Western Confluence

Issue 10

NATURAL RESOURCE SCIENCE AND MANAGEMENT IN THE WEST

INVASIVE SPECIES

Mussels

Cheatgrass

Mountain Goats

Sportfish

Bees

A publication of the William D. Ruckelshaus Institute at the University of Wyoming's Haub School of Environment and Natural Resources

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Western Confluence magazine shares on-the-ground, science-based stories about the interdisciplinary, collaborative solutions to our toughest natural resource challenges.

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EDITOR'S NOTE

By Emilene Ostlind

John M. Randall, The Nature Conservancy, Bugwood.org

Cheatgrass in the American West.

Tens of thousands of invasive species—from cheatgrass, blights, and tamarisk to hogs, fire ants, and boa constrictors—damage natural ecosystems, agricultural systems, human-built infrastructure, and even public health throughout the United States, costing billions of dollars each year. The National Invasive Species Council calls invasives "one of the most significant threats to ecosystems, human and animal health, infrastructure, the economy, and cultural resources," and Hawaii Governor David Ige, leading a Western Governors' Association initiative on invasive species, emphasized that they "pose a significant threat to the western experience." In the American West, invasive species present some of the biggest and most complex environment and natural resources challenges we face today. Addressing them requires not only huge investments of money and human capacity but also creative thinking and innovative approaches.

We hope this issue of *Western Confluence* will contribute to that endeavor. While we can't explore every invasive species and proposed solution, we have curated a mix of stories that paints a picture of the problem's scale, touches on both plants and animals as well as terrestrial and aquatic species, and most importantly shares examples of cutting edge research and approaches.

In many cases, control efforts focus specifically on getting rid of the invaders, whether that means spraying every last patch of a new invasive annual grass, treating a hot spring to kill all the exotic fish, or transporting every last mountain goat out of a mountain range. But as Tessa Wittman writes in her piece about resilience in native plants, we "will never get rid of the last cheatgrass seed." One of the take-aways from these articles is that many invasive species have become permanent additions to the systems they now occupy.

Where eradication is out of reach, managers are shifting from the objective of getting rid of invasives toward figuring out ways to live with them. In these articles, researchers and managers share new strategies for keeping potential invasive species out of new places, identifying first arrivals of new species early, targeting those before they take off, optimizing where to apply control measures, making native systems more resistant to invasion, and even extreme potential future solutions, like genetically engineering diseases to wipe out invasive species. Scaffolding all these solutions are strategies around human coordination, communication, education, and data sharing.

Will these efforts work? There are some encouraging successes, but on a whole, invasive species, seem to be expanding faster than we can keep up with. Meanwhile, managers struggle to find adequate or sustainable funding for a seemingly endless battle that has few wins and little to celebrate. And yet, given the damages they cause and threats they pose, doing nothing about invasive species is not an option. Invasive species require that we keep working on, innovating around, and paying for these and future solutions. We will have to be incredibly informed, coordinated, and responsive. We will have to get creative about directing our limited resources to where they will best improve the situation. We will also have to adjust our expectations of what our ecological and cultivated systems should look like and consider new measures of what counts as a functioning ecosystem. We will have to adapt to a new normal.

On the cover: *Invasive species (on the left) including European honeybees, Russian olive, phragmites, dalmatian toadflax, spotted knapweed, Canada thistle, garlic mustard, medusahead, cheatgrass, quagga mussels, zebra mussels, yellow perch, northern pike, goldfish, and a mountain goat face off against natives (on the right) western bumblebees, sagebrush, broadleaf cattails, wild hollyhocks, showy milkweed, Ownbey's thistle, western wheatgrass, silverberry, cutthroat trout, bluehead sucker, Utah chub, and bighorn sheep. Freelance writer, illustrator, and editor* ***Sarah Gilman*** *covers the environment, natural history, science, and place. Learn more about her work at sarahmgilman.com.*

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Nonnatives, Invasives, Weeds

Plants as stories of human meddling

By Bonnie Heidel

The Wyoming census for the plant kingdom is out! Over 2,900 different kinds of vascular plants grow in the wild in Wyoming according to experts at UW's Rocky Mountain Herbarium. They include more than 2,500 native species along with 372 nonnative ones as of 2018. Every single wild plant falls into one of those two categories: native or nonnative. Native plants belong, not just by living their whole lives here but by having Wyoming-ness inscribed in their genes over the ages. They are each uniquely adapted to their environment and to each other.

What about the nonnatives? They don't have the fine-tuned adaptations or provide the ecological support of the natives. Some, but not all, nonnative plants are invasive, like biological bombs that multiply exponentially across the landscape, wreaking havoc on native plants and animals. People often think of natives as "good" and nonnatives as "bad." But our views and actions haven't always been consistent with these labels. In fact, the Wyoming plant census, with all its nonnatives, is full of stories about how changing human perceptions of good and bad have shaped the flora of our state.

Waves of nonnative plants started showing up on Wyoming landscapes well over 100 years ago and have continued right up to the present. A census never stays the same. One of the earliest weeds to arrive in Wyoming was Canada thistle (*Cirsium arvense*), appearing in Cheyenne in 1901. One of the more recent noxious weeds to arrive was garlic mustard (*Alliaria petiolata*), first appearing in Wyoming in 2014 along a trail in Devils Tower National Monument. Garlic mustard is highly invasive in most of the country, and the National Park Service is trying to eradicate it from the monument. Those 100-plus years of nonnative species arrivals include tales of human intentions and accidents, international storylines, and a few contradictions.

Some nonnative plants once considered desirable are now considered invasive. For example, spotted knapweed (*Centaurea maculosa*; syn. *C. biebersteinii, C. stoebe*) came from central Europe, first arriving in North America by way of British Columbia. Bee keepers planted it in western Montana for the flavorful honey its nectar produced. But in the absence of any natural control, spotted knapweed spreads widely and is recognized as a noxious weed in 15 other states as well as Wyoming.

Similarly, settlers brought Russian olive (*Elaeagnus angustifolia*), a hardy tree found in southern Europe and central and western Asia, to the New World for windbreaks in the arid West. It is very fragrant—Thermopolis takes on aromatic exquisiteness in calm midsummer evenings when Russian olive is in flower along the Bighorn River. Some birds and small mammals like the seeds and carry them far and wide. Now Russian olive has taken over scarce river woodlands at low elevations, making them less hospitable for wildlife and livestock. Wyoming added Russian olive to the state noxious weed list in 2007, making it illegal to sell commercially. A relative called silverberry (*Elaeagnus commutata*) is a native shrub that bears much the same sublime fragrance and is starting to appear in nursery trade featuring native plants.

Other plants were accidental introductions. Canada thistle (*Cirsium arvense*) was likely one of the first weeds early settlers brought to North America, coming as a contaminant of grain crops from the eastern Mediterranean region of Europe. The name Canada thistle comes from early residents of New England who blamed its appearance on the French traders from Canada. It's time to pardon Canada! Historians now

When it comes to addressing the problem of invasive species in our state, the starting point is understanding that humans account for their presence in the first place.

believe it arrived in both countries at about the same time. Today, it grows in moisture-collecting places in every county of Wyoming, a denizen of ditches and dams as well as valleys and wetlands. It spreads by underground root-like stems, often forming large, dense colonies.

Sometimes our attacks on invasive plants bring natives down with them. To keep the invasive musk thistle (*Carduus nutans*) in check, weed managers imported one of its natural pests, the Eurasian flowerhead weevil (*Rhinocyllus conicus*), from the Old World. The weevil's larvae feed on developing seeds in the thistle flowerhead. This biocontrol strategy succeeded in turning around severe musk thistle invasions. However, recent studies suggest the weevil has also taken a liking to the rare native Ownbey's thistle (*Cirsium ownbeyi*). Like invasive plants, the Eurasian flowerhead weevil didn't behave in a predictable way when taken away from its overseas home.

Fortunately, not all nonnative plants are invasive. Crested wheatgrass (*Agropyron cristatum*) is a bunchgrass from Russia widely planted in the western United States to control erosion on reclaimed mines and roadside cutbanks. It is locally abundant in every county of Wyoming, and though persistent where planted, it does not readily spread into surroundings. Likewise, common lilac (*Syringa vulgaris*), a sweet shrub favored in gardens, persists around houses including abandoned homesteads, but is not a wild plant or a species that spreads and invades.

Native plants are never truly invasive in the wilds of Wyoming, but they can be darned pesky for some human tastes and land uses. In the realm of pesky native species, there is exactly one native plant on the Wyoming noxious weed list, skeletonleaf bursage (*Ambrosia tomentosa*). It garnered this dubious distinction by producing spiny burlike seeds and proliferating in some cropland settings. It spreads by seed and creeping roots and can grow over waist high on fertile ground. It is widespread on the High Plains, growing in both cultivated cropland and rangeland. As a designated noxious weed, skeletonleaf bursage is the target of state-funded herbicide spraying in cropland, but it maintains a firm roothold in the state.

The word "weed" has been used indiscriminately to refer to both native and nonnative plants. For example, every kind of milkweed growing wild in Wyoming is actually native. These plants may have gotten the weed moniker by thriving where manmade habitat fostered their spread, for example in planted hay meadows, or because they are poisonous to eat. Showy milkweed (*Asclepias speciosa*) grows in moist, eastern Wyoming valleys and wetlands as well as planted meadows and roadsides. Only recently have we come to appreciate milkweeds as food for resident and migrating monarch butterflies.

These many stories of humans moving plants around and later changing their minds about what's good and bad show that the native and nonnative categories are not as simple as they first seem. When it comes to addressing the problem of invasive species in our state, the starting point is understanding that humans account for their presence in the first place.

***Bonnie Heidel** is botanist at the Wyoming Natural Diversity Database. She also brings news and tales of nonnative plants to the Wyoming Native Plant Society newsletter,* Castilleja.

Cheatgrass on Fire

The race to save an ecosystem

Text and photos by Sarah Jane Keller

Locals speculate that Nevada's largest fire may have started with a Fourth of July firework launched in a canyon. But no one really knows. The 2018 Martin Fire seemed small and innocuous, until a weather cell moved into northern Nevada. With winds suddenly pushing the blaze, it burned through sagebrush rangelands at 11 miles per hour. Firefighters couldn't get ahead of it.

The Martin Fire doubled in size every day for four days, growing to be 57 miles long and 30 miles wide and burning 435,000 acres of Bureau of Land Management, US Forest Service, and private ranch land. Among the biggest losses in the fire were some of Nevada's best sage grouse habitat and at least 35 sage grouse leks, where the birds stage their breeding dances. Ranchers, Elko County, and local hunters all chipped in for a reward to catch whoever started the fire, to no avail.

While fire is a natural part of the Great Basin, massive ones like the Martin Fire were unheard of a generation ago. An ecosystem that evolved with relatively rare fires, occurring every 30 to 100 years or more, can now see fires as often as every 5 years.

Not only are rangeland fires more frequent in the Great Basin today, they are also larger. Historically, rangeland fires grew to the order of hundreds to thousands of acres. Today, they regularly escalate into megafires, the term firefighting experts at the Interagency Fire Center in Boise coined for blazes exceeding 100,000 acres. Megafire captures the disproportionate destruction and expense of those very large fires.

According to data from the Bureau of Land Management, a new trend is emerging where range fires now tend to burn more acres each year than forest fires. That was the case in 13 years out of the last 19. Yet public attention and resources devoted to even mega-sized range fires remain relatively scant compared to forest fires.

Sarah Jane Keller

Several major changes are stoking Great Basin megafires. For one, a long history of fire suppression has led to more continuous shrubby cover of sagebrush and juniper, and less of the native perennial grasses that slowed fires in the past. Two, cheatgrass (*Bromus tectorum*), an invasive annual that most of us take for granted in pastures, along roadsides, or poking at our ankles through our socks, is covering more and more of the West. Plus, the Great Basin has been getting warmer over the last 100 years, a trend that favors cheatgrass.

Not only is cheatgrass prolific, it also makes rangeland more likely to burn. As cheatgrass grows between native shrubs and grasses it coats the landscape in a fine, tissue paper-like fuel. When a lightening strike or errant campfire sparks a fire, slow-growing sagebrush perishes, while cheatgrass seeds persist, ready to germinate quickly and outcompete native grasses. After multiple fire cycles, sometimes fewer, cheatgrass reduces formerly diverse and complex shrublands into fire-prone grassland savannas. This pattern has locked the Great Basin in a vicious cycle of burning, which leads to more cheatgrass, and then more fire.

The sweeping scale of recent rangeland fires and the speed with which they are changing the Great Basin drives home the ecological, economic, and social consequences of invasive species run amok. Ranchers, rangeland scientists, and managers are waking up to the rapid pace at which cheatgrass and fire are altering the

Great Basin's sagebrush ecosystem, and now they are racing to save what remains.

"It's in its own class among invasive species," says Jeremy Maestas, an ecologist who works on sagebrush ecosystem conservation for the US Department of Agriculture's Sage Grouse Initiative. "I think what people have to realize is just the sheer disruptive nature of that plant on western range. If you care about the American West and the rural way of life, this is going to upend everything."

After thousands of years making a successful living alongside people in Europe and Asia, cheatgrass is perfectly suited to exploit the human footprint in North America. Since arriving from Europe nestled in packing material in the late 1800s, it has spread to all 50 states and thrives especially well in the western US.

Range managers in the early to mid 1900s fretted over cheatgrass in the scientific literature, say Maestas. While sagebrush and native bunch grasses are long-term investors, taking years to put down deep roots after a fire or other disturbance, cheatgrass moves fast and gets rich quick. As a winter annual that can germinate in the fall or spring, it has a head start on native plants that are dormant during those times. Then it dries out by June, producing as many as 5,000 seeds per plant.

By the 1930s westerners rationalized that they could learn how to live with cheatgrass. It does have some spring forage value for cattle and it was too hard to control anyway. Aldo Leopold saw this complacency and sounded an alarm about allowing cheatgrass to subtly spread unabated throughout rangelands in Utah and Oregon.

"It is impossible to fully protect cheat country from fire," he wrote in *Sand County Almanac*. "As a consequence, the remnants of good browse plants, such as sagebrush and bitterbrush, are being burned back to higher altitudes, where they are less useful as winter forage."

Sarah Jane Keller

Jeremy Maestas, an ecologist who works on sagebrush ecosystem conservation for the US Department of Agriculture's Sage Grouse Initiative, examines rangeland plants growing in the wake of Nevada's massive 2018 Martin Fire.

As Leopold predicted, overgrazing and drought made the Great Basin vulnerable to initial cheatgrass invasion, and his fears about failing to control the weed came to pass. Today, cheatgrass makes up more than 15 percent of vegetation cover over 52 million acres of the Intermountain West. That means about a third of the region is covered in fine fuel that dries out just as fire season begins. Conversion to cheatgrass monoculture is most severe in lower elevation regions of the Great Basin and on the Snake River Plain of Idaho. It's also starting to spread in the Northern Rockies, showing up in places people never expected to see it.

Cheatgrass cover in the west has increased since 2000, according to Maestas. Along with that, fire frequencies in the Great Basin are now up to four times historic levels. The fire season is also longer. And perhaps most striking, fires are much larger.

"When people's houses aren't burning down, it's really hard to motivate people at a large enough scale to do something about it," says Maestas. That's changed, though, as the cheatgrass and fire cycle has ramped up. About 15 million acres of sagebrush burned from 2000 to 2018, mostly in the Great Basin. Nine million of those acres burned between 2014 and 2018 as fires over 100,000 acres are becoming more common. "People's ranches and allotments are burned out regularly, and they have nowhere to go with their livestock. Now we're seeing consequences of not taking action."

As the economic, ecological, and social fallout of inaction against cheatgrass have come into much clearer resolution, so has the sense of urgency about combating it. Jon Griggs, the manager of the Maggie Creek Ranch near Elko, is among the Nevadans who have experienced the many dimensions of those consequences. One is the emotional toll of seeing livestock get burned over and watching in fear as flames have rushed him on the ranch.

Then there are the tangible consequences for ranching communities that rely on a healthy, functioning sagebrush ecosystem. When ranchers need to stay off their federal grazing leases after fire, they can spend hundreds of thousands of dollars on feed or they may have to sell their cattle. "Fire and the aftermath of fire might be the biggest challenge that we have," says Griggs. "It does put people out of business. It changes our livelihood, sometimes forever."

In addition to the direct threat of being burned over, ranchers and wildlife managers worry about the threats cheatgrass and fire pose to long-term conservation goals in the Great Basin. For instance, when mule deer arrive to their winter range after a fire, they can't find the sagebrush and bitterbrush they rely on, leading to poor reproductive success and outright starvation. Fires in northern Nevada have taken a toll on the herds. For instance, in the early 1990s one of northern Nevada's prime mule deer areas hosted an estimated 20,000 individuals. By 2018 there were fewer than 10,000 mule deer there. "Most in our agency attribute that major decline in population to wildfires that have burned the majority of the winter range for this herd," says Cody Schroeder, the Nevada Department of Wildlife's mule deer staff biologist.

While the fates of 350 wild animal species are tied to healthy sagebrush, sage grouse have driven much of the policy and wildlife

politics in the ecosystem. So ranchers like Griggs have viewed the potential endangered species listing of sage grouse as an opportunity to do conservation work that benefits both cattle grazing and wildlife. But fire can sweep through to undermine that work in a matter of hours.

After a burn, sage grouse will first return to the lek, even if it's black and barren, and try to perform their mating rituals, says Alan Jenne, the Nevada Department of Wildlife's habitat division chief. Sage grouse exposed to open sky are likely to be eaten by predators, so they will abandon that lek rather than mate. If they do mate, nesting success in cheatgrass is low because chicks are exposed to predators like ravens. Even when chicks survive, the birds need to find annual flowering plants to eat. But if cheatgrass has taken over, those forbs won't be growing, and the birds will need to move to a new area. At that point, "they're kind of on this death march to get to something more productive," says Jenne.

When the Martin Fire took out at least 35 sage grouse leks, it was like watching years of collaborative efforts to keep sage grouse populations healthy and off the endangered species list go up in smoke. Griggs calls fire *the* concern when it comes to potential sage grouse listing. "Three quarters of a million acres in two fires last year in the north end of this state burned up the best habitat we got," he says. "Thinking about listing, just those two fires really concern me."

Those concerns are well supported, and shared by the sagebrush conservation community. If current wildfire trends in the Great Basin continue, model projections from a 2016 study published in the *Proceedings of the National Academy of Sciences* point to a 43 percent reduction in sage grouse populations over the next three decades.

After the Martin fire, sagebrush skeletons poke out of black soil and wind whips up sooty dust clouds on the denuded horizon. Returning this landscape to a place where sage grouse chicks can once again thrive means overcoming all the advantages cheatgrass has in an arid and disturbed landscape.

Sarah Jane Keller

Sarah Jane Keller

Liz Munn, rangeland ecologist for the Nature Conservancy's Nevada chapter, displays squirreltail seeds coated in pods of activated charcoal, a technique researchers are experimenting with in hopes of helping native plants compete with cheatgrass.

Sagebrush habitat restoration is an evolving art and science. While we see the aboveground results, a key component of the battle against cheatgrass happens belowground. Research is showing that maintaining or reestablishing the extensive root systems of native plants keeps shallow-rooted cheatgrass from getting a toehold.

People restoring sagebrush ecosystems rely on the mantra of "right seed, right place, right time" to guide their work. The saying is shorthand for the complexities of reestablishing native plants in a harsh, cold desert climate where it rains fewer than 10 inches a year. Restoration in vast, remote areas is resource-intensive, logistically difficult, and subject to the vagaries of desert weather. For instance, it took nine semi trucks carrying up to 30,000 pounds of seed to replant after the Martin Fire, but burned over, snowy, wet dirt roads needed to be repaired first. In the end, it's impossible to touch every acre of a 435,000-acre burn scar.

