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CROWN
of the
CONTINENT
and the
GREATER
YELLOWSTONE

MAGAZINE

Summer/Fall 2015

UNIVERSITY OF
MONTANA

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CROWN of the CONTINENT and the GREATER YELLOWSTONE

"Kiss the Sun" The sun kisses Chief Mountain while settling its way through thick clouds and behind the western horizon. Sunspot AR12192 is visible in several of the upper suns of this interval photograph, made using a solar filter. (Do not point a camera at the sun without the proper solar filter.) More of photographer John Ashley's work can be seen inside on page 28.

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Glacier National Park Field Course

CROWN of the CONTINENT and the GREATER YELLOWSTONE



UM President Engstrom in the North Fork of the Flathead

Our mission is to inform the public about what is happening in the Crown of the Continent and Greater Yellowstone ecosystems.



Yellowstone National Park Field Course



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Photos by Rick and Susie Graetz



Lincoln, Montana Blackfoot Sculpture Park Presentation

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CROWN of the CONTINENT

Bighorn sheep. Will Klaczynski

A large brown bear and a smaller cub are shown in profile, facing each other and touching their noses. They are standing in a grassy field with a shallow stream or wet ground in the foreground. The background is a soft, out-of-focus green field.

A LITTLE HAIR OF THE BEAR

by **Emily Monosson**

We trail a band of French women. We are on our way to Iceberg Lake in Glacier National Park and they are making a racket, singing loudly. Though we revel in Nature's music – a bird call, the rush of water, or the echoing boom of ice fall – we keep the femmes françaises within earshot. They are our “bear blockers.” They sing to warn away grizzly bears; walking behind them we can let down our guard. Immersed in the wilds of Glacier we are filled with both anticipation and anxiety: We hope for an encounter with the wild, yet we carry a holster loaded with a can of pepper spray in case that encounter is too close for comfort.



Even bears use the trails. USGS

Grizzly bears, *Ursus arctos horribilis*, are the wild that we both crave and fear. They are awesome and terrifying, and they exist at our mercy. Tens of thousands of grizzlies once roamed the continent from Canada to Mexico, from the mountains to the plains. Within a hundred years, as settlers advanced, populations were hunted out of existence. Today, five populations remain in the continental US, each clinging to remote mountainsides. One of the largest roams the slopes and valleys of the Northern Continental Divide Ecosystem, a swath of rugged landscape ranging from Lincoln, Montana, through Banff, Canada, including Glacier National Park. Nearly 800 make their home in the US portion of this landscape, many of them in Glacier.

Biologist Tabitha Graves, a one-time German literature major now captivated by the charismatic animals (“I believe I did a dance of joy,” says Graves, upon hearing she’d been offered an opportunity to work on bears for her degree), knows most of them by name. On the wall in her office is a map of the region studded with push pins and bits of yarn revealing a complex network of family ties amongst some 1,000 individual bears. A pin for each bear: Bluto, HanSolo, Jaspar, Kiyo, Jewel...

Graves’ colleague, biologist Kate Kendall, initiated this genealogy of the wildest, extracting DNA and therefore family history from clumps of hair gathered from so-called “hair snags”—a strand of shoulder-height barbed wire strung from tree to tree enclosed a pile of wood soaked with an excessively scented concoction, which brought inquisitive and hungry bears to the sight. As the animals investigated the



Scientists setting up a wire hair-snare. USGS

smell, the barb wire captured tufts of hair. “We have at least three generations collected between 1998 and 2012,” says Graves, her eyes sparkling when she talks about this wealth of data. The data allow the biologists to track how far offspring wander from their mothers and whether they are traversing mountains or roads. Through modeling, says Graves, “we can answer both how far young bears can go and also how likely it is that a young bear will disperse across a high road density area versus a low road density area.” And they can tell that brother bears like Sourdough and Weisner had crossed paths at least once over the course of two weeks. The goal is to one day use the data to figure out who goes where and when – which in turn may lead to developing plans for better bear protection.

Ever since settlers moved west, the fate of these bears has been in our hands. “The limitation has been people killing bears,” explains Graves. Once the slaughter stopped when the bears were listed under the Endangered Species Act populations bounced back.

Yet even as the bears of the Northern Continental Divide system are on the brink of being “delisted” they, along with other species emblematic of the wild—the Big

Horn Sheep, Mountain Goats and diminutive pika—face a new challenge, one that we can’t simply dial back like hunting: climate change.

Glacier is not just warming: on average, it is warming nearly 1.8 times faster than other parts of the globe. There are fewer really cold days and more really hot days, the cold is coming later and the warmth of spring is arriving earlier, snowpack is declining, trees are moving up slope, and seasonally dependent life events in both plants and animals are shifting in time. By some estimates Glacier National Park may be bereft of its namesake glaciers in less than two decades. How climate might impact grizzly populations is anyone’s guess. And so, along with bear genealogy, Graves is joining the growing number of

THE DATA ALLOW THE BIOLOGISTS TO TRACK HOW FAR OFFSPRING WANDER FROM THEIR MOTHERS AND WHETHER THEY ARE TRAVERSING MOUNTAINS OR ROADS.



Success! A little hair of the bear. USGS

scientists working the front lines to assess the impacts of one of humanity's greatest follies.

"I didn't start out doing climate work," muses Graves, "but as we learned what a big role climate plays in our natural world, it clearly became an important stressor to understand. I was always interested in spatial and temporal processes, and climate just drives so many of those processes that potential impacts are clearly huge." While bears, having once inhabited a large swath of the continent, may not be as directly sensitive to warming as other cold-dependent species like pikas and polar bears, grizzlies need to eat. A lot.

Like us, grizzly bears are omnivores. They graze, they scavenge, and sometimes they hunt. When food becomes scarce they may range farther afield. But the farther from the wild they roam, the more likely they are to wind up in conflict with their human neighbors. Says Graves of the park's wildlife managers, "If the conflict is bad enough, they'll remove it from a population. If a bear breaks into a cabin or keeps people locked in a car



Off to the Lab. USGS

– it's probably got a short life ahead of it. But "very few humans are killed by bears." If a bear causes a "minor offense" in the park, says Graves, rather than relocation or worse, a trail may be closed. Where bears are active, a warning may be posted, reminding us humans that we are in their habitat.

Like an oversized oxymoron, the formidable grizzlies living in the western region of Glacier National Park are mostly vegetarians. "Digging roots is what gives bears their hump," explains Graves. "It's sort of a combination of evolutionary processes and, as with any muscle, use." Who would have guessed that one of the more disturbing and defining features of the grizzly, their powerful

muscular hump, is for digging roots, grubs, and ants? When they aren't digging, the bears graze on grasses, shoots, and berries. In West Glacier, huckleberries, a fruit related to blueberries, are one of the largest single sources of nutrition. And this is where climate comes in.

Flowering shrubs and plants around the globe are already responding to Earth's changing climate. Some are creeping up to higher cooler ground. Others are buffeted by increasingly variable temperature. Where I live in western Massachusetts, blueberry and apple crops were hit hard when flowers bloomed early, only to wilt and die from a more seasonal frost. And then there are the pollinators flowers rely on—how will they respond to variations in temperature? Will a mismatch in emergence and subsequent pollination further reduce fruit crops?

How climate change will affect huckleberries isn't yet known, but there are plenty of potential consequences: early blossoming, swings in rainfall, changing wildfire regimes, and changes in disease and insect patterns – including both pest species and beneficial pollinators. And anything that influences berry production will also affect those dependent on the tart blue fruits.

That's why Graves and her team are looking beyond the genetics of grizzly populations to understand what their fate may be. "We don't understand what the effects of climate change will be on bear food sources," says Graves. "Anecdotally, people see huckleberry crops fail and then see increased bear-human conflict. When they don't have food, they look around more and then tend to come in contact with humans more...that is the concern that started this project for me." To better understand these connections, Graves and colleagues are now collecting data not only on bear movement but also on factors like huckleberry production and pollinator schedules.

But, even if food availability related to climate change alters bear habits, this doesn't have to lead to increased conflict, if the bears have the space to move into wilderness. Grizzlies, says Graves, could move north toward Canada along a wildlife "corridor," which brings us back to the yarn and push-pins, an oddly low-tech approach to data handling in this high-tech mathematical modeling world. "The family tree," explains Graves, "is a fairly complex network. I wanted to visualize the tree, and understand any odd relationships."

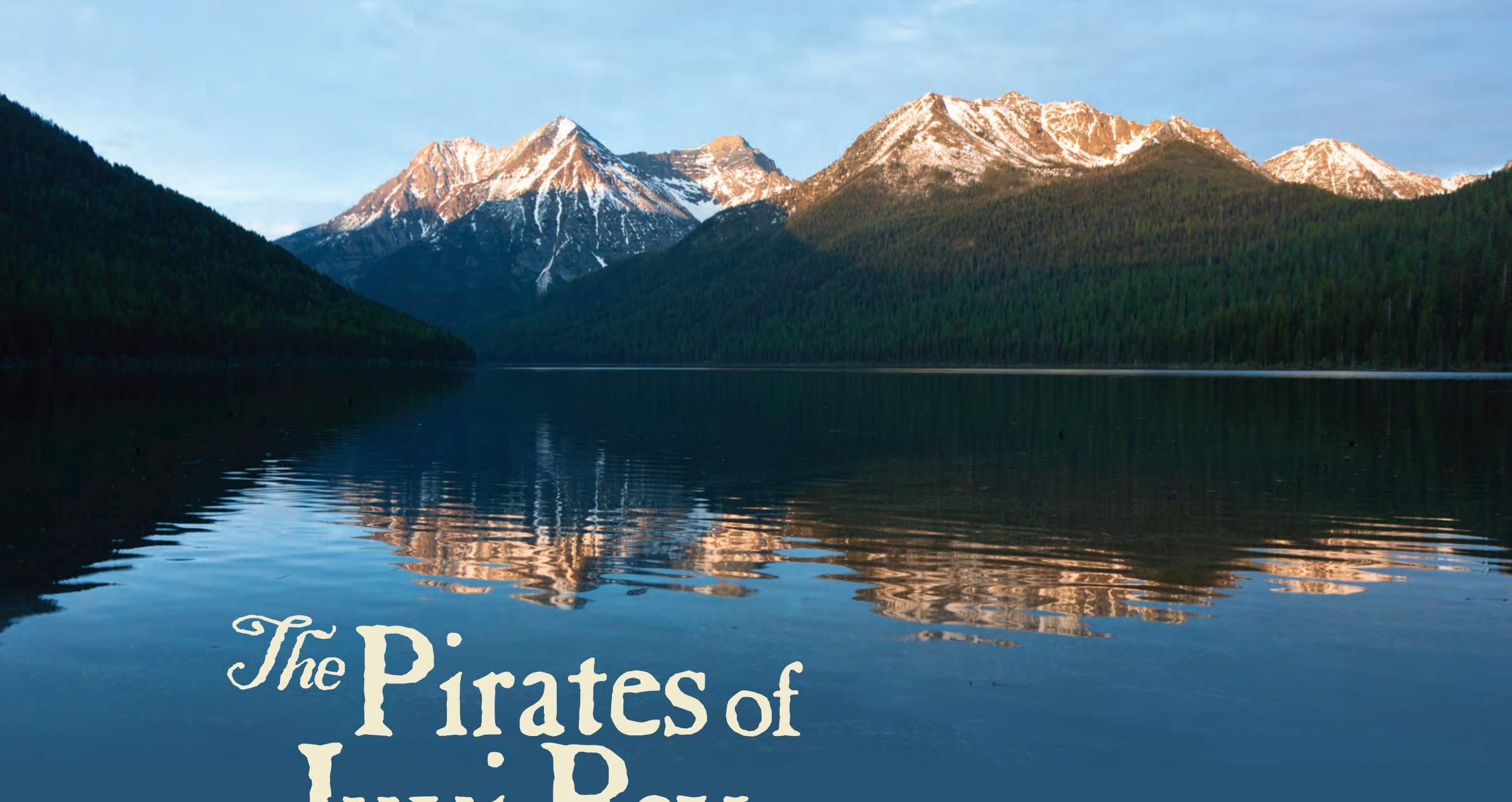
KNOWING
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Graves wanted to "get to know the data at a deep level." Knowing how young rambunctious teenage bears find their way through forests and meadows, around towns and across roads, can help define corridors to protect moving forward. Once defined, maintaining these wildlife corridors may mean the difference between a robust grizzly population and one needing continued human protections, particularly in an age when movement will be essential for both grizzlies and other species that might need to head north to weather the impending climate storm.

Whether thanks to those French women or not, we saw nothing more than bear scat and a few tufts of blond hair. Even so, as anyone who has walked in the footsteps of grizzlies knows, just being in the proximity of a being far more powerful than us awakens ancient senses numbed by the daily experience of an overdeveloped world. Now, we face an overheated world. At the very least we can strive to keep the wild things in the wild; for both their sake, and ours.

Emily Monosson is an environmental toxicologist at the University of Massachusetts Amherst, writer, consultant, and college instructor with an M.S. and Ph.D. in biochemical toxicology from Cornell University.

Tabitha Graves has a Ph.D. from Northern Arizona University and a M.S. in Wildlife Biology from the University of Montana.



The Pirates of Juvi Bay:

Glacier Park netters
make progress against
invasive lake trout

by Rob Chaney

Chris Downs, GNP
fisheries biologist,
measures a lake trout.
Tom Bauer



The skull and crossbones hanging from the light pole on the back of the 18-foot fishing boat has worn to tatters.

So has the population of lake trout in Quartz Lake.

Twice a day, Kevin Perkins and Carter Fredenberg string 1,800 feet of gill net through the waters of Juvi Bay – their name for the most productive summertime corner of this 869-acre Glacier National Park lake where juvenile lake trout linger. They come to pillage. The name of their pirate boat is unprintable.

The boat itself is almost unimaginable. No road goes to Quartz Lake. A helicopter had to airlift the 4,000-pound skiff and its 50-horsepower motor, along with a half-dozen grizzly-bear-resistant gear boxes to the Quartz Patrol Cabin. That’s a big infringement on Glacier’s recommended wilderness status, which generally prohibits mechanized tools of any sort – even wheels.

And that says something about how serious Glacier Park takes the job it sent Perkins and Fredenberg to do.

Every other big lake on the park’s west side has fallen victim to lake trout infestation. As a 2003 U.S. Fish and Wildlife Service report noted: “In just 30 years, the native bull trout populations of Glacier’s wild westside lakes have plummeted to the point that fisheries biologists fear for their ultimate survival.”

Most of the juvenile lake trout are between 8 and 12 inches long.
Tom Bauer



Park biologists think that Quartz Lake is one of the best chances among Glacier's big western drainage lakes to restore a native fish population. Tom Bauer

“Quartz was the last lake remaining with a complete stock of native fish and no lakers,” GNP fisheries biologist Chris Downs said. “We built the fish barrier to keep it that way. Then when they caught a lake trout in Upper Quartz in 2005, they were totally disheartened.”

Lake trout were introduced to Flathead Lake in the early 1900s. They didn't have much impact until state fisheries biologists added mysis shrimp to Swan Lake as a fish feed stock in the late 1960s. The shrimp were

supposed to boost numbers of the popular kokanee salmon fishery – a tactic that had shown success in Canadian lakes.

Unfortunately, the shrimp spread downstream to Flathead Lake, where differences in depth and ecosystem had an unpredicted outcome.

The shrimp acted like a steroid boost to the lake trout fishery in the early 1980s. The lakers in turn went after the kokanee, virtually wiping out that population in a couple years. Then they turned on the harder-to-catch native bull and

cutthroat trout.

In addition, lake trout started following the Flathead River's three branches to new homes. Hungry Horse Dam stopped their progress up the South Fork of the Flathead. Harrison Lake inside Glacier Park is the Middle Fork's only significant lake, and lake trout made it there in 2000.

But the North Fork of the Flathead allowed the lakers access to McDonald, Logging, Quartz, Bowman and Kintla lakes. According to the FWS report, a 1969 gill net survey in the four western lakes caught

250 bull trout and 11 lake trout. In 2000, a repeat survey caught 138 lakers and 26 bulls.

Genetic analysis of Glacier's lake trout show Kintla and McDonald fish come from similar family lines, while Bowman Lake (between the other two) has a different strain.

That could be because it's harder for lake trout to negotiate the climb up Bowman Creek than it is to reach the other two lakes, resulting in a more isolated population. That could be good news for future control efforts on Bowman. It's not so

good for McDonald and Kintla, which keep getting resupplied from Flathead Lake.

