigliano, a UM research associate who studies river systems in Montana and surrounding states. He explains that cottonwoods are a natural clock for creating a timeline of river changes.

"Because they establish and grow on new but stable gravel bars, you can age a tree [determine how old it is] to find out when the bar was deposited," Merigliano says. "Then if you map the aged-tree patches, some of which are quite far from the present river course, you can see how the river has changed over time."

Merigliano's work focuses on how plants, especially cottonwoods, relate to their environment and what will happen to them if the environment changes or doesn't change. He has stacks of data waiting to be published but has difficulty finding time to write, since he is so often called by citizen groups or government agencies to do field studies.

Last fall, for instance, McCone County ranchers and federal National Resource Conservation Service agents were concerned about the lack of young cottonwoods along the Redwater River, which flows to the Missouri from near Circle. Not only do cottonwood trees provide sustenance for wild animals, they are the principal source of shade for livestock in that harsh environment.

An initial survey found many stands of old trees, but very few young ones. A graduate student will return to do a more detailed assessment, but Merigliano's guess is that a combination of ice jams, which scour the river bed and nearby vegetation, plus a general change in climate that is leading to a less active stream, are making the difference. New tree generations also may be impacted by naturally occurring salt concentrations — particularly along the upper portion of the stream — and the many small water developments that together may be reducing the incidence of big floods required to deposit new gravel bars.

Merigliano, UM forestry Assistant Professor Scott Woods and graduate student Millie Bowman are working on another project, one near Ovando on Kleinschmidt Flat — a glacial outwash plain extending from the Scapegoat Wilderness. The North Fork of the Blackfoot River runs along the edge of the flat, and a number of irrigation ditches were put in decades ago to divert water to farmers' fields. Now the U.S. Fish and Wildlife Service plans to retire one of the ditches to increase the river's summer flow helping bull trout migrate to their spawning grounds in wilderness-area creeks. Local landowners are supportive of the plan, but some are concerned about the impact on the large cottonwoods that have become established along the ditches.

To find out what the effects of draining the ditches will be, the researchers are studying the trees in the area to find out where they get their water and how much they need to survive and be healthy.

"How much drought stress can the plants take, and can they adapt to a system with less water?" Merigliano asks. "As the flow in the ditch changes, will that change the water tension in these trees?"

Water tension is a measure of how hard a tree has to work to pull water out of the ground. The higher the tension, the higher a tree's stress. At some point, the stress becomes too high and the plant will wilt or die.

During their initial measurements, the ditch clogged up for a couple of days and the researchers were able to observe an increase in water tension in some of the trees. This indicates that removing water from these ditches may have an impact on the cottonwoods, Merigliano says. If so, the trees may have time to adjust to the new conditions if the flow is reduced incrementally rather than shut off all at once. Knowing where these trees get their water at different times of the year — from the ditches, from other surface water, from deep ground water or a combination — also will help tell what the impacts will be.

Every body of water has its own isotope characteristics, or the ratio of "heavy" oxygen and hydrogen atoms — those containing extra neutrons — to their normal form. Different isotopic ratios are a function of the conditions under which the water formed. Water precipitated as a heavy rainfall has a different signature from water that seeped into the ground from melting snow, which is different from water that has been percolating through the ground for a long time.

Cottonwood expert Mike Merigliano

Cottonwoods come in two sexes, with males producing pollen and females producing cotton-like seeds.

Merigliano and Bowman can cut stems from trees and isolate the water inside. They then have to send the samples to other labs for isotope analysis.

"We can look for a match between likely water sources and water within the trees to find out where they are getting their water at specific times of year," he says.

This information helps landowners predict what will happen to their cottonwoods when the diversion ditch is retired. It also helps Merigliano piece together the larger cottonwood story.

"Considering studies of large cottonwood systems along several rivers, including the free-flowing Yellowstone River, we see that they are skewed toward old stands," Merigliano says.

It also appears that up to about 150 years ago, coinciding with the end of the Little Ice Age, floodplains were larger and more active than today, he says.

To test his idea, Merigliano intends to travel north to study rivers and streams in the colder, wetter climates of Canada and Alaska to see if streams are more active there than here, and to see if that's where cottonwood youth can be found.

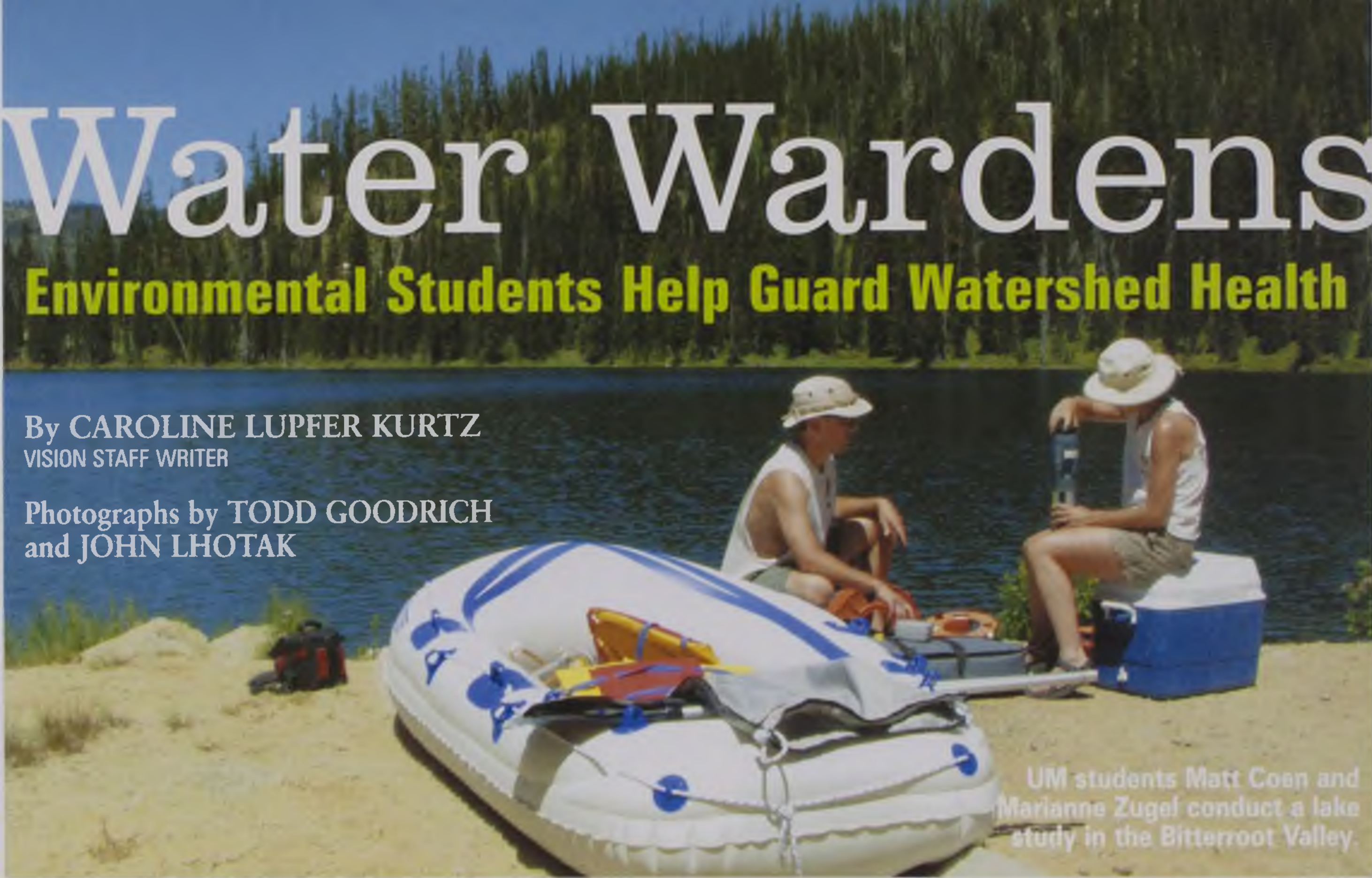
"I'm always looking for links between climate change, geomorphology and vegetation," he says. "Even if I'm just out having fun, I'm always looking at how things connect. But now I'd like to quantify my observations."

Water Wardens

Environmental Students Help Guard Watershed Health

By CAROLINE LUPFER KURTZ
VISION STAFF WRITER

Photographs by TODD GOODRICH and JOHN LHOTAK



UM students Matt Coen and Marianne Zugel conduct a lake study in the Bitterroot Valley.

The phone rings. It's the Montana Department of Environmental Quality. The agency is looking for information about remote streams of the state's northern plains. This sounds like a job for student researchers in UM's Watershed Health Clinic.

"Our main purpose [in this project] was to assess nutrient levels in 10 tributaries of the Milk River, none of which had been studied before," says John Lhotak, an environmental studies master's candidate. "Currently the state bases standards for these streams on standards developed for streams in western Montana, which are completely different systems."

He says the DEQ would like to understand how dams and other water uses affect aquatic life and physical conditions of the Milk River watershed and what, if anything, should be done to mitigate such impacts.

In 2001, Lhotak compiled information on nutrient levels — the amounts of nitrogen and phosphorus present — and physical characteristics of each stream. He now is writing his thesis from the project. Fellow graduate student Marianne Zugel revisited some of Lhotak's streams in 2002 and extended the project to seven more in the extreme northeast corner of the state.