Most invasive weed management programs address less than 10 percent of infested acres, yet invasive plants can spread at a rate of 15 to 35 percent per year, according to the Western Association of Fish and Wildlife Agencies' 2017 report on wildfire and invasive plants in the sagebrush biome. Failing to shift those numbers in favor of sagebrush, bunchgrasses, and native forbs has dire consequences for a sagebrush ecosystem that's already 41 percent gone. "It's hard for me personally, the notion that we could almost lose this ecosystem in its entirety within my lifespan," says Liz Munn, rangeland ecologist for the Nature Conservancy's Nevada chapter.

To help prevent that dire outcome, Munn is collaborating with a number of researchers who hope to improve restoration success by developing technologies to help native plants compete. One technique is trying to give native grasses a head start over cheatgrass. To do this, researchers coat bluebunch wheatgrass and squirreltail seeds in pods of activated charcoal. Those pellets protect them from the herbicides that beat back cheatgrass, giving them a competitive advantage once they germinate. Other seed coatings help bet hedge against variable weather by letting native grasses germinate earlier or later than they would on their own.

"Ultimately we're sort of mimicking what cheatgrass does," says Munn. "Cheatgrass needs a little credit here, really. It's well adapted to this environment. It germinates quickly. It germinates often. So we're trying to basically give native seeds the same advantages that cheatgrass already has." Strategies like this are part of a larger suite of techniques the Nature Conservancy and USDA Agricultural Research Service are borrowing from precision agriculture. These precision restoration technologies, as they are called, are designed to boost the odds of successful restoration. They include different kinds of seed coatings, and also mapping tools that help managers make better decisions about which restoration practices to use and where and when to use them.

Seed coating techniques have been successful in the lab, so the Nature Conservancy is now working with collaborators throughout the West to test them in the real world. One of those places will be on mule deer winter range that the Nevada Department of Wildlife is restoring after the 2017 Snowstorm fire.

While the current seed-coating test isn't large enough to positively affect mule deer habitat yet, it could contribute to the success of ongoing restoration efforts in the future. Mule deer herds near Elko have seen dramatic population declines, largely from loss of winter range to cheatgrass and fire. "We have populations that are solely reliant upon our past efforts at fire rehab at different times of the year," says Caleb McAdoo, a habitat biologist with the Nevada Department of Wildlife.

That's one reason why it's important to protect intact habitats and hard-earned restored areas from fire. Currently the best option available for that is fuel breaks to keep fires from growing so large in the first place. Managers often construct those wide bands of roadside vegetation by seeding with nonnative plants that grow successfully in semiarid climates, like forage kochia, a shrubby perennial with thin leaves and succulent, slender stems. Ideally, that green barrier is moist enough and wide enough to calm a range fire.

Fuel breaks remain a controversial technique because they require intentionally disturbing an area and planting nonnative vegetation. As a 2018 US Geological Survey report points out, substantial scientific evidence supporting their effectiveness, or documenting their impacts, is lacking. But anecdotally, strategic fuel break placement has protected key habitats or restored areas. That was the case in southern Idaho when projections showed the 2017 Centennial Fire could reach 142,000 acres. After a fuel break slowed the blaze, firefighters gained control of it before it reached 20,000 acres.

Fuel breaks, and the scale with which managers need to deploy them, underscore the heavy-handed actions required once an invasive species reshapes how a large landscape functions. The Bureau of Land Management is now proposing to build 11,000 miles of them in Nevada.

"We're trying to figure out what the sweet spot is of basically fragmenting this landscape enough to stop these megafires and to try and get a foothold on some of these restoration opportunities, versus too much fragmentation that is ecologically impactful," say Jolie Pollet, the BLM's division chief for fire planning and fuels management, based in Boise.

Beyond containing Great Basin megafires and restoring habitat where cheatgrass is already widespread, managers are trying to get ahead of the weed before it takes over in new regions.

We go into areas that are broken and try to fix it," says Maestas. "We need to get out of that model. Invasive species management 101 tells you you've always got to prevent first." That means doing what Leopold implored westerners to do nearly 100 years ago: go into areas where cheatgrass invasion is just starting, like the Rocky Mountains, and find strategic ways to eradicate or control it.

For instance, until relatively recently, ecologists considered Wyoming too northerly, and too high elevation, for cheatgrass to really take off there. Now that they are finding large infestations above 9,000 feet, it's clear that even northern states are vulnerable. With 37 percent of the West's sage grouse population, the most leks, and the most sagebrush of any state, the stakes are high for controlling cheatgrass in Wyoming.

In places like the Great Basin, where prevention work didn't happen soon enough, the challenge is learning how to live with cheatgrass. "But that doesn't have to be the future for a lot of West," says Maestas.

"We still have a lot of land that is in really good shape, but it's threatened by invasion. I think it's a cultural mindset, that people have to be ready to respond quickly before there's an obvious problem."

***Sarah Jane Keller** is a freelance science and environmental journalist based in Bozeman, Montana. Find more of her work at sjanekeller.com.*

Sarah Jane Keller

Native wildflowers emerge amidst burned sagebrush stalks nearly a year after the Martin Fire swept across 435,000 acres of Nevada rangeland. Managers, conservationists, and ranchers are in a race to keep cheatgrass from taking over these lands.

Further Reading

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Beth Ledger

On a stormy day one year later, wildflowers blossom across the western edge of the lands burned in Nevada's 2018 Martin Fire.

WHEN NATIVES PERSIST

One researcher examines how native plants can compete with invasives

By Tessa Wittman

In the spring of 2019 Elizabeth Leger drove out from her botany lab at the University of Nevada, Reno to her field site on the western edge of the 435,000 acres burned in the Martin Fire. She was looking for cheatgrass. The 2018 wildfire was the largest in Nevada's history, and cheatgrass is frequently the first thing to grow after a fire on this landscape. But as she approached the burned area, Leger didn't see the invasive grass. Rather she found fields of blooming native wildflowers. How did these native plants survive and thrive after fire? What suppressed the cheatgrass?

Leger studies what makes some individual plants and plant communities resistant to invasive species, like cheatgrass, and resilient after disturbance, like fire. "Resistance," she says, "is the ability to keep the weeds out, and resilience is the ability of the community to come back to some sort of native trajectory after disturbance." In her research, she works to identify the characteristics that enable some native plants to outcompete or recover. Her work could help managers better tailor their efforts to combat invasive species by promoting resistance and resilience in native plants.

A nonnative species is titled "invasive" when it degrades ecosystem productivity, reduces biodiversity, disrupts desirable ecosystem services, or drives sensitive species toward extinction. That happens when it outcompetes natives. Disturbance, such as fire, can expedite invasion. The worst invasive grasses in the West are annuals, which germinate from seed every year, while native perennials, once rooted, come back year after year. Intact sagebrush systems contain a diverse community of shrubs and perennial forbs and grasses that grow and blossom throughout the growing season. Each native species is one component of a continuous cycle of ecosystem productivity. When each of the components are present, the plant community prevents invasive weeds from taking over.

"The problem," Leger explains, "is when you pull some of those components out, that's when you make these windows for cheatgrass or other weeds to come in." For example, when decades of intensive grazing and topsoil erosion removed some native species on western landscapes, cheatgrass invaded.

University of Nevada, Reno

Elizabeth Ledger, a professor in the Biology Department at the University of Nevada, Reno, studies plant ecology and native plant restoration in invaded areas of the Great Basin and works with state, federal, and nonprofit partners to translate her research findings into management.

The standard approach to fighting invasive annuals has been to focus on killing them across the landscape. Land managers invest huge amounts of time, money, and herbicides on invaded landscapes, but they will never eliminate the last cheatgrass seed. At the same time, treating invasives like a cancer can have much the same result on the ecosystem as chemotherapy has on the human body, killing healthy components alongside the target. Relying on conventional solutions like herbicides to manage invasive plants also kills the native plants that have evolved to resist the invaders.

Leger is researching unconventional solutions. Her curiosity was sparked after observing a half-burned hill. On the side untouched by wildfire, native grasses and shrubs grew, while the burned side was covered in cheatgrass. Amidst the cheatgrass, a few endemic grasses persisted. Leger collected plants from both sides of the hill and began experimenting.

To identify characteristics of plants capable of competing with cheatgrass, she first plants cheatgrass in experimental plots containing different compositions of native plant communities and then weighs the biomass of the cheatgrass produced in a season. Thus, her metric to assess resistance is to gauge the effect of the native plants on the productivity of the invader. Natives are more resistant when cheatgrass produces smaller plants and fewer seeds.

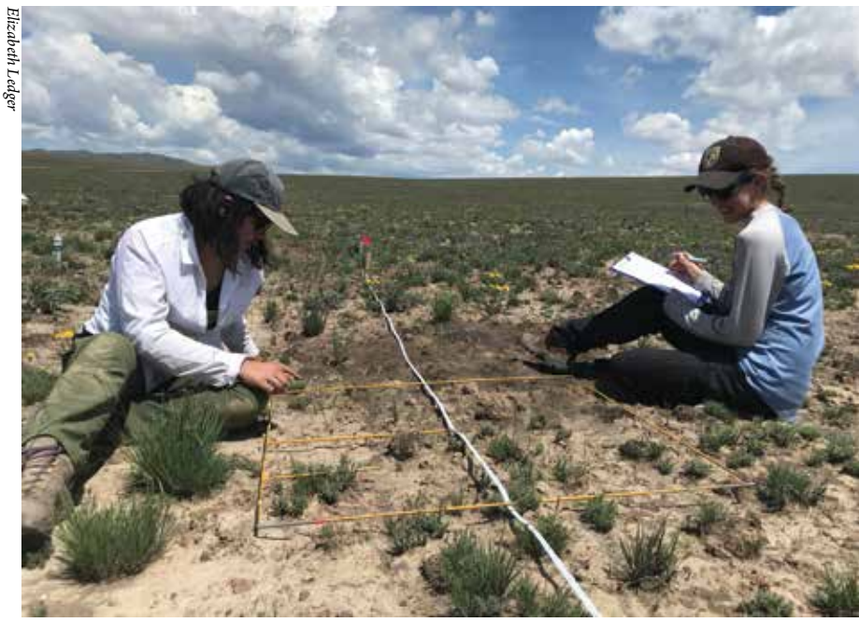
To understand the characteristics of individual native plants surviving in invaded areas, Leger can be found at her field sites and greenhouses measuring plants and excavating root systems. She has found, for established perennials, the best strategy is to green up really early—the minute it starts raining—and put a lot of energy into roots. "Below ground," she says, "that's where all the fighting is in the Great Basin." Her most interesting finding in native seed establishment is, "The plants that survive best are the ones that are small overall." The theory is, plants that require less water and fewer resources have a better chance of surviving in a high competition situation.

Leger's research is informing new management strategies. Whereas seed producers generally select for bigger plants, Leger's work shows that plants that are small, green up early, and produce a lot of below ground biomass are more resistant to invasion. By selecting seeds with these characteristics, managers may get a leg up on cheatgrass. Furthermore, based on the increased understanding about the importance of a diverse, intact native plant community, some managers in sagebrush are seeding native perennials in advance of fire in an effort to restore the ecosystem from historic disturbance such as overgrazing. Leger is also assessing the potential for high-density, short term cattle grazing to mow down the annual grasses, thus opening space for native perennials to establish.

There is no silver bullet solution, Leger emphasizes. No one strategy will work in every place or every year but seeding diverse species with a variety of characteristics and growth strategies may support a stronger and more resilient ecosystem. Restoration seeding efforts are ongoing at select sites among the 435,000 acres burned in the Martin Fire. The spring of 2019 was particularly wet, which helped endemic perennials thrive on the western edge of the burn, and only time will tell how the landscape is rebounding. Leger will return each season to monitor the plant communities, searching for clues to inform wiser management approaches to fighting invasives.

***Tessa Wittman** is a senior in environment and natural resources and wildlife and fisheries biology and management at the University of Wyoming and a 2019 Udall Scholar.*

Elizabeth Ledger



Field researchers Cathy Silliman with the Great Basin Institute and Sarah Kulpa with US Fish and Wildlife Service survey vegetation to quantify the presence of native and invasive plants.

Elizabeth Ledger

One year after the Martin Fire, wildflowers and native bunchgrasses coat the landscape. Leger's research is helping show the importance of diverse communities of native vegetation in combating invasives like cheatgrass.

Sara Teter

Tiny soil organisms may hold the key to managing invasive plants

Text and photos by Sara Teter

The four members of Gordon Custer's research group gather around as he walks through the steps of data collection. It's a sunny June morning at a test area in the High Plains Grassland Research Station outside of Cheyenne, Wyoming, and Custer and the lab members have donned sunglasses and ballcaps to block the sun's rays.

Custer, a University of Wyoming PhD student in ecology, demonstrates how to toss a placemat-sized white plastic square made of tubing, use a tablet to take pictures of it, catalog the plant species within it, and then extract three soil core samples. He places the soil samples into a small plastic bag called a "Whirl-Pak," because, to seal it, he must whirl the pack over itself several times, similar to wringing out a towel.

"It's a super creative name," Custer jokes.

A team member sanitizes the soil core sampler with a blowtorch and ethanol before tossing the white square to another place in the plot, one of 84 individual subplots within the research area. Once he's certain the research team has got the hang of it, Custer retreats from the test plots to set up his workstation.

"If anyone has any questions, don't hesitate to ask," he tells the lab members, and he tells me, "If you need anything give me a shoutout, but otherwise I'm going to be in field work mode."

The group needs to gather 211 individual Whirl-Paks from the research plot, and the weather forecast calls for rain in the afternoon. Any samples that get wet would differ from the other samples, throwing off the data set. It's an ambitious goal for one day, and they're racing against the weather.

"I need a third hand," Custer laments, as he meticulously repeats the steps to process each of the Whirl-Paks.

The group is looking for microbes—microscopic organisms including bacteria and fungi. While they are invisible, microbes play a crucial role in a healthy ecosystem. They cycle nutrients, breaking down compounds into forms that other organisms, such as plants, can use. Custer says many plant species flourish in the presence of compatible microbe communities, and vice versa.

Disruptions—such as wildfires, development, and invasive species—can easily upset microbial communities, throwing the ecosystem out of balance. Learning how disruptions impact microbes can help researchers get a handle on how to return ecosystems to their pre-disruption state. Custer plans to do just that, by homing in on how invasive plant species impact microbial communities. Custer says, in the future, his work could create new strategies for managing invasive species.

The research Custer and his lab are conducting is part of a larger microbial research effort at UW funded by a National Science Foundation grant totaling $20 million over five years. The goal is to gain comprehensive understanding of microbes in Wyoming. Currently, very little is known about the distribution of microbes across the state, or what happens when that is disturbed.

How do you survey microscopic organisms? Linda van Diepen, UW assistant professor in the Department of Ecosystem Science and Management and Custer's PhD advisor, says that while researchers won't ever see the microbes in their soil samples, they can look for markers of microbial communities. Microbes excrete enzymes to break down food—like dead grass—into components small enough for them to consume. As they do this, they also change the nutrient concentration in the soil. Researchers can analyze the enzymes, nutrient concentrations, and the microbe's own DNA to identify which ones are present and how they are functioning.

While they are vital to a healthy ecosystem, little research has been done to discover how microbes, as an integral part of an ecosystem, interact with invasive plant species.

"These invasive plants invade a system and they alter nutrient cycling,

Looking UNDERGROUND

Martina Greenhaw, Emily Repas, and Noah Cheshire, University of Wyoming students in an ecology research group investigating the relationship between soil microbes and invasive plants, collect soil core samples.

alter below-ground interactions," Custer says. "These impacts [could] last long after the plants have been removed."

Custer is working on three projects focused on the interactions between microbes and invasive species. At the site near Cheyenne, Custer and his group are working in a plot treated with an herbicide a year and a half earlier.

"Invasive plants kind of diverge the microbial community away from the native state," Custer says. "When you spray herbicide on it, you may be furthering it away from its native state and imposing additional hurdles to restoration."

Custer's lab, two teams of two, bring him the Whirl-Paks as they finish with each subplot. He breaks up the soil cores, which look like brown apple cores, in the Whirl-Pak and shakes up the soil. He then uses metal instruments to take small amounts of soil and place them into two different tubes, one with a potassium sulfate solution, and a "bead tube" filled with small purple beads. The soil analysis will hopefully yield information about the microbes present in the herbicide treated areas to discover whether herbicides disrupt the microbial community and how.

Herbicide application is just one of the many ways invasion can affect the microbial community. For his second research project, Custer examined the long-lasting impacts of invasion on the microbial community, even after an invasive plant is removed.

To study this, Custer grew native plants in pots for 12 weeks. He then harvested the native plants and re-planted the pots with Russian knapweed, an invasive species, which grew for 12 weeks. Finally, he harvested the invasive plants and re-planted the pots with the native species. Custer examined the microbial community at every step of the process.

Sara Teter

Sara Teter

Student Noah Cheshire (left photo) places a soil core sample into a Whirl-Pak, while while Gordon Custer, a PhD student in ecology at the University of Wyoming, processes soil samples at the High Plains Grassland Research Station outside Cheyenne, Wyoming.

The third project is a general survey across the entire state of Wyoming to compare microbe communities in native, uninvaded prairie with places where cheatgrass has invaded. Van Diepen says the initial survey of Wyoming will help determine which microbe species are present in uninvaded prairie versus invaded prairie. Custer worked with Wyoming Weed and Pest as well as UW Extension to survey 10 to 15 sites across Wyoming.

Custer says his research could lay the groundwork for new approaches to combat invasive plant species. A potential application is in the development of bioherbicides—herbicides that use microbes instead of chemicals to target invasive plant species. Bioherbicides made from microbes could be tailored to attack a specific invasive plant without harming native species. Custer's foundational research efforts could inform future development of such herbicides, helping to put more tools in the hands of land managers.

"A lot of work is still needed on that front, and it is not a silver bullet," he says. "But it is a potential avenue for development."

Custer's projects, as well as the others under the NSF grant, will lay the foundations for future microbial ecology research in Wyoming and beyond. Custer says being able to take part in a project this size with so many people involved feels like a once-in-a-lifetime opportunity.

"The breadth, the knowledge that is working on this is crazy," Custer says. "You have biogeochemists, microbial ecologists, computational biologists, statisticians, GIS people… it's pretty cool, the interdisciplinary research and collaboration."