Last year, the Quartz Lake boat crew captured and killed about 2,000 lake trout in their five-month season. In 2013, it was 2,500.

“It's getting harder and harder to catch an adult lake trout,” Downs said. “This is one of the most productive bays and we got about 25 lake trout on that last catch. We seem to be catching fewer each time. That's good.”

To aid the hunt, Downs invites a group of volunteer anglers to come to Quartz each spring and catch lunkers for radio-tagging.

Early in the program, Downs was able to attract several notable Mack Days competitors from Flathead Lake. They tended to catch either a bull trout or a lake trout every two hours.

Now it takes about 10 hours to hook a big laker. Needless to say, Downs has found flagging interest in hiking all the way to Quartz for such slow action.



Twice a day, 1,800 feet of gill net is set and hauled in by hand. Tom Bauer

The bleached and nibbled set of antlers mounted over the Quartz Patrol Cabin door is one of the stranger things Perkins and Fredenberg have caught in their nets since they started hunting lake trout in 2008.

“We always wonder if we’re going to haul up a mammoth skull or something,” Perkins said. A few years ago, a volunteer angler lost his favorite chartreuse “Deep Diver” lure to a lunger. Three days later, the same fish turned up in the nets, still hooked to the Deep Diver.

Both lake trout and bull trout are slow-growing, late-

maturing top predators. But their life cycles are quite different. That allows humans to target one species without too much risk to the other.

The spring fishing season lasts about three weeks and hammers the shallow areas like Juvi Bay where the juvenile lake trout prowl. The bulls tend to hunt around the inlet and outlet of Quartz Lake, so Perkins and Fredenberg avoid those areas.

The pirate skiff may have a motor, but Perkins and Fredenberg rely on the same technique fishermen have used for centuries to recover their nets. They grab hold and pull.

“You’re crushing doorknobs by the end of the season,” Fredenberg said

of the exercise. They stand together at the side of the boat and haul, one on the lead-lined bottom and one on the floating-line top. When a fish comes up, both put a foot on the net to hold it in place while they untangle it.

Any bull trout caught has a full emergency room service ready for it. There’s a live well with chilled water and an oxygen supplement on board. Bulls tend to freak out when netted, tangling themselves so tightly they tie their gills shut and suffocate.

Lake trout don’t struggle as they come aboard. Fredenberg squeezes them out of the mesh like a hot dog from a bun and tosses them in

a bucket for later analysis. Most of the juveniles range between 8 and 12 inches long. Once their details are recorded, their swim bladders are popped and they’re sunk back in the lake.

The suckers they catch react very differently. They struggle in the mesh, wriggle as they’re released and swim away immediately when tossed back overboard. It’s easy to imagine them making obscene gestures with their tails as they depart.

In the fall, 7-year and older bull trout leave the lakes for their natal spawning streams. Lake trout look for big rock piles to deposit their eggs. In Swan Lake, that’s often where highway crews have dumped waste loads of concrete. In Quartz Lake, it’s where avalanche chutes funnel debris down to the water.

“We’re at 50 meters now,” Fredenberg said, looking at his fish sonar monitor as the boat eased toward the north shore where avalanches had left three bright green slashes in the forested mountainside. “Now we’re at 15. Now we’re at 5 meters. It’s like a reef right here.”

As they move from spot to spot, the netters watch for white mountain goats high in the cliffs of Cerulean Ridge. They’ve seen occasional grizzly bears roaming the shoreline. Nesting loons emit a surprisingly wide range of calls, sometimes sounding like wolves howling.

“I never get tired of the view,” Perkins said. “This is the best job I’ve ever had.”



Quartz Lake gets few visitors in the summer, and it’s virtually deserted by fall. That’s the netters’ busiest season.

“The second the spawn hits, we stay out until it’s done,” Fredenberg said. “It can go 12 or 13 days straight. We turn into vampires – net all night, sleep until noon, and then it gets dark again about 4 p.m. It’s either still and dark and cold with huge stars all over the place, or it’s dark and cold and blizzarding and you get a little wet.”

“Pulling net in the waves is not fun,” Perkins added. “The storms just shoot down the lake and we’re stuck and can’t do much until we’re done. You just have to work backwards, watching the waves.”

Glacier Park is trying other tactics as well. Two falls ago, biologists raided Logging Lake’s spawning streams and captured 115 bull trout and every egg deposit they could.

The fish were moved up to Grace Lake, a mile farther up the Logging Lake Valley and protected by waterfalls that most fish can’t climb. It has a stocked population of Yellowstone cutthroat trout from 1920s fish-planting efforts. The bulls there will become an isolated community, feeding on the non-native cuts and safe from the lakers downstream.

The bull trout eggs were sent to the Creston Fish Hatchery, where they are being raised in isolation as future stock.

“It may have been our only chance,” Downs said. “We found

no bull trout spawning in Logging Creek last year. We may have caught the last spawning age class. Last year, we only caught one bull trout in Logging Lake.”

While Quartz Lake is showing signs of a turn-around and work on Logging Lake is just getting started, Glacier officials aren’t sure there’s any hope for Kintla, Bowman, or McDonald lakes’ infestations of lake trout. This summer, a research team is camped at high-altitude Akokala Lake, checking if its native population remains secure.

A couple things have changed since Perkins and Fredenberg started netting Quartz Lake in 2008. Their appetites have declined in step with the invasive species population.

In the beginning, the lake trout catch was a bonus to be rolled in pancake mix, fried in a skillet and wrapped into a burrito with rice and beans. Or steamed in tinfoil.

“They’ve got bright orange meat and they’re great eating, as far as lake trout go,” Perkins said. “The first two years, it seemed we ate fish every other night. Then it was two nights a week. Then we were done.”

They still get inquiries from friends about surplus fish.

“I say sure,” Fredenberg said. “You can hike in 6 1/2 miles and I’ll load you up. I have yet to have someone take my offer.”

Rob Chaney covers the outdoors, environment and science for the Missoulian and is a frequent contributor to our e-Magazine

**This article has been reprinted courtesy of the Missoulian.*

Where Have All The Boreal Toads Gone?

by Jim Giese

Distant rumbles of thunder creep closer as Blake Hossack, a research zoologist with the U.S. Geological Survey (USGS), finishes inserting a microchip in the back of an adult boreal toad. Standing calf-deep in water, a nervous student looks west toward the thunder, and I imagine she is contemplating the wisdom of her current situation. She and other students from the Flathead Lake Biological Station have come to Glacier's Two Medicine area to learn about amphibians in the park. I joined them to learn about the status of amphibians and the role climate change may have on these cold-blooded creatures. I soon discover there is a lot to consider when dealing with amphibians.

Our main target is the boreal toad, but Hossack also expects we may catch Columbia spotted frogs and perhaps long-toed salamanders. Boreal toads are one of six species of amphibians known in Glacier, and are the only toad found in the park.

Besides being effective controllers of many insect "pests," amphibians are a food source for many mammals, birds, and fish. They are also regarded as excellent ecological indicators due to high sensitivity to slight changes in their environment. A decline or extinction of a population could represent responses to habitat fragmentation, ecosystem stress, disease, pollution from chemical inputs, or other human-caused activities.

Monitoring of amphibians in Glacier began in 2000, as part of the USGS's Amphibian Research and Monitoring Initiative (ARMI). Worldwide declines in amphibian populations prompted the creation of ARMI, a national effort to document trends of amphibian populations on federal lands and to conduct research on the causes of amphibian declines and malformations.

Information collected by ARMI is then used by resource managers to protect amphibian populations.

Microchips, which contain unique identifying codes, are inserted into amphibians monitored in the study in order to estimate population size and individual survival rates. Estimating amphibian occupancy, or the probability that suitable habitat contains breeding populations, is done by collecting larval and adult amphibians using dip nets. A decline in occupancy could indicate a reduction in suitable habitat, a decrease in population, or a response to changes in climate. In Glacier, the boreal toad's occupancy rate is roughly 6% of the suitable monitored sites, whereas the Columbia spotted frog has a higher occupancy rate of approximately 20–25%. Overall, the occupancy rate has remained steady during the study, although there have been shifts in which wetlands are being occupied.

As we gather gear and head into the cool, murky waters of the survey site, Hossack tells me that boreal toads were once common in this particular wetland. However, he and his staff are not finding toads in anywhere near the numbers they have in past years. In fact, he has instructed his crew to stop surveying for amphibians here. "It is one of those dilemmas: the smaller a population gets, the more time you need to devote to it. Yet at the same time, the amount of effort [required to collect such a small amount of data] is so

high you eventually have to say, well, with a limited budget, you are better off doing something else."

Listed as a Species of Concern by the State of Montana, boreal toads were once more abundant in western Montana, as well as in other states throughout its range. The reason for their decline is uncertain, but disease, fragmentation and loss of habitat, and climate change are thought to be contributing factors.

During the drive to the Two Medicine area, I asked Hossack about climate change and its possible effects on amphibians in the park. He mentioned a recent study in which he researched how populations of the Rocky Mountain tailed frog, a frog found in cold streams of Glacier, might respond to long-term effects of climate change.

In previous studies, the consequence of a warming climate on a species with a specific temperature-range tolerance has been applied only to larger geographic areas. Hossack and his colleagues wondered if the same consequences could hold true for populations of the same species on a much smaller, localized geographic scale. They compared the survival rates of six different populations of Rocky Mountain tailed tadpole in Glacier to variations in late-summer temperatures. The results showed that the ability of individual populations to tolerate warming temperatures can indeed vary across a small geographic scale and is linked to the increased

Boreal toads have a prominent white or yellowish line down the center of the back. Andrew Engelhorn, NPS



Tadpoles remain in large groups until they are about 1/2 inch long. flickr.com/photos/richardwc/



Currently, boreal toads are listed as a Species of Concern in Montana. glspics.com

complexity of the local environment.

Additional questions need to be explored, such as how the frogs respond during different life stages and what role genetics may play. However, once these factors are identified, this information may lead to additional tools for resource managers in response to a warming climate. For example, there may be greater value in protecting populations of frogs known to tolerate a wider range of temperatures, as they might repopulate areas once inhabited by other, less-adaptable frog populations.

Back in the wetland, Hossack sweeps a dip net through the shallow water to collect larval forms of amphibians. Students follow his example and soon numerous tadpoles at differing stages of metamorphosis are collected in blue tote boxes.

Hossack pulls a Columbia spotted frog larva from the tote. About two inches long, the tadpole has a brownish-green coloring on its back and gold flecking scattered along the belly. A boreal toad tadpole is next, much smaller, less developed, and nearly jet black. Hossack explains that boreal toads breed later than Columbia spotted frogs. This prompts me to ask about the life cycle of boreal toads, since it is thought that some correlation exists between timing of breeding and success rate.

Hossack explains that adult boreal toads emerge in spring once snowmelt has cleared away from their burrows and daily temperatures remain above freezing. The timing of breeding depends on snowmelt and begins as early as May in lower elevations, but can be delayed

to July or early August in higher elevations. Depending on a female's body condition, breeding may occur every 1–3 years. Eggs are deposited in long strings, which are normally laid in shallow water. Development of egg and larva are temperature-dependent and development from hatching to metamorphosis can take up to 75 days in higher elevations. It is this temperature-dependency that might be affected by a changing climate and is one of the reasons Hossack is monitoring breeding populations.

A new concern for amphibians in Glacier, and one that Hossack is also monitoring, is the emergence of amphibian chytridiomycosis, otherwise known

as chytrid. Chytrid is an infection of skin cells in amphibians, caused by the microscopic aquatic fungus, *Batrachochytrium dendrobatidis* (Bd). It is linked to widespread declines in amphibian populations throughout the world. Chytrid was first discovered in a boreal toad in Glacier's Two Medicine area in 2001. It is now detected in 30–50% of the wetlands sampled each year.

Although present, Hossack says chytrid does not appear to be causing problems within the park: "While it's infecting animals in our area, it does not seem to be causing population crashes. However, we can't rule out a link to slow declines, because that is much harder to tease apart from other sources of decline." In fact, all of his monitoring efforts are geared toward determining the cause of reduced amphibian populations, and, in particular for Glacier, the boreal toad. At this point, the reasons for the declines remain unclear, but Hossack is hopeful that this and other monitoring sites throughout Montana and the West will shed light on this worldwide phenomenon.

The thunder and heavy, dark skies now engulf us as Hossack finishes the final measurements of the last caught toad. The consideration of heading to another wetland is trumped as rain starts to pelt the surface of the wetland and raingear is pulled out of packs.

Our trek out of the soggy wetland in the now cold, steady rain does not dampen the enthusiasm of the students. The group discusses the toads and frogs seen today and the important role they play in a healthy ecosystem. The highlight of the field trip, though, seems to be the constant chirping by a male toad. One student from Kentucky, who is experiencing Glacier for the first time, wonders if he will ever get a chance to hear the toad's chirping again, referring, I assume, to whether he will return to Glacier. My hope is that he will get that chance—both to return to the park, and to hear the toads chirping when he does.

Jim Giese has an MS in Environmental Studies at the University of Montana. He served as a Science Communication Intern for the Crown of the Continent Research Learning Center in the summer of 2013.

**This article has been reprinted courtesy of the Crown of the Continent Research Learning Center. crownscience.org/newsletters*



The toads breed in puddles, ponds, and lake shallows. Christine Haines

HOPE ON THE RANGE

by Melissa Mylchreest



A rancher, a wolf biologist, and an environmentalist walk into a bar.

In many valleys in the West, people would hold up a hand, tell you to stop right there; the statement is a joke all on its own. The very notion of getting those three parties in a room together - let alone a bar! - is laughable. But here in the Blackfoot Valley, it's not a joke.

Despite the iconic status engendered by Norman Maclean's *A River Runs Through It*, the Blackfoot Valley remains more or less as it has for generations. The 1.5 million-acre watershed is home to only 2,500 households in seven small communities, and land use is still predominantly agricultural. In many ways, this valley is much the same as many others in the state: Cattle roam the river bottoms and range into the hills, the local

economy inextricably linked to beef prices and weather and range science and luck.

But here, there's something different happening as well.

Outside of Ovando, on this late October day, the cottonwood are pulling out all the stops before winter, their yellow riotous in the autumn sun. The Blackfoot itself meanders south of town, looping lazily in this wide, glacial valley. Tawny hills run off toward the mountains, and the creeks are lined with red foliage. Clouds pile up on the horizon, and here and there, the landscape is punctuated with dark shapes in the distance: Horses. Cattle. Barns.

"What was that?" says Eric Graham, stopping and throwing the truck into reverse on the deserted dirt road.

"Can you see it out your window?" He asks. "Was it bear, or just horse?"

I peer over the edge of the passenger-side window at the pile along the roadside. Though mashed flat, from this view it becomes clear it's only a pile of horse manure, not bear scat. We drive on, and soon find ourselves parked in front of a gate, overlooking a field full of grazing cattle.

Getting out of the truck, he cautions me, "Now, don't touch the dang fence! I got zapped the other day, and they have it cranked way up." His sun- and wind-weathered face cracks into a self-deprecating grin, the dark beginnings of a winter beard shadowing the lower half of his face. He hoists a backpack, pulls a fleece hat down over his ears, and heads toward the pasture.

Safely through the gate, we survey the cows as they eye us disinterestedly, and Graham explains how he found himself out here in the first place, looking for animal scat, getting shocked by fences, and learning the back roads. As he does, it becomes clear that his presence is only one piece in a much bigger, longer story.

"Back before conservation was sexy," says Jim Stone, a born-and-raised Blackfoot rancher, "there were all these conversations milling around the valley, and they were landowner generated." In the 1970s, the Blackfoot was on the verge of being named one of the top-ten imperiled rivers in the country, a designation that would likely trigger federal management and restrictions. On hearing the news, locals sat up and took notice. Stone says, "We didn't want outside people dictating how we were going to manage one of the most critical resources in the valley." They also knew that they wanted to maintain the rural, agricultural character of the valley, and to address long-standing access issues for hunters and fishermen.

At that time, distrust ruled the day between ranchers and government employees. "Nobody had ever talked to the Fish Wildlife and Parks guys," says Stone, "Because nobody really liked them." Showing incredible foresight, especially in a state known for its staunch individualism, landowners understood the need to work collaboratively with agency representatives in order to ensure the success of their vision for the valley. Little by little, the lines of communication opened. In due time, agency folks came to the table as well.

