JIM PEACO/NATIONAL PARK SERVICE

When wildfires raged through more than a million acres of a beloved national park, the destruction seemed complete. But a UW researcher looked closer — and found hope growing among the remains.

By Jill Sakai PhD'06

JEFF HENRY/NATIONAL PARK SERVICE

RISING FROM THE ASHES

Monica Turner was not sure what to expect as she boarded a helicopter in Yellowstone National Park. After months of planning, she had come to Wyoming with hopes of studying the ecology of the park's pristine wilderness. But that was before the fires. Now the park was ablaze, grappling with its largest fires ever, and her intended research subject was going up in smoke.

That 1988 "summer of fire" made Yellowstone history. Early blazes, sparked in June by a combination of lightning and human activities, burned for several weeks without raising much concern. As the summer got hotter and drier, though, the situation quickly turned. In July, "we had active fires spread, but nothing that we hadn't previously experienced," recalls Roy Renkin, a Yellowstone biologist. "But then, here came August. … Then things started to really pick up and go."

Fueled by drought conditions and raging winds that topped sixty miles per hour, the fires began to sweep through the park. As the flames blazed out of control, they consumed the beauty of this symbol of the rugged American West and threatened the iconic Old Faithful geyser. The extent and ferocity of the fires — surprising even to park managers and scientists — riveted the public. Fiery images dominated television sets and headlines across the nation with a horrifying message: the crown jewel of America's National Park System was in trouble.

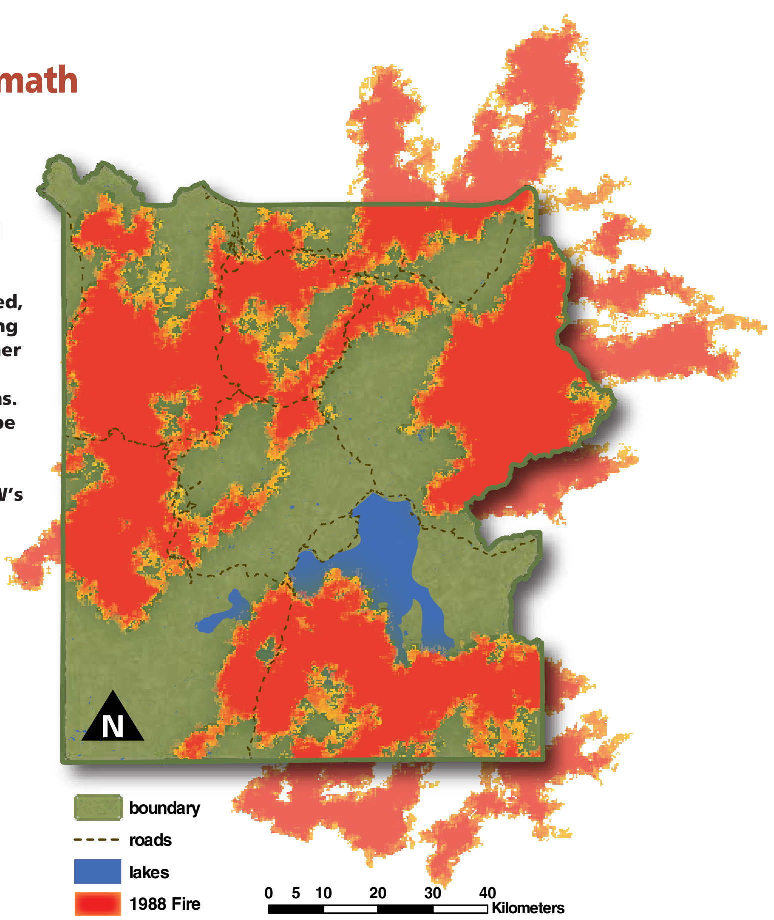
Defying all attempts to curtail its spread, the inferno raged for months, forcing temporary park closures and launching the nation's single largest firefighting effort, which drew more than twenty-five thousand firefighters from across the country. A reporter for the *Washington Post* likened the sights and sounds in the Yellowstone basin to a war zone in Vietnam. Before fizzling under a mid-September snowstorm, the record-breaking fires engulfed more than 1.2 million acres in the greater Yellowstone area, comprising more than one-third of the park. Lingering flames would smolder into November.

Arriving in Yellowstone in October 1988, Turner, today on the UW faculty, and her colleague Bill Romme, a forest ecologist now at Colorado State University, steeled themselves for their first look at the remains of the park. But as the copter lifted them over the charred landscape, they were immediately taken by the presence of lush, green islands dotting the sea of black. Even in the areas most severely affected by the flames, large chunks of the forest appeared virtually untouched.