Lhotak, Zugel and those who helped them racked up serious tire time traveling from Missoula to Glasgow — the nearest town to their study area with a store that sold the dry ice needed to preserve water samples. From Glasgow they would head into the hinterland for a week to measure and sample, then return to Glasgow for more dry ice to last the trip home to Missoula. They each repeated their circuit several times.

"The WHC provides a great chance to get out there and learn the field methods needed to do water-quality research," Lhotak says.

Thanks to that opportunity and his undergraduate degree in geography, Lhotak recently was hired as an intern hydrologist with the National Weather Service.

Students who participate in the WHC are used to taking initiative and helping each other. They also learn to put their research into action, not only by accumulating hard data, but by making recommendations to help communities and agencies prioritize and tackle specific local water-quality issues.

"The Watershed Health Clinic was conceived to put science in the service of communities and protect natural systems," says environmental studies Professor Vicki Watson, one of the driving forces behind the clinic's success for the past 15 years.

"For students the clinic is an opportunity to get scientific experience — often for the first time — and to realize they can go the next step with that information," she says. "They're not just studying something, but trying to work with citizen groups that want to do something to improve the environment, that want to know whether there is a problem and what to do about it, and that need the best information to make their decisions."

Undergraduate and graduate students in the Environmental Studies Program choose to participate in the clinic. Requests for help come to Watson, who also does much of the grant development for the studies, and the students as a group decide who will lead each project.

Students in the Watershed Health Clinic take a holistic approach to water-quality problems. In addition to in-stream studies, they also tackle projects aimed at restoring natural watershed conditions, such as replanting native vegetation along O'Brien, Bear, Pearson and Warren creeks. They also help restore uplands by removing invasive weeds, which in turn reduces the need to use herbicides. They even work to protect Missoula's drinking-water aquifer by collecting household hazardous waste for disposal and stenciling storm drains to deter dumping wastes. And they help train a new generation of watershed guardians by taking schoolchildren on monitoring field trips.

Some of the clinic's studies are long term and involve many students, such as the ongoing monitoring of Clark Fork River nuisance algae, which in some places grows so thick it completely chokes the river. On warm summer nights, such excess plant growth can lower the oxygen content of the water. More often it clogs ditches, interferes with fishing and alters the insect communities that live in the river. As one of the longest and most complete data sets on river algae, the study has been used by the U.S. Environmental Protection Agency to set national nutrient and algae criteria and was essential to developing the Voluntary Nutrient Reduction Plan for the Clark Fork River.

Other WHC projects are specific responses to community requests for help. For example, Sean Sullivan, who received his undergraduate degree in May, spent the last year conducting a watershed assessment of Lolo Creek for the Missoula Water Quality District. This is the first comprehensive study to be made of Lolo Creek, which provides water for agriculture, industry and a growing population, from its Bitterroot Mountain headwaters to Travelers' Rest State Park, near the confluence with the Bitterroot River. At five evenly spaced sites, Sullivan described the creek's physical character, communities of aquatic insects and nutrient concentrations. His baseline information will be of great use for future studies, such as one being undertaken by a Lolo community group on the quality of the fishery in the watershed.

Matt Coen, another environmental studies graduate, has a similar perspective. He recently worked with the Lakeside Community Council and the Flathead Basin Commission on a study of the chemical, physical and biological characteristics of Stoner Creek. The purpose was to identify points of concern — especially the source of excess sediment and nutrients.

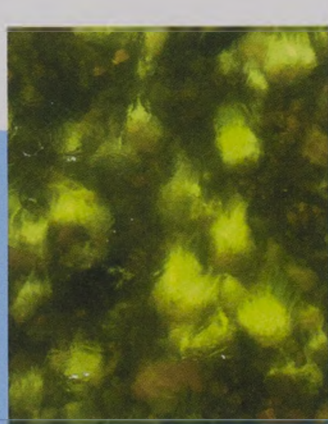
"I liked being involved with the community to help people decide what approach to take in solving [some of these issues]," Coen says. In fact, he has been hired to speak with school and public groups to inform them about the creek and its problems and to help citizens sort out their values and priorities for their water resource.

"I'm not just strictly interested in research any more," he says. "I might do the best science possible but if the results just sit in a filing cabinet, what's the point?"

In helping communities safeguard the health of their watersheds, Vicki Watson says, the Watershed Health Clinic helps students transition from the classroom to the real world.

"We try to get students to look at the larger picture," Watson says. "What changes have happened at the land-water interface and back into the watershed? What causes the problems we see and what could reduce these problems without causing a whole chain of other problems? You can't just look at one question; you need to look at the whole system."

For more information about the Watershed Health Clinic, go to www.cas.umt.edu/evst/watershedclinic. ■


Left to right: Environmental studies Professor Vicki Watson, algae blooms in the Clark Fork River near Missoula, UM Watershed Health Clinic students sample at the Milk River.

Positive steps made to lessen nutrient loading

Thanks in part to data provided by clinic students and faculty, the city of Missoula has reduced nutrient loading to the Clark Fork River, significantly lessening nuisance algae problems downstream. But the upper Clark Fork presents a more difficult problem, environmental studies Professor Vicki Watson says. It is shallower— allowing more light for algal growth — and receives more of its nutrient load from hard-to-control nonpoint sources. Any kind of land disturbance — development, timber harvesting, agriculture — causes a release of nitrogen, which is the most damaging nutrient in the upper river.

However, there have been positive developments upstream: The historic Grant Kohr's Ranch is doing its bit to reduce nutrient loading by applying wastewater from Deer Lodge to some of its fields. While this may not be a true historical use of the property, ranch managers felt they should do something to help fix the larger problem and so make the applications on a part of the ranch not typically seen by visitors.

The city of Butte also is helping reduce nutrients in the upper Clark Fork by using waste water to grow sod, rather than directly discharging to the river. The effects of these and other efforts are being seen downstream and are part of a positive trend in improving the overall health of the Clark Fork, Watson says. ■

Tallying Tadpoles

GRADUATE STUDENT UNCOVERS MONTANA AMPHIBIANS

BY HOLLY FOX
VISION STAFF WRITER

Photographs by BRYCE MAXELL
and TODD GOODRICH

WHAT CLASS of organisms plays a critical role in transferring energy up the food chain, shapes terrestrial and aquatic communities, and serves as an important bioindicator of environmental quality? The answer is amphibians —cold-blooded vertebrates such as frogs, toads, newts and salamanders that begin life submerged as tadpoles and grow up to live not only in the water, but on land as well.

Sure, amphibians sound important, and the ability to be at home in a pond or on a grassy knoll is impressive, but as one famous amphibian Muppet said, "It's not easy being green" — or any other color, it seems.

In fact, some amphibian populations around the world and in Montana are in decline or have disappeared all together. Because of their amphibious lifestyle, they often slip through the cracks when it comes to wildlife management — are they the responsibility of terrestrial or aquatic wildlife managers? But these multifaceted animals are getting some serious attention from a UM student who has devoted his time at the University to inventorying the amphibious populations of the Big Sky state and to documenting the life story of the Columbia spotted frog, the state's most common frog species.

Bryce Maxell, who is earning a doctorate degree in fish and wildlife biology at UM, says he decided to study amphibians when he realized how little is known about them, specifically in Montana. "I guess I was looking for a niche that needed to be filled where my efforts might be most meaningful," he says.

"Within the last decade a number of people who study amphibians and reptiles have noticed declines all over the world," Maxell says. "In some cases it's pretty straightforward what the causes are, but there are a lot of cases in which they haven't been able to identify what is causing the declines — they just don't know what's going on."

To identify the causes, Maxell says, many researchers are conducting short-term experiments to determine the effects of certain environmental changes on eggs or larvae.

"They might expose eggs to ultraviolet radiation or larvae to some sort of chemical," he says. "But their results aren't very meaningful because they don't really understand the demography of the species."

Part of Maxell's research is dedicated to studying the life histories of Columbia spotted frogs to obtain basic information about their life cycles and habitats. "Researchers don't know what the typical survival rates are for these frogs at each life history stage," he says. "So part of my research is directed toward documenting the background demography of the survival rates on the eggs, the larvae, the newly metamorphosed frogs and the adults, both male and female.

"I want to provide agencies in Montana with the first scientifically defensible overview of the status of amphibians across the state and add as much to the body of knowledge about the demography and general biology of these species as I can," he says.

Research runs in the Maxell family — Bryce's father studied small mammals in Wyoming for his Ph.D. research. "From an early age I was surrounded by a wide variety of domesticated and wild animals," Maxell says. "We spent a lot of time camping in the summer and dogsledding in the winter when I was growing up, and my dad knew the names of almost every plant and animal, which made me interested in wildlife since I was very young."

Maxell studies the frogs in three study basins — two in the Bitterroot Mountains and one in the Cabinet Mountains.

The three basins have varying numbers of water bodies, which have varying numbers of fish.

"The basins in the Bitterroot have multiple

A northern leopard frog

UM doctoral candidate Bryce Maxell

lakes, ponds and water systems, on the order of 15 to 20 ponds or lakes," Maxell said. "One basin has a lot of fish in the lakes and the other is basically fishless. The third basin in the Cabinets is just a single pond with no fish. I wanted to look at interactions between local amphibious populations in ponds with and without fish in a couple of basins, and then study the populations in a single control pond.