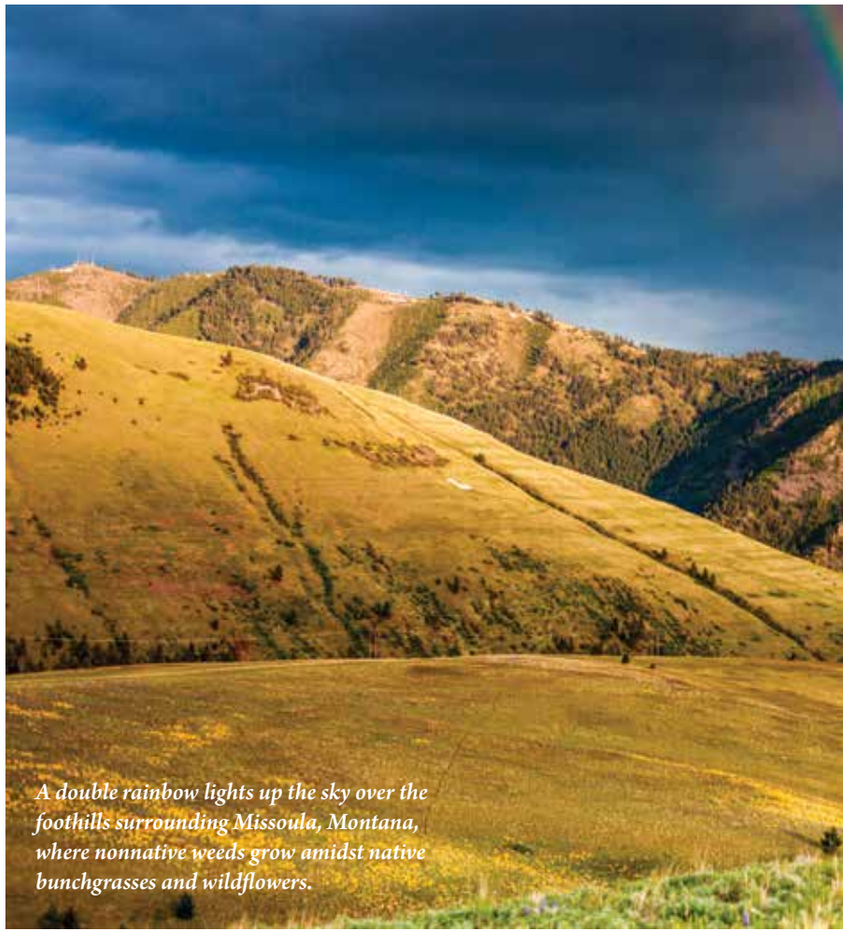
In the research plot, Custer's group stands around his workstation as he processes the few remaining Whirl-Paks. The clouds have turned a dark, gloomy purple and the wind has picked up. The rain is coming. In the semi-arid climate of Wyoming, Custer says there is a "pulse" of microbial activity after a wetting event like a rainstorm.

Custer twists the lid on the last tube, as the groups loads their materials into the UW van. One student slams the trunk shut, and the volunteers pose for a picture—a souvenir of a successful field day. The phone camera flashes, and the rain starts to come down.

***Sara Teter** was the summer 2019 Science Journalism Intern for the Ruckelshaus Institute and a graduate student in the Communications and Journalism Department at the University of Wyoming.*

HERBICIDES in WILDLANDS

What do we really know about their effects?



A double rainbow lights up the sky over the foothills surrounding Missoula, Montana, where nonnative weeds grow amidst native bunchgrasses and wildflowers.

By Lauren Dunn

As Cara Nelson, a researcher and professor of ecosystem science and restoration at the University of Montana, hiked around Missoula's foothills, she noticed abundant knapweed and cheatgrass growing amidst native bunchgrasses and wildflowers. She became interested in studying approaches to control invasive plants. One of the most common techniques is spraying herbicides on noxious weeds and re-seeding afterwards with native seeds. Since spraying paired with re-seeding didn't seem to be keeping the weeds under control, Nelson wanted to learn what the literature had to say about the efficacy and effects of herbicide use on wildlands. She was surprised to find limited research on the effects of herbicides on complex ecosystems.

For managers to make evidence-based decisions, they would need to understand more about how herbicides impact native plant and soil communities. Nelson decided to collaborate with land managers on several studies to increase knowledge on this topic.

Herbicides are chemicals designed to kill unwanted plants, originally in crop agriculture. They interrupt normal plant growth and can be classified as selective or non-selective. Selective herbicides kill either all broadleaf plants (dicots) or all parallel veined plants (monocots), for example grasses. In contrast, non-selective herbicides kill all plants they come into contact with, which includes both desirable and undesirable plants. One of these, glyphosate, is a chemical most commonly sprayed on wildlands, including forests, grasslands, and shrublands. Glyphosate is commonly used because it rapidly spreads through plant tissue, is cost effective, and degrades rapidly. Regulatory entities have concluded that glyphosate poses a low risk to wildlife; however, independent research has shown glyphosate is carcinogenic.

Agencies at the federal, state, or county level can designate a plant as "noxious" if it is considered "injurious to public health, agriculture, recreation, wildlife, or property." National policies then require public land managers to regulate designated noxious plants, including in wildlands, and herbicides are a common treatment. For example, the National Park Service sprays to meet the management goal of maintaining historic ecosystem functions. Other agencies spray rangelands, highly trafficked areas such as along roads and trails, and areas burned by wildfires.

Even though agencies consider herbicides useful, there are unwanted side effects. Herbicides can kill both native and invasive plants, and spraying opens up the door for secondary invasion. For example, when managers spray knapweed, cheatgrass may aggressively colonize the area, even after native seed mixes are reseeded. Herbicides can also affect soil, water, and even human health. Given that these potential hazards are not fully understood, Nelson saw a need to gain a better understanding of how herbicides affect wildlands.

"Walking around Mount Sentinel, you can see areas that were sprayed for knapweed [that] now have cheatgrass," Nelson explains. Nelson adds that, herbicides can be effective at controlling invasive plants. However, in many areas that are sprayed, weeds persist even after spraying. "Reseeding is one method to avoid secondary invasion. However, there is a research gap here."

Linda Thompson, The Missoulian

Cara Nelson, a researcher and professor of ecosystem science and restoration at the University of Montana, studies the effectiveness of herbicide spraying and approaches to control invasive plants.

She wondered how effective reseeding into soils recently sprayed with herbicides was, so Nelson and her Restoration Ecology Lab partnered with Morgan Valliant at Missoula County Parks and Recreation to study that question. The first study, led by Viktoria Wagner, a post-doc in the lab, uncovered that seeding immediately after spraying prevented the seeds of native species, both grasses and herbaceous plants, from germinating. A follow-up study led by Christine McManamen, a graduate student in the lab, showed that herbicides also have long lasting effects, decreasing seed germination up to one year after spraying. Seeds of some species were more sensitive to herbicides than others. Findings suggest the need to identify the sweet spot—seeding too soon will result in poor germination, while seeding too late misses the window of opportunity and permits secondary invasion. Nelson, Wagner, and McManamen published these findings in the journal *Restoration Ecology* in 2014 and 2018.

Leading up to this reseeding research, Nelson and Wagner collaborated on another study with Canadian researchers and land managers to assess knowledge about herbicide effects on native plants and the extent of herbicide spraying on public lands in North America. They reviewed articles on herbicide use and found most existing research looked at the effects on agricultural plants, not wild plants or soil organisms. The researchers found 40 publications on the oldest and most commonly used herbicide active ingredient, glyphosate, and far fewer on the effects of several of the next most commonly sprayed active ingredients. "That is very low considering how much we use these," Nelson explains. Furthermore, in addition to few overall articles, Nelson and her team found that more than half of the published studies had design flaws. Their research did not stop there.

Nelson and Wagner, looking specifically at herbicide use in the United States, attempted to compile data from seven federal agencies that spray herbicides on wildlands. But they found that some agencies did not document their herbicide use. Only five tracked herbicide use on public lands, and only four of those—Bureau of Indian Affairs, Bureau of Land Management, Fish and Wildlife Service, and National Park Service—agreed to share their data. The Forest Service declined because of data quality concerns.

Furthermore, Nelson and Wagner's analysis of the agencies' data disclosed that land managers sprayed herbicides on 2.5 million acres of US federal and tribal wildlands from 2007 to 2011. The researchers conservatively estimated that in a single year, 2010, managers sprayed 1.2 million acres, an area the size of Delaware, with over 220 tons of herbicide, enough to fill two train tank cars. In 2017, the researchers published these findings in a *Journal of Applied Ecology* paper titled "Herbicide usage for invasive nonnative plant management in wildland areas of North America."

Nelson's findings about the volume of herbicides sprayed and the shortage of understanding about their effects highlight the need to better understand invasive species management on wildlands. Nelson suggests that managers "focus on the ecosystem as a whole rather than a narrow goal, such as removing a weed." And, she proposes when they do spray herbicides, managers could do more to design effective monitoring programs to compare herbicide effects on control and treated sites. "The problem is not that there is not enough money for monitoring effects but rather," Nelson says, that monitoring often fails due to poor experimental design. Effective monitoring requires planning how data will be analyzed, archived, and shared, and how the monitoring plan will be assessed, prior to implementing herbicide treatments. This is the foundation of evidence-based management, which requires a systems-thinking approach with broad goals. "When we manage for ecosystems, we have to manage that complexity," Nelson says.

Lauren Dunn *graduated with a bachelor of science in resource conservation from the University of Montana and has worked as a field botanist on various endangered species habitat monitoring projects all over the West. She is interested in the interface of human-land relationships.*

Further Reading

Christinine McManamen, Cara Nelson, and Victoria Wagner. "Timing of seeding after herbicide application influences rates of germination and seedling biomass of native plants used for grassland restoration," *Restoration Ecology* Vol. 26, 6 (2018): 1137-1148.

Viktoria Wagner et al. "Herbicide usage for invasive nonnative plant management in wildland areas of North America," *Journal of Applied Ecology* 54 (2017): 198-204.

Viktoria Wagner and Cara Nelson. Herbicides negatively affect seed performance in native plants. *Restoration Ecology* 22 (2014):288-291.

EARLY DETECTION AND

Can a highly coordinated team of experts and weed managers stop a new invasive species?

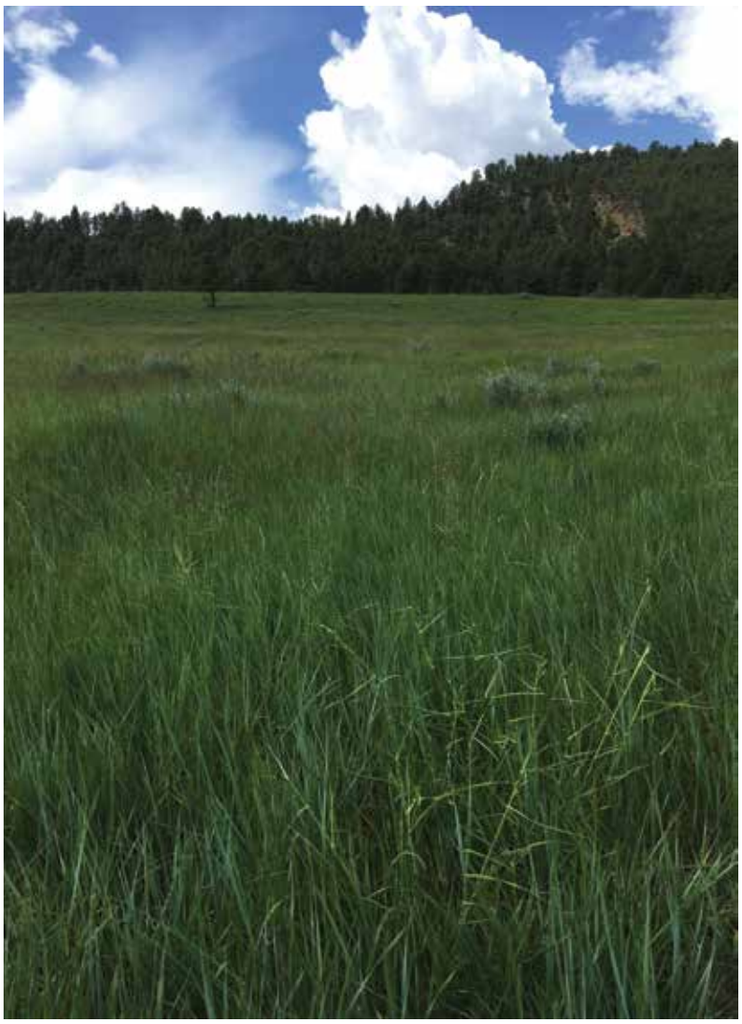
By Emilene Ostlind

For many westerners, cheatgrass (*Bromus tectorum*) is the exemplar invasive weed, well known for thriving in sagebrush landscapes where it crowds out native plants, fuels a devastating fire regime, and threatens wildlife and livestock grazing. Over the passing decades, researchers, weed specialists, and rangeland managers have learned a lot about cheatgrass, including the patterns of mowing or grazing, kinds of herbicides, and range conditions that can slow it down. But we still haven't figured out how to really stop cheatgrass's spread or clear it out of the vast acreages it's invaded. One of the main lessons has been, keeping cheatgrass out in the first place is much more effective and cheaper than trying to fight back the weed once it takes over.

So when another invasive annual grass—one that's supposedly even worse than cheatgrass—popped up in Wyoming a few years ago, managers knew they had a small window of time to get control of this new invader, and they leapt into action. Given the cheatgrass situation, no one really believes an invasive annual grass can be controlled once it takes hold. But armed with lessons learned from decades of combatting various annual grasses, the best new herbicide chemical concoctions, and carefully developed strategies for a coordinated plan of attack, one team of weed specialists is out to break that barrier and prove it can be done.

In the summer of 2016, a University of Wyoming professor named Brian Mealor took a group of students to the National Guard Training Area in Sheridan, Wyoming, a community of 18,000 nestled against the eastern slope of the Bighorn Mountains, to collect data for a graduate research project. As they set up transects and identified plants, a weird grass kept showing up. Mealor took some photos of it and started emailing his colleagues around the state, setting off a firestorm of worry and action.

The grass was ventenata (*Ventenata dubia*), also known as North African wiregrass, and it has been creeping outward from Washington and Idaho since its arrival there in the 1950s, spreading by as much as 3 million acres per year. In western North America, annual grasses like cheatgrass and ventenata are the worst of the worst when it comes to invasive plants. These exotic annuals have found an unexploited niche in the ecosystem. They germinate in the fall and sprout in early spring, stealing soil moisture before the native, long-rooted perennials get a chance at it. That gives the invasives a jump start on their growing season and helps them outcompete native plants. The produce prolific seeds, which spread by wind or by snagging on shoelaces and animal fur and drill into the soil, where they can persist for many years.



Emilene Ostlind

Ventenata grows among native plants in the Amsden Wildlife Habitat Management Area, land managed for elk winter range at the foot of the Bighorn Mountains.

If rangeland managers thought cheatgrass was bad, ventenata is worse. Its tough stems tangle in mower blades and are inedible to grazers, even early in spring when cows or deer might eat cheatgrass. In the fall, ventenata creates a thick thatch of wiry stems over the ground, further choking out native plants. Like cheatgrass, it promotes fire. It is destroying already-threatened Palouse prairie and ponderosa ecosystems in states to the west.

One of the people Mealor first contacted about the weed was Beth White, a rancher with land adjacent to the National Guard Training Area. Mealor showed her the grass and asked her to keep an eye out for it. Over the next two weeks, as she checked on cows around her grazing association lands, she spotted the grass in more and more places.

"We went from thinking it was in a couple-hundred-acre patch we could get our arms around to it spread to an hour's drive from one side to the other, in just in a couple weeks," Mealor says.

RAPID RESPONSE

Then, in August of that summer, a Natural Resource Conservation Service soil conservationist named Oakley Ingersoll was patrolling a piece of state land where ventenata had been found, trying to get a sense of how bad it was, when he came across another suspicious looking grass. This one had a bristly head of sharp seeds. He identified it as medusahead.

Medusahead wildrye (*Taeniatherum caput-medusae*) showed up in Oregon in 1887 and took off in the mid-twentieth century, spreading across much of northern California and into the surrounding region. It thrives in the wake of cheatgrass-driven fires and even crowds out the cheatgrass itself. Like ventenata, grazers can't eat medusahead, which is high in silica and has sharp seeds. In some places, medusahead has reduced grazing capacity by 80 percent as it pushes out the palatable plants.

As ranch manager JD Hill put it while speaking on a panel about the two grasses at Sheridan College last summer, "What's scarier than something that outcompetes cheatgrass?"

Within a week or two of the medusahead discovery, Sheridan County Weed and Pest sprayed 200 acres there with herbicide.

"At that point we treated every known acre in the state of Wyoming," Mealor says, "but we'd found it late enough in the season that there was not a lot of time to survey other places."

Mealor, who talks like a scholar, dresses like a ranch hand, and signs his emails "Grace and peace," specializes in invasive plant ecology with a focus on sagebrush ecosystems and rangelands. He is described as "the guy who wrote the book on cheatgrass in Wyoming." (He is the lead author on the 2013 publication *Cheatgrass Management Handbook*). Though he wasn't exactly sure how medusahead and ventenata would act in northeast Wyoming's environment, he knew well the threat these two grasses could pose to wildlife and agricultural operations. And he was already in close contact with a strong team of specialists, land managers, and ranchers in the region.

Mealor teamed up with Luke Sander, an energetic young man who serves as supervisor for Sheridan County Weed and Pest. The two reached out to everyone they could think of who might care about new invasive grasses including Wyoming Game and Fish, US Fish and Wildlife Service, Natural Resource Conservation Service, conservation districts, and ranchers. They called a meeting at the end of that summer, 2016, and began to map out a plan for addressing the two new grasses.

They focused on a few actions. First, they would thoroughly survey Sheridan County (and beyond as necessary) for the two grasses and make careful maps of the plants' distribution. They would use those maps to create landscape-scale management strategies, identifying the places where treatments would best contain the grasses' spread. From there they would spray the infested areas with herbicide. And they would carefully study those treatments to determine which chemicals sprayed at which time of year best suppressed the invasives while letting native and desired plants grow.

"It feels kind of like we are … doing a military planning exercise: We stare at maps and we draw polygons," Mealor jokes.

Along with this on-the-ground work, the group committed to share all their data and information broadly, tackling the monumental effort of compiling and making accessible observations and spraying activities from a whole range of entities. Additionally, they committed to increase awareness about medusahead and ventenata in the immediate community, as well as among weed districts and other partners across the state and beyond through signage, pamphlets, presentations, and other outreach.

Wyoming has its share of other noxious weeds to control, from leafy spurge and dalmatian toadflax to spotted knapweed and cheatgrass, but because ventenata and medusahead were thought to be limited to relatively small acreages, "it presents an opportunity, where if everyone focuses on it as a high priority, maybe we can mitigate it becoming a bigger issue than it is right now," says Slade Franklin, weed and pest coordinator for the Wyoming Department of Agriculture.

Mealor and Sander's group met again in January 2017 where they adopted the title Northeast Wyoming Invasive Grasses Working Group, which shortens to NEWIGWG ("nuh-wig-wig") and articulated a mission: "Minimize impacts to rangelands for wildlife and agriculture by reducing, containing, or eradicating medusahead and ventenata in northeast Wyoming." More specifically, they aimed to contain ventenata, which has the wider spread of the two grasses already, and eradicate medusahead, meaning get rid of every last plant in the state.

"I think 'eradicate medusahead' is a pretty lofty goal. We all think that," Mealor admits. "But we thought we would go ahead and say the word to try to hold ourselves to a high standard."

They began to apply for funding to cover the costs of the work they had planned for the coming growing season.

One of their early proponents was Lindy Garner, invasive species

UW photo

Brian Mealor, a University of Wyoming professor and extension agent specializing in rangeland weeds, has been spearheading the effort to hold two new invasive grasses at bay in northeast Wyoming.

coordinator for the US Fish and Wildlife Service. She quickly recognized that the NEWIGWG effort had all the elements for potential success. Further, medusahead and ventenata posed an imminent threat to the National Wildlife Refuge System and the sagebrush ecosystem where the greater sage grouse is a focus of her efforts within the agency. Wyoming is home to the largest remaining populations of greater sage grouse, a species that narrowly escaped being listed as an endangered species in 2015 with the understanding that states and agencies would continue massive west-wide efforts to protect them and their sagebrush habitat. That would mean keeping invasive grasses out.

One tool at the group's disposal was a strategy known as "early detection and rapid response." Taking a metaphor from cancer treatment, early detection and rapid response has long been one way to address newfound invasive species, and recently the Department of Interior formalized this approach with a 60-page document outlining a framework that government agencies and their partners can adopt.

