

# THE TRACKER



YERC'S NEWSLETTER

"Intelligence is the ability to adapt to change."

STEPHEN HAWKING

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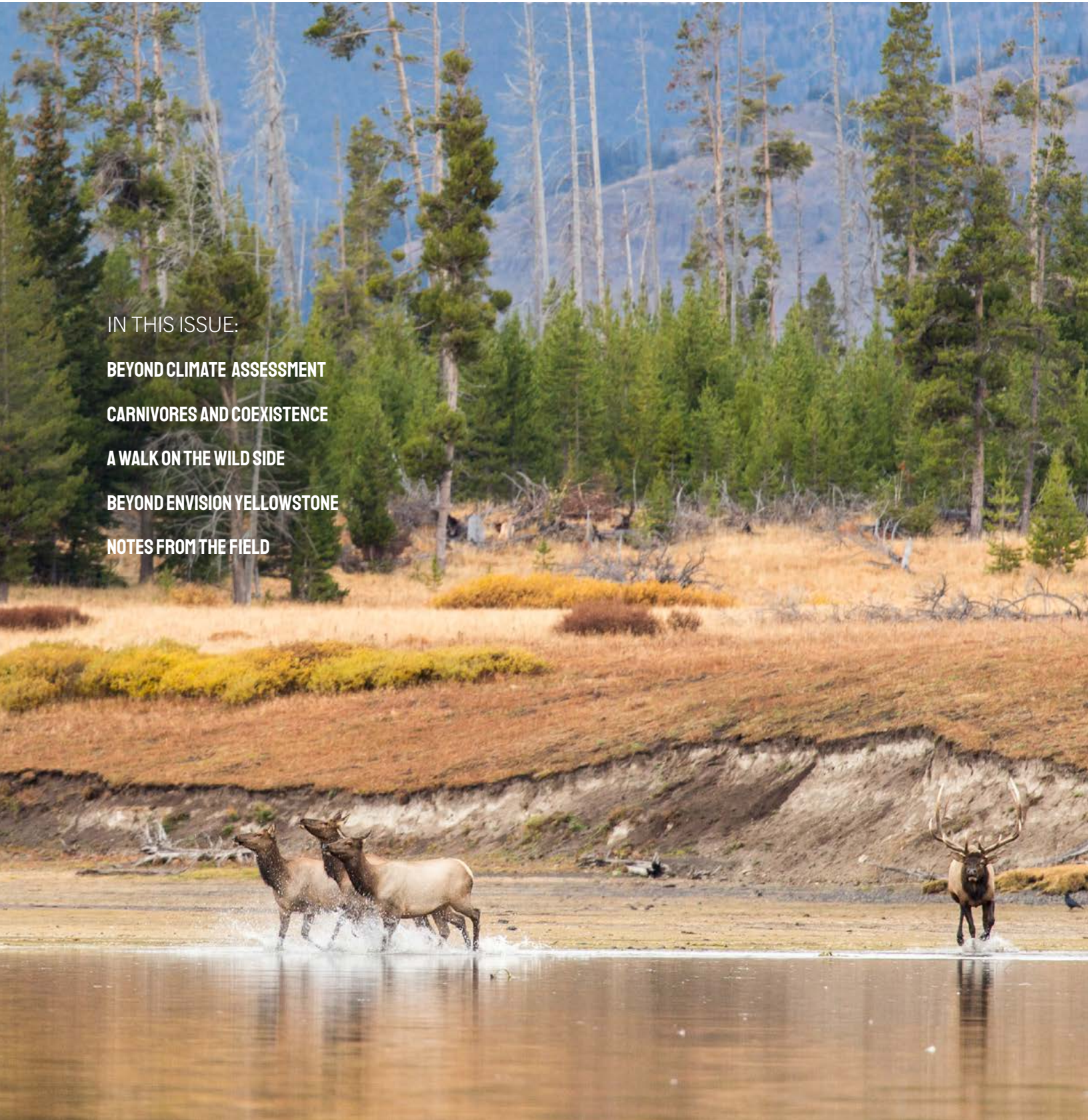
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NOTES FROM THE FIELD



## A NOTE FROM BOB CRABTREE, YERC'S CHIEF SCIENTIST

This spring, the staff and Board of Directors welcomed Tory Dille as YERC's new Development and Communications Coordinator.