"On top of that, not all the ponds provide the habitats they need year-round — some are only good for overwintering, some are only good for breeding — so we are studying the survival rates in conjunction with the use of seasonal habitat," he says.

Maxell and his researchers count the number of eggs at each pond, cage the eggs, then come back later to count the number of hatchlings that resulted from those eggs. They return to get an estimate of the metamorphosed animals, and again to estimate the number of adult frogs. This process has been going on for four years.

"So far we have marked around 12,000 animals in all three basins combined," Maxell says. "We combine the survival rate information with habitat information to see if there are differences in survival rates based on fish, solar exposure, elevation, vegetation, things like that. For example, last spring was very cold and there was simply not enough growing season for the tadpoles to metamorphose and about 85 percent of the tadpoles at my sites froze."

As ectotherms, amphibians control their body temperature behaviorally — by sitting on a hot rock to keep warm or getting in the wind to cool off. This also means they need a certain thermal environment, warm weather, to grow and develop.

Maxell devotes the rest of his research to a broad-scale inventory of amphibians in Montana. "Right now we are inventorying in western Montana, but it is in the process of becoming statewide," he says.

Frog eggs

Maxell and his inventory crew divided the western part of the state into nine sampling areas from which they randomly selected several watersheds. The crew then visits every single body of standing water in that watershed they can find on maps, photos or by word of mouth and inventories what amphibians and aquatic reptiles are present.

Why? "Even for the most common amphibian in western Montana we don't have very good information about where they live and how long," Maxell says. "If we don't have good basic information now about what species live where, how will we know if their status has changed in 20 years? It's the same issue for the landscape — if you don't know the status of the landscape now, how will you be able to assess it later?"

The process is long and physically draining, says Maxell, but the results are rewarding.

"The most challenging part of my research is the long hours dealing with massive amounts of data that is sometimes not that exciting to deal with," he says. "But the data is essential, and it is really rewarding to find species where they have never been reported before and to provide state and federal agencies with information that will be used to ensure that these species are more properly managed and protected."

The inventory information Maxell is compiling will be useful for years to come as a key to understanding changes in Montana's landscapes and species. For example, future researchers or wildlife managers will be able to use this information to determine into which habitats or elevations they should reintroduce a species.

Maxell plans to finish his Ph.D. work at UM next spring. What's next?

An outdoor enthusiast who swam competitively in high school and as an undergraduate at the University of Puget Sound in Tacoma, Wash., he looks forward to a little time off from his strenuous research work. "Canoe and backpacking trips are my favorite activities, and I love swimming and bicycling to stay physically fit," he says. "On the professional side, my career goal is either to work as a zoologist/ecologist for a non-government conservation-oriented organization or government agency where my research efforts would be applied to species management, or to teach biology and ecology and conduct research at a smaller four-year university." ■

FISH FINDERS:
Researchers Use Genetics to Detect What's in Water

By HOLLY FOX
VISION STAFF WRITER

Photographs by TODD GOODRICH

TODAY it is possible to detect mutations, diagnose diseases and infections, determine the sex of an unborn child or get a genetic fingerprint of a crime suspect from evidence collected at the scene — all from a single cell. The technology that makes this possible — the polymerase chain reaction — is being used today by UM researchers in their conservation efforts.

In the laboratories of UM's Division of Biological Sciences, and in streams in western Montana and Alaska, UM's researchers are applying the principles of genetics to the problems of conservation. Most of their research deals with salmon and trout, although they also work with grizzly bears, bighorn sheep and plants.

Research Specialist Kathy Knudsen has been studying fish for more than 20 years. Her latest project, funded by a grant from the National Science Foundation, has been to determine whether techniques used in human forensics and conservation genetics can be used to determine what species of fish are present in a stream from a small sample of stream water.

"People are familiar with the polymerase chain reaction (PCR) technique used in human forensics because it is the technique that allows researchers to determine who a small sample of blood or semen came from in crime investigations," Knudsen says. "Our goal was to see if we could use that technique on a sample of stream water to determine which fish species are present."

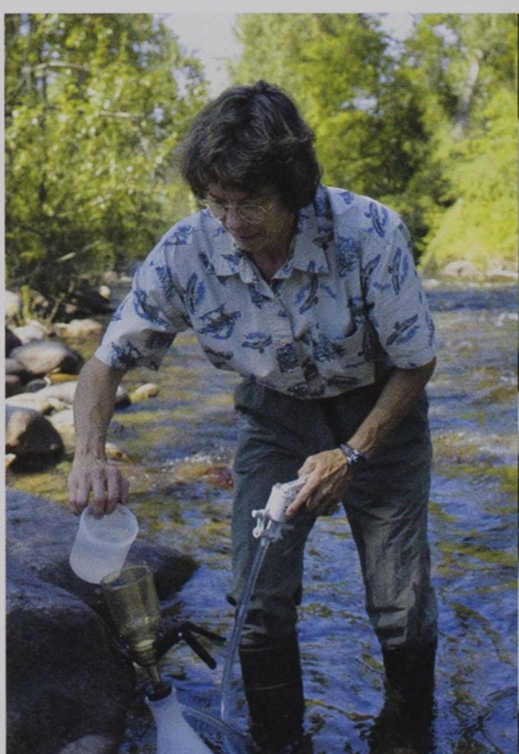
PCR was invented in 1988 by Kary Mullis, who used a DNA polymerase enzyme from the heat-stable organism Thermus aquaticus or "Taq," which he obtained from the hot springs of Yellowstone National Park in Montana and Wyoming. Starting with small quantities of DNA — as small as one target molecule — PCR can generate millions of copies of a specific target DNA sequence in about three hours.

First, the double-stranded DNA sample is denatured, made into a single strand, by heating it. The sample is cooled to allow two primers to connect to the regions on either side of the target sequence. The primers flag the beginning and end of the DNA sequence to be copied. The sample is then reheated slightly to allow the enzyme "Taq" polymerase to read the code of the desired sequence and build a copy, creating two double-stranded copies of the original DNA sample. The process is repeated 30 to 40 times until the millions of copies necessary for analysis of the DNA sequence variation have been created.

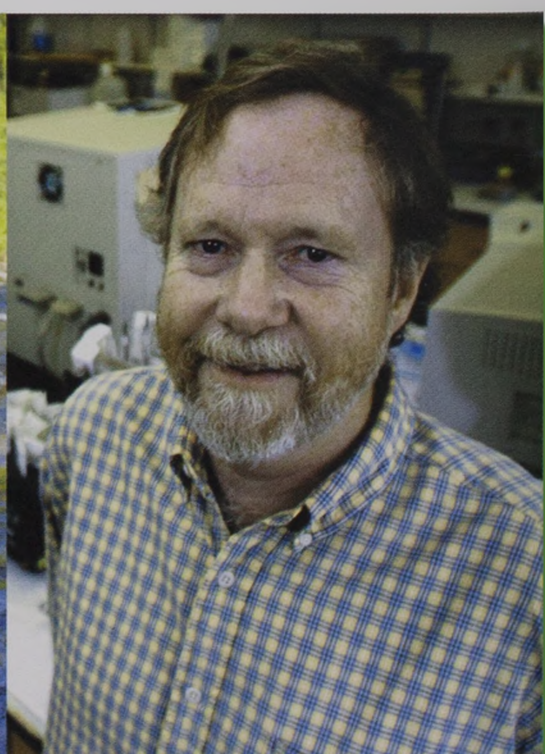
The technique itself is nothing new, Knudsen says, the research is just starting from a different point.

"We've been doing this technique with fish for several years," she says. "But instead of starting with a small piece of fin or a piece of liver, we're starting with some water that we hope has fish cells in it."

To get the cells from the water samples, Knudsen designed a simple sampling apparatus consisting of a vacuum flask with a filter holder above it and a



Research Specialist Kathy Knudsen samples water from Rattlesnake Creek near Missoula using an apparatus she invented.



Professor Fred Allendorf

small hand pump. The entire contraption is the size of a small cooler, and thus, easily transported. All a researcher needs to do is scoop up some water, which gets sucked through the filter with the pump. The water is discarded and the filter, which contains the cells, is stored in a vial filled with alcohol until it reaches the lab.

In the lab the DNA is extracted from the cells in the filter. PCR is used to make enough copies of the DNA so that researchers can look for certain species-specific fragments. If a bull trout-specific band shows up, for example, researchers know that bull trout live in the stream where they took the sample.

Knudsen says this new method of inventorying streams is a big improvement over the traditional method, electrofishing.

"In electrofishing researchers use electrodes to stun the fish so that they can scoop them up and identify them," she says. "That process is still useful and effective, but it's very labor-intensive and a lot of streams are completely inaccessible, especially with all the equipment that is needed, in addition to the crew of people necessary. Also, in electrofishing, the researchers need to be very close to the fish — the fish have to swim between the electrodes. With our new technique, you just have to get a sample of the water downstream from the fish."

The research on the new inventorying technique began in Division of Biological Sciences' fish tanks. "We started there because we knew, with the density of the fish in the tanks, there would be a lot of cells in the water," Knudsen says. "It worked there, so we tested it in Rattlesnake Creek, where we knew there was a large population of fish, and it worked there, too."