When Garner heard that the National Invasive Species Council was looking for pilot projects to demonstrate the early detection and rapid response framework, "I said, hey, there's this one. They've got their act together." The council gave some early funding to NEWIGWG. That opened the door to additional federal agencies getting involved and helped set NEWIGWG in motion.

In its first three years, the group raised over $900,000 which they directed toward surveying more than 20,000 acres for the two grasses each summer, using contractors, drones, remote sensing, and other approaches. The group also coordinated spraying every known acre of medusahead, the less widespread of the two species, over thousands of acres each fall, while partnering organizations worked with landowners to tackle ventenata.

In 2016 and 2017, they used a mix of Plateau and Milestone, two herbicides approved for grazing lands that were known to be effective on annual grasses. "With Plateau/Milestone, you can get pretty good control for a year and then … ventenata starts infiltrating back in," says Sander. "In some places in the second year it looked like we had never even been there."

In 2018, they received special approval to use a chemical called Esplanade, which works better but is not yet widely approved for grazed lands. Esplanade penetrates the top inch or so of soil and inhibits root growth, stopping the shallow-rooted invasive grasses, "while your other natives are a little bit deeper rooted so they can grow through it just fine," Sander explains. "It's a very selective herbicide at the correct rate." And whereas the Plateau-Milestone mix has to be sprayed in the fall to protect native plants, managers can spray Esplanade throughout the growing season. Esplanade is set to be approved for widespread use on grazing lands later this year.

Almost all the spraying is done by air, which is cost effective because a plane can cover in a couple of hours what would take ground crews several days to spray, but still pricey. "All those medusahead treatments have gone out at no cost to landowners. Zero. Which is starting to get pretty expensive," Mealor says.

"Sustainable funding has been one of our big pushes," Sander adds. "We can gather a bunch of grant money because it's new and sexy and there is a bunch of hype around ventenata and medusahead for three or four years, but we need a funding source that we can rely on for 15 to 20 years." Even if a dose of Esplanade beats the weeds back for three or four years, "We're assuming that we have to do at least two treatments and possibly three treatments to be able to completely remove it from the area," says Sander. "We kind of have a 10-year plan in place for areas, and knowing that going forward we have to manage funding to be able to have money to come back and retreat."

There is also a research component to NEWIGWG's work. "We have flight tracks and spray tracks from all the aerial pilots. They have mapping programs in their planes and they give us the data afterwards so we can see exactly where they turned on, where they turned off," Sander says. "We keep track of what they sprayed, the rates, and the time of year, weather conditions, all that stuff."

Then Mealor and his students follow up by monitoring the effects on the ground to both the invasive grasses and the desirable native species and analyzing their findings relative to the herbicide application data.

"It's been kind of a cool collaboration to get some hard figures and facts of what the herbicide is really doing to the landscape," Sander says. "It's very surprisingly positive from everything we have seen so far, so that's good."

In addition to the surveying, treatments, and research, NEWIGWG also put up information signs and boot brush stations in eight locations, published and distributed a one-page "field guide" to help citizens and partners identify the two grasses, gave over 15 public presentations, and began hosting an annual "Medusa-Nata Tour" that attracts attendees from all over Wyoming and several surrounding states and Canadian provinces, as well as federal representatives from across the West and from DC. The group reports having reached some 4,500 people with information about the threats medusahead and ventenata pose and how to respond.

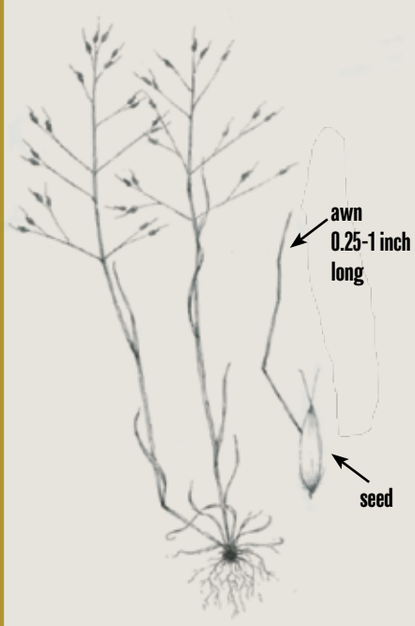
It remains to be seen whether these efforts will stop ventenata and medusahead from spreading eastward into more rangelands, sage grouse habitat, and the Great Plains. For now, ventenata has been detected

Emilene Ostlind

In June, delicate shoots of ventenata are visible amidst native plants in the Bighorn Mountain foothills in Sheridan County.

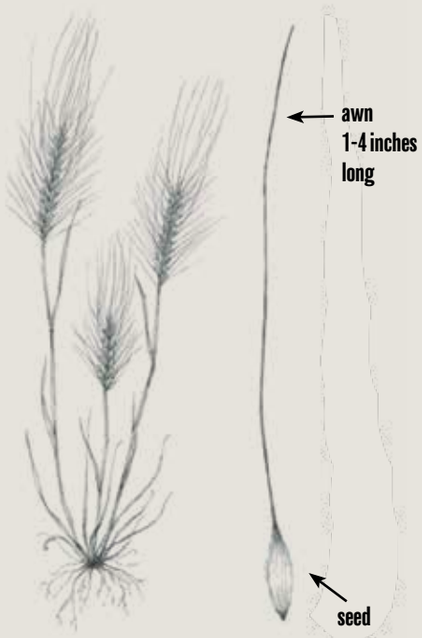
WATCH FOR WEEDS

How to identify ventenata and medusahead and what to do if you think you found them



Description: Fine grass about 18 inches tall. Each plant produces 15-35 seeds, visible June through August, on the ends of thin stems about 3 inches long, that branch off the main stem at a 90-degree angle. One distinguishing characteristic is the awns, hair-like threads poking out of the seeds, that bend at a nearly right angle half-way up.

Ventenata ***(Ventenata dubia)***



Description: Grows up to about 2 feet tall with 100 or more plants per square foot. The most distinguishing characteristic is the seedhead, visible late June until early fall. A dense cluster of spiky seeds grows around the top couple inches of the grass stem, each with a long, stiff awn sticking out of it, like a bottle brush.

Medusahead ***(Taeniatherum caput-medusae)***

How to Report a Weed

For an urgent finding that needs a quick response, contact your local weed and pest office directly.

You can also report any suspicious plants using the free EDDMapS app. If you live between Kansas and the west coast, search for EDDMapS West in the app store and download it to your phone.

Create a username and password in the app.

Next time you see a suspicious-looking grass, create a record in the app.

- Take several clear photos of the plant with your phone's camera. Closeups of the stems, leaves, and seed heads are helpful. Consider laying the plant on a solid-colored jacket or hood of a vehicle so it won't have a busy background. Make sure the plant is clearly lit.
- Your phone will automatically add your name and contact info as well as the date, time, and GPS location to the report. You can select the species or choose "Unknown Plant" if you're not sure. Add up to five photos.
- You can also submit reports via the website, www.eddmaps.org. Manually add the date and location (by dropping a pin on a map).

Every report of an invasive plant in Wyoming goes to the state's verifiers: Slade Franklin, invasive species coordinator at the Wyoming Department of Agriculture, and Dan Tekiela, assistant professor and extension specialist of invasive plant ecology at the University of Wyoming. They will review your report, contact you if they have further questions, and decide on the next steps, whether that is to send someone out to check out the area, notify the local weed and pest district, or something else.

Once verified, your report will be added to the larger EDDMapS database where it is accessible to researchers and managers. You can look at maps on the database to see where else the species you found is showing up.

Botanical illustrations by ***Katherine Benkman****, artist intern at the University of Wyoming Biodiversity Institute.*

on an increasing number of acres throughout not just Sheridan County, but also in Johnson and Campbell Counties. The known reach of medusahead in Wyoming has also increased. These expansions are likely due to both increased awareness of the species as landowners are starting to recognize and report the weeds as well as the weeds actually cropping up in new areas. Late summer aerial photos show the telltale blond swaths of ventenata infestations like brushstrokes on the Bighorn Mountain foothills.

And yet, Sander, Mealor, and the other NEWIGWG partners remain optimistic.

"I-90 is our new fire line, if you will," Sander says. "If we can keep it north of I-90 and east of the Bighorns and try to contain it in that zone if possible. Our high priority areas are going to be any of those outliers or places that it is encroaching that boundary."

This winter, NEWIGWG is applying for funding to hire a director and coordinator, someone who can take on the grant writing and bringing together stakeholders as a full-time responsibility rather than piling that work on top of already full-time jobs as Mealor and Sander have done. And the group continues searching for additional funding to cover the costs of this year's surveying, outreach, research, monitoring, and spraying. In the few years they have been working on this, they have made progress on understanding the weeds and finetuning their management strategy.

Luke Sander

Luke Sander, supervisor for Sheridan County Weed and Pest, is at the frontlines of the fight against ventenata and medusahead in Wyoming, coordinating spraying of thousands of acres each growing season among other tactics.

"I would describe this project as a flagship project to address this," says Garner. "They have all the components to make it successful, and they did everything they need to do, and they have the resources to do it."

"So far to date we have done more landscape treatments than anywhere in the nation, so people are kind of looking to us of what to do," Sander adds.

In his office at the extension building on the Sheridan College Campus, with a sweeping view across the college's agricultural experiment fields toward the Bighorn Mountains, Mealor shares a parable. Goatsrue, a plant from the Middle East, was intentionally cultivated in Utah in the 1980s for forage but ended up being toxic to livestock and very invasive.

"It got to be 40,000 acres of documented spread," he says. "A bunch of agencies came together, very similar to what we are doing here, and implemented a goatsrue eradication program. And over ten years they got it down to a few sporadic patches spread over tens of acres. They almost got rid of it."

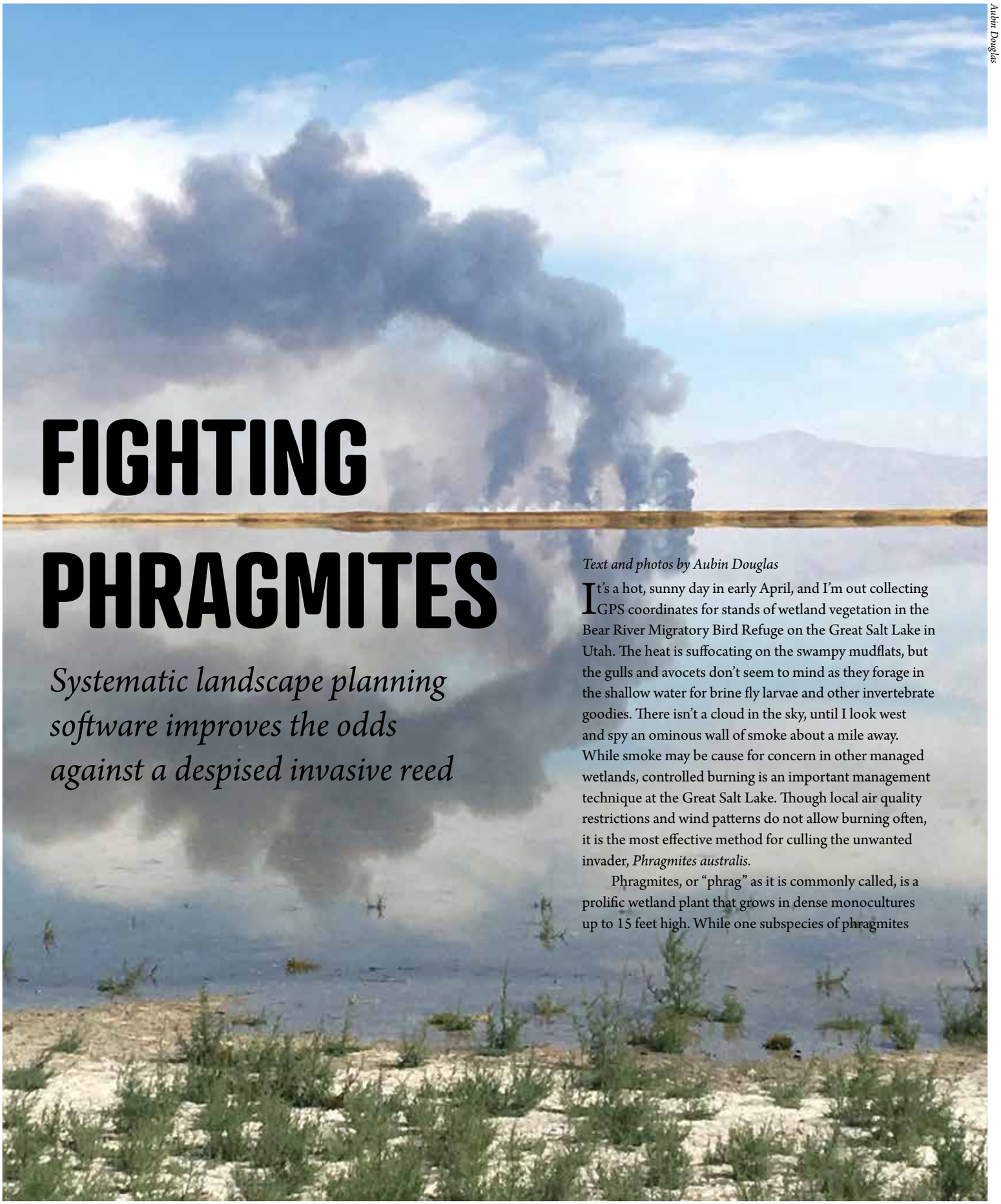
But then, as he tells it, people moved, administrations changed, and federal funding went away. Now there are more than 40,000 acres of goatsrue in Utah again.

"That's the scary part. We could dump all this time and effort into it, and then some significant thing changes out of our control and it could come undone. That's the unfortunate reality." He knows eradicating the species is a stretch, but adds, "We have to build at least management of these species into the culture of this region. … I think we can try."

Emilene Ostlind *is communications coordinator at the University of Wyoming Ruckelshaus Institute of Environment and Natural Resources and is founding editor of this magazine.*

Emilene Ostlind

More than 100 participants from across the West and beyond attended the third annual "Medusa-Nata Tour" in Sheridan County in June of 2019 to see two invasive grasses growing in the wild and to learn from Mealor, Sander, and other experts about the best practices for controlling them.



Aubin Douglas

FIGHTING PHRAGMITES

Systematic landscape planning software improves the odds against a despised invasive reed

Text and photos by Aubin Douglas

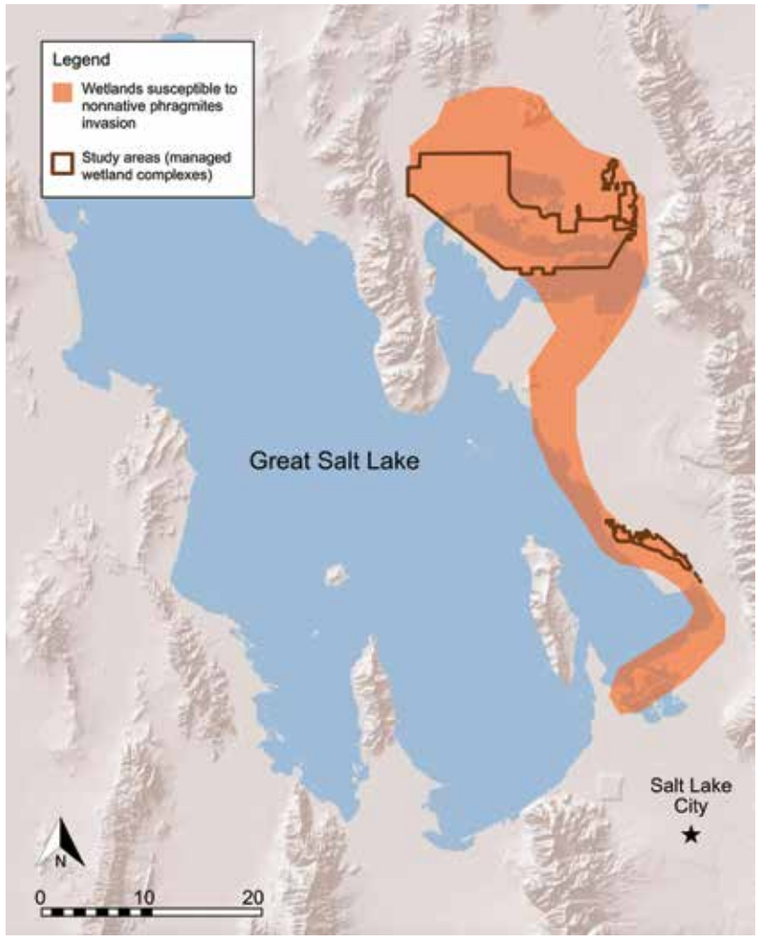
It's a hot, sunny day in early April, and I'm out collecting GPS coordinates for stands of wetland vegetation in the Bear River Migratory Bird Refuge on the Great Salt Lake in Utah. The heat is suffocating on the swampy mudflats, but the gulls and avocets don't seem to mind as they forage in the shallow water for brine fly larvae and other invertebrate goodies. There isn't a cloud in the sky, until I look west and spy an ominous wall of smoke about a mile away. While smoke may be cause for concern in other managed wetlands, controlled burning is an important management technique at the Great Salt Lake. Though local air quality restrictions and wind patterns do not allow burning often, it is the most effective method for culling the unwanted invader, *Phragmites australis*.

Phragmites, or "phrag" as it is commonly called, is a prolific wetland plant that grows in dense monocultures up to 15 feet high. While one subspecies of phragmites

is native to Utah, an introduced, more pervasive European lineage causes land managers much more anxiety than its well-behaved native counterpart. Nonnative phragmites is despised for many reasons, including its penchant for clogging waterways, disorienting and trapping hunters within its fibrous walls, and displacing native vegetation and critical bird habitat. Its capacity to quickly populate barren patches of soil has caused a major headache for wetland managers around the Great Salt Lake and across North America.

In 1983, severe flooding caused the Great Salt Lake level to rise dramatically. The briny lake water stripped most of the established vegetation away and left bare earth behind once the water receded. The invasive European strain of phragmites is a disturbance specialist. As such, in the mid to late 1980s it spread like wildfire across the eastern edge of the Great Salt Lake, encroaching wherever bare soil or shallow freshwater was found. Today, European phragmites has carpeted 24,000 acres of the eastern shore, which is almost 38 square miles altogether. Phragmites control now commands the bulk of wetland managers' resources, including both time and money.

Since 2015, the management agency that manages the lakebed—the Utah Division of Forestry, Fire, and State Lands—has annually requested funds to manage the spread of phragmites around the Great Salt Lake. In 2019, they applied for $500,000 to treat just under 6,300 acres of invaded land, only about a quarter of the total impacted area. But, as a new study out of professor Karin Kettenring's Wetland Ecology and Restoration Lab at Utah State University shows, successfully removing phragmites requires at least three consecutive years of repeated treatments, ongoing spot treatments of new satellite colonies, and the restoration of previously invaded areas back to native habitat. Given that managers simply do not have enough money or manpower to treat the entire phragmites-invaded area each year, how do they decide where to target their efforts? They require a methodical, data-supported process for determining where their limited management efforts will best contain phragmites and protect the remaining native wetlands.



Since the 1980s, an nonnative species of phragmites, a tall, fibrous wetland plant, has been spreading across the eastern side of the Great Salt Lake. Graduate student Aubin Douglas is working with managers in two wildlife refuges on strategies to optimize application of limited management resources and best reach conservation targets.

As a graduate student at Utah State University in the Wetland Ecology and Restoration Lab, I learned about the difficulties facing wetland managers, especially in regards to justifying funding requests to contain the spread of invasive phragmites and to ensure the successful restoration of native habitat. This uphill battle may seem futile to potential funding agencies and organizations, especially without any guarantee that what land managers accomplish this year will persist through the next growing season. After talking to several land managers, I realized I could design a research project to help them address the disparity between their goals and the available resources while limiting the risk of failure for restoration projects. This research would give funders greater confidence in management actions and increase their likelihood to provide resources.