"Our general human nature," says Stone, "is that we love to fight and butt heads. And then we walk away and we don't have to do anything about it. Fighting is an easy out. But we realized, it's really about communities and people. We don't have to agree, but we can have the same values. Trying to do the right thing is pretty powerful."

By 1993, a truly collaborative - and truly unique - partnership had evolved, and the Blackfoot Challenge was born. A nonprofit organization, the Challenge aims to conserve and enhance natural resources and a rural way of life throughout the watershed, through cooperation and conversation among *all* stakeholders. Committees within the organization reflect this



Downtown Ovando. Will Klaczynski

all-inclusive approach. Seth Wilson, Blackfoot Challenge wildlife coordinator says, "The make-up of the Challenge represents the realities on the ground. All of our committees are comprised of landowners, representatives from all seven communities in the valley, and all the agencies - Forest Service, BLM, DNRC, USFW, county weed districts, everyone."

"It took some coming together," says Stone. "Us ranchers went out and learned about fish, water temperature, stream dynamics. And the biologists had to learn what a cow looks like, and the needs of a cow. They learned about irrigation and weed control." In this way, a "ridge-top-to-ridge-top" management strategy developed, based on transparency,



Wolves. Jim Burdic

cooperation, and realistic on-the-ground strategies.

While many agricultural valleys throughout the West remain vehemently divided, the Blackfoot has seen collaborative progress. While not all landholders are interested in partnering with others, most are. Several ranchers have put their land in conservation easements, which restrict development but support agricultural practices. Easements also allow for hunting and fishing access; today, more than 30 miles of the Blackfoot river corridor are open for public recreation. Rare bull trout and westslope cutthroat trout are receiving the protection that they need to rebuild populations. Wetlands are thriving at the same time as cattle operations.

For the most part, it's a good system, says Stone, especially as problems arise and solutions need to change or grow. "I don't care how educated you think you are, these places are dynamic as hell. We've had to neighbor up, and build on partnerships. We've got a Rolodex of resource management now, and I can call all these folks up. I think it's critical to survival."

And on any given day, it's possible to find a rancher, a wildlife biologist, and a conservationist drinking beer together at Trixie's, the local watering hole. While they may have their differences, they all agree on one thing: the Blackfoot Valley is a pretty special landscape, and not

a bad place to spend some time.

The only problem is, they're not the only ones who think that.

"Oh, now here's a good one," Graham says, pointing down at a clear, four-toed paw print. We're walking in the ruts of a ranch road that loops around a handful of man-made ponds, and the wolf track is a small one, but distinct and unmistakable. "This is only the second time I've seen wolf sign up here all season, so this is interesting," he says.

Graham works as a range rider for the Blackfoot Challenge, a malleable and growing position currently in its fifth year. A grant-funded program, the general goal of the range rider is to reduce the incidence of negative encounters between livestock and wild predators. For those familiar with ranching, the notion of a range rider is nothing new; historically, this was the realm of the cowboy, and earlier, the semi-nomadic pastoralists who moved and lived with their herds. But in the Blackfoot Valley, the range rider had long been gone from the landscape.

The absence wasn't an oversight; there simply hadn't been a need. With big predators extirpated from the valley during generations past, cows were largely safe to wander as they pleased, free from supervision. But to wolves and bears the Blackfoot watershed is a natural paradise, and following reintroduction and protection programs of the 1990s, carnivores came back home.

"By the late 1990s, we had grizzly bears, and confirmed losses of livestock," says Seth Wilson. "There's this great natural river bottom habitat, and on top of it bears were finding bone yards, carcasses, beehives, garbage, pet food." When a grizzly killed a hunter in the Blackfoot in 2001, the community was galvanized into action. Through a long public process, the Challenge identified problems - bear attractants, prime grizzly habitat, public safety concerns - and solutions.

Because grizzlies are known for snatching newborn calves, the Challenge procured funding to provide

permanent electric fencing for 18 calving areas. Because carcasses are a primary attractant, and many ranches have long disposed of carcasses in designated bone yards, an innovative carcass removal program was implemented: When ranchers have a mortality in their herd, they can call a Fish Wildlife and Parks representative, who will come out and discretely remove the carcass and transport it to a fenced composting facility run by the Department of Transportation. Since 2003, more than 1,700 livestock carcasses have been removed from the project area.

But it soon became apparent that grizzlies were not the only returnees to the valley, and they weren't the largest threat to livestock. "The Blackfoot was one of the final big watersheds in the western part of the state without wolves," says Wilson. "But the first pack showed up in 2007, and now we have eleven or twelve confirmed packs." In an effort to get out ahead of the curve, keep wolf depredation numbers low, and help ranchers as much as possible, the range rider program was born.

"The main purpose of the range rider is to increase herd supervision rates, and to better understand where wolves are in relationship to cattle," says Wilson. "We communicate across the watershed, and tell landowners where wolves are, how their herd is reacting. When you increase supervision, you can take preventative action. If we find naturally dead livestock, we can remove the carcass. We find sick or injured animals, we can get them home and doctored up. We mend fence. We get lost



A view of the Blackfoot Valley from the Rolling Stone Ranch. Melissa Mylchreest

calves back to their moms. It's just an extra set of eyes on them."

Watching over hundreds of thousands of acres may seem a tall order for Graham and his small crew of helpers, but he says it's nothing in comparison to the work the ranchers do. Because of that, "I'm not just the range rider," he says. "I'm a helping hand. These guys get super busy with haying and everything, it's just useful to have someone out there checking their cows on a regular basis."

Standing on a rise over the river, Graham turns on his radio telemetry equipment and aims the antenna into the mountains. Through an agreement with Fish Wildlife and Parks - a result, in part, of the long-standing collaborative work fostered by the Challenge - Graham is able to track radio-collared wolves in the area he covers. When he picks up a signal, he'll call ranchers who have cattle nearby, and alert them to the presence of predators. He publishes a weekly wolf report that documents where the packs are and what they're up to.



Wolf paw print. Melissa Mylchreest

He's also aware, though, of the limitations of telemetry - and the power of on-the-ground knowledge. "I've heard of rangers becoming too dependent on a collar. They pick up a signal and say, 'The wolves are right there.' But the rancher looks at his cows all bunched up and unhappy says, 'Well, I know your wolf with the collar is over there, but I think there's some wolves over here too.'"

Graham says he learned early on to trust ranchers' intuition. "These guys know what's going on. They've been out here their whole lives. Don't ever come to these guys acting like you know what's going on."

Building trust has been one of the most crucial aspects of the range rider position, a task made easier by the decades-old spirit of valley-wide collaboration. "Most people around here are great, and that is one of the biggest reasons I was willing to do this job," says Graham. "Try working this job somewhere else, it could be really ugly."

In a state where the debate over predators regularly

Eric Graham tracking collared wolves. Melissa Mylchreest



deteriorates into fisticuffs and even death threats, people in the valley, for the most part, remain civil. Graham says that he steers clear of Trixie's, the local bar, because "wolves and alcohol don't mix," but he's never felt anything but welcomed by the ranching community. And he's careful, he says, to stick to the middle of the road. "I see both sides. Somebody's pro-grizzly, pro-wolf? Great. But on the other hand, it would certainly help the ranchers to have a lot fewer wolves around. And if they get their wolf [hunting] tags and want to go shoot one, I can absolutely see why they would."

In many respects, the range rider is the embodiment of the trust that has grown between vastly different constituencies over nearly forty years of conversation, compromise, and trial-and-error. Ranchers in this valley have every reason to fear and hate wolves, and many, if not most of them, still do. But they've agreed to work with agencies, implement the management tools available, and trust a stranger to come onto their land and keep tabs on their stock. Biologists and conservationists have put aside their preconceived ideas and asked ranchers for help and advice.

And so far, the gamble seems to be paying off. For the past six years, the valley has lost roughly four head of livestock each year to depredation. In turn, roughly four wolves have been removed each year as well. In comparison to places like the Big Hole Valley, where in two years 25 livestock and 72 wolves were killed, these numbers are astonishingly low. As for this year? So far, not a single livestock depredation has been reported.

Standing in a vast field, watching a couple hundred cattle graze contentedly, Graham shrugs his shoulders. "I don't look forward to the day a cow gets killed on my watch. And I'm sure it will happen. But so far, I've lucked out this year."

I suggest that it's not luck, perhaps it's the result of his own hard work and dedication. He shakes his head. "There's depredation going on all over the state, wolves killing cattle and sheep everywhere. And somehow it's not happening here. But it's really hard to gauge our success. Really, I measure my effectiveness by a rancher

In a state where the debate over predators regularly deteriorates into fisticuffs and even death threats, people in the valley, for the most part, remain civil.

telling me 'Hey, thank you, you did a good job.'"

He looks around him and takes it all in, here at the tail end of his season in the field. The ranchers are bringing home their cattle for the winter, touching base with him to let him know if they're missing any, and then he'll wrap up his work and be done. The relationship between ranchers and predators - and the people tasked with protecting them - will always remain fraught. But here in this big, wild valley, with the wind kicking up and the cows safely munching away and the wolves keeping to themselves for now, the picture looks hopeful.



Jim Stone demonstrates a portable, wildlife-friendly, predator-deterrent flagged power fence. USDA NCRS

Melissa Mylchreest is a freelance writer, editor and artist based in western Montana.

She holds an MS in environmental studies from the University of Montana as well as a MFA in creative writing, and has taught college-level classes. Her nonfiction has been published widely, and she is also an award-winning poet.

**This essay originally appeared in Ranch & Reata magazine, in 2014*

SUNSET TO SUNRISE IN A BELOVED NATIONAL PARK

We are used to seeing and photographing the soaring peaks, thunderous waterfalls, riotously colorful wildflowers, and shimmering lakes of Glacier National Park between the hours of sunrise and sunset. But, when most of us are tucked in bed, the curtain opens and a whole new cast of characters appears. Set against a vast, dark night sky, the Wolf's Trail (Milky Way), shooting stars, blazing comets, soft alpenglow, the moon in all of its phases, creatures of the night (constellations), the dancing northern lights, and others strut their stuff.

At once quiet, spiritual, and awe-inspiring, the view transports us from the chaos of our daytime lives to a place of inner peace, wonder and humility.

In his book, *Glacier National Park AFTER DARK*, photographer, writer, biologist and educator, **John Ashley** calls on his past wealth of experience and knowledge to bring clarity to the many facets of these night-time players. Ashley's stunning photos will hopefully entice you to get out of the artificial city light and to, "Look up, and that's the first step to discovering a world at night that most of us have forgotten or maybe never even knew. If curiosity tugs at you as it does me, then subtle mysteries await you. All you need are a few keys to unlock the secrets of your own night vision." Hopefully, you will find the answers.

"BLACKFEET WARRIORS"

Moonlight sparkles in the eyes of a mounted warrior, poised to meet travelers at the northern border of the Blackfeet Reservation, on Glacier's east side. The steel sculptures were created by Blackfeet artist Jay Polite Laber using materials reclaimed from the 1965 flood.



"SPIRIT ABOVE, SPIRIT WITHIN"
The stars circle Polaris as Earth turns between dusk and dawn at a tepee sculpture overlooking the Saint Mary Valley.

"MIDNIGHT SYMPHONY"
Northern lights dance and sway across a Lake McDonald dance floor in April 2003. These northern lights were caused by a blast of solar radiation, so I knew there was a good chance for them to appear on schedule. A yellow band appeared at about 11:30 p.m., and the colors started dancing just after midnight.





▲ **“MIDNIGHT TRAIN”**
The Wolf’s Trail Milky Way sparkles above Mount Saint Nicholas, while the headlight from a midnight train shines across the lower foothills.

▼ **“ANCIENT CIRCLES.”** *The night sky appears to revolve around Polaris, the North Star, in this north-facing time-lapse image. But it’s really the Earth that is rotating in this view of the sky from the Lake McDonald shoreline near Sprague Creek. Lake McDonald is a sacred area to the traditional Kootenai. For generations, the tribe gathered each spring on the shores of Lake McDonald for the Bear Dance Ceremony. The original Kootenai name for the lake is Yakilhaqwilnamki, which translates into, “Where (people) dance.” The Blackfeet name for this lake is Kyaiyo-Ahtiwapixi, or “The Bear Wags its Tail.”¹*



“LOVEJOY” Comet Lovejoy of 2013 (C/2013 R1) rises above Mount Brown on a moonless night in December 2013.



▲ “SWIFTCURRENT LOOKOUT.” A full moon at dawn slips silently behind the fire lookout on Swiftcurrent Peak. To reach the precise camera location where this would line up, I had to head up the trail in the dark hours before dawn. I arrived to discover that the tree canopy was too thick, and I had to move downslope to find an opening, which is why there is slightly less than half of the moon showing above the mountaintop.

▼ “GOING TO THE SUN.” While Mount Reynolds waits in twilight, Going-to-the-Sun Mountain reaches for the first rays of sunlight on a winter morning. Blackfoot once knew this mountain as, Nitai’ Ispi Istuki, or “Lone High Mountain.”



BOOK
REVIEW

Susie Graetz is a
Managing Editor
at the
University of
Montana Press

**GLACIER NATIONAL PARK AFTER DARK:
SUNSET TO SUNRISE IN A BELOVED MONTANA
WILDERNESS**

Photographs and Essays by John Ashley

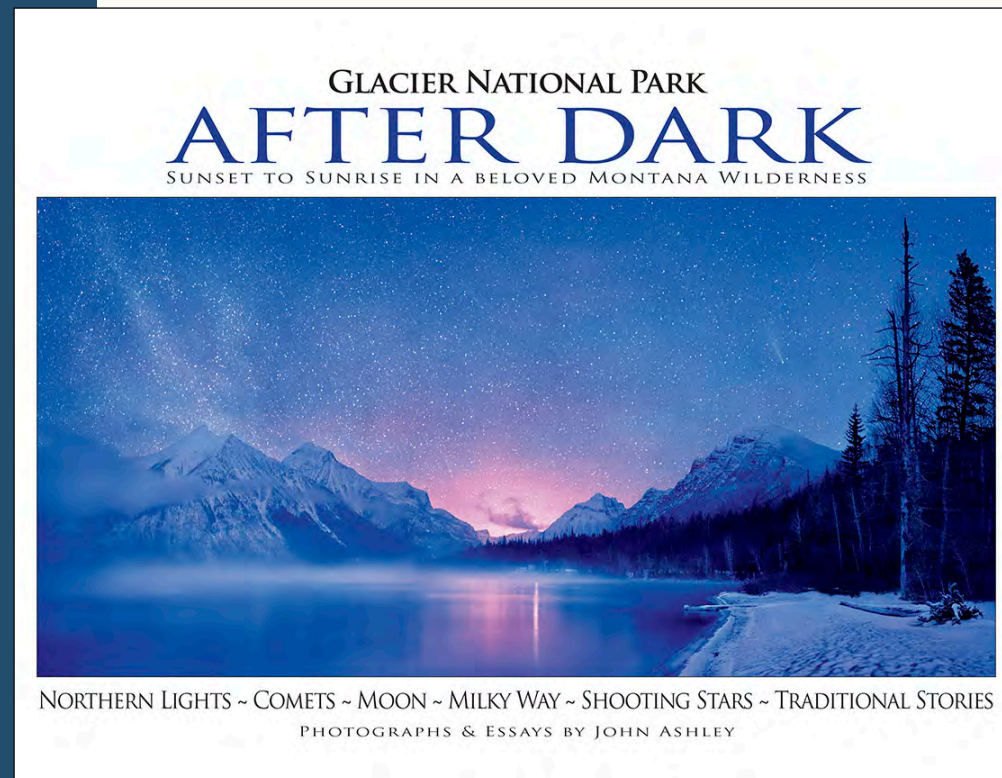
90 pages - 8.5 x 11 - 110 color photos – soft cover - Published by John Ashley Fine Art Photography

Like a beauty queen with a genius-level IQ, this coffee table book is far more than the stunning photo on its cover. If you can tear your eyes away from the 110 color photos long enough to read a passage or two, you will be gifted with an insight into the magic that is created by the stars we and our ancestors have followed since time began. Author and photographer John Ashley is a man of many talents, but the one I find most compelling is his ability to teach complex subjects to the everyday person. Part history, photography how-to, astronomy, guide, Blackfeet story, and encyclopedia book, it reads easy and stays in your mind.