The research continues in streams all over Montana, as well as in Alaska, including many waterways that would be difficult to access for researchers who want to electrofish.

There are still some questions left to answer, Knudsen says. "We need to do a lot more research to determine how many fish need to be in the stream before this technique will work, or how close we need to be to the fish to pick up their cells. We haven't determined the sensitivity of this method yet."

Regardless, research thus far has yielded some interesting results that point to the importance of this technique.

"It's really clear that where fish populations are doing well are places where there are no roads," says UM Professor Fred Allendorf, who works with Knudsen on this project. "It's obvious from our research that roads have a major harmful effect on fish populations, so it is really important to have a way of accessing and inventorying roadless areas."

The technique is also hugely important in conservation efforts, Knudsen says. "Two of the main questions you have to answer in conservation are what species do we have and where are they living? The great thing about this technique is that it can provide that information with much less effort and field equipment than electrofishing, which means you can sample streams that would otherwise be inaccessible." ■

Of fish & human fertility

It seems UM researchers think racing might be the key that unlocks the mystery of male infertility ... sperm racing, that is.

Professor Fred Allendorf, along with Neil Gemmell of the University of Canterbury in New Zealand, is taking a closer look at mutations on the cellular level that may lead to male infertility in fish, after recent research that suggests a certain type of mutation may be responsible for the same malady in human males. The work is being funded by a grant from the Royal Society of New Zealand.

The suspected mutations occur in the mitochondria — small structures in each cell that supply energy and are inherited from the mother. Since sperm are powered by a group of mitochondria at the base of the flagellum, any mutation in the mitochondria could result in a reduction of power output, and therefore, reduce sperm mobility and male fertility.

"The original observations for this research were concerned with male infertility in humans," Allendorf says. "But because of the type of mutation, because it isn't eliminated through natural selection, it could have serious effects for populations of any species."

The mutation isn't eliminated through natural selection because the variation does not affect female reproduction. For example, if a female has the mitochondrial mutation, she still can reproduce and pass the mutation along to male and female offspring. The mutation does not affect those female offspring, who will later reproduce and pass the mutation along again. But it is suspected that the mutation will cause the male offspring to have low sperm mobility, and therefore, be less fertile. In time, this cycle will produce greater numbers of subfertile or infertile males.

"The implications of this mutation could be very important," Allendorf says. "If small populations of any species have a high proportion of males who aren't fertile, they could be very susceptible to extinction."

Allendorf studies the relationships between sperm motility, egg fertilization and the genetic information in the mitochondria of the sperm through sperm races. "We mix equal amounts of sperm from two male fish with different genes for the DNA in the mitochondria," he says. "We then put eggs from a female fish in the water and put the sperm on top. It really is a race because only one sperm gets to fertilize each egg. We're testing to see how fast the sperm swim, to see if there are deformities— we're basically measuring sperm performance of males with different genes."

It is especially important that fish have sperm that are strong swimmers since many species, such as trout and salmon, spawn in fast-moving water.

"We're studying infertility in fish," Allendorf says, "but, because it's all related, whatever we find out will be relevant for humans." ■

Q&A A Quick Primer on Montana Aquatic Life

By GARY JAHRIG
VISION STAFF WRITER

ILLUSTRATIONS by JOE TOMELLERI

Montanans love to boast of their state's pristine lakes and blue-ribbon rivers and streams. And rightfully so. But how many residents of the Big Sky state actually know what lives beneath the surface of Montana's famous waters?

Lisa Eby does.

Eby, an assistant professor of aquatic vertebrate ecology at UM's College of Forestry and Conservation, is an expert on fish. Eby, who holds a doctorate degree in aquatic ecology from Duke University, came to UM a year ago to teach about and research aquatic life.

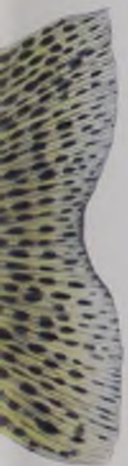
"I came here because I knew UM had a good program and it's such a great place to live," Eby says. She recently shared some of her knowledge by providing answers to some often asked questions about fish and plants in Montana's waters.

Q: Compared to other areas, are Montana waterways relatively sterile or lush with life?

A: Compared with other areas of the United States, Montana's waterways are very clear and pristine, which allows the native trout species to thrive. But there is low diversity for freshwater fishes. For example, the Clark Fork River has about 12 native freshwater fish species, while rivers further east often have between 50 to more than 200 native freshwater fish species. The distribution of Montana's fish fauna is interesting because of the Continental Divide, which has separated westward-flowing and eastward-flowing waters for millions of years and has had a major influence on the distribution of native fish in the state. Although there are species that are found throughout the state, the native fish communities in eastern and western Montana are very different. Eastern Montana has more species than west of the divide. There are both more families of fishes, as well as more species within families, such as minnows and suckers.

Q: How do fish survive under the ice in winter?

A: Fish remove oxygen from the water as it flows across their gills. In streams, many fish take refuge in pools during the winter. In lakes, ice cover only becomes a problem if it lasts a long time and is thick, separating the water from its source of oxygen — the atmosphere. This results in a decrease in oxygen concentration in the water. Fish typically don't freeze under the ice as they have slightly higher concentrations of ions (salinity) than water, and therefore, have a



lower freezing point than water. Fish that live in very cold climates have different abilities to deal with freezing temperatures. For example, some fish have blood that contains "antifreeze" compounds that depress the freezing point of their body fluids and make it possible for them to live in water that is colder than the freezing point of most fish blood.

Q: How high up can fish species live in the mountains?

A: Fish can survive in the highest mountain lakes of Montana. Originally some high-mountain lakes in Montana were without fish because of barriers to movement such as waterfalls. Many of these lakes and streams are nutrient poor and do not have much food for the fish, resulting in very slow growth rates and stunted populations. The stocking of some of these lakes with hatchery fish can result in a large change in the aquatic community and may be creating problems for several species of amphibians that have historically reproduced in that area.

Q: What are the largest and smallest fish found in Montana?

A: There is a large amount of variation in size and growth rate for fish depending on where they live. In western Montana, the white sturgeon is probably the largest adult native fish species. But in eastern Montana, paddlefish are the largest fish. The smallest fish is difficult to determine because many fishes are pretty small. For example, the brook stickleback reaches only about 2 inches in length. And many fishes in the minnow family — such as the fathead minnow and the red belly dace — only grow to a few inches. Western mosquitofish, a nonnative species often introduced to control mosquito populations, reach only 1 to 2 inches.

Q: What is the biggest threat to Montana's native fish species?

A: Some of the biggest threats to Montana's native fish include fragmentation of habitat and the introduction of exotic species. Many species of fish have large ranges and migrate between areas where they reproduce, over-winter and forage. The building of dams, roads and culverts can keep these fish from reaching habitats that are necessary to complete their life cycle. Exotic fishes are problematic because they can displace native fish (out-compete or prey upon), hybridize (interbreed) or bring in parasites and disease, resulting in declines in native fish populations.

Q: What is the most interesting Montana fish species?

A: I guess one of the most interesting fish that I have learned about is the N. Redbelly dace-Finescale dace hybrid. These hybrids have an unusual reproductive strategy called gynogenesis. The hybrid dace are female clones with identical eggs. To reproduce, the females must mate with a sexually reproducing related species (Redbelly or Finescale dace) to stimulate egg development — even though the genetic material is not incorporated into the offspring.

Q: Why are there so few aquatic-rooted plants in Montana lakes and streams?

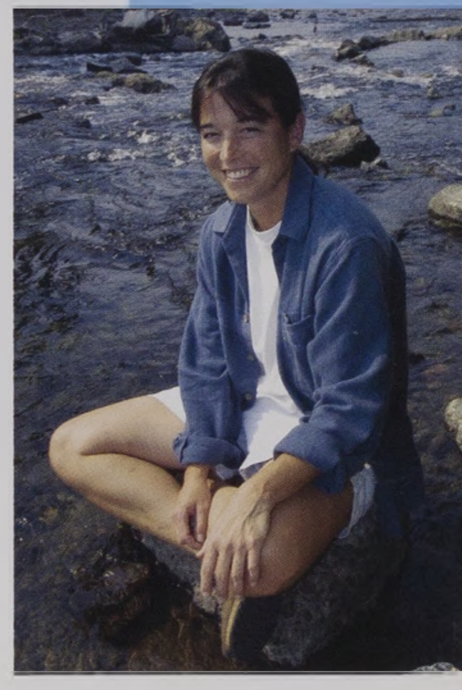
A: The physical and biological characteristics of the stream and large lake systems (rocky bottoms, low productivity, stream flows and ice scour) will keep plants from growing in the water. But in other systems, such as wetlands, there is more sedimentation and muddier bottoms for plant life to grow. There you will see typical wetland plants such as sedges.

Q: What are the dominant plants that fuel lakes and streams?