After much discussion with land managers and my thesis committee, I decided to use an approach known as systematic landscape planning to tackle this issue. Systematic landscape planning addresses conservation planning problems by identifying areas within a landscape that together meet management goals while limiting management cost and risk of failure of management actions. I decided to use the software Marxan, because it is the most widely used systematic landscape planning software in the world. It is open-source, highly customizable, easy to employ, and can process a wide variety of spatial data inputs. Marxan optimizes the selection of planning units—in this project, areas to guard against phragmites—to meet set conservation targets, like protecting bird habitat, while minimizing the management cost and risk of phragmites taking over an area. The ultimate goal for this project is to create a spatial plan-of-attack that will attain the desired goals on the landscape for the least amount of management resources and with the greatest potential for successful implementation.

To employ a Marxan optimization solution to this problem, several spatial data elements were needed, including a gridded representation of the study area, a valuation of risk associated with phragmites, management costs, and conservation targets. To create such layers, I developed cost data in accordance with local managers' knowledge of phragmites control and water management. Next, I subdivided the study area into 1-hectare units, which is a manageable scale for local crews, yet still large enough to be impactful on the landscape. I created the risk layer by employing machine learning algorithms to classify aerial imagery into likely locations of specific wetland plant species. I then used an ecological niche model and landscape data, such as where phragmites is currently found, distance to water, and distance to disturbance, to model phragmites invasion potential across the study areas.

I then developed conservation targets with the US Fish and Wildlife Service and The Nature Conservancy—the two agencies managing these study areas. They were primarily concerned with migratory bird habitat and other ecological functions performed by wetland vegetation, such as soil carbon sequestration, heavy metal retention, and above-ground biomass. I spatially modeled these and several other ecological functions and am using them as the conservation target inputs. Marxan will run each scenario millions of times to generate a near-perfect network of planning units that meet

the set targets for the least amount of cost and risk. Marxan accomplishes this objective by randomly selecting planning units until all conservation targets are met for each run. If the new run creates a management plan with less risk and cost than the previous run, it will select the new run as the "current best" and move onto the next run. It runs these random scenarios millions of times so you end up with a management plan with the lowest risk and cost based solely on data inputs. Marxan can also show the user which units were selected the most and least often. The units selected most often are critical to meet set targets while those rarely or never selected are not likely to provide much benefit. While I am still finalizing my modeled conservation targets, I expect to complete this project by the fall of 2020. Through this process, I will show wetland managers which planning units they should treat given their limited resources to best meet their conservation targets while reducing the risk of phragmites undoing their on-the-ground work.

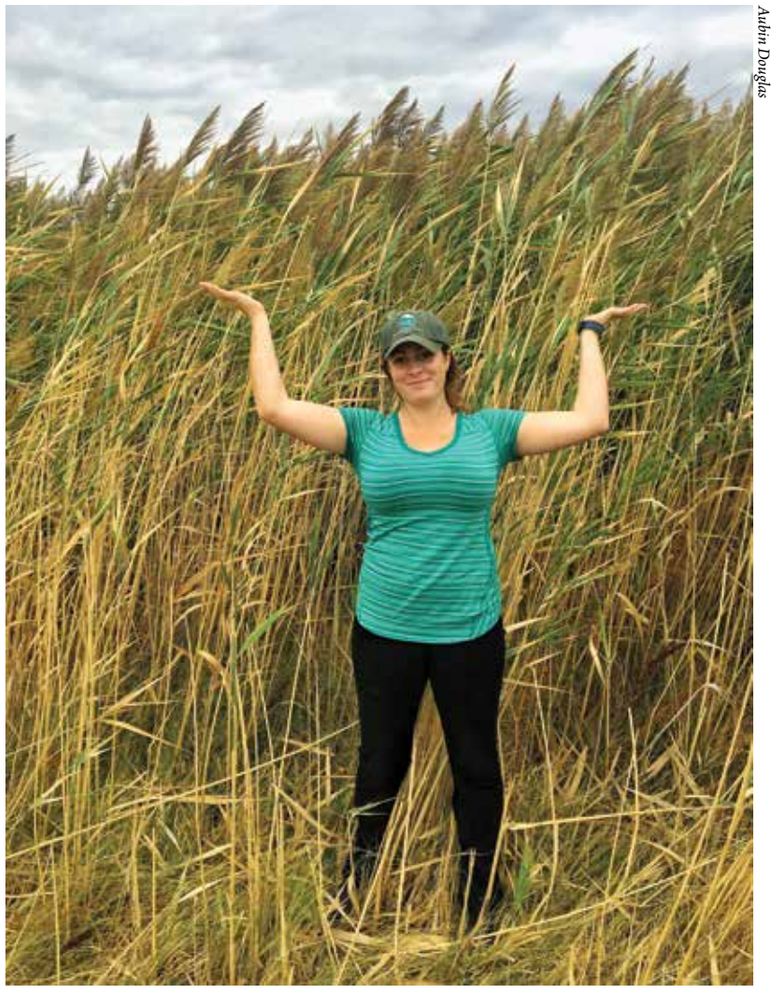
The methods developed in this study are transferable to other areas facing similar issues with invasive species, especially invasive plants. As long as land managers and planners can identify areas that are suitable to an invasive species (whether that is through mapping, using a species distribution model, or any other method), they can use the risk-aversion aspect of systematic landscape planning with Marxan to optimize their choice of treatment areas on a landscape. The other layers—cost data, a gridded study area, and conservation target data—can be as simple or complex as the project requires. This method could be used to plan treatments for other problem species in the West including purple loosestrife, cheatgrass, tamarisk, Russian olive, or other areas impacted by the dreaded phragmites. This tool can help land managers like the Bureau of Land Management, US Forest Service, National Park Service, and state agencies address the daunting task of invasive species control, which is an ever-growing nuisance in the West.

Aubin Douglas

Nonnative phragmites grows thick and tall in the wetlands on the east side the Great Salt Lake where it clogs waterways, disorients and traps hunters within its fibrous walls, and displaces native vegetation and critical bird habitat.

When hard decisions must be made concerning where to allocate limited resources, managers and planners can use systematic landscape planning to create a defendable management plan based on data rather than relying solely on expert or stakeholder opinion. Systematic landscape planning provides a comprehensive and transparent method for prioritizing management efforts where location information or management resources are limited and prudent decisions are required. As phragmites continues its march across Great Salt Lake wetlands and other parts of North America, managers employing this approach will have an advantage in the never-ending battle against its far-reaching roots and shoots.

***Aubin Douglas** is a Cartography and GIS Fellow at the US Fish and Wildlife Service in Lakewood, Colorado. She is concurrently completing her second MS in the Ecology Center and Watershed Sciences Department at Utah State University. Visit karinkettenring.com to find out more about the Wetland Ecology and Restoration Lab at Utah State University.*



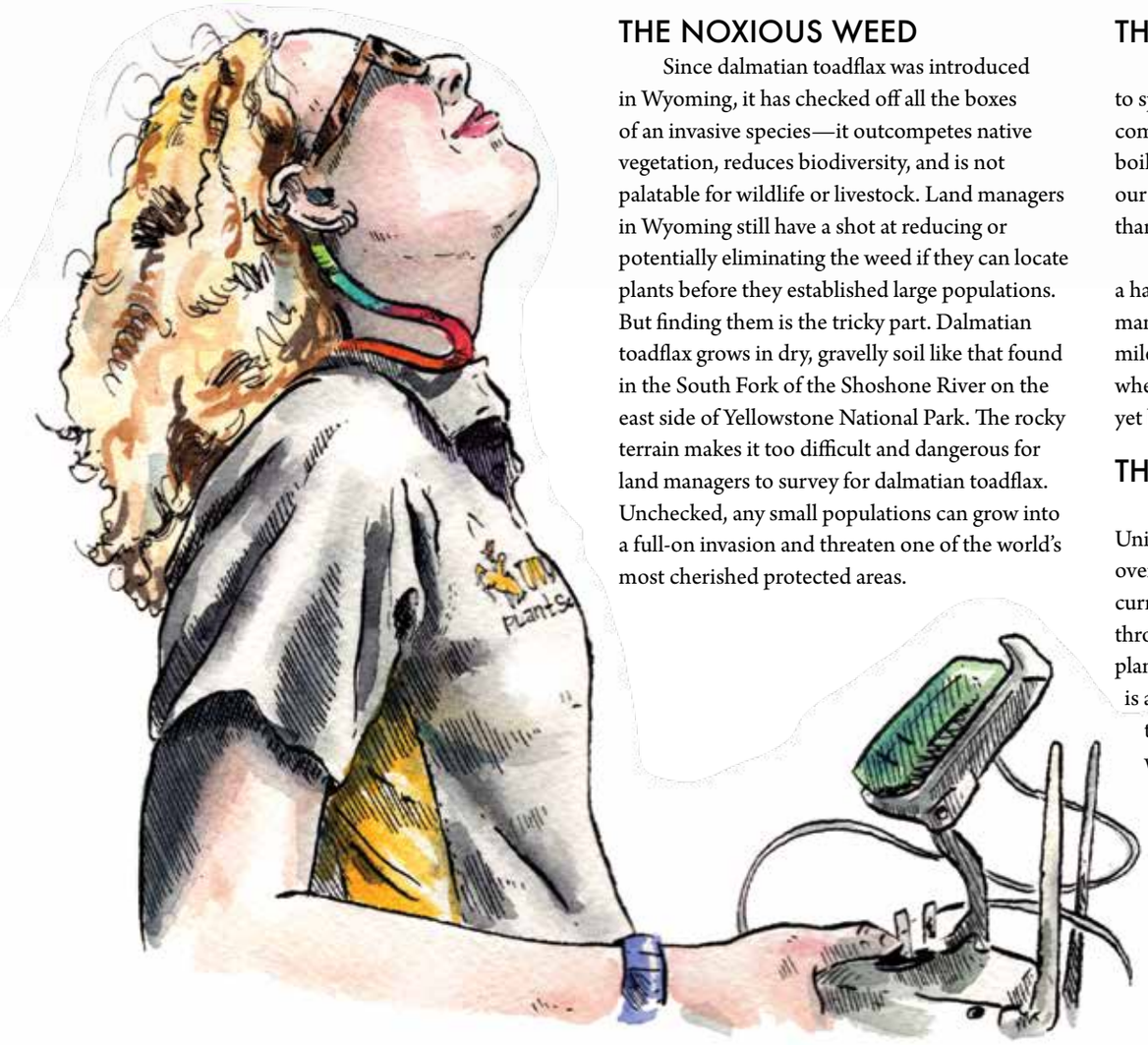
Aubin Douglas

Aubin Douglas, a graduate student in the Ecology Center and Watershed Sciences Department at Utah State University, is developing an approach for using systematic landscape planning software to strategize which areas managers can apply limited phragmites treatment resources to best meet their conservation targets.

The Toadflax Needle in the Wilderness Haystack

Using technology to detect and map new invasive species arrivals

Text by Sara Teter, artwork by Cal Brackin



THE NOXIOUS WEED

Since dalmatian toadflax was introduced in Wyoming, it has checked off all the boxes of an invasive species—it outcompetes native vegetation, reduces biodiversity, and is not palatable for wildlife or livestock. Land managers in Wyoming still have a shot at reducing or potentially eliminating the weed if they can locate plants before they established large populations. But finding them is the tricky part. Dalmatian toadflax grows in dry, gravelly soil like that found in the South Fork of the Shoshone River on the east side of Yellowstone National Park. The rocky terrain makes it too difficult and dangerous for land managers to survey for dalmatian toadflax. Unchecked, any small populations can grow into a full-on invasion and threaten one of the world's most cherished protected areas.

THE MAP

Land managers don't have the time and money to spray every plant. Creating effective strategies to combat invasive species like dalmatian toadflax, then, boils down to mapping their locations. In Wyoming, our maps of invasive species are much more limited than one might think.

Current mapping strategies typically involve a handful of people driving Wyoming's roads and manually entering data. With thousands of square miles to cover, this approach misses secluded areas, where invasive species might have appeared but not yet become widespread.

THE RESEARCHERS

Chloe Mattilio, a PhD candidate at the University of Wyoming, is researching ways to overcome the current obstacles to mapping. Her current work focuses on detecting invasive plants through aerial imagery and creating management plans through mapping. Chloe's advisor, Dan Tekiela, is an assistant professor and extension specialist in the UW Department of Plant Sciences. Dan works with federal, state, and local agencies as well as private land managers to create more efficient plant management strategies.

THE QUADCOPTERS

To solve Wyoming's mapping problem, Chloe and Dan turned to an unexpected solution—drones. They fly consumer-level quadcopters to take pictures of the landscape using multi-spectral sensors that can detect five different bands of light, identifying invasive plants by the wavelengths of light their leaves and flowers give off. Using the quadcopters, mappers can search larger or more dangerous and secluded areas for invasive species.

THE FUTURE

Dan says this research is garnering a lot of interest from land managers, landowners, and others. It's no mystery why. The images the quadcopters collect could create comprehensive maps of invasive species in Wyoming and help prioritize which areas to target.

Dan is careful to say this application still a bit far down the road, but has the potential to save land managers time, money, and energy in combating invasive plant species. Creating affordable, user-friendly software to analyze the quadcopter data is the biggest hurdle to overcome before the technology can be widely available.

"When you have so few people, that's the important thing. If you can chip away at the fact that we don't have those eyes on the ground by using those sensors, I think it could have major implications," Dan says.

***Sara Teter** was* Western Confluence's *2019 Science Journalism Intern.* ***Cal Brackin** is a Wyoming-based illustrator and community development professional who understands how artists are creating change in an interconnected world. See more of his work at onboardinnovations.com.*

Released to the Wild

Unwanted pets take a toll on ecosystems

By Kristen Pope

Stepping through the tall grass, a family made their way to the edge of Kelly Warm Spring, a geothermal spring with a temperature that hovers around 77 degrees Fahrenheit year-round, in Grand Teton National Park. A young child carefully held a small bucket containing his first pet: a goldfish. The family was moving and didn't want to bring it with them. At the water's edge, the boy knelt down and slowly dunked the container, letting the fish swim away. After a tearful wave goodbye, the family returned to their car and drove back to the highway, relieved they had found a place for the fish to live out its life. What they didn't know was that they were breaking both Wyoming state law and National Park Service regulations and contributing to an invasive species catastrophe.

And they aren't alone. According to Grand Teton National Park spokesperson Denise Germann, people have dumped aquarium fish in Kelly Warm Spring since the 1960s. The spring is so enticing because its warm temperature offers a better chance of survival than other waterways.

Many warm water and tropical species have survived in Kelly Warm Spring, including goldfish, koi, tadpole mad toms, swordtails, guppies, and convict cichlids, along with red rimmed melania snails and American bullfrogs. They threaten native species like native Utah chubs, redside shiners, longnose dace, and speckled dace as well as those downstream—like Snake River cutthroat trout and bluehead suckers.

"The native species are pretty rare now in Kelly Warm Spring, and I think that's direct and indirect competition and predation as well," says Grand Teton National Park fisheries biologist Chad Whaley. "We also see a suite of pathogens and diseases that we wouldn't typically see in Wyoming waters, and those are likely associated with the aquarium [fish]."

Scientists found "popeye," an infection which causes fishes' eyes to bulge, along with tapeworms, yellow grubs, salmonella, *E. coli* in excess of EPA limits, and evidence of naegleria fowleri, also known as "brain eating amoebas."

When the family released their goldfish into the waters of Kelly Warm Spring, they weren't thinking about how it could grow and outcompete native species, spread pathogens, or harm the ecosystem. They just wanted the fish to have a chance at survival. And they're not the only ones to unleash an unwanted pet on an ecosystem. Exotic pets released into the wild are a concern throughout the country and beyond.

"I would say it's a monstrous problem really," says Leah Elwell, executive director for the Invasive Species Action Network. "In this day of being able to purchase whatever you want online it can be really easy to buy whatever [pet] you're interested in internationally."

Elwell's organization educates everyone from school kids to pet store owners about the importance of not releasing unwanted pets into the wild through the "Don't Let It Loose" campaign. "Our mission is to promote behavior change that helps prevent the spread of invasive species," Elwell says.

She says many people don't know certain animals, such as bullfrogs, may be illegal to own, even though they are easy to obtain. And people don't understand the threats those animals pose to native ecosystems.

With abandoned pets thriving in the warm waters of Kelly Warm Spring—despite the fact releasing them is a Class B misdemeanor with penalties of up to $5,000 in fines and/or six months of jail time—

Join the "Don't Let It Loose" Campaign

Pets released into the wild usually suffer and die as well as harm native ecosystems. The Invasive Species Action Network partners with wildlife agencies and pet stores to help people find alternatives to releasing pets into the wild.

- If you can't keep a pet—whether it's a horse, a goldfish, or even a tiny snail—find it a new home.
- Ask local wildlife agencies, animal shelters, and even pet stores for help.
- Check if your community has an amnesty day where you can turn over exotic pets without penalty.
- Learn more at www.dontletitloose.com

Chad Whaley, Grand Teton National Park

Kelly Warm Spring, on the eastern edge of Grand Teton National Park, is around 77 degrees Fahrenheit year round. For decades, people have released unwanted pet fish to the spring despite the fact releasing them is a Class B misdemeanor with penalties of up to $5,000 in fines and/or six months of jail time.

managers wanted to take action before these animals spread even further.

Outflows from Kelly Warm Spring are located within a mile of the Snake River. Introduced warm water species were already in nearby Ditch Creek, and managers wanted to make sure they wouldn't continue to spread.