That variegation of black and green, burned and unburned, was exactly what Turner was looking for. A pioneer in the burgeoning field of landscape ecology, she had spent several years studying the relationships between a region's physical features and its ecosystems — the workings of a forest on a ridge versus in a valley, for example, or the ecological impacts of being near a road or stream. The complex patterns of damage left by the vast 1988 burns offered an unprecedented opportunity to study how such variation might affect the landscape's recovery.

In the twenty years since these historic fires, research undertaken by Turner — now a zoology professor and the Eugene P. Odum Professor of Ecology — has grown and developed along with the recovering forest, each reshaped and redefined in unpredicted ways by the fires. Guided by her unflagging curiosity and a keen eye for the unexpected, she has provided the first insights into how a large ecosystem responds to such a major event and unearthed the answers to dozens of ecological questions — many of which no one else had even thought to ask.

The Aftermath



Nearly one-third of Yellowstone National Park, shown here in red, was ablaze during the 1988 "summer of fire," which raged for months. It left a landscape ripe for study by researchers, including the UW's Monica Turner.

A Bleak Beginning

In the early aftermath of the fires, the ground-level view of Yellowstone was of a black-and-white world. Many burned areas were stripped of every sign of life.

Turner and Romme began working in the park in summer of 1989 under challenging conditions. With no funding, they recruited volunteer labor. Friends, former students, and family members pitched in when they could. Even Turner's mother spent her two weeks of vacation in the park measuring burned trees. The forest was dusty and brutally hot, with the sun's heat radiating from the black ground and the black trees, and no shade in sight. "It was like being in an oven," Turner says. "You would come out of working in the field looking like a chimney sweep — just black, everywhere."

Despite the land's desolate appearance, they scoured it to see what — if anything — would grow back. Their persistence was rewarded as bits of green appeared among the ashes. Beneath the forest's blackened facade, the fire had penetrated less than an inch into the soil and left surviving roots, rhizomes, and seeds. Other plants reseeded from unburned forest patches. Initial sprouts emerged in 1989, followed by an incredible profusion of wildflowers in 1990. By 1991, seedlings of native plants had taken hold throughout the burn region.

"We didn't expect the ground vegetation [to return] as quickly as it did. I think we were as influenced by how it looked visually in 1988 as everybody else was," says Turner.

Just as quickly, however, they noticed that the growing plants were not appearing uniformly throughout the burned regions — especially the seedlings of lodgepole pine, the dominant tree species in the park. "We had areas where you could walk hundreds of meters trying to find a seedling of a tree, and other places where if you put your foot down, you squashed fifty of them," Turner remembers. "That's ecologically a huge range."

The researchers traced the differences to the prevalence of a trait called "cone serotiny." Lodgepole pine trees produce one of two different cone types, one that opens to scatter seeds as soon as it matures and another — called serotinous — that is coated with a thick resin that seals seeds inside until melted open by the heat of a fire. Turner and her colleagues had just discovered that trees bearing serotinous cones were unevenly spread throughout the forest, which meant that regions that looked identical before the fires could regrow in very different ways. "It was a bit of serendipity," Turner says. "We had no idea that the presence of that trait would vary so much spatially across the landscape."

COURTESY OF MONICA TURNER

Monica Turner, now a UW zoology professor, began her twenty-year study of Yellowstone National Park when the park's 1988 fire left complex patterns of damage — and a rare chance to explore the ecological impact over time.

Turner and her colleagues had stumbled onto the first of what would become many ecological surprises in Yellowstone. They were beginning to realize just how much scientists had yet to learn about basic forest processes and their response to fire.

Reshaping the Land

The fires also acted as a creative force, reshaping the Yellowstone wilderness and setting the stage for nature's own rebirth and healing processes. As Turner watched this "natural experiment" at work, new research questions arose as quickly as the sprouting plants. Undaunted when these questions ranged into scientific fields beyond her expertise — entomology, botany, soil chemistry — she has assembled an impressive array of collaborators from the UW and across the continent.

> Turner's two-decade connection to the park has also given her team the perspective of time as it charts the forest's recovery.

"She excels at getting the right team of people together to address complex questions about landscapes," says Phil Townsend, a UW-Madison associate professor of forest and wildlife ecology and Turner's colleague. "She's really the glue that holds them together."

This interdisciplinary approach has generated studies spanning all levels of the Yellowstone forest ecosystem, from tiny microbes in the soil to tree seedlings and from bark beetles to browsing elk. The researchers' identification of unfamiliar green shoots as aspen seedlings turned on its head the prevailing dogma that Rocky Mountain aspen reproduce only from existing roots. The thick carpets of pine seedlings guided studies on plant growth and nutrient cycling, helping them identify a critical role of soil bacteria in priming the ground for new trees.