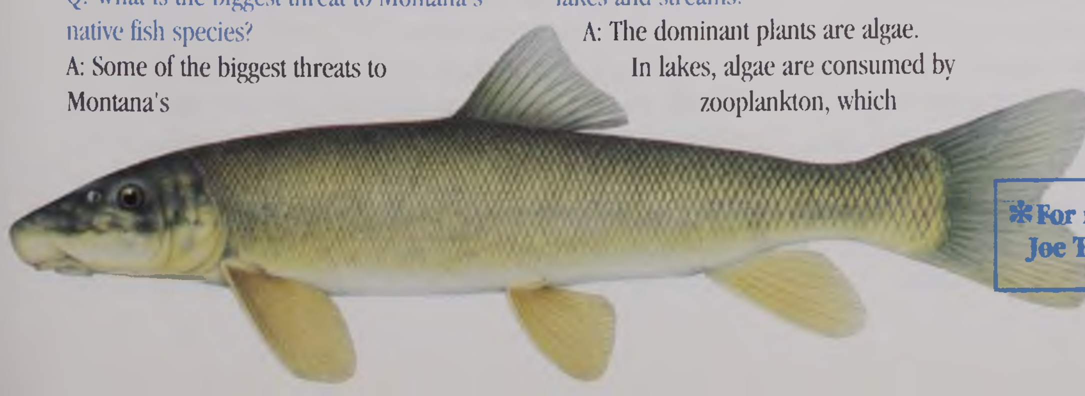
A: The dominant plants are algae. In lakes, algae are consumed by zooplankton, which are then consumed by fish. In many streams, the production is dominated by algae and bacteria attached to the bottom or to rocks — what some people think of as slime.

Q: What is Montana's state fish?

A: The cutthroat trout (Oncorhynchus clarki). ■



Lisa Eby, assistant professor of aquatic vertebrate ecology.



Fish (clockwise from top): Westslope Cutthroat Trout, Paddlefish, Longnose Sucker, Brook Stickleback

✻For more fantastic fish images visit artist Joe Tomelleri at www.americanfishes.com

WATER THAT WAS

Unearthing the many secrets of Glacial Lake Missoula

By PATIA STEPHENS
VISION STAFF WRITER

SOMETIMES science is spooky. Take, for example, the study of geology. Step out of your daily routine — the hum-drum world of alarm clocks, dirty dishes and must-see TV — into the realm of billion-year-old sedimentary rocks, lava flows erupting from vents in the earth and 30-mile wide chunks of ice damming rivers. It's enough to freak a person out a little.

In Missoula, a glimpse of ancient shoreline on a mountainside is all it takes to yank us out of, say, a traffic-induced coma into the sudden sensation of being at the bottom of a 1,000-foot deep lake. Glub, glub. It makes you realize how insignificant you and your problems are, and how terribly fascinating this planet is.

Though it has been gone for about 12,000 years, Glacial Lake Missoula is never far from mind at UM, which sits on the ancient lakebed. Our mountains bear its scars: horizontal lines where waves once lapped; vertical crevices where soggy mud collapsed when its watery support was suddenly withdrawn; bare rock and talus slopes where fast-moving water stripped topsoil. Spoony Rock in the middle of the campus Oval is one of dozens of boulders scattered throughout the otherwise flat University neighborhood.

Scientific inquiry into Glacial Lake Missoula and its floods has only revealed the tip of the iceberg, so to speak. The subject remains an extraordinary enigma. However, recent scholarly efforts at UM have produced some interesting material on Glacial Lake Missoula, including a book, a children's video, an economic analysis and at least one master's thesis.

Forging a trail of discovery

A National Park Service proposal currently before Congress would create a national geologic trail stretching from Montana through Idaho and Washington to the Oregon coast. The Ice Age Floods National Geologic Trail would connect existing efforts to educate the public about the Missoula floods, which sculpted the landscape in the four states. Like the Lewis and Clark Trail and the Oregon Trail, it also would establish interpretive centers, wayside exhibits and highway signs.

Congressional approval of the geologic trail would stimulate local economies and, perhaps most importantly, further scientific research into this fascinating story.

"Modern science knows little about Lake Missoula and the channeled scablands [in eastern Washington]," writes UM environmental studies student Daniel Berger in his 2002 master's thesis, titled "Ice, Water, Land, and Time: A Partial Story of Glacial Lake Missoula and the Missoula Floods."

"As far as I can tell," Berger continues, "the vast majority of geologists who have looked into it feel certain that Lake Missoula existed and that the channeled scablands were formed by floods, many of which likely originated from the Purcell Trench area of Idaho. That's it. The rest is up for grabs.

"Some geologists believe that Lake Missoula existed

between 40 and 100 times. Many believe that the ice dams holding back Lake Missoula failed catastrophically at the end of each period of lake formation and that the following floods were responsible for carving the channeled scablands in eastern Washington. Some geologists believe that Lake Missoula existed once and went away slowly and that the channeled scablands were formed by other flood mechanisms larger than what Lake Missoula could have produced.

"The permutations of ideas surrounding these two giant phenomena and their relationship are endless, and none are widely accepted."

Outbursts, jökulhlaups and blowouts

Indeed, the controversies spawned by the lake and floods, combined with the all-too-human foibles of its researchers, have created a tale of conflict and rivalry.

The story begins in the early 1900s, when Montanan Joseph T. Pardee identified Glacial Lake Missoula, and University of Chicago Professor J Harlen Bretz announced that the channeled scablands had been formed by massive floodwaters. Though both geologists knew of the other's work, it was decades before anyone connected the dots out loud. In the meantime, Bretz's assertion made him the laughing-stock of the geologic community, which then believed that landscapes were only shaped by slow processes like erosion. Bretz's reputed cantankerousness probably didn't win him any converts, either. But Bretz finally was vindicated in 1979, when he received the Geological Society of America's highest honor, the Penrose Award.

"Pardee and Bretz were geniuses," says UM geology Professor Emeritus Dave Alt. "Then we mere mortals can come along and put details on it." Alt is author of "Glacial Lake Missoula and Its Humongous Floods," a guidebook to the lake and flood path. Alt's floods expertise has earned him the nickname "Mr. Blowout" among colleagues, though he claims never to have heard it. He also, when contacted for this article, insists he has no idea what "outburst flooding" is, though it is a term commonly used in the scientific community to describe any sort of sudden flood event. Asked if he prefers the alternate term "jökulhlaup" (an Icelandic word pronounced "yo-kul-hloip"), Alt has a bit of an outburst himself.

"'Jökulhlaup' is absurd. I don't recognize it as a valid scientific term," he says. "A jökulhlaup specifically refers to a glacier melted by a volcano beneath it. Outburst floods happen for a variety of reasons. ... Outburst flood makes a lot more sense." Alt goes on to say he prefers the term "'giant flash floods.' ... At least then you're communicating, not trying to bamboozle people."

Whatever you call them, outburst floods are a hot topic in this time of global warming, and Glacial Lake Missoula is a contender for the mother of all outbursts. Discovering the signature it left on the landscape has helped scientists recognize past and potential outburst floods around the world.

One such disaster-in-the-making is in the Peruvian Andes, where scientists are keeping a close eye on a glacier just above Lake Palcacocha and the city of Huaraz. According to an April NASA news release, "an ominous crack has developed in the glacier. Should the large glacier chunk break off and fall into the lake, the ensuing flood could [reach] Huaraz and its population of 60,000 in less than 15 minutes."

NASA is using ASTER, an earth-observing instrument aboard its Terra satellite, to monitor the Peruvian glacier. ASTER is a sister instrument to MODIS, which was designed by researchers in UM's College of Forestry and Conservation.

The case of the missing water

One mystery that remains to be solved is whether Glacial Lake Missoula provided all or just some of the water that swept across the Northwest. According to U.S. Forest Service geologist Jim Shelden, about five years ago a team of Japanese researchers broke in their new supercomputer by modeling eastern Washington's channeled scablands, a vast web of floodpaths carved into the earth. They discovered that Glacial Lake Missoula's volume, estimated at 530 cubic miles, may have been as much as 25 percent short of the amount of water needed to produce the scablands. "They took their best guess about the biggest flood event, about how many channels were active at the same time," Shelden says. "Their conclusion was that we needed more water."

No one is sure where the rest of the water could have come from. Shelden says maybe it came from the Flathead Valley basin, which at the time was filled with ice. Or maybe it came from a volcano that erupted underneath the massive Cordilleran Ice Sheet that covered Canada, as some Canadian geologists believe.

Alt doesn't think so. "That volcano is just a cute little thing," he says. "It's not very fierce. It doesn't erupt very often."

He does agree that the missing water could have come from the Flathead. Another possibility, he says, is "seiching," or wave action, created when Glacial Lake Missoula broke through its dam and splashed into the shallower Glacial Lake Columbia, which covered the Spokane region.

Another mystery concerns the 2,000-foot-tall ice dam that blocked the Clark Fork River near the Montana-Idaho border. How, exactly, did it fail? Was it floated out of its moorings when the lake reached critical mass? Did the water tunnel underneath it — or over it — creating a canyon through the ice? Did the dam fail partially or catastrophically? Or was it D, all of the above?

One more question: Were humans around to witness the

(continued next page)

giant lake and floods? No geological evidence has been found, but Alt and others expect it will turn up eventually.

Perhaps the next generation of UM students will solve these mysteries.

Captivating kids of all ages

Educating that generation is already well under way in K-12 schools across Montana. Teachers who come to UM for continuing education have carried lessons about the Missoula floods back to their students. The UM-affiliated Montana Natural History Center offers exhibits, educational activities and teaching materials about the floods. And a children's video produced by John Twiggs at UM's Broadcast Media Center has brought the flood story to an even broader audience.