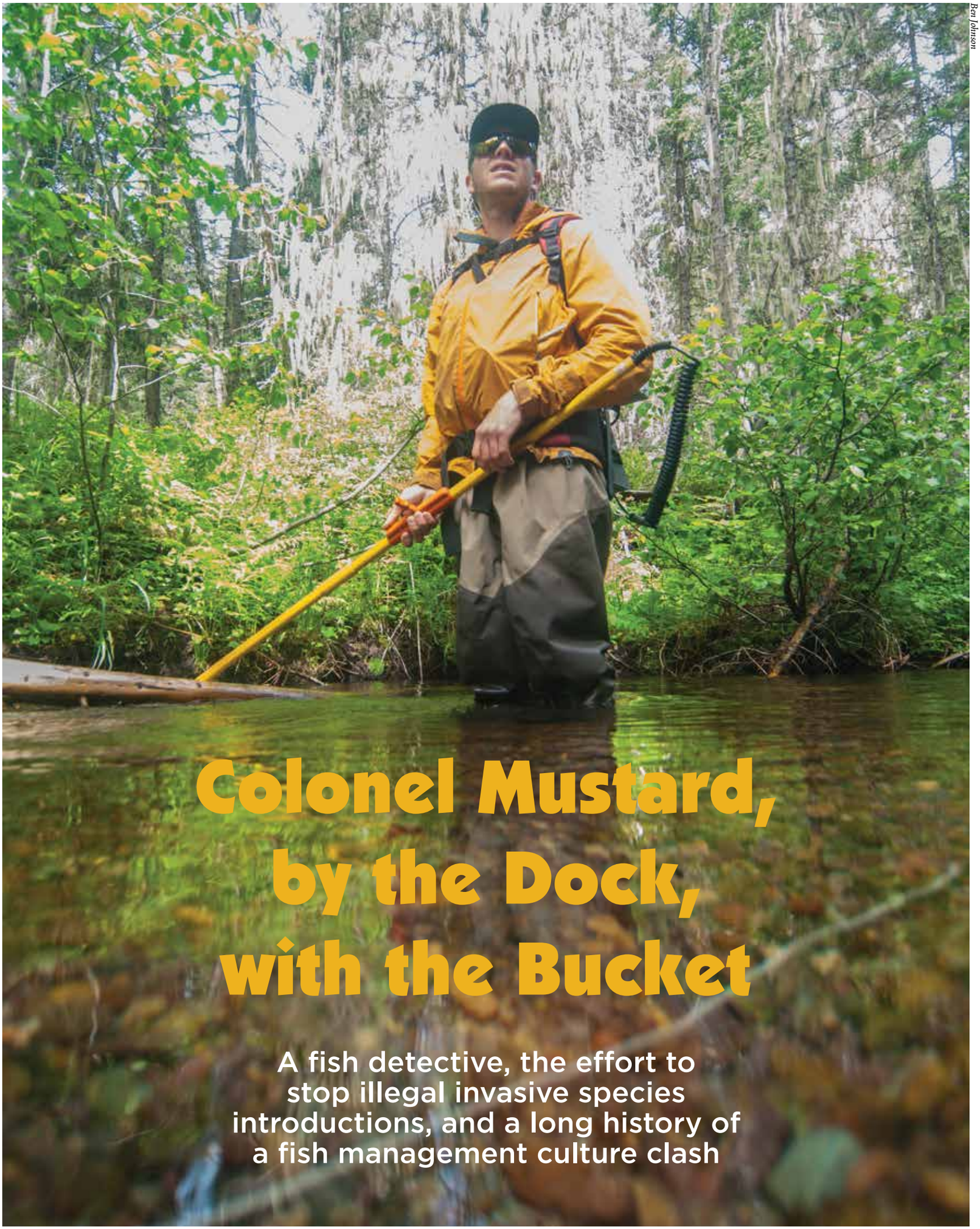
After analyzing options like trapping, netting, and electrofishing, the park selected a pesticide-based treatment. They opted for rotenone, a chemical widely used in fisheries work. After spending hundreds of hours preparing the site and clearing vegetation, they donned protective equipment and applied liquid and extended-release "sand balls" of the chemical in August 2018. They then spent days scooping dead fish from the water. Rotenone kills species that breathe through gills, and Whaley says they timed the treatment for when native amphibians wouldn't have gills and for when Ditch Creek was dry.

"We want to make sure that we do everything right," Whaley says.

While the treatment didn't kill all the fish in the spring, it substantially reduced their numbers. "We brought the risk level associated with Kelly Warm Spring down quite a few notches," Whaley says. The goal is to restore native species, but they may need to apply more rotenone or implement new strategies to eliminate the rest of the invasive fish first. Restocking native fish may also be a possibility down the line if they don't naturally recolonize from nearby waters.

While releasing a small fish into the wild may seem like an inconsequential act, the case of Kelly Warm Spring shows how introducing even seemingly harmless pets can create damage that ripples throughout the ecosystem and causes land managers to expend a tremendous amount of effort to restore native wildlife populations.

***Kristen Pope** is a freelance writer and editor. She has written about white-nose syndrome in bats, tiny houses, conservation easements, and more for* Western Confluence. *Learn more about her work at kepope.com.*



Ben Johnson

Colonel Mustard, by the Dock, with the Bucket

A fish detective, the effort to stop illegal invasive species introductions, and a long history of a fish management culture clash

By Ben Johnson

One summer day in 1992, two teenage boys fishing Lake Mary Ronan watched a man dump a cooler of fish near the lake outlet and leave. Sensing something amiss, the boys wrote down the license plate number and then quickly netted a couple dozen small yellow perch. They called Montana Fish, Wildlife, and Parks, and reached Jim Vashro, the state fisheries biologist at the time, who recalls making a split-second decision that day. "We just happened to have a leftover barrel of rotenone in Kalispell." (He describes the situation as an ask-for-forgiveness-later type of decision, knowing that the normal channels for rotenone approval would come too late for the situation he was faced with.) Vashro arrived within hours and treated the bay with rotenone, a powerful chemical that fatally interrupts oxygen intake of gilled organisms at the cellular level. Any desirable fish caught in the crossfire would be replaced from hatchery stock. The treatment of the bay yielded a couple dozen more perch.

Yellow perch, a popular sport fish native to Atlantic and Arctic Ocean watersheds including the Great Lakes and Mississippi River Basins, but not to any watershed west of the continental divide, are spiny with cartilage and voracious. Salmonids such as kokanee and rainbow are smooth and fleshy: good eating for anglers and predators alike. The introduction of yellow perch in Lake Mary Ronan meant adding a new predator to the system, something that could both prey on and compete with the existing salmonids, a wrench thrown into a delicate biotic system.

At the time, Vashro feared if the perch took hold and spread across the lake, eradicating them would cost up to $300,000.

"At least two perch got away from us though." Vashro, now retired from more than 30 years in fisheries management, purses his lips as he recalls the incident over coffee.

In the 27 years since, yellow perch exploded to about 80 percent of the lake's biomass, wiped out the lake's westslope cutthroat, and created a management situation where Montana Fish, Wildlife, and Parks (known regionally as FWP) now spends $40,000 per year to stock kokanee and rainbow trout. The estimated cost to rotenone the entire lake and restock desired species is now around $1 million, in addition to the burden of years of permitting and public comment. The perch have simply become part of the lake's biome.

Tax payers, state coffers, anglers, and nearby communities take the hit for the short-sighted and short-term benefit of the "bucket biologist," anglers who bring in new species with the intent to improve their own fishing opportunities. Whether their intent lays in convenience, preference, or simply nostalgia, their actions can have far-reaching effects. Such bucket biologists are the bane of wildlife managers, who already have a hard job. They are tasked with maintaining ecological health as well as providing sportfishing opportunities, not to mention juggling the fundamental and competing philosophies that underpin each of those, in waterways transformed by decades of illegal fish introductions and misguided stocking programs inherited from a bygone era, all on a short budget and with little sympathy from the public. One biologist tells me frankly, "We can't do everything we'd like to, and we can't make everyone happy."

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A long history of heavily managed fisheries doesn't help the case against the bucket biologist. State-sponsored bucket biology of the 19th and 20th centuries is responsible for much of the sport fishing touted across the West. This was a time where fisheries managers acted without fully understanding larger ecological effects of introducing a species. Two of Montana's beloved trout species are nonnative. Though rainbow trout are native to the upper Kootenai River, which flows south from British Columbia into a tiny corner of northwest Montana, they are nonnative and have been widely introduced elsewhere across the state. Brown trout were introduced from Europe in the 1880s. Very few waterways in Montana house a true native assemblage of aquatic species. Fisheries managers largely manage for ecological stability in a system, mated with some semblance of public whim and what anglers want in a fishery.

Montana Fish, Wildlife, and Parks managers strive to keep yellow perch, walleye, and northern pike—three nonnative predatory sportfish—out of waterways west of the Continental Divide where they would threaten westslope cutthroat and other native species.

Historically, a waterfall just downstream of Lake Mary Ronan meant the lake had no native fish. In the 1890s, an agent for the Flathead Indian Reservation, whose wife is the namesake of the lake, introduced the first fish to the lake. Fishing became popular there, and by 1913 the Somers State Fish Hatchery was stocking cutthroat and rainbows. Numerous other species, including kokanee, as well as chinook and coho salmon, Yellowstone cutthroat, grayling, brook trout, largemouth bass, and sunfish, were introduced over the following century. Eventually, three salmonids—the cutthroat, kokanee, and rainbow trout—came to comprise a stable ecosystem that, though not native, supported well-liked sport fishing and provided a very important kokanee brood stock to feed the state's fish hatcheries and stocking programs.

While early state-sponsored fish stocking was not grounded in science, decades of improved ecological understanding have contributed to the decision-making actions of fisheries managers, who still utilize stocking programs as a tool across the state. Bucket biologists, in contrast to fisheries managers, do not take into account the drastic ecological and economic effects that may come with an introduced species. Many bucket biologists consider their actions to be for the ultimate benefit of the fishery, though recent history suggests long-term negative impacts.

"It's just a boom and bust cycle." Vashro describes how a bucket biologist's introduced species such as pike, perch, or walleye, with no competition, will initially blow up and be good fishing. But then they reach carrying capacity, and, like in Lake Mary Ronan, there will be a few 10- to 12-inch perch, but many more 4- to 6-inch ones. "No one wants to fish that."

Lake Mary Ronan, about 15 miles south of Kalispell, Montana, has seen its share of sportfish introductions, both those condoned and managed by wildlife officials as well as those perpetrated illegally by "bucket biologists" out to create their own version of a fishery.

One of Vashro's legacies was establishing a state-wide database of over 600 unlawful fish introductions, most of which resulted in decreased fishing opportunities. He estimates that just a couple of the 600 unlawful introductions documented in Montana improved the fishing. Furthermore, improved fishing conditions in the eyes of the bucket biologist are not improving the angling opportunities for the rest of the sportsman in the state or the long-term viability of a fishery. Introduction, particularly of an apex predator, might create a short-term boom (as it fills up on a surplus of prey), followed by a crash of both that species, as well as the pre-existing species that are now predated on or out-competed.

Vashro has even heard of bucket biologists with a 10-year plan. "They just move from lake to lake, introducing a species and fishing the boom, then moving on to the next boom as the lake busts behind them."

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On a Saturday in June, I walk past a stock tank of sodas outside a school house turned community center about five miles from Lake Mary Ronan and make my way through small clusters of people milling around plates of home-baked cookies and carafes of coffee.

The community center is serving as a venue for the Friends of Lake Mary Ronan open house. Fifty-odd lake residents, anglers, and other community members gather, taking seats in an assemblage of folding chairs, old church pews, easy chairs, and couches. I settle for an old school desk, my notebook taking the majority of the surface. On the docket for the afternoon are presentations on water quality, septic upgrade cost-sharing grants to address leaks, as well as illegal fish introductions.

The crowd, gathered in the interest of their lake, which some describe as dying, is charged. They cite a variety of concerns: decreased fishery productivity, eutrophication related to development, increasing numbers of nonnative cormorants feeding on the lake's fish, and a newly introduced nonnative fish. Some care about algae and poor water quality disrupting swimming or boating. Some care about fishing for rainbow trout. Some care about fishing for perch. Others care simply about the lake's kokanee brood stock. The perch population, spilled from that cooler in 1992, is on the bust end of its cycle, with a high population of stunted individuals.

Sam Bourret, in a blue plaid shirt with hands stuffed into jeans pockets, takes the stage last. In his mid-30s, Bourret, a fisheries biologist with Montana FWP based nearby in Kalispell, is here to talk about illegal fish introductions and the research he does to identify them. He clicks through his first few slides, flashing a bright smile with the slightest gap between his two front teeth as he mixes light-hearted jokes in with dense explanation of his otolith research.

"Oto: ear. And lith: stone." Bourret enunciates slowly. "Oto-lith." He has a goofy slide with a human ear superimposed on a fish and Stonehenge. For those a little foggy on their fish physiology or Latin, he explains, the otolith is the ear bone of a fish. As a fish grows, the otolith records the unique geochemical profile of the body of water where the fish lives. Similar to tree ring data, it provides a timeline of a fish's life history. Bourret takes a slice of that otolith, using it to identify the body of water a fish came from, and subsequently, whether a drastic change in habitat has occurred, such as in the instance of a fish being moved to a new body of water. He takes a pause to pass a plastic sandwich bag containing actual otoliths around the room, adding that they make great earrings for fish lovers.

Bourret clicks to the next slide. In 2015, a commercial fishing crew contracted by FWP to remove nonnative lake trout raised the alarm when they unexpectedly plucked two walleye—toothy, nonnative predators, previously not present—from Swan Lake. Walleye are a big fish; the Montana record stands right around 17 pounds, though most are just a pound or two. While Montana fisheries managers stock and manage walleye for sport fishing east of the continental divide, they fear the threat walleye pose to westslope cutthroat west of the divide in places such as Swan Lake.

Bourret quickly jumped on the case. His slide shows a slightly oscillating line with a dramatic y-axis shift when the fish arrived in Swan Lake. By collecting and analyzing other walleye otoliths from Montana (there are just a handful of lakes, reservoirs, and associated rivers where walleye are found), Bourret identified the source of the introduced fish as Lake Helena, more than 150 miles away. A local paper picked up the story and dubbed Bourret "the Fish Detective," a moniker he's carried ever since.

This presentation at the community center isn't his first in the region or the state. He has presented his otolith research everywhere from a "Science on Tap" event at a nearby brewery to the American Fisheries Society student chapter at

Montana State University. Bourret knows his research isn't catching bucket biologists, but hopes that the education piece that comes along with his presentations can continue to raise awareness and help shift the culture away from bucket biology, whether that be through the fear of being caught, or the understanding of the severe ecological and financial costs of managing an introduced species.

"This is 100 percent preventable," Bourret tells me, shaking his head.

Vashro concurs. "Prevention is where it is at. People need to knock it off."

Across the West, states are getting serious about stopping illegal fish introductions. Around the time of the 1992 perch release in Lake Mary Ronan, Montana FWP first designated reward money for informants who turned in bucket biologists. The current bounty on those responsible for the two walleye in Swan Lake that Bourret's team identified is $30,000, offered by the state of Montana and Trout Unlimited.

Montana is not alone facing the issue of bucket biologists' attempts to curate their preferred fishing spot. In Alaska, the fine for transporting a nonnative species to new waterways can be up to $10,000. In 2018, the state of Utah drained Kolob Reservoir near St George, treating it with rotenone after yellow perch, green sunfish, and bluegill—three species that threatened the endangered Virgin River chub and woundfin—showed up. When northern pike appeared in a Colorado reservoir in 2018, Colorado Parks and Wildlife, in conjunction with local and state partners, started paying anglers $20 for every pike pulled out of the reservoir and the White River. And after a bucket biologist released northern pike into Nevada's Comins Lake in 2004, angler user days dropped from about 35,000 to an estimated 2,000. In 2015, Nevada spent $250,000 to remove the pike, but in 2017 someone released more northern pike into the same water body. The state has offered a $10,000 bounty for information about this latest pike introduction.

The license plate number those teens grabbed in 1992 at Lake Mary Ronan identified Gregg Mosely as the bucket biologist behind the devastating yellow perch release. Law enforcement located him and cited him; he received a restitution fine for FWP's mitigation efforts and two years loss of fishing privileges. But when he received the bill to the tune of $1,500, he balked. The case ultimately went to the Montana Supreme Court in a jurisdictional feud, where Mosely successfully argued that the court in which he was charged did not have the power to levy restitution fines for a misdemeanor in excess of $500. The remainder of his fine was thrown out.

To this day, Montana has not paid out a major bounty for someone reporting any bucket biology. Of the 600 documented illegal introductions Vashro has cataloged, he points to about a dozen instances in the state where someone was prosecuted for an illegal fish introduction.

"It's mostly the private pond vector," he says. "Someone steps around the law to stock their own property with whatever, not realizing and not caring about the downstream effect." He describes how one man put grass carp in his pond to help control the reeds so he could have a better pond habitat to train his hunting dog in. "Putting grass carp at the headwaters of the Columbia River watershed…" Vashro trails off, shaking his head. In that instance, the individual had forged import papers three times, ultimately earning himself a $3,500 fine for the removal of the species. In the end, it's much easier for FWP to clean up unlawfully stocked private ponds than larger water bodies like Lake Mary Ronan, or instances when fish enter entire watersheds.

"We know people who know who is doing it," Vashro tells me. "We even had an informant who knew who was introducing walleye to Noxon Reservoir. We were waiting for him to tell us the next time the guy was going to release the walleye, but he [the informant] went to jail for something else and clammed up."

"We need a citation," Bourret tells me. "Someone needs to get slapped with a big fine."

Ben Johnson

Sam Bourret, a fisheries biologist with Montana Fish, Wildlife, and Parks, has earned the moniker "Fish Detective" for his research analyzing the geochemical profiles of otoliths, or ear bones, to trace illegally dumped fish back to the bodies of water where they were born.

Back at the community center, the projector screen flashes again. A murmur emerges from the crowd as Bourret explains what we are looking at. The slide shows the otolithic profile of a northern pike indicating the fish was born in Lake Mary Ronan. Pike are an aggressive predator, known to eliminate their own food supply within a couple years and turn cannibalistic in the absence of other prey. In eastern Montana, pike wiped out several prairie minnow species. While a sought-after sport fish, illegally introduced pike are a fisheries manager's nightmare. This isn't the first pike to be pulled from the lake. It's the fourth that's been turned in to FWP since 2015 and other sightings have been reported. But Bourret's research indicates this is the first evidence of a pike born in the lake, which means the population is establishing. Just the day before, Montana FWP issued a mandatory kill order for any pike discovered in the lake.

Bourret concludes his presentation and begins to take questions. The first hand shoots up.

"Is having pike in this lake such a bad thing?"

Bourret sticks to the science, not taking the bait into what is obviously an emotionally charged debate. "We know pike are voracious. They may prey on the perch, but they are likely to prey on the kokanee and rainbows as well."

A week later on Bourret's porch, he talks more about the answer that man might have been looking for. "He wanted me to say that having an apex predator present in the lake would put pressure on the yellow perch and make better perch fishing. But we don't know that. We, the FWP, have to be concerned about the effect that pike may have on kokanee. That's Montana's sole brood stock for the state's hatcheries."

***Ben Johnson** is a former environmental educator and freelance writer who lives in northwest Montana.*

The Four-Footed Watercraft Inspector

Can specially trained dogs keep invasive mussels out of western waterways?

Text and photos by Maria Anderson

A mile outside of Browning, Montana, a watercraft inspector sits on the side of the highway next to her kennel. She's waiting for boaters heading to and from Glacier National Park to pull onto the side of the road for a mandatory invasive species check. Meet Lily, a 55-pound, 11-year-old, golden Labrador retriever with a white face. She wears red booties on her front feet and a red vest. Today, Lily and Aimee Hurt, her trainer, are here to support two Blackfeet Fish and Wildlife rangers, Lia Rattler and Leander Butterfly. Together the team is searching for signs of zebra and quagga mussels, two invasive species threatening Montana's beloved rivers, lakes, and streams. Lily is not only speeding up the searches, but she's also helping spread the word about how critical these inspections are in protecting the West's waters from invasive species.

These mussels are prolific, pistachio-sized creatures which affix themselves to surfaces with a byssus, a clump of secreted filaments. In Michigan, the mussels have already caused huge, ecosystem-wide shifts in Lakes Michigan and Huron, two of the world's biggest lakes, where trillions thrive. Mussels, which have been moving west over the last few decades, pose a massive threat to Montana's aquatic ecosystems and struggling native fish populations like Arctic grayling, bull trout, and westslope cutthroat. The mussels consume all of the microscopic food in a water system, leaving little for other wildlife, including native fish. They also encrust infrastructure, like water pipes, and ruin beaches. Imagine cutting your feet on decaying mussel shells any time you tried to walk barefoot along your favorite lake.

Mussels spread quickly in part because they produce up to one million eggs per year. Fertilized eggs develop into microscopic larvae, called veligers, within a few days. These near-invisible larvae can survive for weeks in river currents and travel hundreds of miles. They love lakes and sluggish rivers, and they can live undetected inside motors or tanks, where human inspectors can't reach. This is where the dogs come in. Unlike humans, they're extremely effective at detecting mussels in the larval stage. While humans must use sight and touch to search boats, feeling for the sandpaper-like texture of juvenile mussels just beginning to grow their hard shells, dogs are able to smell the veligers in water, where they're completely invisible to humans.

Maria Anderson

Lily and her trainer, Aimee Hurt, check a boat for signs of mussels outside Browning, Montana.