The phases of light, the path of the moon, constellations, planets, meteors, moonbeams, aurora borealis, and alpenglow are interspersed with fascinating stories such as... While the Romans called it the “Milky Way,” to the Greeks it was the “Milky Circle,” but the Blackfeet said it was the “Wolf’s Trail.” When people die, their spirits travel along the Wolf’s Trail to the Sky World, where their campfires sparkle once again at night like so many stars.

In closing, the author leaves us with a solid argument as to the perils of light pollution, not only to all wild creatures, but also to us humans. John is the present-day Paul Revere, warning us in an eloquent way of what we will lose if we continue to artificially light the night sky. He has made a believer out of me.

Reviewed by Susie Graetz



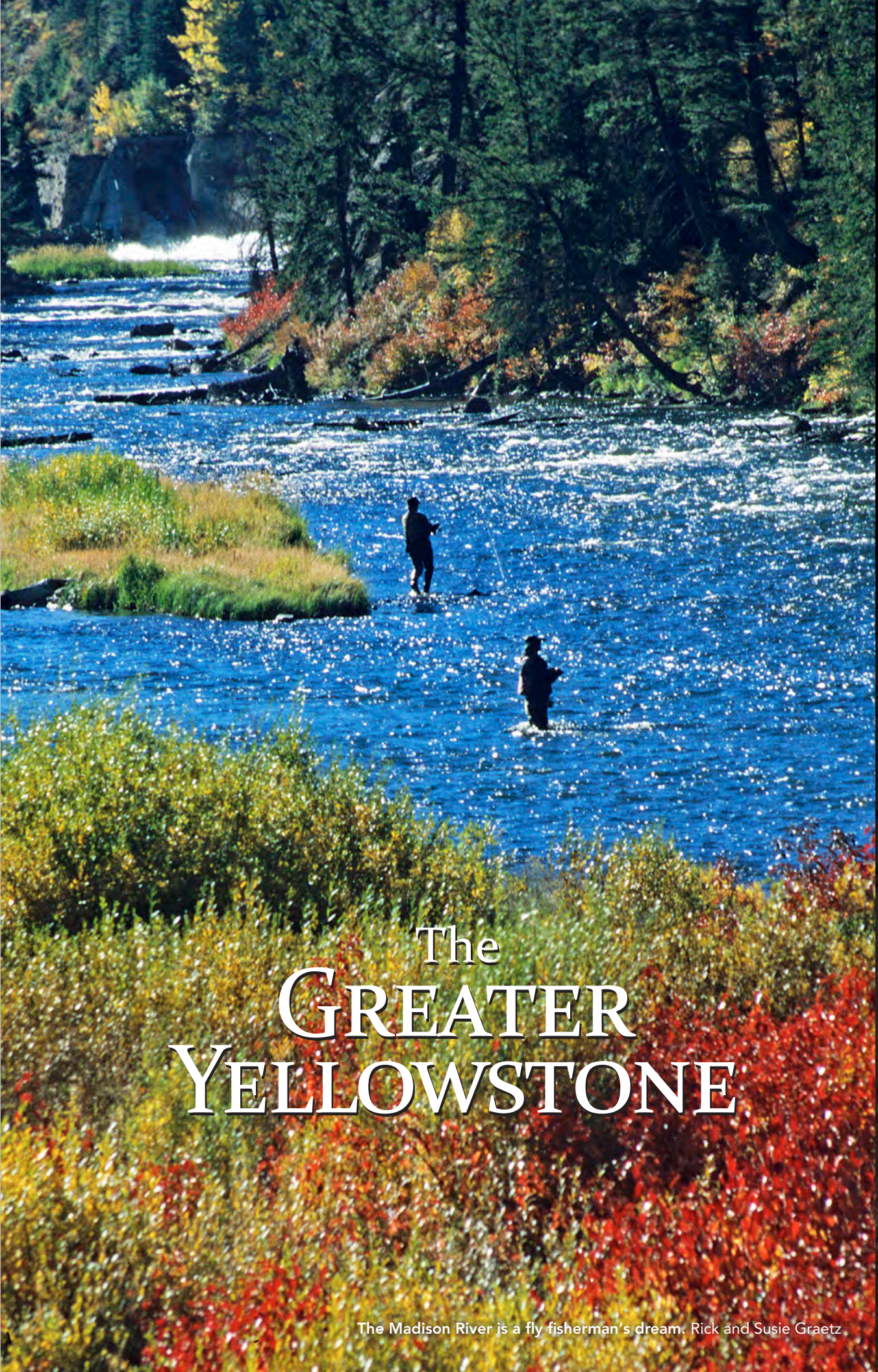


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The GREATER YELLOWSTONE

The Madison River is a fly fisherman's dream. Rick and Susie Graetz



SPRINGS, GEYSERS, AND LEMONADE

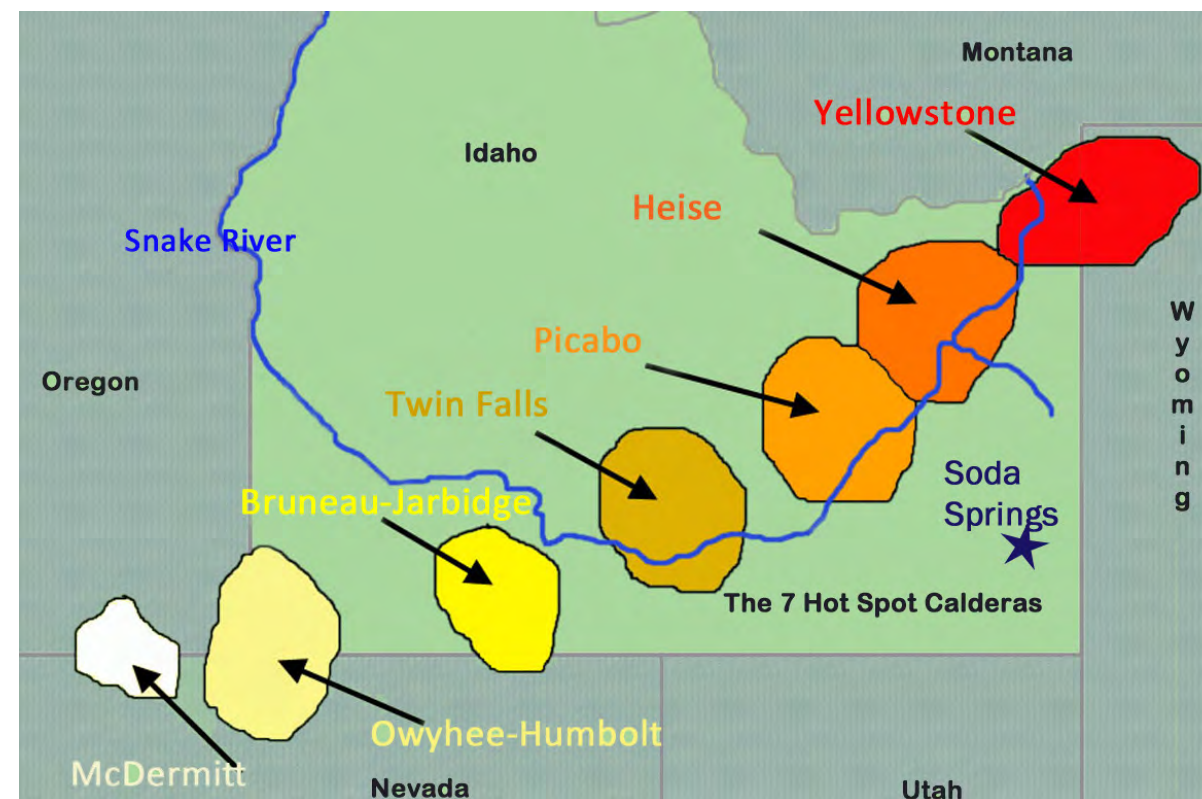
by Ben Wagner

On Memorial Day in 2012, I drove with a Korean classmate to Yellowstone National Park. It was his first visit, as well as mine. He was utterly fascinated. Surprisingly, it did not instill in me any greater sense of wonder or appreciation for natural scenes than I already possessed.

Many people may point to their initial excursions to YNP as the beginning point of a long love affair with the outdoors. Some look back fondly on childhood trips with their families or school groups, recalling things they learned about wildlife and conservation, and the effects these new impressions had on their young minds. I grew up spending many summers in the farther reaches of the Greater Yellowstone Area, especially on the southwestern edge of Caribou National Forest, in Bear Lake County, but I had never been to the park until that day. I wondered, then, where my own feelings of affection for the natural world had come from. Of all the time I have spent wandering the hills and canyons of Southern Idaho, I can point, specifically, to only one experience. I was eight or nine years old, and my grandfather, a resident of Bennington, Idaho, loaded my younger siblings and me into his pickup truck and drove us to Soda Springs, only 20 miles away.

Soda Springs—one-time stop of pioneers on their way to Oregon, now just another town on US Hwy 30, sporting the usual grocery and hardware stores, the car dealership, and a few gas stations—is so named because of the very active system of springs which bubble, full of soda water, right up out of the ground. Located in Caribou County, Soda Springs is situated on the southwestern edge of the well-known Yellowstone hotspot. The hotspot, a chamber of molten rock under YNP, has produced a string of volcanic eruptions and geologic oddities as the North American plate moved across it—at the rate of about 1 inch (2.5 cm) per year.

Some springs in the area produce water fresh and sparkling—Ninety Percent Spring, bottled under the name Idan-Ha, for example, took first prize at the Chicago World's Fair in 1893, and then again in Paris, France in 1900. In contrast, some generate so much hydrogen sulfide and sulfur that passing drivers, overcome by the smell and fearing the worst, have reported chemical leaks to local emergency services. Of the fresher sources, the best known, Hooper Spring, pours water and gas from the ground around the clock, rain or shine, freeze or thaw. Developed as a park, it attempts to appeal to the few tourists who might wander



The seven Hot Spot Calderas.

To a nine-year-old, what can be better than soda-pop from a mysterious source?

through their way west to Pocatello, north to Jackson, or south to meet I-80 near Green River, Wyoming. Depending on the day, or even the hour, the taste ranges from light and somewhat sweet to dense and

metallic—thanks to a great deal of calcium carbonate and magnesium and iron compounds dissolved in it.

As a nine-year-old, swept up with the fascination that bubbling water can come from the ground, I did not notice the unappetizing flavor of the water. Not only was it coming from the ground, but it was drinkable, and when my grandfather added powdered lemonade mix to it, we had homemade soda-pop. To a nine-year-old, what can be better than soda-pop from a mysterious source? I was enthralled. My grandfather, amateur geologist, and ever the teacher, explained that the water coming from deep underground was a result of the mixing of Paleozoic carbonates and hot, acidic water. I strained to understand, but my attention was still fixed on the magical lemonade.

Soon Grandpa loaded us all back into the truck, and we left to make our way to nearby Soda Springs geyser—unlike any other in the Greater Yellowstone Area. It is as regular as Old Faithful, though much smaller, and it sprays water 100 feet in the air, a feat accomplished by only a few in Yellowstone—Old Faithful, Giantess, and Beehive, for example. The unique quality of the Soda Springs geyser, however, is that instead of being pressurized by hot water and steam, it is pressurized by carbon dioxide, and shoots cold water instead of hot. This geyser was an accident. In November 1937, well drillers, in search of a hot spring as a water source for a town swimming pool, picked a spot off of Main Street to try. They began drilling and were surprised to find cold, not hot, carbonated water spraying up from the ground. Eventually, the geyser was capped with a valve, and a timer was added—it now goes off at the top of the hour, every hour—creating what is probably the only accidental, natural, man-made, regularly-timed, cold water carbon dioxide geyser in the world.



Above: Before water could be artificially carbonated, Hooper Springs water was bottled and won the top prize at the 1893 Chicago World's Fair and again in Paris in 1900. Patty Pickett ppphotographs@live.com

Below: Minerals in the Soda Springs water slowly build up and create stone terraces. John R. Nelson



Grandpa pulled up behind the old Enders Hotel, parking farther away than the tourists, whose cars were gathered close around the base of the geyser. We were about 20 minutes too early, torture for us youngsters, but we waited anyway, making and drinking more underground lemonade from water we had brought with us from Hooper Spring. Finally the top of the hour came and the water started spouting. It started off slow, shooting only six or seven feet into the air, but soon the jet rose to its full height, taller than I could ever have imagined. For ten minutes I stood watching the water, wanting to play in it, but knowing that would not be allowed—Grandpa frowned upon soggy seats in the truck. Having had enough of the whole spectacle, my siblings began complaining, asking when it would end, wanting to go home, but I was transfixed. When it finally ended, I noticed the rock surrounding the geyser was the color of rust and sulfur, and asked my grandfather why it was that way. He explained the water had minerals dissolved in it, and that when it landed on the ground, the water evaporated, leaving behind what was left of the dissolved calcium carbonate and iron.

This was the moment! This was when I knew I had witnessed something amazing! I had just seen water, to my eyes clear and clean and pure, creating the rocks upon which I was standing, seemingly from nothing! As we were all climbing back into the truck, I ran back to grab a broken piece of that soft stone to take home with me.

My love of the natural, before vague and undefined, became real and concrete. I began studying geology, enthralled with the idea that natural processes could provide so many resources for people. I learned of obsidian, and its crucial role in the survival of early people in the area. Fossils, too, grabbed my attention, leading me to study plant life and how trees currently living might eventually turn to stone. My love of nature knew no end. My affection has continued unabated to this day, spawned, if not by Yellowstone National Park itself, then certainly by the western edge of the Yellowstone hotspot—source of springs of underground lemonade and bubbling new ideas.

Oh, and the reason my grandfather parked behind the Enders Hotel? The cars close to the geyser had

Soda Springs is the only natural, man-made, cold-water carbon dioxide geyser in the world. Geraldine Curtis

small spots of lime scale, speckled like measles on their hoods and windshields—the price of parking too close to a supersaturated geyser—Grandpa taught me a lot of things.

Ben Wagner is a student at BYU-Idaho studying creative writing. He plans to focus his graduate work on American Indian literature, especially groups inhabiting Eastern Idaho and Western Wyoming and Montana.



Reservoir is super-sized, but no increase in danger

by Lee Siegel

University of Utah seismologists discovered and made images of a reservoir of hot, partly molten rock 12 to 28 miles beneath the Yellowstone supervolcano, and it is 4.4 times larger than the shallower, long-known magma chamber.

The hot rock in the newly discovered, deeper magma reservoir would fill the 1,000-cubic-mile Grand Canyon 11.2 times, while the previously known magma chamber would only fill the Grand Canyon 2.5 times, says postdoctoral researcher Jamie Farrell, a co-author of the study published online today in the journal *Science*.

“For the first time, we have imaged the continuous volcanic plumbing system under Yellowstone,” says first author Hsin-Hua Huang, also a postdoctoral researcher in geology and geophysics. Contrary to popular perception, the magma chamber and magma reservoir are not full of molten rock. Instead, the rock is hot, mostly solid and spongelike, with pockets of molten rock within it. Huang says the new study indicates the



Grand Prismatic hot spring. James Wolman



Firehole River steam vents. John Lambing

upper magma chamber averages about 9 percent molten rock – consistent with earlier estimates of 5 percent to 15 percent melt – and the lower magma reservoir is about 2 percent melt.

No increase in the danger

The researchers emphasize that Yellowstone’s plumbing system is no closer to erupting than before, only that they now have used advanced techniques to make a complete image of the system that carries hot and partly molten rock upward from the top of the Yellowstone hotspot plume – about 40 miles beneath the surface – to the magma reservoir and the magma chamber above it.

“The magma chamber and reservoir are not getting any bigger than they have been, it’s just that we can see them better now,” Farrell says.

Study co-author Fan-Chi Lin, an assistant professor of geology and geophysics, says: “It gives us a better understanding the Yellowstone magmatic system. We

can now use these new models to better estimate the potential seismic and volcanic hazards.”

The researchers point out that the previously known upper magma chamber was the immediate source of three cataclysmic eruptions of the Yellowstone caldera 2 million, 1.2 million and 640,000 years ago, and that isn’t changed by discovery of the underlying magma reservoir that supplies the magma chamber.

“The actual hazard is the same,” says study co-author Robert B. Smith, a research and emeritus professor of geology and geophysics at the University of Utah.

The three supervolcano eruptions at Yellowstone covered much of North America in volcanic ash. A supervolcano eruption today would be cataclysmic, but Smith says the actual chance is 1 in 700,000.

Before the new discovery, researchers had envisioned partly molten rock moving upward from the Yellowstone hotspot plume via a series of vertical and horizontal cracks, known as dikes and sills, or as blobs. They still believe such cracks move hot rock from the plume head to the magma reservoir and from there to the shallow magma chamber.