Turner's two-decade connection to the park has also given her team the perspective of time as it charts the forest's recovery. One of her former graduate students, Dan Kashian PhD'02, was intrigued by the differences between regions of sparse and crowded young pine trees. "What's going to happen to these patches of seedlings as they grow up?" asks Kashian, now an assistant professor at Wayne State University. While conducting his dissertation research in the park, he reconstructed past examples of similar types of regional variation and found that fire-forged patterns have a lasting footprint.

With "a series of fires like the ones in 1988, obviously they shape the landscape today," he says. "But they'll probably leave their mark for at least two hundred years."

Let it Burn?

The 1988 burn nearly left a similar mark on the park's fire management policy, sparking an intense nationwide debate about the natural fire management plan implemented in Yellowstone in the early 1970s. Many critics blamed the severity and extent of the 1988 fires on this so-called "let it burn" policy, which dictated allowing most naturally started fires to run their course without intervention.

"That whole programmatic [let-it-be] approach could have been shut down from the highest levels of government," says park service biologist Renkin, who has been involved with Yellowstone's fire program for thirty years. "They could have reverted back to policies that were implemented early in the 1900s."

But they didn't. In fact, Turner says, fire is a natural and vital step in this forest lifecycle and fires like those in 1988 — though the largest to date in the park's 136-year history — are not unusual in the context of the ecosystem. "This type of severe, large fire is the natural fire regime in Yellowstone," she says. "The forests have burned in this way since the Pleistocene — so for the past ten thousand years — in intervals of one hundred to four hundred years or so."

She also suggests that earlier suppression attempts in 1988 probably would not have changed the outcome. "There's a relatively narrow window where you can effectively suppress fires," she says. "This was well beyond that."

The work of people like Turner helped uphold the hands-off approach for the Greater Yellowstone area. "I think the educational component of the fires of '88 was a positive influence on society and really resulted in a lot of people's curiosity," Renkin says. "It really heightened their awareness and understanding of fire ecology."

In addition, Turner and her colleagues determined that the 1988 conflagration was a product of extreme climate conditions. "In 1988 it was so dry — it was the driest summer ever recorded there — winds of sixty miles an hour, and the fuels were burning so intensely, it didn't matter if there was a lot of fuel or a little fuel. It didn't matter if the forest was young or old, it didn't matter if there was a road in the way, it didn't matter if the Grand Canyon [of the Yellowstone] was in the way. The fires just blew across the canyon," she says. "They were really a weather, climate-driven phenomenon, and that's true for this type of system."

The role of climate in this fire regime lends urgency to Yellowstone fire research. Other scientists have recently linked rising temperatures and earlier spring snowmelts to more frequent intense fires, suggesting that severe conflagrations may become more common as the world warms. Turner has already compared many of her findings from the 1988 fires against more recent, smaller Yellowstone burns.

"From what we learned in 1988, can we predict what happened in this burn in 2000?" she asks. "And how well does our knowledge transfer — what things are the same, what things are different, and why?"

Such work "contributes greatly to a fundamental understanding of how these systems work, and that is important because it helps feed into making management decisions," says Renkin. Not all ecosystems respond to fire in the same way, he emphasizes, and "what works or is prescribed in one area may not fit to be prescribed in another area."

Fire management remains an active issue. In 2006, Turner presented a summary of the role of fire in different forest ecosystems at a briefing on Capitol Hill. Renkin hopes that fire policy will continue to be guided by science. In resource management, he says, often "there's no ecological rationale for implementing a particular treatment, especially at the landscape level. ... [But] management activities can fit and dovetail with ecological considerations."

> "The fires of Yellowstone … provided opportunities to study things at scales that ecologists simply hadn't worked at before."

Seeing the Big Picture

Yellowstone's forests have provided a relatively simple ecosystem for tackling big questions, with only a few major trees and animals in the mix, but the past twenty years have shown that even relative simplicity can be unexpectedly complex. By establishing ways to approach landscape-level questions, Turner's studies have valuable applications far beyond forest fires.

"So many of the questions that we face in ecology and the environmental sciences are about phenomena that occur over a large area, whether it's changing land-use patterns or climate change," she says. Her approaches can be generalized to ask similar questions about ecosystem impacts and recovery following other large and infrequent disturbances, such as floods, hurricanes, or even volcanic eruptions. "The fires of Yellowstone … provided opportunities to study things at scales that ecologists simply hadn't worked at before," she says.

With her Yellowstone work, Turner has also established an impressive legacy in the field of landscape ecology, offering the first glimpse into how a major disturbance like fire shapes an ecosystem over space and time. In recognition of her tremendous contributions to a growing field, Turner was elected in 2004 to the National Academy of Sciences — one of the highest honors available to an American scientist.