"The Really, Really Big Floods" first aired on Montana PBS in September 2002. Host Wynne Renz, then a Hellgate High School senior, leads viewers through conversations with middle-school kids and geologists, experiments involving ice blocks and fire hoses, and graphic animations of how the Missoula Valley might have looked filled with water. The end result is a fun, witty romp of a geology lesson.

"This is the cool part about science," Renz tells viewers. "You find one answer, and it opens up a thousand new questions."

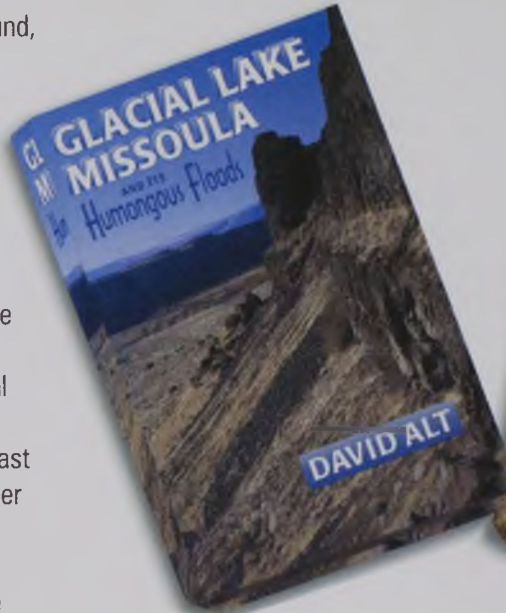
Getting down to business

Over in UM's School of Business, three graduating seniors — Casey Engel, Leisha Warren and Bobby Wilken — prepared a fall 2002 report on the economic impact a Missoula ice age floods interpretive center might have. The economic analysis was contracted from the school's Small Business Institute by the Ice Age Floods Institute's Glacial Lake Missoula Chapter, a nonprofit group that wants to tell the story of the floods.

Using statistics from similar facilities, such as the Lewis and Clark Interpretive Center in Great Falls, the report suggests that out-of-state visitors alone could contribute an average of more than $2 million to the economy each year. But while some people want to see Congress enact the National Geologic Trail for economic reasons, others simply want to share this incredible mystery with others, in the hopes of someday solving it.

As Dan Berger says when discussing failure of the ice dam: "God knows exactly how that happened; the rest of us are still trying to figure it out."

The book "Glacial Lake Missoula and Its Humongous Floods" and the video "Really, Really Big Floods" can be ordered from Mountain Press: (800) 234-5308.



Top to bottom:
Book and video about Glacial Lake Missoula.
Video clips: Ancient shorelines on Mount Sentinel.
Professor Emeritus Dave Alt.
Host Wynne Renz watching a simulated flood hit Missoula.

A Brief Glance at 2003 UM Research

UM Adds New Research Vice President

A chemist with research administration experience at universities in New Mexico and Maine now heads UM scientific efforts. Daniel J. Dwyer, formerly vice provost for research at New Mexico State University in Las Cruces, became UM's vice president for research and development in August.

He replaces T. Lloyd Chesnut, who left UM to assume a similar position at the University of North Texas in Denton. In his six years at UM, Chesnut more than doubled the amount of grant-funded research, propelling it beyond the $60 million mark. Dwyer had similar success and much the same duties when he served as vice president for research at the University of Maine during 1996-2000.

Dwyer oversees UM's research and sponsored programs, technology transfer, information technology, federal legislative relations, international programs, environmental health and occupational safety, and laboratory animal resources. He earned a master's in chemistry and a doctorate in physical chemistry from Lehigh University in 1974 and 1976.

He has been both a teacher and researcher, specializing in surface science and technology. Dwyer spent 12 years on the Maine faculty after working for a decade as senior staff chemist and group leader of surface chemistry and physics at Exxon Corporate Research Laboratory in New Jersey.

Research Dollars Flow to UM

University faculty brought in a record $60.9 million in external funding during 2002-03, creating more jobs and providing better opportunities for students to be involved in cutting-edge research.

More than 60 percent of grant proposals submitted by UM faculty were funded last year, which is above the national rate. During his tenure, President George Dennison — now entering his 14th year at the UM helm — has pressed for continual growth in funding from outside sources. When he came to UM in 1990, research funds totaled $7 million.

"Each year, I raise the bar," Dennison said in challenging faculty to exceed $65 million in the coming year, while also praising researchers for their current success. "The faculty members of this University have established a truly astonishing record in the success rate and volume of funded research awards."

Science Reveals Greener Planet

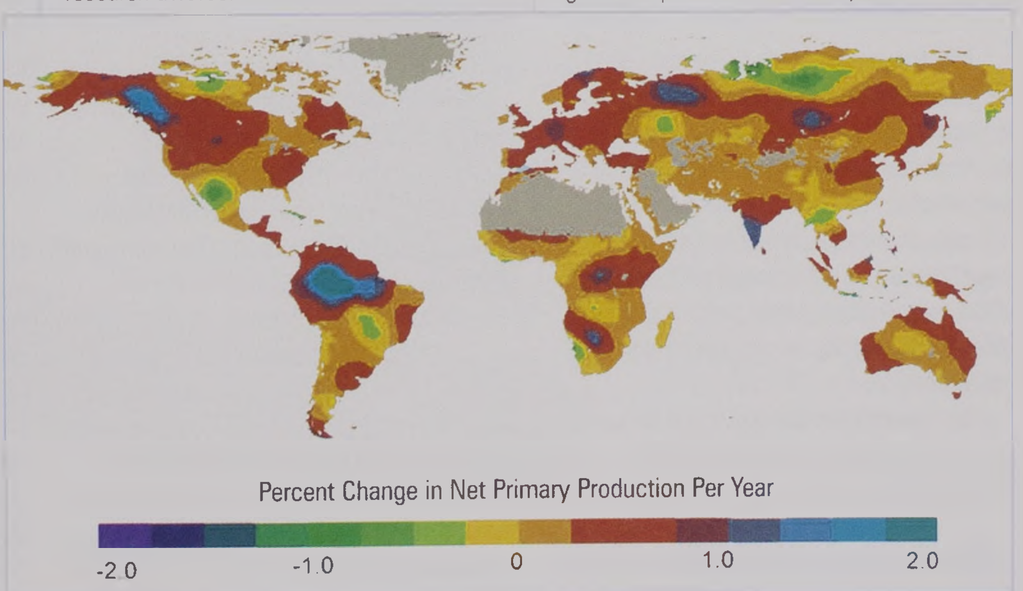
A NASA and Department of Energy study led by UM researcher Ramakrishna Nemani concludes the Earth has been greening over the past 20 years. As climate changed, plants found it easier to grow.

The globally comprehensive, multi-disciplinary study appeared in the June 6 edition of Science magazine and received major media attention around the world, including CNN, the BBC, Newsweek International and Pravda.

The study finds that climate changes have provided extra doses of water, heat and sunlight in areas where one or more of those ingredients may have been lacking. Plants flourished in places where climatic conditions previously limited growth.

"Our study proposes climatic changes as the leading cause for the increases in plant growth over the last two decades, with lesser contribution from carbon dioxide fertilization and forest re-growth," Nemani says.

Nemani and his colleagues constructed a global map of the Net Primary Production



(NPP) of plants from climate and satellite data of vegetation greenness and solar radiation absorption. NPP is the difference between the CO_2 absorbed by plants during photosynthesis and CO_2 lost by plants during respiration. NPP is the foundation for food, fiber and fuel derived from plants, without which life on Earth could not exist. Humans use about 50 percent of global NPP.

Ramakrishna Nemani

NPP increased globally on average by six percent from 1982 to 1999. Ecosystems in tropical zones and in the high latitudes of the Northern Hemisphere accounted for 80 percent of the increase. NPP increased significantly over 25 percent of the global vegetated area but decreased over 7 percent of the area, illustrating how plants respond differently depending on regional climatic conditions.

For online information about the research, visit www.gsfc.nasa.gov/topstory/2003/0530earthgreen.html.

UM President Leads Research Group

UM President George Dennison has been elected to lead the Inland Northwest Research Alliance, a consortium of eight research universities in the northwest.

A nonprofit, scientific and educational organization, INRA fosters collaborative research programs that educate America's future scientists and engineers. It is the only program of its kind in the nation. INRA was formed to promote science and engineering research with a focus on studies that will result in practical applications, such as water treatments, soil remediation and forest fire prevention.

INRA is a partner with Bechtel National Inc. and BWX Technologies in the management and operations contract of the Department of Energy's Idaho National Engineering and Environmental Laboratory. Member universities are in Montana, Alaska, Idaho, Utah and Washington.

Students Garner Research Funds

Doctoral students in UM's Division of Biological Sciences earned unprecedented funding from the National Science Foundation this year. Three students were awarded prestigious Doctoral Dissertation Improvement Grants, while another earned a rare NSF Graduate Research Fellowship award.

"The fact we got three improvement grants and a fellowship in one year is a smashing success for our program," said Associate Professor Doug Emlen, the faculty adviser for two of the winners. "The number of awards we won is comparable to the very best programs in the country."

The research fellowship was awarded to Christine Miller of Billings. Her award includes $27,500 for research during the coming year, as well as a stipend and full tuition for the next three years. She studies the genetics and behavior of leaf-footed bugs and does her fieldwork in Panama.