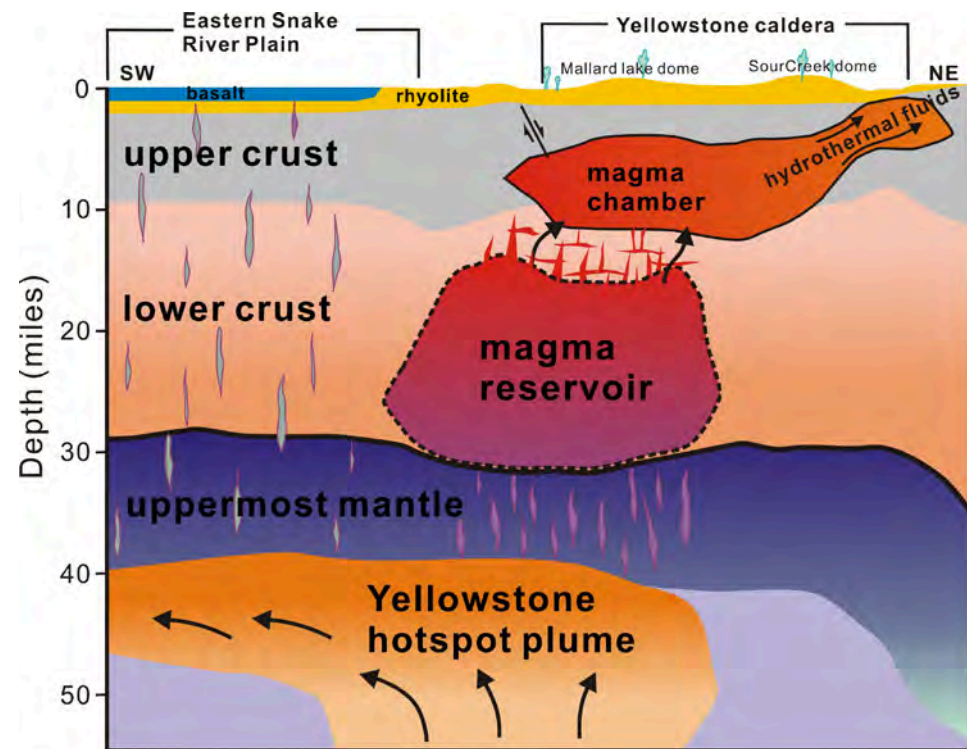
Anatomy of a supervolcano

The study in *Science* is titled, “The Yellowstone magmatic system from the mantle plume to the upper crust.”

Yellowstone is among the world’s largest supervolcanoes, with frequent earthquakes and Earth’s most vigorous continental geothermal system.

The three ancient Yellowstone supervolcano eruptions were only the latest in a series of more than 140 as the North American plate of Earth’s crust and upper mantle moved southwest over the Yellowstone hotspot, starting 17 million years ago at the Oregon-Idaho-Nevada border. The hotspot eruptions progressed northeast before reaching Yellowstone 2 million years ago.

Here is how the new study depicts the Yellowstone system, from bottom to top: Previous research has shown the Yellowstone hotspot plume rises from a depth of at least 440 miles in Earth’s mantle. Some researchers suspect it originates 1,800 miles deep at Earth’s core. The plume rises from the depths northwest of Yellowstone.



The Park's plumbing system is revealed by seismic imaging. Hsin-Hua Huang

The plume conduit is roughly 50 miles wide as it rises through Earth's mantle and then spreads out like a pancake as it hits the uppermost mantle about 40 miles deep. Earlier Utah studies indicated the plume head was 300 miles wide. The new study suggests it may be smaller, but the data aren't good enough to know for sure.

Hot and partly molten rock rises in dikes from the top of the plume at 40 miles depth up to the bottom of the 11,200-cubic mile magma reservoir, about 28 miles deep. The top of this newly discovered blob-shaped magma reservoir is about 12 miles deep, Huang says. The reservoir measures 30 miles northwest to southeast and 44 miles southwest to northeast. "Having this lower magma body resolved the missing link of how the plume connects to the magma chamber in the upper crust," Lin says.

The 2,500-cubic mile upper magma chamber sits beneath Yellowstone's 40-by-25-mile caldera, or giant crater. Farrell says it is shaped like a gigantic frying pan about 3 to 9 miles beneath the surface, with a "handle" rising to the northeast. The chamber is about 19 miles from northwest to southeast and 55 miles southwest to northeast. The handle is the shallowest, long part of the chamber that extends 10 miles northeast of the caldera.

Scientists once thought the shallow magma chamber

was 1,000 cubic miles. But at science meetings and in a published paper this past year, Farrell and Smith showed the chamber was 2.5 times bigger than once thought. That has not changed in the new study.

Discovery of the magma reservoir below the magma chamber solves a longstanding mystery: Why Yellowstone's soil and geothermal features emit more carbon dioxide than can be explained by gases from the magma chamber, Huang says. Farrell says a deeper magma reservoir had been hypothesized because of the excess carbon dioxide, which comes from molten and partly molten rock.

A better, deeper look at Yellowstone

As with past studies that made images of Yellowstone's volcanic plumbing, the new study used seismic imaging, which is somewhat like a medical CT scan but uses earthquake waves instead of X-rays to distinguish rock of various densities. Quake waves go faster through cold rock, and slower through hot and molten rock.

For the new study, Huang developed a technique to combine two kinds of seismic information: Data from local quakes detected in Utah, Idaho, the Teton Range and Yellowstone by the University of Utah Seismograph



Yellowstone National Park mud pot squirt. Rick and Susie Graetz.

Stations and data from more distant quakes detected by the National Science Foundation-funded EarthScope array of seismometers, which was used to map the underground structure of the lower 48 states.

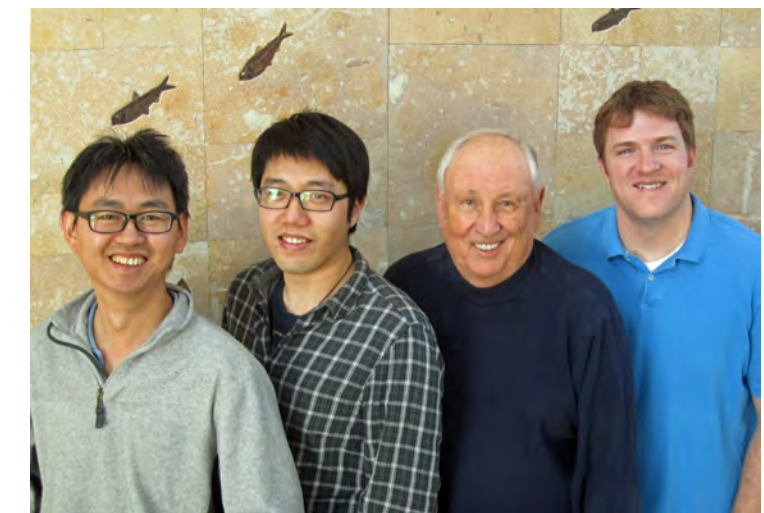
The Utah seismic network has closely spaced seismometers that are better at making images of the shallower crust beneath Yellowstone, while EarthScope's seismometers are better at making images of deeper structures.

Lee J. Siegel is a Professor of Geology and Geophysics at the University of Utah

A National Science Foundation video on the new study is here: <https://vimeo.com/125823038>

Huang, Lin, Farrell and Smith conducted the research with Brandon Schmandt at the University of New Mexico and Victor Tsai at the California Institute of Technology. Funding came from the University of Utah, National Science Foundation, Brinson Foundation and William Carrico.

**This article is reprinted courtesy of the University of Utah.*



Seismologists: Fan Chi-Lin, Hsin-Hua Huang, Robert B. Smith and Jamie Farrell. Lee J. Siegel



Morning light, Hayden Valley and the Yellowstone River. edgeofdayphotography.com

The River Leaves Yellowstone Lake

by Rick and Susie Graetz

Consider this study in contrasts... At the same time a farmer and his sons near Glendive in far eastern Montana are pumping warm irrigation water from a slow paced silt-laden river for their fields, far upstream in the Thorofare Valley a grizzly sow and her cubs are splashing through the Yellowstone River's cold, clear, fast moving water in search of breakfast. While aspen above the riverbanks in the headwaters quake in a cool mountain breeze, big cottonwoods downstream are providing much needed shade for floaters on the river's segment near Savage and the North Dakota border.



LeHardys Rapids. Jim Peaco, NPS

Leaving the vast, enchanting and remarkable Yellowstone Lake, the Yellowstone River resumes its travels, cruising under Fishing Bridge before tumbling through LeHardys Rapids (created by a fault) then holding back as it lazily forms long smooth arcs in the pastoral Hayden Valley, prime grizzly bear and cutthroat trout habitat.

Geologic studies show the Hayden Valley is an ancient lakebed filled with glacial and stream gravel and was probably once part of Yellowstone Lake. The glacial till contains clay that tends to clog the earth's pores and prevent water from seeping deep into the ground. This condition brings about the area's marshy surface and allows for the river's lethargic meanders.

In the Park, widespread thermal activity is found mostly off to the west of the Yellowstone River, but some places along its route exhibit fine examples of the hot water displays that awed the early-day mountain men. Since an ample groundwater supply is needed to create hot springs and geysers, something Hayden is lacking, here, Sulphur Caldron and Mud Volcano—fumaroles and mud pots—flaunt their magic.

Fumaroles occur when the underlying water supply is scarce and what little there is boils away before reaching the surface, the new supply filling the void seeps in slowly, hence steam rises out of the vent instead of a spout of water. Bubbling mud pots are the outcome of the high sulfuric acid contents of the water and vapor leaching underlying rocks, breaking them down to pieces of fine clay and spitting it to the surface.

After flowing out of Hayden Valley, the river's mood changes drastically from unhurried and independent to a dynamic showoff.

As the sleepy Yellowstone River leaves the Hayden Valley, it becomes the centerpiece of one of the most spectacular scenic wonders of Yellowstone National Park, the 20-mile-long Grand Canyon. Here the river puts on perhaps its most striking display. Suddenly squeezed between multicolored rocks and 1,200- to 1,500-foot deeply etched canyon walls, the now roiling water plunges 109 feet over Upper Falls, creating a deafening roar as it then plummets down the often-photographed 308-foot drop of Lower Falls.

To ensure that this amazing presentation has an audience, the Park Service has provided roads to Upper Falls and aptly named viewing spots such as Artists, Grandview and Inspiration points, each providing a different perspective to the thunderous wonder. Artist Point is perhaps the finest overall look at the Lower Falls and the impressive depths of the severe cut the Yellowstone has made through the soft rhyolite lava. Upper Falls, while not giving quite the grandiose performance of its downriver version, represents the start of the deepening canyon.

Brilliant yellow, red and orange hues dominate the ragged walls of the canyon. Over eons of



A mudpot near Sulphur Caldron simmers and swirls. Diane Renkin, YNP



The colorful walls of the Grand Canyon. Rick and Susie Graetz

time, this spectrum of color was created by acid steam and water rising from vents deep inside the earth. This caustic concoction carried the dissolution of minerals from heated stones to the surface and deposited it on the rocks of the canyon—a chemical process that continues today.

The most exhilarating of the vantage points is adjacent to the rim of Lower Falls. The only access to this close-up encounter to the thunderous spillway is via a precipitous footpath down the cliff wall. Back in 1889, someone wanted to install an elevator down the cliff, but the superintendent of the Park wouldn't allow it. Today, in order to experience the power of the Park's highest waterfall, you still have to earn the privilege the old fashioned way by climbing down and up again.

Near the canyon rims, spread out in the timber, are ancient visitors from Montana's Beartooth Range, 45 miles to the north. These enormous granite boulders, looking distinctly out of place in this area of lava flow, were carried over on the back of a glacier during the ice age.

From here, the Grand Canyon of the Yellowstone continues on out of sight of roads and is only visible in places from a trail on its west side, an area few people ever visit. The river passes the steep east slopes of former volcano, 10,243-foot-high Mount Washburn, before widening out about four miles up from Tower Creek's entrance and the road coming from Dunraven Pass. Here, well-defined strata of columnar basalt flows sandwiched between glacial till give the steep faces and cliffs of the canyon the resemblance of a layer cake.

The show is not over yet. After a brief respite in the Tower section, the river once again drops rapidly roiling into the inner depths of



The Yellowstone River near Tower Creek. Rick and Susie Graetz

the exceptionally wild and seldom seen Black Canyon. Floating this stretch is illegal, therefore only adventurous hikers catch a glimpse of this magnificent chasm. As Black Canyon plays out, the Yellowstone reaches the tourist town of Gardiner, Montana, some 2,500 feet lower in elevation than Yellowstone Lake.

Entering Montana

Taking leave of Wyoming and the Park, it now enters human environment, sometimes sparsely inhabited and other times a bit crowded. The wilderness of its birth and the phenomenal natural wonders of the nation's oldest national park that it has been an intricate part of have been left behind, but more adventures, wild country and beauty in view of the river lies ahead.



“
To really understand what the wild flowers are doing, what the scheme of each one is, besides looking beautiful, is to give one a broader sympathy with both man and Nature and to add a real interest and joy to life which cannot be too widely shared.
 ”

Wildflowers Worth Knowing, 1917
 Neltje Blanchan

THE GEOLOGY OF WILDFLOWERS

by Beth Pratt

Nature greets the arrival of spring as enthusiastically as we do, and celebrates with a festival of color. The spectrum of the land rainbow of the wildflower bloom soon banishes the memory of winter’s monotone greys and whites. Even Yellowstone’s subzero temperatures and blinding snowstorms eventually yield to the pink earthy stars of the spring beauties or the first tentative blue-colored buds of the marsh marigold. As Emerson once remarked, “the earth laughs in flowers,” and laughter becomes abundant in Yellowstone as the snowfields retreat and surrender to spring.

The dazzling beauty of wildflowers elicits our admiration, evokes gratitude toward nature for generously sharing with us her loveliest creations. Many an intrepid mountaineer remembers the joy of discovering the vibrant blue sky pilot nestled among the rocks like a colorful gemstone; a fisherman strolling along a stream bank cannot help but halt in his quest for a trout in order to admire the beaming, sunshine-colored petals of the yellow monkeyflower.

We appreciate wildflowers for their handsomeness; we should also appreciate them as chroniclers of time and place. Beyond their aesthetic value, wildflowers also tell a fascinating story, acting as interpreters of the natural world they inhabit. A population of flowers can reveal ancient tales of the landscape dating back millions of years and provide us with lessons in geology, climate, wildlife biology, fire history, and an array of other scientific information.

Yellowstone’s varied terrain gives birth to a diverse array of wildflowers. Thermal features raise heat-loving children; alpine tundra are the proud parents of hardy, small offspring. As wildlife evolve and adapt in concert with their landscape, so, too, do wildflowers. You would no more expect to observe a sky pilot in a foothill meadow than you would presume to encounter a bison grazing at the top of a 12,000-foot peak. A rose by any

other name may smell as sweet, but an evening primrose transported from a dry, open site to a shaded, boggy meadow would not live long enough to transmit its fragrant scent.

GEOLOGIC ORIGINS

The epic story of Yellowstone’s wildflowers begins not with a tiny, germinating seed, but with the gigantic shifting of the earth’s crust over the eons. To discover their geologic ancestors, to determine why the delicate alpine forget-me-not thrives on the slopes of Mount Washburn, or why Ross’s bentgrass lives near thermal sites on the Firehole River, one must leave present day and journey back 80 million years to the Cretaceous era.

Sir Joseph Dalton Hooker, director of Royal Botanic Gardens, 1865-1885 affirms, “Of all the branches of botany there is none whose elucidation demands so much preparatory study or so extensive an acquaintance with plants and their affinities as that of their geographic distribution.”



Yellowstone’s turbulent geologic past shaped a varied landscape, where a series of transformations cumulated in the ecological system that

supports the wildflowers we admire today. As Don Despain, author of *Yellowstone Vegetation* states, “Present vegetation is the result of past climatic forces.” His book accordingly divides Yellowstone into five geologic-climatic provinces, characterized by bedrock and soil type and the microclimate of each area. The gradual formation of these provinces occurred over millions of years, and each region’s distinct geologic genetics produces very different plant types, just as the genes of parents contribute to the eye or hair color of their children.