"For dogs like Lily," says Hurt, "this is the most fun thing they could do."

At this point, Montana is not infested. Water sample tests do show, however, that the mussels are making their way west, though officials have not found any established populations or adult mussels. In 2016, Montana Fish, Wildlife, and Parks found low-density traces of larvae in water samples from the Tiber Reservoir, near Shelby. Subsequent water samples in Canyon Ferry Reservoir, the Milk River below the Nelson Reservoir, and the Missouri River near Townsend showed inconclusive but suspect results. In mid-June of this past year, North Dakota had its first mussel contamination, after an angler spotted them in Lake Ashtabula. Wyoming, Washington, Oregon, New Mexico, and Idaho are the only states in the West which have no known mussel detections—and which conduct sufficient monitoring to determine with any degree of certainty that they likely don't have mussels.

In Montana alone, these creatures could cost the state $234 million annually by decreasing water quality, lowering recreation revenue, clogging irrigation equipment, reducing real estate prices, and damaging infrastructure, according to a 2019 report by the Montana Invasive Species Council.

Lily and Hurt are here through Working Dogs for Conservation (WD4C) in an attempt to keep the mussels out of Montana for as long as possible. Hurt, who holds a biology degree from the University of Montana, cofounded the Bozeman-based company, which trains high-energy, tough-to-home shelter dogs to protect ecosystems and wildlife around the world. WD4C has 12 mussel-sniffing dogs on staff, and 35 dogs total who work in 16 countries across five continents. They've partnered with dozens of conservation groups, helping protect ecosystems from invasive species by catching invaders early—brook trout, emerald-ash borer, yellow star thistle, rosy wolf snails, and brown tree snakes, to name a few. The dogs are especially good at identifying the first colonizers of an invasive species, so that managers have a chance to intervene before a population establishes.

"I see dogs as a way for us to buy more time before mussels hit Montana," Hurt says, "while researchers come up with more tools to deal with the invasion."

WD4C looks for what Hurt calls "needle-in-a-haystack dogs" by tossing a ball down the aisle of a shelter and looking for the dog that tracks it. They go through about a thousand dogs to find one who is suitable for this type of work. A good working dog like Lily is too much for a typical household. "I've learned that if there's some point during the dog's initial stay where I think, 'This is a huge mistake,' then I know the dog is a good fit," says Hurt, who found Lily through a private shelter near Atlanta. Lily was on her fifth home before she came to live with Hurt and three other dogs in Missoula.

Hurt describes their first training exercise together as a disaster. "I was tangled up and she was barking and frothing and confused." But Lily soon improved. In another exercise, Hurt would place a scent inside cinder blocks, and when Lily sniffed the target scent, Hurt would throw a ball across her line of vision. Quickly, Lily realized that all she had to do to earn playtime was to approach a target scent and sit. Many veteran dogs like Lily learn scents in a few hours. (Wicket, a retired dog in Hurt's household, knows 32 scents—from Hawaiian rosy wolf snails to Chinese moon bear scat—and has traveled more than 100,000 miles in 12 years of field work.)

Lily knows 19 scents so far, including white-footed vole, grizzly scat, and Lespedeza, a flowering plant also known as bush clover. She can even tell the difference between an invasive species of Lespedeza and a native species. This summer, she worked in Ravalli (a small town near Flathead Lake), both ends of the Bighorn Canyon, Yellowstone Lake, and Lake Roosevelt.

Hurt considers dogs supplementary to human searchers. "Dogs are good at the prevention piece of conservation; low-density, hard to spot things. They're also great for quickly confirming human finds," she says.

As of late July, Montana Fish, Wildlife, and Parks inspectors had checked over 50,000 watercraft, and found 12 boats containing traces of mussels this year. This morning, outside Browning, a truck pulling a large motorboat stops and two men climb out.

"Mind if Lily here checks your boat?" asks Hurt. She wears muck boots and a fluorescent yellow vest with dog toys in the pockets that Lily keeps trying to grab.

"Oh, you got dogs doing this?" the man with the ponytail says. "That's really neat."

"Okay, sweet pea," says Hurt, and Lily approaches the boat, wriggling with excitement.

"Show me," says Hurt. Lily shuffles, squeaking, tail wagging. She trots back and forth, going where Hurt points.

"Come check right here," Hurt says.

Lily puts her nose on the bumper, leaving a wet mark in the dust. She walks all the way around the boat. Hurt takes extra care to direct Lily toward the drainage holes in the back, where Lily jumps and places her booties on the boat to balance while she sniffs. Nothing. The rubber ball on a rope stays in Hurt's pocket.

The inspection is over in less than five minutes. Hurt hands the men a card with Lily's picture on it and information about WD4C and mussels. Public education is an important part of Lily and Hurt's job. WD4C trained Alberta Environment and Parks' Conservation K9 teams in mussel prevention, and they did more than $1 million worth of outreach in the program's first year.

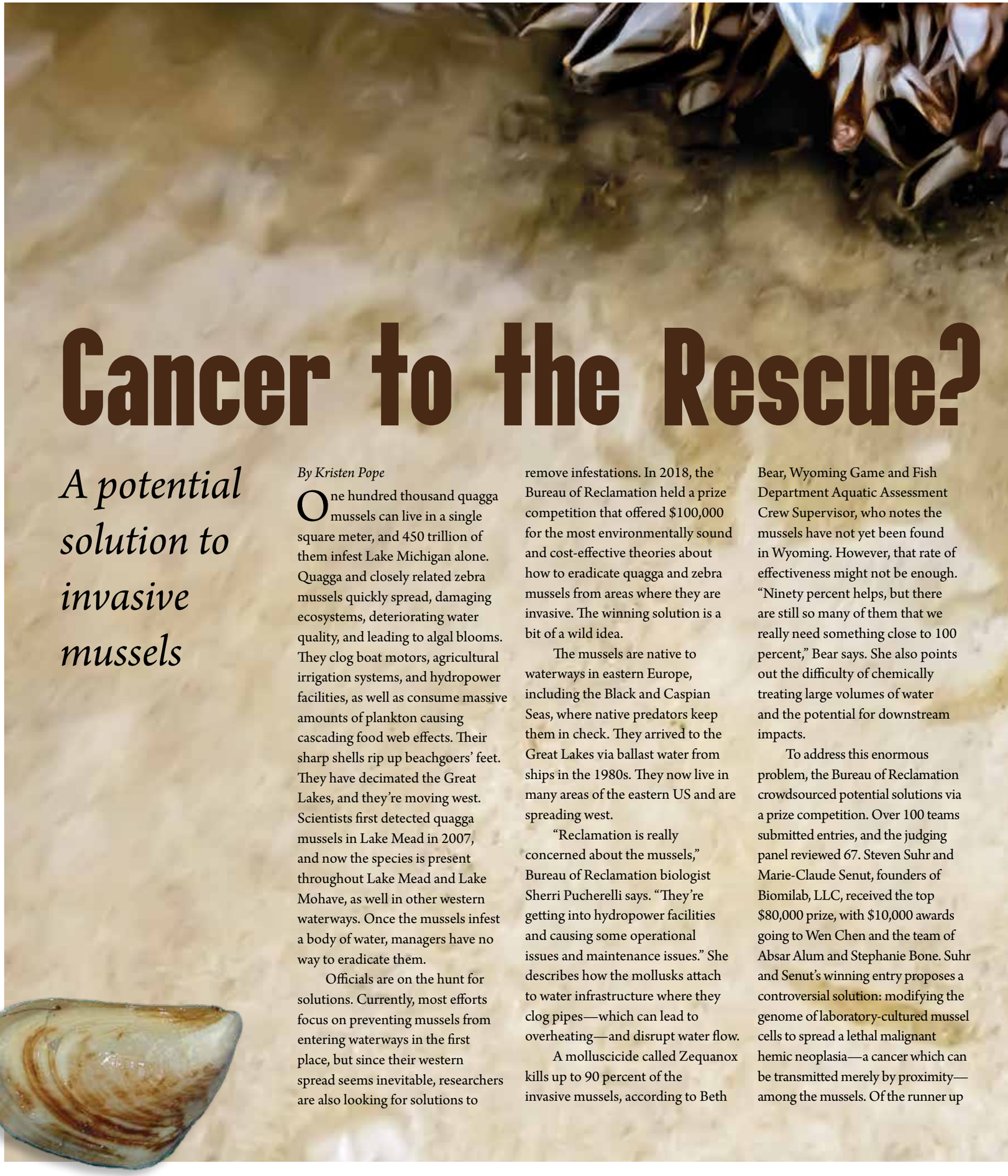
The men climb back into their truck, pull onto the highway, and drive away. After a few chilly hours, the sun comes out. Vehicles stop every 15 to 20 minutes. Lily sniffs kayaks, motorboats, and blow-up paddleboards. No sign of mussels today, but Lily doesn't mind. Every so often, Hurt hides a vial of frozen mussels somewhere on her truck so that Lily can find them and earn some well-deserved play time.

Mussels haven't infested Montana yet, and dog-handler teams like Lily and Hurt could be critical in keeping these high-stakes invaders away for as long as possible.

Maria Anderson's *work has recently appeared in* Alpinist, Climbing, 32 Degrees, *and* Best American Short Stories 2018. *She earned her MFA from the University of Wyoming and currently lives in Bozeman, Montana. Find her on Twitter @mariauanderson.*

Maria Anderson

Lily carefully checks each vehicle and watercraft, sniffing for both adult mussels and their microscopic larvae called veligers.



Cancer to the Rescue?

A potential solution to invasive mussels

By Kristen Pope

One hundred thousand quagga mussels can live in a single square meter, and 450 trillion of them infest Lake Michigan alone. Quagga and closely related zebra mussels quickly spread, damaging ecosystems, deteriorating water quality, and leading to algal blooms. They clog boat motors, agricultural irrigation systems, and hydropower facilities, as well as consume massive amounts of plankton causing cascading food web effects. Their sharp shells rip up beachgoers' feet. They have decimated the Great Lakes, and they're moving west. Scientists first detected quagga mussels in Lake Mead in 2007, and now the species is present throughout Lake Mead and Lake Mohave, as well in other western waterways. Once the mussels infest a body of water, managers have no way to eradicate them.

Officials are on the hunt for solutions. Currently, most efforts focus on preventing mussels from entering waterways in the first place, but since their western spread seems inevitable, researchers are also looking for solutions to remove infestations. In 2018, the Bureau of Reclamation held a prize competition that offered $100,000 for the most environmentally sound and cost-effective theories about how to eradicate quagga and zebra mussels from areas where they are invasive. The winning solution is a bit of a wild idea.

The mussels are native to waterways in eastern Europe, including the Black and Caspian Seas, where native predators keep them in check. They arrived to the Great Lakes via ballast water from ships in the 1980s. They now live in many areas of the eastern US and are spreading west.

"Reclamation is really concerned about the mussels," Bureau of Reclamation biologist Sherri Pucherelli says. "They're getting into hydropower facilities and causing some operational issues and maintenance issues." She describes how the mollusks attach to water infrastructure where they clog pipes—which can lead to overheating—and disrupt water flow.

A molluscicide called Zequanox kills up to 90 percent of the invasive mussels, according to Beth Bear, Wyoming Game and Fish Department Aquatic Assessment Crew Supervisor, who notes the mussels have not yet been found in Wyoming. However, that rate of effectiveness might not be enough. "Ninety percent helps, but there are still so many of them that we really need something close to 100 percent," Bear says. She also points out the difficulty of chemically treating large volumes of water and the potential for downstream impacts.

To address this enormous problem, the Bureau of Reclamation crowdsourced potential solutions via a prize competition. Over 100 teams submitted entries, and the judging panel reviewed 67. Steven Suhr and Marie-Claude Senut, founders of Biomilab, LLC, received the top $80,000 prize, with $10,000 awards going to Wen Chen and the team of Absar Alum and Stephanie Bone. Suhr and Senut's winning entry proposes a controversial solution: modifying the genome of laboratory-cultured mussel cells to spread a lethal malignant hemic neoplasia—a cancer which can be transmitted merely by proximity—among the mussels. Of the runner up

solutions, Wen's proposal involved disrupting the proteins mussels use to attach to surfaces, and Alum and Bone proposed modifying genes so fertilized mussel eggs would die in sunlight.

Suhr and Senut, who both hold PhDs in molecular biology, came up with the winning idea based on canine disseminated neoplasia, a cancer spread from dog to dog, and a similar disease decimating Tasmanian devils. When they learned about a form of disseminated neoplasia in bivalve shellfish, they decided to investigate whether this could potentially work to wipe out invasive quagga and zebra mussels.

Their idea is only a hypothetical solution for now. Before unleashing it in the wild, a number of steps must take place. First, they will collect invasive mussels and culture their cells in a lab, making sure they aren't affected by bacteria, fungi, or other contaminants. Since many forms of cancer involve mutation of genes that regulate cell division, they propose to mutate one critical regulator known as P53 to induce cancer. Suhr says this type of modification is different than germline gene modifications, where genes are modified so future generations inherit certain traits. Suhr and Senut's solution changes an independent cell and does not affect the mussels' progeny.

"We're in the weird position of actually trying to use cancer to an advantage as opposed to prevent cancer," Suhr says.

Next, they will introduce the modified cells into live mussels in the laboratory to confirm the cancer can move between mussels and kill them. They also must run tests to ensure the cancer won't harm other organisms. After seeing if the idea is feasible and possible, regulatory agencies would study the plan to make sure it is safe and effective before allowing any experiments in the wild.

Extreme caution is required since no experiment is foolproof. Any potential solution could have unforeseen implications when released into an ecosystem. With concerns about genome modification and unintended consequences—such as spreading to other species or moving into the species' native range—development is slow and painstaking. "It takes time to develop because you also have to be careful with it," Suhr says. He anticipates up to four years of laboratory work and says it could take a decade before their idea would be ready to apply on a large scale in an ecosystem.

"A lot of people would worry about this kind of stuff because obviously you don't want to introduce something that's going to impact the local shellfish population or any other kind of organisms," Suhr says. "So there's going to have to be a lot of testing in advance."

While it seems like a wild idea to inflict cancer on a species to eliminate it, Suhr says sometimes the wild card option is the best one. "When you're really trying to talk about eradication of zebra and quagga mussels in open waters and there aren't a lot of good options, the crazy ideas may turn out to be the best possible choice," Suhr says.

__Kristen Pope__ is a freelance writer and editor.

Unsung Pollinators

UW photo

Christy Bell holds up one of the thousands of bees she has collected across Wyoming in her effort to better understand native pollinators.

Native bees are forgotten in the clamor to save exotic pollinators

By Sally Leaf

Christy Bell rifled through a series of shallow drawers lining the walls of a dark, windowless lab. She opened drawer after drawer, pointing out different species, speaking their scientific names rapidly.

"Halictid bees," she said. "You might have heard them called sweat bees." Her finger swept a layer of dust from the protective glass as she traced a row of green insects. "That cuckoo bee over there is also a sweat bee, but she parasitizes other nests." She pointed to another row, her hand already on the next drawer. "Right here are mining bees from genus *Andrena*."

We hovered over the pinned specimens. It was as if she were digging through a box of family photos, pointing out close friends, old memories. There were thousands of bees. I tried to keep up.

There were social bees. There were solitary bees. There were furry bumblebees that looked like plush yellow toys. There were bees that looked like wasps. Some seemed more like beetles. There were green bees and blue bees and metallic bees with backs the color of an oil spill in a parking lot. There were bees the size of cherry tomatoes, and bees as tiny as the head of a sewing pin. All of them had different life stories and habitats and job descriptions.

Bell can recognize more bees by their scientific name than I can put names to faces in my own extended family. She doesn't need a field guide to do it. "And this is just Wyoming," she said. "Wheatland and Torrington, these are from the Black Hills, here's from Tetons, Yellowstone, Lander, Big Horn Basin."

Wyoming is home to an estimated 700 to 800 native bee species. In North America, scientists have identified 4,000. Globally, the number of species is around 20,000. But of the hundreds of species in the state and thousands in the world, Bell explained that we still don't know the life stories of the overwhelming majority. And it's hard to protect what you don't know.

She gestured to several long rows of bees with furry white bottoms. "From here to here are *Bombus occidentalis*. Those used to be one of the most common bumblebees, but now they are really rare. Up for petition to be on the endangered species list."

Bombus occidentalis, the western bumblebee, is not alone. Thousands of bee species—essential to the pollination of both native and crop plants—are in similar trouble. But while researchers are aware that bees are in dire need of protection, the public conservation effort has centered almost entirely around one nonnative species: the European honeybee (*Apis mellifera*).

Most people know this bee. It lives in a geometric above-ground hive, socializes with a waggle dance, and produces a surplus of honey. But most people don't know it's not native. Honeybees were introduced to North America by European settlers. "They are essentially managed livestock," Bell explained.

Over the last decade, problems facing honeybees have gotten a lot of press. But they are just one of many bee species in decline. The trouble, Bell told me, is getting people to understand there are a lot of different kinds of bees and they all contribute to the work of pollination differently. What works to protect honeybees, won't protect all bees.

But understanding how to protect all bees is challenging. A lot of scientists research bees in the lab, but very few actually study them out in the field like Bell does. Last year, she became the first person to survey the entire state for native bumblebees. Over two summers, she drove 20,000 miles across Wyoming, collecting bees. That's the equivalent of seven cross-country road trips without ever crossing state lines. "I'm a notorious bee murderer," she said. "I think I killed like 3,700 bumblebees in those two summers. For the sake of science," she clarified quickly with a nervous laugh. Bell told me to join her in the field the next day. "I'll show you what bees are really like—while they're still alive," she said with a smile.

The next afternoon, I met Bell near a pollinator garden at the University of Wyoming. Seven researchers trailed behind her in a straight line, grasping long wooden handles with mesh nets gathered into pointy ends. If there had been more wind, the mesh might have flapped behind them, like triangular flags held by scientists on a pollinator parade.

Bell spotted something flying and placed her net over a lupine the way you might set the mouth of a jar over a crawling insect. "They pretty much always fly up," she said as the bee headed toward the top of the mesh. She swished her net through the air to fold it over itself, then eased her bare hand into the buzzing net. She slipped the bee into a cylindrical vial about the size of a film canister. Inside, the captured bumblebee tried desperately to escape, its six legs slipping against the sides of the plastic. "This one is a *Bombus huntii* queen," she confirmed, examining it more closely.

Unlike the familiar story of hive-dwelling honeybees, the vast majority of bees, like *Bombus huntii*, live underground and lead solitary lives, the details of which remain elusive to scientists. In late fall, Bell explained, most bumblebees die. The species survives by a queen who mates and crawls underground to sleep off the winter with a belly full of eggs. In the spring, she wakes and searches for suitable real estate to make a new nest and raise her young—usually a small hole or old rodent burrow in the ground.

Like these bumblebees, thousands of other species have evolved in North America to carry out a range of specialized pollination tasks. Some bees—like the native *Perdita*—can crawl deep inside tiny wildflowers honeybees wouldn't touch. And certain crops—like tomatoes and peppers—require buzz-pollination, a process where native bumblebees vibrate their bodies at a high enough frequency to shake pollen from one flower to another. Without native bees, much of this specialized work of pollination would go unfinished.

Researchers like Bell are still in the early stages of understanding native bees and their role in certain habitats. But as more and more researchers sample regions for native bees, they are discovering a similar story: There are far fewer than before.

Bell thinks part of the reason we don't hear more about native bees is we just don't know much about them. "But all native bees are important, even if we don't understand exactly what they do," Bell said. "We're not comfortable saying we don't know, but honestly that's what science is about."