The Doctoral Dissertation Improvement Grants went to Jose Hierro of Argentina, Judy Perkins of Denver, Colo., and Tara Prestholdt of Bridgewater, N.J. Each received between $10,000 and $15,000 for their doctoral research, and the awards generally cover two years.

Hierro is doing a comparative study of yellow starthistle invasive weeds in California and Argentina. Perkins studies seedling regeneration in whitebark pines. Prestholdt is delving into limb regeneration in walking sticks.

Grant Targets Cleaner Water

The Tri-State Water Quality Council has landed a $1 million grant for water-quality improvement projects with help from many partners, including UM's Watershed Health Clinic.

The council is a collection of citizen, business, industry, government and environmental leaders interested in improving waterways in the 26,000-square-mile Clark Fork-Pend Oreille watershed. The group was one of 20 organizations nationwide selected to receive a grant through the U.S. Environmental Protection Agency's Watershed Initiative.

UM environmental studies Professor Vicki Watson has worked with the Tri-State Water Quality Council since its formation in 1993. She directs UM's Watershed Health Clinic, which matches University students and staff with community groups that need technical assistance with watershed conservation, preservation and restoration.

Regional and national experts selected the grant winners from a highly competitive field of more than 176 nominations. The grant will implement a set of restoration projects — ranging from dairy waste management to riparian habitat restoration — which are aimed at reducing nutrients and improving fish habitat in the northern Rockies. The council also is matching the grant with more than $1 million in non-federal funds.

Web Site Offers Asbestos Resources

The UM Rural Bioethics Project has launched a Web site to promote public education about health issues related to asbestos exposure. The site, "Asbestos and Libby Health," is at www.umt.edu/libbyhealth. It includes fact sheets, links to asbestos research findings, answers to frequently asked questions, educational activities and more.

The site is supported by a grant from the National Institute of Environmental Health Sciences and is part of a five-year effort to offer a broad range of information about asbestos-related diseases, contamination and exposure. A partner in the effort is the Center for Asbestos Related Diseases clinic in Libby, a community struggling with asbestos issues because of a closed vermiculite mine in the area.

Ecologist Takes Trip of a Lifetime

UM ecologist Paul Alaback appeared in a two-hour PBS documentary last spring about one of the most important scientific treks in American history, the Harriman Alaska Expedition.

A century ago railroad tycoon Edward H. Harriman decided to lead one of the most ambitious scientific expeditions the world had ever seen to Alaska. In 1899 Harriman invited the top scientists and artists in the country to join him on a 9,000-mile exploration of the Alaskan coast. Many of these men were famous, and the trip would change them forever.

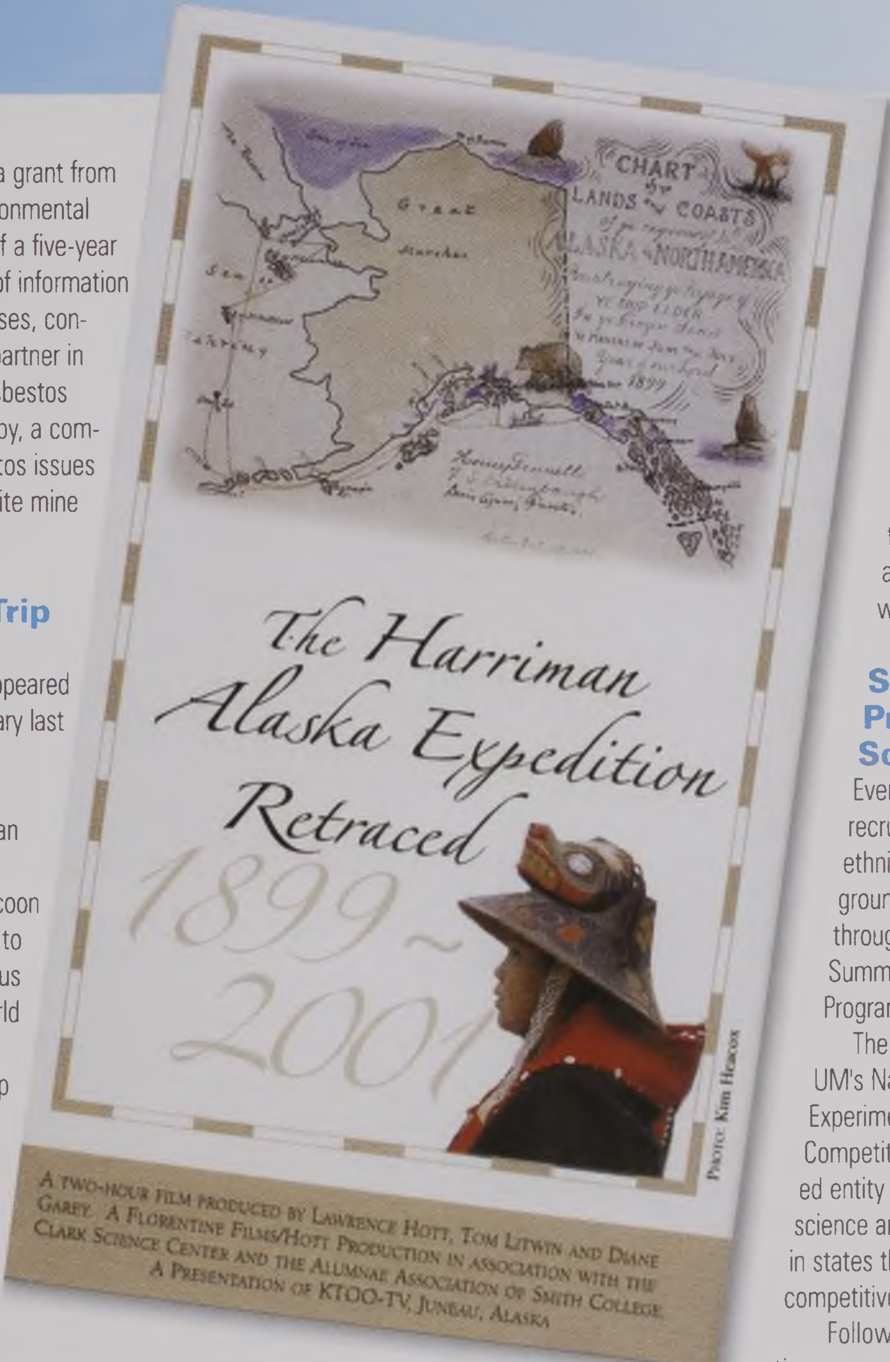


Photo: Kim Heacox

In 2001 Thomas Litwin, director of the Smith College Clark Science Center, organized an expedition to follow the path of the original one. Again it was stocked with a collection of top scientists — including UM's Alaback — though this time Alaskan native people were included. Called the Harriman Expedition Retraced, its purpose was to visit exactly the same places and see what changes the 20th century had brought to Alaska.

"I have studied the temperate and coastal rainforests of Alaska and South America for about 20 years," Alaback says, "which is how I got connected with the project. Our modern expedition took one month by ship and retraced the exact route of the original, exploring ways in which native peoples, the ecology, resource extraction and views of nature have changed in the intervening 100 years."

Alaback's principal role was to examine the writings of Bernard Fernow, the father of forestry in the United States, and his predictions about the prospects for the development of the sustainable timber industry in Alaska from the 1899 expedition, contrasting that with the controversies that beset the timber industry in Alaska's Tongass National Forest over the past half century. More information about the 2001 expedition, the film and an educational teacher study guide is available online at www.pbs.org/harriman.

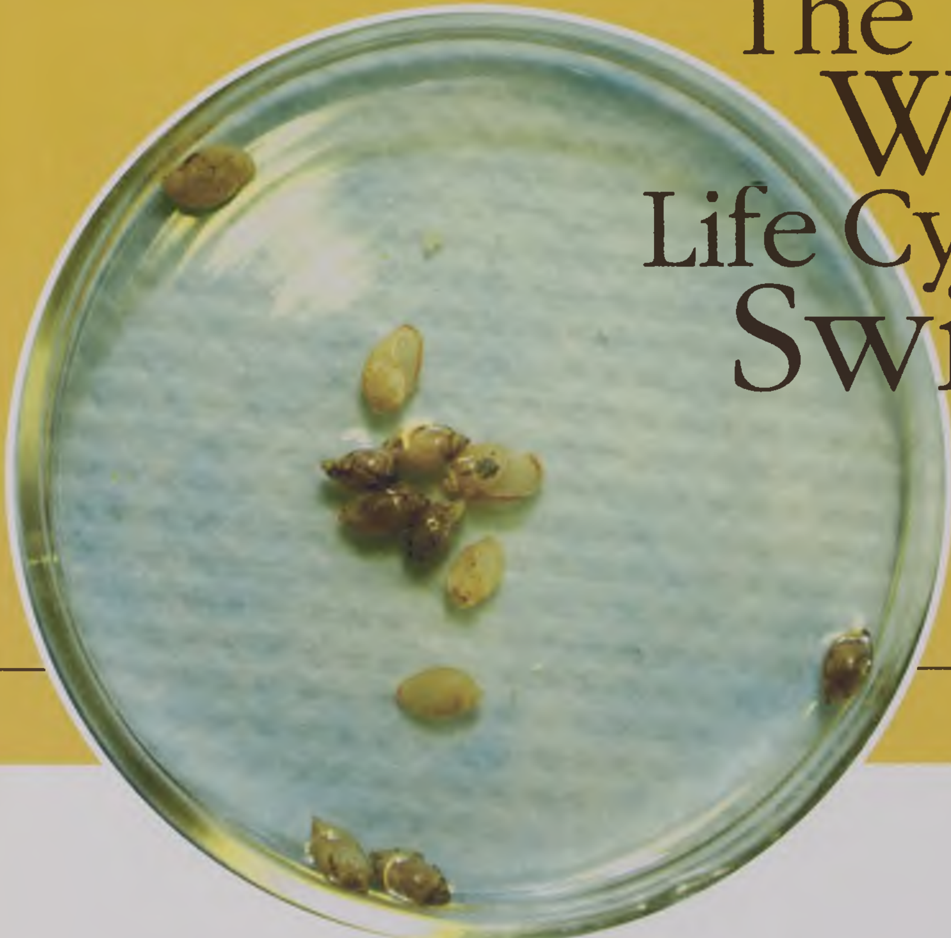
Summer Program Promotes Scientist Diversity

Every summer UM strives to recruit students from diverse ethnic, racial or cultural backgrounds into science fields through its Undergraduate Summer Diversity Research Program.