Over 90 million years ago, a visitor to Yellowstone would have gazed upon ocean waters and coastal swamps, felt a sticky humid breeze on their skin, and observed palm and fig trees growing on low

Opposite: **Glacier lily**. Neal Herbert, YNP
 Above: **Buckwheat**. Neal Herbert, YNP



Top: **Yellowstone sand verbena.** Jennifer Whipple, NPS
 Middle: **Yellow monkey flower.** NPS
 Bottom: **White marsh marigold.** NPS

hills. Approximately 80 million years ago marked the beginning of a major geologic event that significantly altered Yellowstone's topography—the Laramide orogeny (orogeny is the Greek term for “mountain generating”). Through a series of geologic pulses throughout the next 30 million years, the Rocky Mountains slowly climbed out of the sea. The coast of the Pacific Ocean retreated to the Oregon/Idaho border, and since no mountains existed between the coast and Yellowstone at that time, the park retained a maritime-like climate.

When the Cascade Range emerged at the edge of the Miocene and Pliocene and limited the transfer of ocean moisture to the area, tropical species vanished; coniferous forests appeared; and Yellowstone's climate assumed characteristics similar to modern day: cool-temperate to subarctic. With freezing temperatures possible every month in the year and snow accounting for a large portion of the precipitation, the growing season for most of Yellowstone is brief—June through August. Additionally, the majority of Yellowstone's terrain derives its moisture source from the melting snowpack and spring precipitation, not from summer rains—another factor shortening the growing season.

As a result, the park's wildflowers experience a botanical spring fever, knowing the days of plentiful sunshine and water are in short supply. Some of Yellowstone's wildflowers attest to the truth of the Chinese proverb—“spring is sooner recognized by plants than men.”

Even before winter has fully retreated, the impatient marsh marigold (*caltha leptosepala*) emerges from hibernation, seeking sunshine by extending its blue-tinted buds through the melting snowbanks, and blossoming into showy white flowers within 48 hours. Montana's state flower, bitterroot lewisia (*Lewisia rediviva*) also appears ready for spring. As the snow recedes, the fleshy leaves sprout excitedly from the ground, followed shortly by delicate rose-pink flowers.

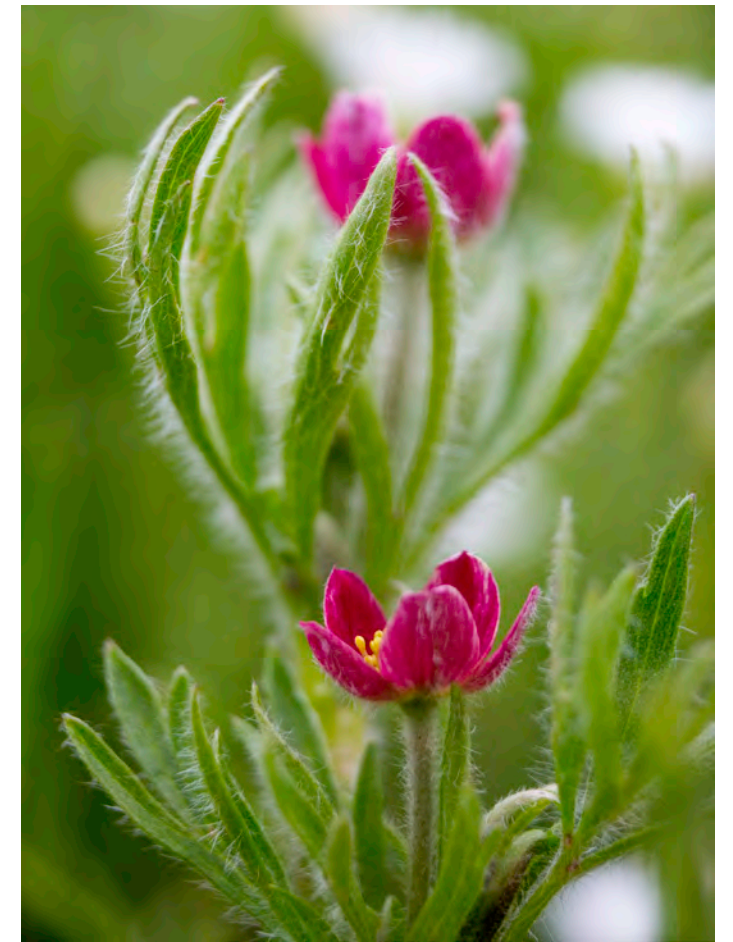
Along with geologic uplift, a series of volcanic events built Yellowstone's foundation with two primary materials: rhyolitic and andesitic. Most of the younger rhyolite bedrock in the central part of the park formed between 2 million and 76,000 years ago, while segments of andesite bedrock in the rest of Yellowstone cooled and hardened 70 to 80 million years ago.



Shooting stars. Neal Herbert, YNP

As Despain notes, “Soils that developed in the two distinct rock types differ in mineral nutrient content and water-holding capacity, both factors of primary importance to plants.” Andesitic soils, because of the higher nutrient content of calcium, magnesium, and iron, and enhanced moisture-retaining capabilities, provide better growing conditions for plants.

In Yellowstone, a very general rule of thumb can be employed for bedrock and soil identification: If you are standing in a large, open meadow filled with wildflowers, it's a safe bet the andesitic bedrock beneath your feet may have formed when dinosaurs walked the earth. A continuously forested area, on the other hand, usually



Cut-leaved anemone. Neal Herbert, YNP

indicates a rhyolite base with thin, nutrient-poor soils. As with any rule, exceptions do occur. The exceptions to the bedrock-soil relationship result from another geologic force: glaciation.

Imagine an ancient wind riding across the smooth surfaces of the icecaps and glaciers covering the Yellowstone landscape. Underneath the vast weight of the ice and glaciers, rock has been crushed into a soft, light soil called loess. Water running beneath the ice transports the soil into riverbeds, where, once dry, the loess meets the wind and travels above its creators to rest near or far from its place of birth.

Loess may help boost nutrient and water content in rhyolite-based soils and create more favorable growing conditions for plants in areas where rhyolitic bedrock exists. Similarly, although Hayden and Pelican valleys are located on rhyolitic plateaus, sediments from an extended Yellowstone Lake during glacial periods have boosted soil conditions and produced an environment more favorable for plants and wildflowers. Today, a visitor watching the wind ring the silent blossoms of yellowbells in Hayden Valley is benefiting from the patient handiwork of glaciers during the last ice age.

GEOTHERMAL INFLUENCES

Perhaps the geologic force most unique to Yellowstone in shaping wildflower habitat is its geothermal activity. The steaming spray of geysers or the boiling water of hot springs tourists marvel at when visiting the park don't appear readily hospitable to plant life. In addition to the high temperatures (an average of 199°F), the waters of the thermal features can be extremely acidic or alkaline. Yet geothermal activity in Yellowstone has created mini-habitats and microclimates that enable a selection of species, some more typically found in tropical or temperate environments, to exist and even thrive.

Thermal features act as natural heating systems for plants both above and below ground—shielding them against winter's severe temperatures and accelerating the melting of the surrounding snow cover. Additionally, substances dissolved from the water flowing from thermal activity can also impact plant communities by creating soils rich in alkali or other substances. Protection from winter's chill and enhanced nutrients come at a price, however, as inhabitants of thermal



Sego lily. Diane Renkin, YNP

Prickly pear cactus. Neal Herbert, YNP



communities must always be vigilant. Rapidly changing conditions in geothermal areas can quickly destroy any residents.

One wildflower influenced by the park's thermal activity is the Yellowstone sand verbena (*Abronia ammophila*)—a flower found nowhere else on earth. The plant's dainty, creamy to greenish-yellow blossoms decorate the shores of Yellowstone Lake from mid-June to early September—an unusually long blooming period in the park. Botanists know little about the plant's biology (such as how it pollinates or how long the seeds survive), but as its name suggests, this exceptional wildflower prefers sandy soils.

ADEPT AT ADAPTING

Another wildflower endemic to Yellowstone, Ross's bentgrass (*Agrostis rossiae*), braves winter's chill with the help of its thermal home and blooms in purple-hued spikelets as early as January. For the species to thrive, thermal activity must create natural greenhouse conditions with an average of 100°F within an inch of the surface under the plant. The geothermal heat, which provides an advantage in the winter, becomes a liability in the summer months, and most plants have dried out and died by July. The bentgrass also has the assistance of another of Yellowstone's famous features—its mega fauna (large animals)—which assist with seed dispersal. Visitors can look for Ross's bentgrass while exploring the geyser basins near the Firehole River or Shoshone Lake.

The yellow monkeyflower (*Mimulus guttatus*) has developed an interesting adaptation for life near hot springs. In thermal areas, the plant changes costume from winter to summer, donning the practical dress necessary for its seasonal role. During the winter, the stems assume a short stature and sprout leaves that remain close to the pocket of warm air near the ground. Once spring and summer arrive, the monkeyflower transforms itself into a confident character and produces an abundance of "grinning" yellow blossoms. As its genus name *mimulus* is derived from the Latin term for actor, its role changing adaptation seems especially appropriate.

Yellowstone's landscape is not static. As one of the largest active hotspots on earth, its geologic underpinnings continually transform the region in the



Top: Western blue-eyed grass. Neal Herbert, YNP
Bottom: Indian paint brush. Neal Herbert, YNP



Bitterroot. Neal Herbert, YNP

“ Nature, in her slow and patient way, is still developing her flower children. ”

Edith Clements, *Wildflowers of the West*, 1927

same hotspot track as Yellowstone and as such has been termed the park’s “geologic prelude.” The monument resembles a moonscape; its craggy terrain is filled with almost every variety of basaltic lava from volcanic activity that ended only 2,000 years from present day. Yet among the moisture-deprived and windswept lava fields, and despite poor soil conditions and temperatures exceeding 150°F, stalwart wildflowers like the bitterroot and monkeyflower still brighten the landscape with their colorful smiles.

Beth Pratt is the California Director for the National Wildlife Federation and has worked in environmental leadership roles for over 20 years, and in two of the country’s largest national parks: Yosemite and Yellowstone. Her upcoming book, *When Mountain Lions are Neighbors: Wildlife in Today’s California*, will be published in early 2016.

**This article has been reprinted courtesy of the Yellowstone Association’s Discovery publication.*



Mountain bluebell. Neal Herbert, YNP

form of earthquakes, volcanoes, geothermal activity, and other processes.

Robert Smith and Lee Siegel, in their book *Windows into the Earth*, characterize the greater Yellowstone area as a “geoecosystem” to demonstrate the dependence of flora and fauna on the underlying geology. Geologic change—whether gradually over millions of years or abruptly in hours or days—continually alters Yellowstone’s ecological system. Natural processes, such as fire and drought, along with environmental threats such as climate change, pollution, and exotic species encroachment, can cause still further disruptions.

Whatever the resulting change, wildflowers will continue to provide nature’s laughter in Yellowstone. Even if the much-debated super volcano erupts, wildflowers will eventually adapt to the new landscape, rising like small phoenixes from the ashes, and with a fascinating geologic story to tell their admirers of the future.

For proof of the tenacity of plant life, one can travel about 200 miles southwest of Yellowstone to Craters of the Moon National Monument and Preserve. Craters of the Moon inhabits the





Bark Beetles Are Decimating Our Forests. That Might Actually Be a Good Thing.

They gobble up trees and send politicians into a frenzy. But do the bugs know more about climate change than we do?

by Maddie Oatman

There is an eerie feel to this grove of lodgepole pines that I can't quite put my finger on as entomologist Diana Six tromps ahead of me, hatchet in hand, scanning the southwestern Montana woods for her target. But as she digs the blade into a towering trunk, it finally hits me: the smell. There's no scent of pine needles, no sharp, minty note wafting through the brisk fall air.

Six hacks away hunks of bark until she reveals an inner layer riddled with wormy passageways. "Hey, looky!" she exclaims, poking at a small black form. "Are you dead? Yeah, you're dead." She extends her hand, holding a tiny oval, maybe a quarter of an inch long. Scientists often compare this insect to a grain of rice, but Six prefers mouse dropping: "Beetle in one hand, mouse turd in another. You can't tell them apart." She turns to the next few trees in search of more traces. Pill-size holes pock their ashen trunks—a sign, along with the missing pine scent, of a forest reeling from an invasion.

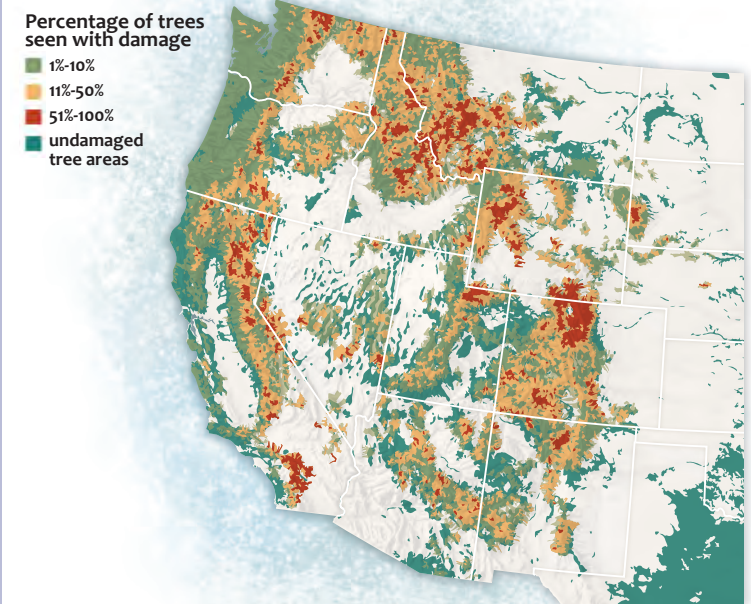
Beetles are chewing their way through American forests, sometimes felling as many as 100,000 trees a day.

These tiny winged beetles have long been culling sickly trees in North American forests. But in recent years, they've been working overtime. Prolonged droughts and shorter winters have spurred bark beetles to kill billions of trees in what's likely the largest forest insect outbreak ever recorded, about 10 times the size of past eruptions. "A doubling would have been remarkable," Six says. "Ten times screams that something is really going wrong."

Mountain pine, spruce, piñon ips, and other kinds of bark beetles have chomped 46 million of the country's 850 million acres of forested land, from the Yukon down the spine of the Rocky Mountains all the way to Mexico. Yellowstone's grizzly bears have run out of pinecones to eat because of the beetles. Skiers and backpackers have watched their brushy green playgrounds fade as trees fall down, sometimes at a rate of 100,000 trunks a day. Real estate agents have seen home prices plummet from "viewshed contamination" in areas ransacked by the bugs. And the devastation isn't likely to let up anytime soon. As climate change warms the North American woods, we can expect these bugs to continue to proliferate and thrive in higher elevations—meaning more beetles in the coming century, preying on bigger chunks of the country.

BEETLEMANIA

From 2000 to 2014, bark beetles destroyed large swaths of forests in the American West—and they're not done yet.



Source US Forest Service. Illustration by Karen Minot.

In hopes of staving off complete catastrophe, the United States Forest Service, which oversees 80 percent of the country's woodlands, has launched a beetle offensive, chopping down trees to prevent future infestations. The USFS believes this strategy reduces trees' competition for resources, allowing the few that remain to better resist invading bugs. This theory just so happens to also benefit loggers, who are more than willing to help thin the forests. Politicians, too, have jumped on board, often on behalf of the timber industry: More than 50 bills introduced since 2001 in Congress proposed increasing timber harvests in part to help deal with beetle outbreaks.

But Six believes that the blitz on the bugs could backfire in a big way. For starters, she says, cutting trees "quite often removes more trees than the beetles would"—effectively outbeetling the beetles. But more importantly, intriguing evidence suggests that the bugs might be on the forest's side. Six and other scientists are beginning to wonder: What if the insects that have wrought this devastation actually know more than we do about adapting to a changing climate?

A BUG'S LIFE

An adult mountain pine beetle lays her eggs under the bark. On her way, she disperses fungi that turn the trees' tissue into food for her babies, eventually killing the tree.