With UW-Madison collaborators Phil Townsend and Ken Raffa, Turner is now studying the interplay of wildfires and the Yellowstone forest's other major natural disturbance: bark beetles. Trees damaged or killed by beetle outbreaks were long thought to be more susceptible to future fires. "For years, people just assumed that if you had a bark beetle outbreak, that meant a fire was almost certain to happen," says Raffa, an entomology professor and expert on the insect. "Monica's work and the work of her collaborators have shown that it's a lot more complicated than that — there's a lot more heterogeneity in the response due to the landscape, due to weather, due to a variety of factors."

The complexity of this interaction has called into question the common practice of salvage logging damaged trees. "After fire or after insects, the trees are killed, but the wood is still sound," Turner says. "It sometimes is argued that by harvesting the wood, you'll reduce the likelihood of a subsequent disturbance, but there are very few data on that."

She and her students are now exploring the management side of forestry and ecosystems, with ongoing projects investigating salvage logging in the national forest areas near Yellowstone's boundary.

"There's a mismatch between public perception of these interactions and the evidence," explains Jake Griffin PhDx'09, one of Turner's graduate students. Working at a landscape level is critical to help resolve such differences, he says, because it allows researchers and resource managers to operate on similar scales. For policies, "from a management and conservation perspective, anything that crosses ecosystem boundaries has a better chance of being sustainable," agrees fellow graduate student Martin Simard PhDx'09.

The need to study landscapes as a whole emphasizes the value of Yellowstone and other protected wilderness areas as irreplaceable natural laboratories. "Most of Yellowstone is very wilderness-like in character and hasn't been very strongly affected by management," Turner says. "Those [properties] give us the opportunity to understand the baseline conditions of how our ecosystems are responding — even to big drivers like global climate change — in the absence of the much more intensive modifications that characterize so much of our landscapes.

"We learn a lot about the mechanisms of nature without our intervention. How does it work? How does it recover from events like this? How does that help us manage landscapes where we do have more of an impact? And what does that mean for the future?"

Twenty years is just a blink of an eye for a dynamic forest ecosystem, and rising global temperatures are likely to affect Yellowstone's recovery and future patterns in ways yet to be discovered. "Fire frequency is likely to increase, not only in Yellowstone, but throughout the West," Turner says. "Long-term studies like ours may help us understand what we can expect in the future."

Even after two decades of working in the park, Turner doesn't look like she'll be slowing down anytime soon. For every question she answers, another springs forth — like new life emerging from Yellowstone's ashes.

Jill Sakai reports on UW-Madison research as a writer for University Communications.

Nature's Rx for Recovery

Yellowstone National Park's 1988 "summer of fire" set in motion a natural cycle of regrowth and renewal that has kept Monica Turner busy for twenty years. Her studies of post-fire recovery have touched on all levels of the forest ecosystem, from the soil to the treetops. Here are a few of her notable discoveries.

Elk

Yellowstone's large animal populations, mostly unharmed by the fires, adjusted quickly to life in the recovering forest. Turner's group found that elk seem to frequent the young stands of trees springing up in burned areas, despite the dense growth and fallen logs that make maneuvering difficult. The researchers think that the thick vegetation and obstacles may provide protection from wolves.

Ground cover

The Yellowstone fires traveled quickly through the canopy of the forest, consuming pine needles and small branches but leaving trunks and larger branches merely scorched. Logs that were down prior to the fire were charred, but did not burn through, Turner says, having little impact on the flames' severity. The soil burned only shallowly, leaving many surviving roots and seeds.

Life returned quickly to the blackened forest, with green sprouts appearing among the ashes the next spring, followed by carpets of wildflowers. Despite worries that invasive species would infiltrate the forest, Turner and her colleagues found that native plant communities returned and out-competed the few invaders.

"We were really surprised that the system — without any intervention from us — recovered very quickly. It's much more resilient than anyone expected," Turner says.

Pine trees

As the fires swept through the park, they released the seeds of a new generation of lodgepole pines, the predominant tree in the Yellowstone forest. Some lodgepoles produce serotinous cones, which were sealed shut with resin until melted open by the intense heat of a fire. Turner and her collaborators found that trees bearing these fire-adapted cones are spread unevenly through the forest, varying with the frequency of past burns. In essence, she says, the trees have adapted based on historic patterns of forest fires. "I think the public expected we'd have to go into the park and plant trees or grow grass [after the 1988 fire]," Turner says. "But the fact is, we don't have to fix it."

JEFF HENRY (ELK), JIM PEACO (GROUND COVER), ANN DEUTCH (PINE TREES)/NATIONAL PARK SERVICE