Honeybees are a fine pollinator, she explained. They just aren't the only one. And in some cases, their presence can cause more harm than good. For example, when a managed honeybee hive—which can include anywhere from 10,000 to 60,000 bees—is placed in an area where pollen is already scarce, native bees can be outcompeted by sheer number alone. And like anything raised in close quarters, pathogens can spread before amateur beekeepers are aware their hive has been compromised. Those sick bees can then spread diseases to native bee populations by pollinating the nearby flowers. It's something like touching a tissue someone else has sneezed on.

One way people can help native bees would be to get rid of lawns. "They're a huge waste. They don't provide pollen and just take up space and water resources. And people sometimes spray them with chemicals," Bell said. "Plant native wildflowers instead. Bumblebees love delphinium, lupine, hollyhocks."

Ignoring gardening altogether can be a big help to bees, she explained. Nearly 75 percent of native bee species are ground nesters and a lot of them require patchy, bare earth to burrow. "It's ugly, but leave some bald areas on your lawn," Bell said. "And don't clean up yard waste right away. Hold off on landscaping until early June when there's been a couple weeks of warm weather." Queen bees can overwinter in old hollyhock stems, she explained.

But those are small steps in the scope of a far-reaching problem. Without more researchers like Bell who study native bees in their natural habitat—and the accompanying funding to support that research—we risk losing species faster than we can understand their place in the world.

That evening, after I put away my net in the lab, I waded through a familiar tangle of last season's hollyhock stems in my backyard. The ground was patchy and bald in places. Not much was blooming. Before, I would have said it didn't look like a promising place to find bees.

But when I knelt close to the dirt, I saw metallic blue mason bees and reddish-brown *Andrena* mining bees. I saw green halictid sweat bees and a lone *Bombus huntii* queen with her orange striped bottom and yellow face. I saw a patch of bare earth that was alive in a way I'd never noticed before.

Sally Leaf *is a nonfiction writer pursuing a master of fine arts at the University of Wyoming. Her current book explores loss on a personal and global scale. Drawing on the sudden death of her father and the sharp decline in the migratory monarch butterfly population, she hopes to encourage conversation about what it means to lose a person (or a species) forever.*

Mark Gocke, Wyoming Game and Fish Department

TO KILL OR NOT TO KILL?

Managing charismatic ungulates in the Tetons

By Emily Reed

The first time Michael Whitfield saw bighorn sheep in the high country he stood on a ridgeline in the shadow of the Teton Range and watched a group grazing along a plateau. As he snuck up to get a closer look, "the sheep … disappeared right into the cliffs … and then they were gone," he says. Whitfield spent most summers in the 1980s chasing these high-country ungulates across cliff faces through harsh weather for his graduate research. At the time, nobody knew much about the Teton sheep except that they seemed to be declining fast.

Over years of field work in the high country, Whitfield discovered a small, isolated population of bighorn sheep, surviving off very little food. Bighorn sheep were not the only mountain climbing ungulate that Whitfield observed in the Tetons––he also found a few shaggy-bearded mountain goats occasionally moving

A mountain goat peers down from a cliff in the Snake River Range, where the animals were introduced for hunting in the 1960s.

in and out of the range. Whitfield warned in his graduate thesis that if mountain goat numbers increased, they could threaten the bighorn sheep in the Tetons.

Now, 30 years later, that exact situation has occurred. Mountain goats have established a breeding population in the Teton Range. Meanwhile, the bighorn sheep herd is declining. Managers now face a decision about which species to prioritize, and to what extent.

Bighorn sheep across the West have been in trouble for the last century. Biologists have estimated that in the early 1800s more than 1 million bighorn sheep lived in North America. But by the 1960s, market hunting, habitat loss, and diseases introduced from domestic sheep drove that number to fewer than 10,000 animals. Today, one of the three subspecies—Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*)—is listed as endangered. Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) and desert bighorn sheep (*Ovis canadensis nelsoni*) are not listed as endangered, but they are not doing well.

To restore wild sheep populations, wildlife managers implemented intense recovery programs, translocating animals from healthy herds to struggling populations and to vacant habitats that historically supported wild sheep. The Teton herd is one of four core native herds in Wyoming, meaning that the herd has never gone extinct and no sheep have ever been translocated into it. The herd is considered genetically valuable because its ancestors survived the severe reduction of the species in the 1800s and early 1900s. It is also the smallest and only non-migratory core native herd in the state. "This is a remnant of a population that has been there for thousands of years," Whitfield says, "but now the goats threaten that."

"We don't want the Teton herd to go extinct and we don't want to augment it with other sheep because the risk of accidentally introducing disease into the herd is too high," Wyoming Game and Fish biologist Aly Courtemanch adds.

That will mean protecting the small Teton herd from all sorts of threats, including mountain goats. In the 1960s, Idaho Department of Fish and Game officials wanted to establish a mountain goat herd for hunting. They identified the Snake River Range in Idaho, west of the Tetons and Wyoming state boundary line, as an ideal place, even though mountain goats had never been in that area previously. Mountain goats are native from western Montana into the far north of Alaska but not within Wyoming. Deceiving as it may seem in today's day and age where parts of Wyoming boast populations of mountain goats, there is no historical or archeological evidence that mountain goats were ever present.

Over time, animals from the Idaho translocation trickled into Wyoming. By the 1970s and 1980s, people saw the occasional mountain goat in the Tetons. By the late 2000s, the mountain goats had made a new home and established a reproducing population, smack in the middle of the Teton Range, nestled between two sub-populations of Teton sheep.

Wildlife managers began monitoring the goats. As researchers like Whitfield had predicted, the growing mountain goat population began to threaten the native bighorn sheep. In recent years, the sheep herd has declined to fewer than 100 animals due to a combination of factors. During the same time period, the mountain goat population doubled; due in part to the fact that females often give birth to twins. Last winter, Courtemanch counted 81 bighorn sheep and 88 mountain goats, marking the first time goats outnumbered sheep in the Teton Range.

In the winters of 2018 and 2019, Courtemanch observed mountain goats moving into the northern and southern parts of the range, "areas [that] have historically been important wintering habitat for bighorn sheep," she said. One study that took place near Yellowstone's Northern Range suggested that in areas where their ranges overlap, the two species have similar diets and compete for food. In an area like the Tetons where winter food is extremely limited, wildlife managers predict that mountain goats could outcompete bighorn sheep for resources. Where mountain goats and bighorn sheep have lived together in Canada and Montana for thousands of years, both species have enough habitat and the goats choose steeper terrain than the sheep.

As mountain goats move closer to bighorn sheep in the Teton Range, the risk of disease transmission

Mark Gocke, Wyoming Game and Fish Department

Two bighorn rams are some of the few last remaining members of the iconic Teton herd, which has remained intact, if diminished, while other herds around the West blinked out. Nonnative mountain goats now threaten to bring disease to the Teton sheep.

Mark Gocke, Wyoming Game and Fish Department

Wyoming Game and Fish Department biologist Aly Courtemanch examines a mountain goat captured in the Tetons in 2018. This goat was released back to the mountains wearing a GPS collar to help managers understand how the animals use habitat relative to native bighorn sheep.

increases. Bighorn sheep are especially vulnerable to pathogens that cause pneumonia, a disease that has left the entire species across the West in shambles. Domestic sheep can introduce pneumonia to wild sheep. While all the domestic sheep grazing allotments in the Teton Range are now closed, some still remain in the Snake River Range where they overlap with mountain goats that have tested positive for pathogens that can cause pneumonia.

The Teton bighorn sheep herd has evaded the disease thus far, but a pneumonia outbreak would seriously threaten this small herd. In many cases, a pneumonia outbreak can cause 50 to 80 percent mortality of a herd within a couple of years. Managers want to make sure that doesn't happen.

The agencies that manage bighorn sheep and mountain goats are working to address the problem. To manage goats in the Tetons but outside of the Grand Teton National Park boundary, the Wyoming Game and Fish Department changed hunting regulations to help reduce the herd. Until 2018, hunters could harvest only one mountain goat in Wyoming during their lifetime, but that year the legislature approved changing that law. Now hunters can harvest an unlimited number of goats in their lifetime in certain hunt areas. In addition, the Wyoming Game and Fish Department also adjusted the boundaries for a new mountain goat hunt area. Last fall, in the first year of the new hunt area that lies just outside of the Grand Teton National Park boundary, the department issued 48 licenses. Due to the extremely difficult terrain and few numbers of goats outside of the park, the harvest was expected to be low. However, hunters harvested 23 mountain goats, more than expected.

Increased hunting outside of the park is not enough to reduce goat numbers and protect the Teton Range's iconic bighorn sheep because a majority of the mountain goats live within Grand Teton National Park. So, in 2014, as part of the National Park Service's policy to prevent exotic species from displacing native species, Grand Teton National Park began the planning process to decide how to manage mountain goats in the park. They considered approaches including no action, lethal removal from the air, using skilled volunteers to shoot goats, non-lethally capturing and relocating mountain goats, and fertility control.

Meanwhile, other factors in addition to mountain goats are also threatening Teton bighorn sheep. Winter recreation in important habitat areas and overly zealous fire suppression are also to blame for the sheep's trouble. Currently, winter recreation is prohibited in two areas within the Tetons from December 1 to April 1 to prevent backcountry skiers from disturbing critical sheep winter areas. However, large areas of critical winter habitat currently remain open to recreation. Wildlife managers are also planning controlled burns to open up more sheep habitat outside of the park.

Park officials in Washington state faced a similar situation and are already carrying out a mountain goat removal program. In Olympic National Park, where nonnative mountain goats damage fragile alpine plants and threaten public safety, officials aim to capture and relocate around 600 goats and lethally remove those they can't capture over five years.

At the end of the planning process in 2019, Grand Teton National Park released its final Mountain Goat Management Plan. The decision was to relocate some goats to areas where the species is native or to accredited zoos and lethally remove the rest using qualified volunteer sharpshooters on the ground and a contracted professional helicopter crew from the air. Park officials would monitor the status of carcasses, and, depending on location and situation, may either leave the carcasses in place or remove the mountain goat meat for donation and distribution to Indian tribes, food banks, and other organizations.

The final plan received some push back from the Wyoming Game and Fish Commissioners, who disagreed with the method of removal for the mountain goats. In a letter to the acting superintendent of the park, Game and Fish Commission President David Rael wrote "The use of aerial gunning by GTNP [Grand Teton National Park] personnel to remove these goats is inconsistent with all notions of game management, fair chase, and totally inconsistent with years of GTNP management of big game animals in the GTNP.…The Commission strenuously urges the National Park Service to immediately cancel plans to kill the mountain goats via aerial gunning and implement a plan allowing the mountain goats to be removed by skilled volunteers."

Grand Teton National Park moved forward with the plan, and aerial shooters killed 36 mountain goats in February before Wyoming's Governor Mark Gordon prompted Interior Secretary David Bernhardt to intervene and stop the culling.

Regardless of the disagreement on the method of removal, the agency's goal remains the same: to remove all mountain goats from the Tetons as quickly as possible. Promptly removing mountain goats from the Teton landscape will give the bighorn sheep a better chance at survival, which is what Whitfield has wanted ever since he first spotted them back in the 80s.

***Emily Reed** was born into a fifth-generation working ranch family, growing up on the fringes of the prairie and alpine landscape of Wyoming. She is a conservationist by training and a writer by passion, drawn to stories that illuminate modern-day life in the West where humans and nature intersect.*

Bye Bye, Baseline, GOODBYE

Rethinking our goals for ecosystem conservation

By Melinda Harm Benson

Natural resource managers strive to keep ecosystems functioning on their own. When nonnative species are present, the standard management approach is to remove them in order to restore the ecosystem to historical, baseline conditions. This reflects our general sense that, whenever possible, we want to keep ecosystems intact. In other words, keeping ecosystems "intact" involves *keeping out* things that do not belong.

Managers and scientists are starting to recognize, however, that the challenges associated with eradicating nonnative species can be resource intensive and expensive, often necessitating ongoing management requirements that never quite succeed.

As rates of biodiversity plummet due to a range of threats, including competition from nonnative species, there is a growing recognition that, in many cases, there is no going back. Restoration to historical baseline conditions is simply a not a realistic goal for many ecosystems.

In response, scientists are working with managers to look for new approaches to nonnative species. And while most conservation biologists still eschew all nonnative species, some are now arguing for a more nuanced approach. In his essay "Do Native Birds Care Whether Their Berries Are Native or Exotic? No.," Macalester College professor Mark Davis argues that "as we enter the second decade of the twenty-first century … the native-nonnative paradigm is losing its value, and is often an impediment, in the conservation and restoration world." Instead, he notes instances in which nonnative species are playing new and much needed roles.

Focusing on birds and berries, Davis gives nonnative honeysuckle (*Lonicera* spp.), present throughout forests in the eastern United States, as a primary example. In those forests, honeysuckle actually helps *native* berry-producing plants disperse fruit. This situation is referred to as the "car dealership effect." In the analogy, competing car dealerships cluster together in order to attract large numbers of customers. Honeysuckle creates a large "dealership" and therefore a proximity hub, attracting seed-dispersing birds and benefiting nearby native berries that get in on the action.

To think more productively about the role some nonnative species now play, Richard Hobbs, Eric Higgs, and other practitioner-scholars have proposed the concept of "novelty ecosystems." Generally speaking, a novelty ecosystem is one that, by virtue of human influence, differs from what prevailed historically but still works just fine. In other words, it functions as a self-organizing ecosystem while also manifesting novel characteristics that were not historically present.

An example can be found in the Florida Everglades. The endangered Everglade snail kite (*Rostrhamus sociabilis plumbeus*) feeds almost exclusively on snails—historically on native apple snails (*Pomacea paludosa*) to be exact. Recently, one of the world's most invasive species, the apple snail *Pomacea maculata*, established in portions of the Everglades and is outcompeting the native snails. These invasive snails are typically much larger than the native snail and provide an abundant food source for the endangered bird.

Even designed, human engineered ecosystems merit reexamination in a world beyond baseline. New Mexico's Rio Chama, the largest upper tributary to the Rio Grande, provides an example. The Rio Chama is unique in that it has *more* water in it these days than it did historically. This is because New Mexico diverts water from the Colorado Basin into the Rio Chama as part of its trans-basin diversion of water under the Colorado River Compact.

Brown trout (*Salmo trutta*), intentionally introduced from Germany in the 1800s throughout the United States, are thriving under these conditions. These nonnative trout are sometimes in conflict with native species, yet they also provide a valuable fishery and a basis for recreation and tourism for many communities. The brown trout fishery in New Mexico's Rio Chama is actually protected as part of a federal Wild and Scenic River designation and supports a robust angling economy.

Recreational boating is also benefiting from the extra water, which is mainly released to downstream farmers and the communities of Albuquerque and Santa Fe during the summer weekends. The high flows allow for permitted white water rafting. Both the extra water and the brown trout are new, human-induced additions to the ecosystem—but does it follow that they do not belong?

The world as we humans have known it is just that—a relatively short snapshot in geological time. Defining baseline conditions for ecosystems is an anthropocentric project, work conducted by humans *since* we've been paying attention. Which is not to say that this cannot be useful, only that baseline conditions are now—and have always been—limited in their capacity to inform the types of complex and often contentious decisions natural resources managers have to make. Increasingly, managers need to anticipate how species will adapt to anticipated future conditions that may bear little resemblance to the past. In such instances, nonnative species may be evaluated, not by referring to the past, but instead by anticipating the ecosystem dynamics of the future.

***Melinda Harm Benson** is associate professor in the Department of Geography and Environmental Studies at the University of New Mexico and recently served as dean of the Haub School of Environment and Natural Resources, publisher of this magazine.*

REMEMBERING BILL RUCKELSHAUS

In a long and storied career that included major policy accomplishments to protect clean air and water, William D. Ruckelshaus was known for his integrity and ability to build robust solutions that benefitted both the environment and business. He served as administrator of the Environmental Protection Agency under two different Republican presidents as well as working as a lawyer, environmental consultant, forestry company vice president, CEO of a major waste management company, and in other roles. In 1993 he came to the University of Wyoming at the behest of Senator Alan Simpson to help create a new institute that would bring together stakeholders with differing perspectives to build collaborative solutions to natural resource challenges. He has remained a mentor and model to all of us at the William D. Ruckelshaus Institute of Environment and Natural Resources (publisher of this magazine) ever since. Bill passed away at his home in Seattle on Wednesday, November 27, 2019. We miss his clear leadership and commitment to honesty, transparency, and thoughtful, inclusive approaches to critical issues, and we are heartened that his style and methods continue to shape the thinking of so many people engaged in current and future environment and natural resource problem solving.

LISTEN TO THE MOUNTAIN AND PRAIRIE PODCAST

If you're not already listening to the Mountain and Prairie podcast (and I know many of you are because I received a bunch of new subscriptions from people who heard about our magazine there) you should be. Host Ed Roberson holds candid and thought provoking conversations with characters from all over the West including artists, adventurers, writers, ranchers, and more. These engaging dialogs explore themes of place, conservation, history, connections to the land, and what it means to be a westerner. We thank Ed for inviting Western Confluence lead editor Emilene Ostlind onto his show and encourage all our readers to check out his work at mountainandprairie.com.

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Time to Revisit our Invasive Species Strategy

Perspective from Governor Mark Gordon

Invasive species are not a new phenomenon, but over the past few decades the West has seen an explosion of all types in all ecosystems. From quagga mussels, New Zealand mudsnails, and lake trout in fisheries and waterways, to injurious plants like leafy spurge, cheatgrass, and salt cedar in our rangelands and riparian areas, species that are foreign, aggressive, and pervasive are threatening native ecological communities, changing productivity, altering disturbance regimes, and generally wreaking havoc on land managers and agricultural producers.

Through improved transportation networks, increased levels of outdoor recreation, and new development, we are seeing the number of potential vectors increase to infect additional landscapes ever more rapidly. As a result, we have mobilized local responses through coordinated planning and direct management efforts while improving monitoring and prevention campaigns. With new herbicides and mechanical measures, use of satellite imagery and predictive modelling, new grazing schemes, efforts to cultivate more benign competitive species, and a host of potential biological controls, land managers are approaching the problem from all angles. However, these measures can be expensive, especially when management necessitates repeated treatments.

For all of the good work, our approaches always seem to be too slow in reacting to continually evolving challenges; every time

we believe we are getting ahead, the goalposts move.

Although research has helped, we still need to better understand ecology, succession, and the dynamics of natural systems across spatial and temporal scales, and the value of placing practitioners in the same room with researchers. We have the opportunity to improve our odds through a more comprehensive and holistic approach to management and control. For these reasons, among others, I established the Invasive Species Initiative: a group of 32 practitioners, managers, scientists, local, state, and federal government entities, and representatives of private landowners and industry.

These members have been split into two teams, Policy and Technical, to approach the massive issue of invasive species from all angles. I have asked them to focus first on terrestrial invasive plant species and deliver a report to me on issues and potential fixes. The teams have had multiple meetings to date and a final report is expected this spring, which I eagerly anticipate.

Wyoming can lead the way. From our on-the-ground experts in Weed and Pest Control Districts, to researchers at the University of Wyoming and all the ranchers, wildlife managers, and other experts in between, Wyoming has the knowledge and the wherewithal to truly fight this battle. In tandem with other states, and through a demonstrable commitment of effort, energy, and finances, we can stem the flow and move towards an ultimate goal of reversing the damage of invasive species. It is high time we stop being reactionary and commit to a more proactive approach to invasive species control. Doing so will give us the ability to put our efforts on a more sustainable and economically logical course while at the same time leaving this wonderful place we call home better off for generations to come.

I applaud the efforts to date, but I also recognize we can do better. I am excited to see what our state can do in the future and my confidence in our citizens' ingenuity and ability to build true solutions could not be greater.

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