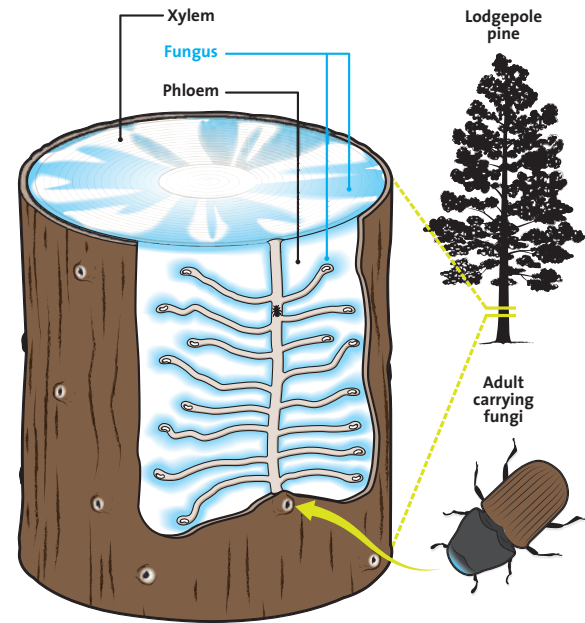


Illustration by Chris Philpot

THOUGH THEY'RE OFTEN described as pesky invaders, bark beetles have been a key part of conifer ecosystems for ages, ensuring that groves don't get overcrowded. When a female mountain pine beetle locates a frail tree, she emits a chemical signal to her friends, who swarm to her by the hundreds. Together they chew through the bark until they reach the phloem, a cushy resinous layer between the outer bark and the sapwood that carries sugars through the tree. There, they lay their eggs in tunnels, and eventually a new generation of beetles hatches, grows up, and flies away. But before they do, the mature beetles also spread a special fungus in the center of the trunk. And that's where things get really interesting.

Six focuses on the "evolutionary marriage" of beetle and fungi at her four-person lab at the University of Montana, where she is the chair of the department of ecosystems and conservation sciences. Structures in bark beetles' mouths have evolved to carry certain types

of fungi that convert the tree's tissue into nutrients for the bug. The fungi have "figured out how to hail the beetle that will get them to the center of the tree," Six says. "It's like getting a taxi." The fungi leave blue-gray streaks in the trees they kill; "blue-stain pine" has become a specialty product, used to make everything from cabins to coffins to iPod cases.

A healthy tree can usually beat back invading beetles by deploying chemical defenses and flooding them out with sticky resin. But just as dehydration makes humans weaker, heat and drought impede a tree's ability to fight back—less water means less resin. In some areas of the Rocky Mountain West, the mid-2000s was the driest, hottest stretch in 800 years. From 2000 to 2012, bark beetles killed enough trees to cover the entire state of Colorado. "Insects reflect their environment," explains renowned entomologist Ken Raffa—they serve as a barometer of vast changes taking place in an ecosystem.



Under the microscope, Diana Six picks up a dead mountain pine beetle in her Missoula lab. Shawn Gust

Typically, beetle swells subside when they either run out of trees or when long, cold winters freeze them off (though some larvae typically survive, since they produce antifreeze that can keep them safe down to 30 below). But in warm weather the bugs thrive. In 2008, a team of biologists at the University of Colorado observed pine beetles flying and attacking trees in June, a month earlier than previously recorded. With warmer

springs, the beetle flight season had doubled, meaning they could mature and lay eggs—and then their babies could mature and lay eggs—all within one summer.

That's not the only big change. Even as the mountain pine beetles run out of lodgepole pines to devour in the United States, in 2011 the insects made their first jump into a new species of tree, the jack pine, in Alberta. "Those trees don't have evolved defenses," Six says, "and they're not fighting back." The ability to invade a new species means the insects could begin a trek east across Canada's boreal forest, then head south into the jack, red, and white pines of Minnesota and the Great Lakes region, and on to the woods of the East Coast. Similarly, last year, the reddish-black spruce beetle infested five times as many acres in Colorado as it did in 2009. And in the last decade, scientists spotted the southern pine beetle north of the Mason-Dixon Line for the first time on record, in New Jersey and later on Long Island. As investigative journalist Andrew Nikiforuk put it in his 2011 book on the outbreaks, we now belong to the "empire of the beetle."

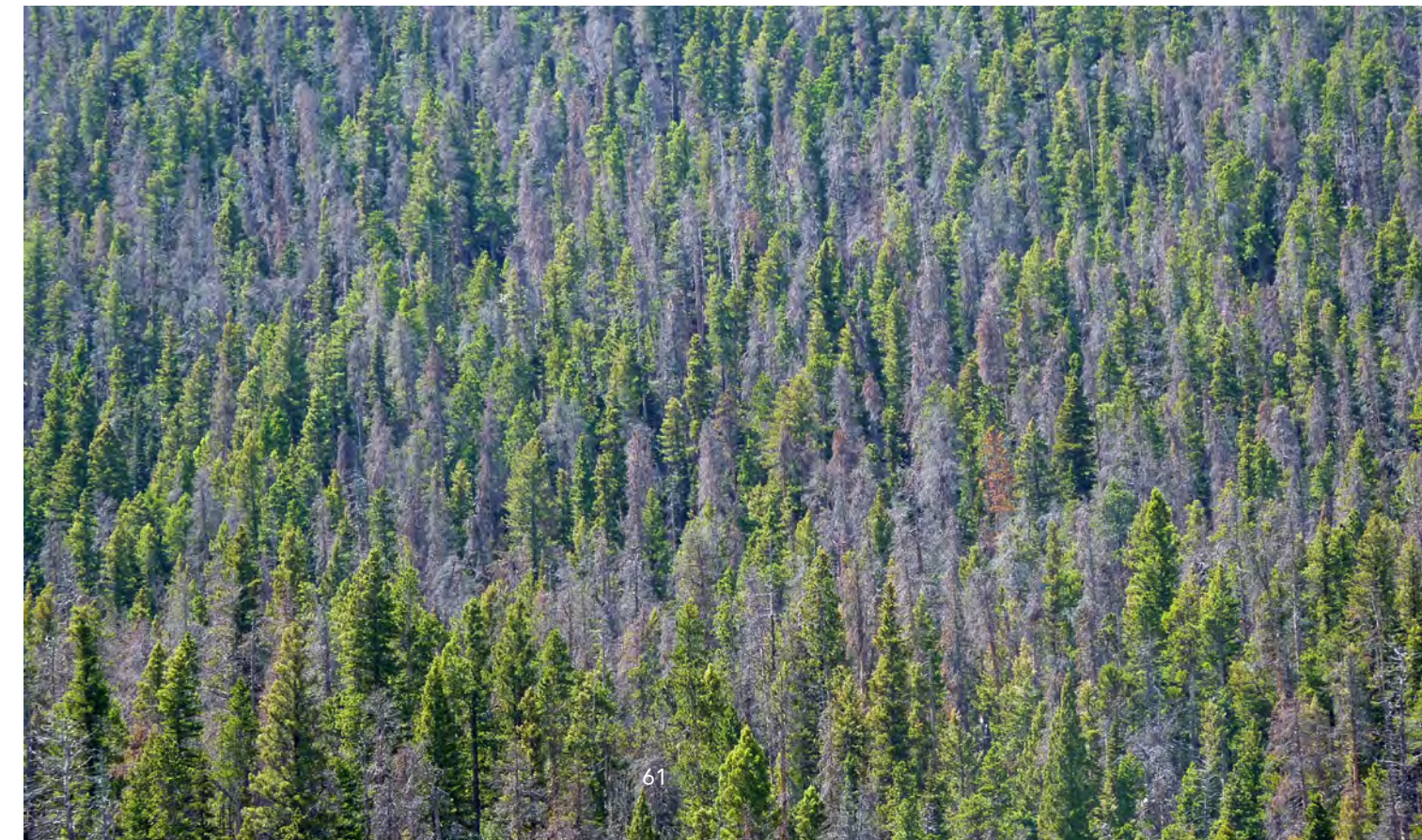
IN A WEIRD WAY, all of this is exciting news for Six, who is one of the world's foremost experts in beetle-fungi symbiosis. In college, classes in microbiology and

integrated pest management led to a master's degree in veterinary entomology, then a Ph.D. in entomology and mycology and a postdoc in chemical ecology, focused on insect pheromones. And as several fellow researchers stress to me, she is the rare scientist who's also a powerful communicator. "I think about what it means to be a tree," she told a rapt audience at a TEDx talk about global forest die-offs. "Trees can't walk. Trees can't run. Trees can't hide," she continued, her sonorous voice pausing carefully for emphasis. "And that means, when an enemy like the mountain pine beetle shows up, they have no choice but to stand their ground."

To a tree hugger, that might seem a grim prognosis: Since trees can't escape, they'll all eventually be devoured by insects, until we have no forests left. Especially since, with our current climate projections, we might be headed toward a world in which beetle blooms do not subside easily and instead continue to spread through new terrain.

But Six has a different way of looking at the trees' plight: as a battle for survival, with the army of beetles as a helper. She found compelling evidence of this after stumbling across the work of Forest Service researcher Constance Millar, with whom she had crossed paths at beetle conferences.

Beetle-killed forest. Laura Bojanowski



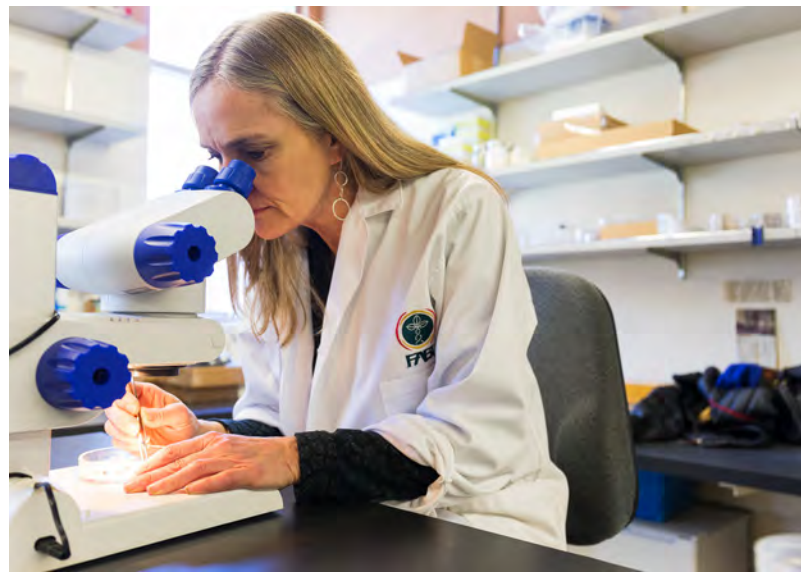
Millar was comparing tree core measurements of limber pines, a slight species found in the eastern Sierras of California that can live to be 1,000 years old. After mountain pine beetles ravaged one of her study sites in the late 1980s, certain trees survived. They were all around the same size and age as the surrounding trees that the beetles tore through, so Millar looked closer at tree ring records and began to suspect that, though they looked identical on the outside, the stand in fact had contained two genetically distinct groups of trees. One group had fared well during the 1800s, when the globe was still in the Little Ice Age and average temperatures were cooler. But this group weakened during the warmer 1900s, and grew more slowly as a result. Meanwhile, the second group seemed better suited for the warmer climate, and started to grow faster.

When beetle populations exploded in the 1980s, this second group mounted a much more successful battle against the bugs. After surviving the epidemic, this group of trees “ratcheted forward rapidly,” Millar explains. When an outbreak flared up in the mid-2000s, the bugs failed to infiltrate any of the survivor trees in the stand. The beetles had helped pare down the trees that had adapted to the Little Ice Age, leaving behind the ones better suited to hotter weather. Millar found similar patterns in whitebark pines and thinks it’s possible that this type of beetle-assisted natural selection is going on in different types of trees all over the country.

When Six read Millar’s studies, she was floored. Was it possible, she wondered, that we’ve been going about beetle management all wrong? “It just hit me,” she says. “There is something amazing happening here.”

LAST YEAR, SIX AND ERIC BIBER, a University of California-Berkeley law professor, published a provocative review paper in the journal *Forests* that challenged the Forest Service’s beetle-busting strategies. After scrutinizing every study about beetle control that they could get their hands on, they concluded that “even after millions of dollars and massive efforts, suppression...has never effectively been achieved, and, at best, the rate of mortality of trees was reduced only marginally.”

Six points to a stand of lodgepoles in the University



Diana Six in her lab at the University of Montana. Shawn Gust

of Montana’s Lubrecht Experimental Forest. In the early 2000s, school foresters preened the trees, spacing them out at even distances, and hung signs to note how this would prevent beetle outbreaks. This “prethinned” block was “the pride and joy of the experimental forest,” Six remembers. But that stand was the first to get hit by encroaching pine beetles, which took out every last tree. She approached the university forest managers. “I said, ‘Boy, you need to document that,’” Six says. “They didn’t. They just cut it down. Now there’s just a field of stumps.”

For the timber industry and its friends, beetle invasions have been a handy excuse to open wild areas for logging.

Six and Biber’s paper came as a direct affront to some Forest Service researchers, one of whom told me that he believes changing forest structure through thinning is the only long-term solution to the beetle problem. Politicians tend to agree—and beetle suppression sometimes serves as a convenient excuse: “It is perhaps no accident that the beetle treatments most aggressively pushed for in the political landscape allow for logging activities that provide revenue and jobs for the commercial timber industry,” Six and Biber wrote.

Take the Restoring Healthy Forests for Healthy Communities Act, proposed in 2013 by then-Rep. Doc Hastings (R-Wash.) and championed by then-Rep. Steve Daines (R-Mont.). The bill sought to designate “Revenue Areas” in every national forest where, to help address

insect infestations, loggers would be required to clear a certain number of trees every year. Loggers could gain access to roadless areas, wilderness study areas, and other conservation sites, and once designated, their acreage could never be reduced. The zones would also be excluded from the standard environmental-review process.

Six and other scientists vehemently opposed these massive timber harvests—as did environmental advocates like the Sierra Club and Defenders of Wildlife, the latter warning that the harvests would take logging to “unprecedented and unsustainable levels.” The bill passed the House but died in the Senate last year. But Daines, now a senator and one of 2014’s top 10 recipients of timber money, vows to renew the effort so as to “revitalize Montana’s timber industry” and “protect the environment for future generations.”

THIS SUMMER, SIX PLANS to start examining the genes of “supertrees”—those that survive beetle onslaughts—in stands of whitebarks in Montana’s Big Hole Valley. Her findings could help inform a new kind of forest management guided by a deeper understanding of tree genes—one that beetles have had for millennia.

If we pay close enough attention, someday we may be able to learn how to think like they do. University of California-Davis plant sciences professor David Neale champions a new discipline called “landscape genomics.” At his lab in Davis, Neale operates a machine that grinds up a tree’s needles and spits out its DNA code. This technology is already being used for fruit tree breeding

and planting, but Neale says it could one day be used in wild forests. “As a person, you can take your DNA and have it analyzed, and they can tell you your relative risk to some disease,” Neale says. “I’m proposing to do the same thing with a tree: I can estimate the relative risk to a change in temperature, change in moisture, introduction to a pathogen.”

Right now, foresters prune woodlands based on the size of trees’ trunks and density of their stands. If we knew more about trees’ genetic differences, Neale says, “maybe we would thin the ones that have the highest relative risks.” This application is still years off, but Neale has already assembled a group of Forest Service officials who want to learn more about landscape genomics.

Six, meanwhile, places her faith in the beetles. Whereas traditional foresters worry that failing to step in now could destroy America’s forests, Six points to nature’s resilience. Asked at TEDx how she wants to change the world, she responded, “I don’t want to change the world. We have changed the world to a point that it is barely recognizable. I think it’s time to stop thinking change and try to hold on to what beauty and function remains.”

Maddie Oatman is the research editor at Mother Jones. She’s also written for Outside, the Bay Citizen, and the Rumpus, and is a 2013 Middlebury Fellow in Environmental Journalism.

**This article has been reprinted courtesy of Mother Jones.*

Signs of beetle invasion on a whitebark pine tree in Montana’s Big Hole Valley. Maddie Oatman



BLACKFOOT REDEMPTION A Blood Indian's Story Of Murder, Confinement, And Imperfect Justice

by William Farr

312 pages – 6 X 9 - soft and hard cover -
published by the University of Oklahoma
Press

The late Lakota anthropologist Dr. Beta Medicine lamented that scholars rarely write about “ordinary” native people and she hoped one day their lives would garner interest. *Blackfoot Redemption* is one of those rare stories of the “random ordinary life” of a blood (or Kainai) Indian named Spopee, or Turtle, who was convicted of murdering a white man in 1879 in Montana Territory and, in an odd turn of events, was confined to an insane asylum in Washington, DC, where he languished for over 30 years before he was “discovered” by his own countrymen. In what could have been written as a tragic true-crime novella, William Farr instead vividly re-creates a story of “language, place, and time” in turn-of-the-century Montana.