The program is offered by UM's National Science Foundation Experimental Program to Stimulate Competitive Research, a grant-funded entity that works to improve the science and technology infrastructure in states that have historically not had competitive extramural funding levels.

Following a competitive selection process, students are matched with UM faculty members who are actively involved in research. These select students are flown to Missoula in June for a 10-week program designed to expose them to UM's research and academic opportunities. The students then work side by side with world-renowned researchers to experience firsthand what a science career has to offer. With the aid of faculty mentors, they are counseled about graduate school and the various science programs available at UM. ■

The Weird Life Cycle of Swimmer's Itch



By CARY SHIMEK
VISION EDITOR

Photography by TODD GOODRICH

PURE AND PRISTINE though they seem, western Montana's lakes and rivers sometimes offer an itchy surprise.

Bill Granath Jr., a UM microbiologist, says from mid-July to the end of August is the peak time to contract swimmer's itch: an irritating rash caused by an aquatic parasite. The itch, also called schistosome dermatitis, afflicts people in waterways around the world and is especially prevalent in the Upper Midwest. In Montana, Flathead Lake is a prime location to catch swimmer's itch.

"It's horribly itchy and takes about seven to 10 days to clear up," Granath says. "It affects everybody differently, but some people think it's worse than poison ivy. And there is no cure."

Granath did a study on Flathead Lake itch in the 1990s. He and his fellow researchers learned that the parasitic flatworm — *Trichobilharzia ocellata* — has a convoluted life cycle before it ends up as a series of red bumps on some unfortunate swimmer.

In Flathead Lake, he says, the natural hosts of the parasite are common merganser ducks and pea-sized snails called *Stagnicola elrodi.* Seagulls and Canada geese sometimes are hosts as well.

The adult flatworms are about a quarter inch long and customarily start their life cycle in the intestinal veins of mergansers. Granath says these parasites are an unusual species of flatworm because they have separate sexes. (Most flatworm species have both male and female sex organs.) The male is leaf-shaped, and the female cigar-shaped. Both have two suckers to affix to their host. These worms normally are found with the male wrapped in a canoe shape around the female, and they copulate for life. Because they reside in veins and feed on blood, they are often called blood flukes.

After they mate, the female lays spiny eggs, each containing a larval stage. These eggs then are passed out of the merganser duck in feces. When the eggs hit water they hatch, and microscopic critters called

Photos from left to right:
Host snails carry the parasite.
Microbiologist Bill Granath Jr.
The aquatic creature responsible for swimmer's itch.

miracidia swim forth using hairlike cilia to propel themselves. A miracidium has one goal: to find a certain species of snail before it dies in a few hours.

If the parasite finds the right snail, it penetrates into the flesh and begins reproducing asexually. After six or seven weeks, the parasite becomes a cercaria — a sperm-shaped creature with a forked tail. The cercaria then exits the snail, departing directly from the flesh, and begins swimming around looking for a nice cozy merganser to call home. Granath says cercariae are tiny, right at the edge of human visibility.

If the proper duck is found, the cercaria bores into the bird's flesh, losing its no-longer-needed tail in the process. The creature then migrates to the merganser's intestinal veins where it can reach adulthood and start the cycle anew. Granath says the ducks and snails are seldom harmed by this process and probably don't realize they are hosts.

However, cercariae can cause problems for humans. If the parasite bores into wet human skin in cercaria form, it soon recognizes it's not in a duck and dies. Penetration enzymes and all sorts of waste products then are released, causing intense inflammation and itching to the accidental host after about 12 hours. Each red bump contains one dead cercaria.

There is no cure for swimmer's itch, but Granath did offer some tips to help avoid the parasite:

- **Don't swim in July and August. This is a hard sell, but Granath says these two months are when the parasite swims around in its cercaria stage and can impact humans.**
- **Stay in deep, cold water. Snails, one of the parasite's primary hosts, prefer warm, shallow areas with vegetation.**
- **Wear a coating of baby oil or waterproof sunscreen. Any barrier on the skin may prevent cercariae from burrowing in ... at least until it washes off.**
- **Towel off promptly and thoroughly after being in the water. Often the parasites can be rubbed off. Slowly evaporating water on skin prompts cercariae to burrow in. Especially watch areas that trap moisture such as the belt line on swimming trunks.**

Granath says cortisone creams work for those who contract the itch. Extreme reactions may require a prescription cream. People who catch schistosome dermatitis start noticing itchy red bumps about 12 hours after they have been in the water.

"People can enjoy the water and still stay itch-free," he says, "but they should watch where they go swimming."

Above: Two microscopic views of *giardia lamblia*.

Giardia: A Water Drinker's Gut-wrenching Surprise

By HOLLY FOX
VISION STAFF WRITER

Images courtesy of BILL GRANATH

YOU'VE HEARD IT BEFORE— don't drink the water!

That mantra holds true whether you're sightseeing in another country or exploring the wilderness of your own backyard. While the water in Montana's lakes, rivers and streams may look refreshingly clear, just one sip could make you a very unhappy camper.

The culprit? *Giardia lamblia*, one of the most common intestinal parasites in the world. The waterborne parasite can be found anywhere from remote areas to high-density, high-dollar resort towns — anywhere there's water and a host.

Hosts can be people or any mammal. Beavers have taken the brunt of the blame for spreading giardiasis, which is often called "Beaver Fever."

"While beavers can carry the parasite, I think they have been blamed excessively for spreading the disease," says UM Professor Bill Granath. "Most mammals — dogs, sheep, cows, any livestock — can carry and spread the parasite. I think beavers have probably been blamed because the water in beaver ponds can look clean, leading people to drink from them."

Giardia lamblia has two life stages — trophozoite and cyst. In the trophozoite stage, the parasite latches on to the small intestines where it feeds and reproduces. As it nears the large intestine, the parasite forms an outer covering — a cyst — which is excreted from the body into the environment. People contract giardiasis when they drink water that has been contaminated with giardia cysts.

"People used to think giardia cysts were dormant," Granath says, "but actually, the parasite divides twice in the cyst, so for every cyst ingested, you actually get four trophozoites."

Classified as a protozoan and a non-invasive parasite, giardia doesn't feed on its host's tissue like other such bugs. Instead the teardrop-shaped organisms attach to the intestinal lining where they feed on mucus and other secretions. Their attachment to the intestinal wall prevents the host from absorbing water or nutrients from food.

Giardiasis is rarely fatal and the symptoms can vary widely. Half of infected people show no symptoms, while others experience mild diarrhea. In the worst cases, people infected with giardia can develop malabsorption syndrome — dehydration so severe that hospitalization is required. Severe dehydration can lead to an electrolyte imbalance, which can lead to shock or death.

Granath says that humans have a difficult time killing the parasite because as soon as we have developed enough antibodies to fight it off, giardia changes form just enough to require a different antibody.

"When the antibodies reach a certain level, the parasite changes and we have to start making new antibodies all over again," he says. "All the while, the parasites are feeding and reproducing."

Luckily, the ailment can be treated with any one of three prescription drugs, all of which have good rates of success.

So how do you avoid getting giardiasis in the first place?

Forget any type of chemical treatment — including the chlorine tablets many campers use to purify their water in the woods — the amount of chemicals needed to kill this parasite is not safe for human consumption.

"The cysts can't survive freezing or drying out, so freezing or boiling water will kill the parasite," Granath says. "Also, water filtration kits for campers and hikers will remove the parasite."

Campers, hikers and outdoor enthusiasts of all kinds — get out there and enjoy Montana's natural beauty — just remember to think before you drink. ■

Water:

If there is magic on the planet it is contained in water. It touches the past and prepares the future; it moves under the poles and wanders thinly in the air. It can assume forms of exquisite perfection in a snowflake, or strip the living to a single shining bone cast up by the sea.

— Loren Eiseley, 1957, The Immense Journey

Photo by Patia Stephens: Twilight catches a pond near Kalispell.

A view from the east side of Flathead Lake.

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