Spopee's story is pieced together from a great variety of sources, primarily government documents and newspaper reports, but Farr was unable to utilize an oral history of Spopee because none existed. Spopee could not speak or understand English, and the reliance on translators and interpreters for his murder trial and subsequent incarceration drastically limited his ability to communicate. The use of English as a tool of subjugation and racism plays a key role in Farr's story. Adding to this difficulty, Spopee, frustrated or tired, stopped talking altogether.

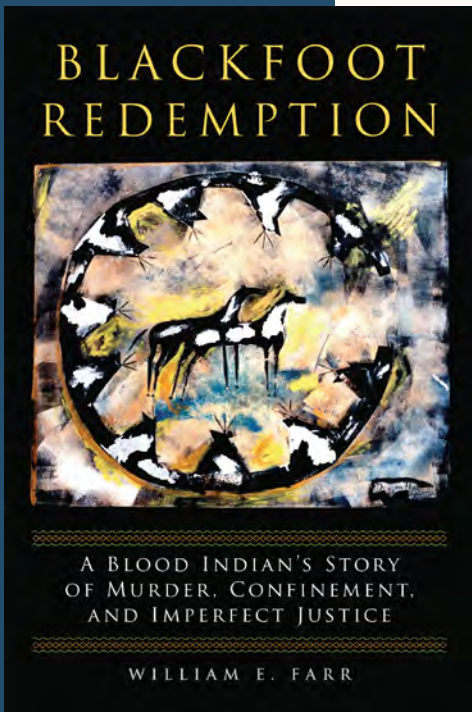
Montana Territory and the Northern Great Plains in 1879 were enduring a devastating shift. Bison, the keystone to both the culture and the economy of the region, were nearly destroyed. Farr's storytelling skills illuminate this place for his readers. He also reconstructs the budding governmental and judicial systems of a territory that was soon to be a state. The days of frontier justice were fast disappearing. This is where Farr's story of Spopee becomes complicated--what exactly happened on the prairies? Was it murder? We may never know. But Farr illustrates how changing places, times, and laws also changed ideas about justice within the emerging place called Montana.

The most dramatic time in Blackfeet history was perhaps the turn of the last century, from the 1880s to the 1920s, when the tribe transitioned from a nomadic lifestyle to a sedentary one on the reservation. Farr describes this tragic process by comparing Spopee's confinement and inability to communicate to the entire tribe's situation. Farr explores the idea that the Blackfeet were living in a “parallel confinement.” Similar to Spopee, the Blackfeet tribe was confined to their reservation, which they could not leave without written permission, and they also suffered under the colonizing power of an English-speaking authority with which they had limited ability to communicate.

William Farr's elegant telling of Spopee's life is more than what Dr. Medicine would have hoped for. *Blackfoot Redemption* is not a biography; as Farr states, “in its essence it was not an Indian story, not a Blackfeet story.” Instead, it is a story of “language, place, and time” that gracefully and poetically explains how history impacts the life of one “ordinary” Indian.

The author, William E. Farr, is a Senior Fellow at the O'Connor Center for the Rocky Mountain West and Professor Emeritus of History at the University of Montana.

Reviewed by Rosalyn LaPier



Rosalyn R. LaPier
is an Environmental
Studies professor at the
University of Montana

ROADSIDE GEOLOGY OF YELLOWSTONE COUNTRY Second Edition

by William Fritz and Robert C. Thomas

311 pages - 6 X 9 - soft cover - published by
Mountain Press Publishing Company

I am convinced that, at its best, science is simple – that the simplest arrangement of facts that sets forth the truth best deserves the term scientific. So the geology I plead for is that which states facts in plain words - in language understood by the many rather than by the few.

George Otis Smith, 1921, Director U.S.
Geological Survey 1907 – 1930

These words serve as a lead into the second edition of *Roadside Geology of Yellowstone Country*. Authors William Fritz and Robert Thomas took note and followed Smith's plea.

Unlike Glacier and the Teton national parks, the majesty of Yellowstone Country doesn't show itself at the moment of first glimpse. Far more than scenery and wildlife, it takes an understanding of why this treasure chest of science is such a magnificent place. Unlike other roadside guides, this volume goes well beyond what the traveler might see at a quick glance. Each route followed is more of a well-written chapter rather than a mile-by-mile portrayal.

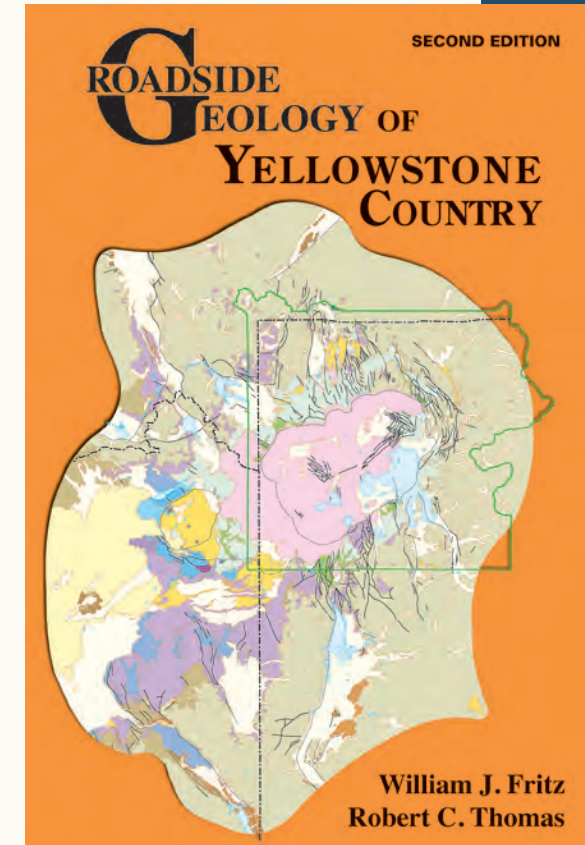
In 311 pages, through words, photographs and illustrations—there are plenty of well-done visuals—the authors tell the story of what Yellowstone is all about. And the discussion isn't limited to the national park. The make up of the roads leading to the park from the north, west and east, and the geography that surrounds them is well explained.

Earthquakes, petrified forests, glaciation, mountain building, how geysers and other geothermal features work are part of this

book's content. For those who desire to gain more knowledge, near the conclusion of the work, a thorough glossary, followed by a listing of hundreds of outside reading sources is provided.

In my view, Yellowstone smells of science and is a textbook without a page missing. *Roadside Geology of Yellowstone Country* brings this concept to life in “public speak.” I use it for Greater Yellowstone related field courses I teach at the University of Montana.

Reviewed by Rick Graetz



Rick Graetz
is a Geography professor
at the University of
Montana



NO LONGER A DEEP DARK SECRET

by Kayde Kaiser

Within the vast and rugged terrain of the Bob Marshall Wilderness, lies the deepest cave in the continental United States. Discovered only recently, the limestone Tears of the Turtle cave is currently measured at a whopping 1,629 feet from the bottom to the top, and since it hasn't completely been explored, climbers suspect it may likely be deeper. It was in 2006, when longtime explorers and avid spelunkers, Jason Ballensky and Hans Bodenhamer along with two others found the opening. But it took eight long years to map and get to today's depth.

The remoteness of the entry—it's a 21-mile, 2-day trek into the wilderness—and the necessity of carrying equipment and supply packs weighing in excess of 100 pounds may have been a factor in the delayed discovery of the cave. In addition to Tears of the Turtle, other incredibly deep caves have been found nearby. Virgil the Turtle's Greathouse Cave, which was discovered first and has been measured at 1,586 feet, wins second prize for the deepest limestone cave.

Kayde Kaiser is the editor of the This Is Montana newspaper column.

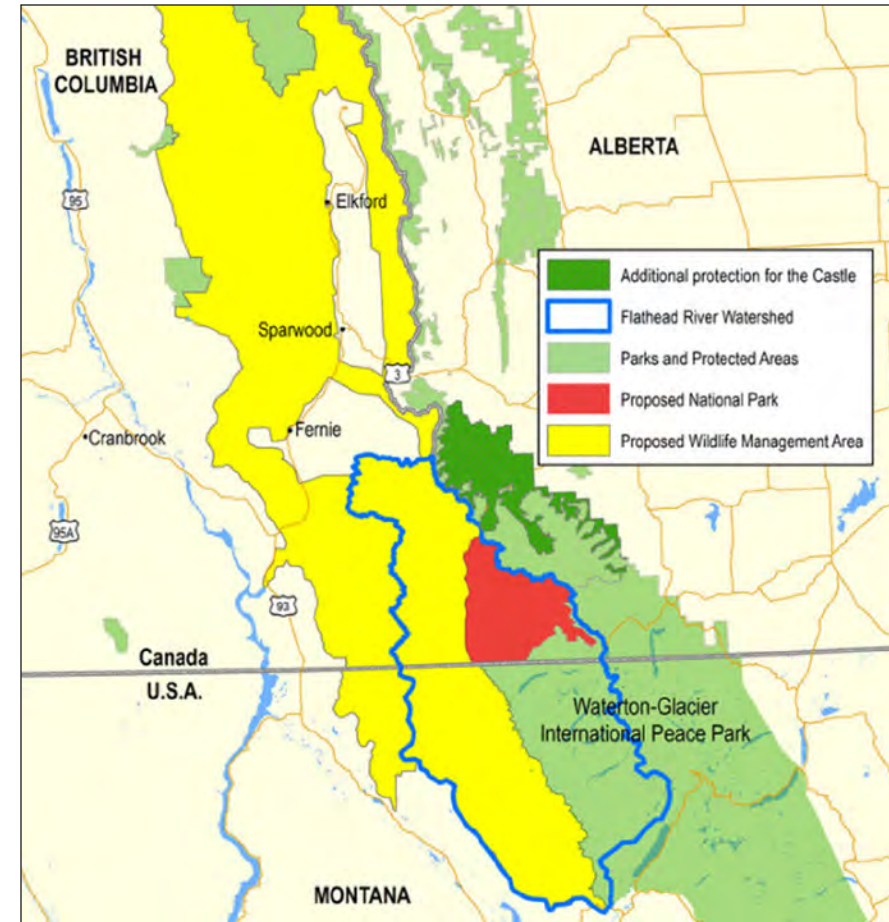
ALBERTA ANNOUNCES NEW PARKS IN CASTLE WILDERNESS

by Harvey Locke

Conservationists rejoiced as Shannon Phillips, Alberta's Minister of Environment and Parks, announced the province's new government would create two parks totaling a quarter of a million acres in the mountainous Castle area. It marked the turning point in a 40-year effort to protect this spectacular and biologically diverse area that is adjacent to Waterton-Glacier International Peace Park just north of the Canada-US border.

Located in the narrowest waist of the Rocky Mountains, the Castle has long been identified as an important priority for conservation because of its rich natural values and as an important international priority due to its key location in the Yellowstone to Yukon corridor. The Castle is a continental ecotone, where species from the north, south, east and west meet to make it the most biologically diverse area of Alberta. Particularly rich in plants, it is also a major part of the headwaters of the Oldman River, which is important to many downstream users on the dry Canadian Prairie before it eventually flows into Hudson's Bay.

Heavy logging, oil and gas development, off road vehicle use and random trailer camping threatened to overwhelm the area's value as secure habitat for grizzly bears, bull trout, bighorn sheep and mountain goats. It suffered under



The two new Parks in Alberta's Castle adjoin Waterton -Glacier International Peace Park in Alberta and Montana. The Flathead Valley in British Columbia and Montana is outlined in blue. Map courtesy of Flathead Wild.

a management policy that sought to provide all things to all people in a finite and fragile space. Previous conservation-oriented management designations in the Castle had left out valley bottoms and low elevation wintering range.

Nature knows no borders. The Castle area's north/south valleys feed out of the wildlife sanctuary of Waterton-Glacier International Peace Park and also funnel wildlife north toward Banff National Park. This will be increasingly important as climate change causes species to want to move north or upslope in search of cooler places to live.

The Alberta Government's

decision to protect 1050 square kilometers of the Castle with two new parks is a major step towards protecting the integrity of nature across this international landscape. Transboundary conservation of this kind is essential to maintaining habitat security and connectivity for wildlife at the Yellowstone to Yukon scale.

Harvey Locke is a conservationist, writer, and photographer, and for the past 22 years has been a strategic advisor to the Yellowstone to Yukon Conservation Initiative

**This article has been reprinted courtesy of the Y2Y Conservation News*

GILL NETTING UPDATE ON YELLOWSTONE LAKE

by Mike Koshmrl

Biologists are making their first use of electroshock in their efforts to save native cutthroat trout in Yellowstone National Park from another voracious species of trout.

The electroshock treatment is being done to kill off lake trout that have invaded Yellowstone Lake when the unwanted fish is still spawning and in the earliest stages of its life. Adult lake trout in Yellowstone can top 30 pounds, living almost exclusively on a diet of cutthroat trout, according to researchers. Cutthroat were historically a vital food for bears each spring, and their decline has worried park officials.

Until now, netting of lake trout has been the park's main method of suppression for the past decade. But new tactics being employed this fall by crews headed by park fisheries supervisor Todd Koel target the non-native fish in their spawning beds. "The two tools that we used are still prototypes," Koel said. "One of them is electroshocking and the other is a placer gold mining suction dredge system." That means park officials are



attempting to electrocute lake trout eggs and are also trying to suck them out of cobble below Yellowstone Lake.

In places where biologists tried the suction method over already-electrified spawning beds, most of the thousands of eggs and fry captured were dead, he said. Where the electricity had not yet been applied, the spawn were mostly alive.

After declining to a fraction of historic levels, the cutthroat appear to be bouncing back. US Geological Survey research biologist

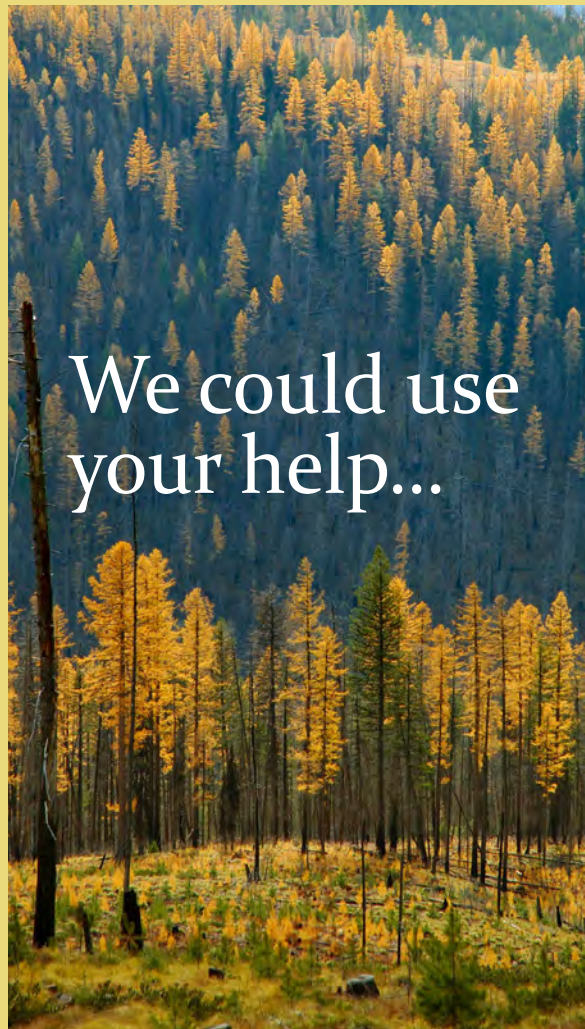
Bob Gresswell said, "Cutthroat are becoming more abundant, they were getting caught by anglers off the shore."

Someday, Gresswell said, spawning bed treatments may be an integral part of the attempt to hold lake trout at low levels. But biologists believe eradicating lake trout from the 136-square-mile lake is impossible. "Gill netting won't go away," Gresswell said. "It'll be part of the scene, but within five years or so I think you'll see it cut back to a spring and fall activity.

If it proves effective, spawning treatment will "slowly, incrementally" become part of the lake trout suppression effort, Gresswell said.

Mike Koshmrl is an environmental/federal reporter at Jackson Hole News & Guide

**This article has been reprinted courtesy of the Jackson Hole (Wyo.) News And Guide jhnewsandguide.com*



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Rick and Susie Graetz

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The editors—Rick Graetz, Susie Graetz, and Jerry Fetz



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