Tory is originally from St. Louis, Missouri and the Olympic Peninsula of Washington State. Tory holds an M.S. in Science Education from MSU and a B.A. in Anthropology and Environmental Science from Washington University in St. Louis. Prior to joining the team at YERC, Tory spent a number of years designing place-based high school science curricula, instructing field science programs, and coordinating and leading multi-day wilderness trips for organizations across the Rockies. Most recently she served as a science faculty member for the Bozeman Field School, worked with youth across Montana as the Outreach Manager for the Montana Wilderness School and instructed online leadership courses centered around climate change for underserved youth through Northwestern University. Tory's favorite ways to enjoy the GYE are through rock & ice climbing, backpacking, and mountaineering from her home base in Livingston.

During the search we received a surprising number of highly-qualified applicants. Yet, Tory stood out for a variety of reasons. Her genuine love of wilderness and the outdoors was compelling as was her authentic set of skills and talents - all matched with an energy and enthusiasm about the natural world. It was clear that she has a keen sense of what it will take to sustain it. Her communication skills and understanding of anthropology will come as no surprise once you get a chance to meet her!

Understanding human behavior and what we do on the land we rely upon is something that the Greater Yellowstone Ecosystem needs. Tory's generation's views combined with her extensive background in ecological research

and education is well tuned for that. The GYE is lucky to have her on its side! Tory jumped right in and reports having a fantastic experience connecting with our donor community--thank you for welcoming her!

One of Tory's first projects was managing our fundraising campaign during Give-A-Hoot 2021--Park County's Community Giving Challenge. With matching funds from Park County Community Foundation we raised nearly \$29,000 for RiverNET on the Upper Yellowstone. What will that funding look like in practice as we round out 2021 and move into 2022?

- Continued monitoring of water quality (26 sites) and quantity (16 sensor stations) at the tributary-level
- Critical data shared in near real-time on our RiverNET platform
- Hands-on experience for local youth in conservation science through paid field technician positions
- Outreach on water quality and quantity data in the Upper Yellowstone River

Watershed including working with local schools and community groups to collect and share data

- Riparian songbird surveys, macroinvertebrate surveys, and monitoring of other biological indicators of watershed health
- Shifting RiverNET into Phase II: Predictions so we can provide freshwater forecasts and a Total Water Budget for the Upper Yellowstone River Watershed
- Capacity to allow us to expand our LandNET and WildNET programs in the Upper Yellowstone Watershed

We truly couldn't do this without our incredible community of donors and partners. Thank you for your continued support--we look forward to growing with you.

With gratitude,

**Bob and the team at YERC**



Want to support us? Visit

[www.yellowstoneresearch.org/donate](http://www.yellowstoneresearch.org/donate)

Interested in joining the Adopt-a-River program through a donation? Reach out to [tory@yellowstoneresearch.org](mailto:tory@yellowstoneresearch.org)



Tory on the West Ridge of Prusik Peak in the Cascade Range of Washington State  
Photo: Colin Chupik



Lamar Valley. YNP

(Cover: Neal Herbert, NPS)

**The mission of the Yellowstone Ecological Research Center is to empower individuals and communities with data-driven science and technology to active land, water, and wildlife conservation across the Greater Yellowstone Ecosystem and beyond.**

**Our programs** provide critical diagnostic monitoring and prognostic forecasting to sustain the health and resiliency of the GYE—all hosted on our cloud-based data sharing platform, EPIIC.

Our community science cooperative model gives stakeholders the ability to collect and share trusted data to be used towards conservation decision-making and collaborative solutions to address our ecosystem’s most pressing challenges.

**RiverNET**—Watershed health—monitoring water quality and quantity that also drives freshwater forecasting for drought adaptation.

**LandNET**—Landscape health—soil moisture, soil carbon, vegetation and grazing diagnostics for conservation-minded ranching that sustains resilient soil-plant-animal relationships.

**WildNET**—Wildlife health—diagnostics and tools for population monitoring, habitat protection, and coexistence strategies.

Interested in learning more about our programs? Visit [www.yellowstoneresearch.org](http://www.yellowstoneresearch.org)

**Land Acknowledgement:** *YERC’s programs take place in the Greater Yellowstone Ecosystem on the land of the 30+ tribal nations and communities with current and ancestral connections to the Greater Yellowstone Ecosystem.*



## BEYOND CLIMATE ASSESSMENT: ADAPTING TO IMPACTS ON THE GROUND

Sitting around in my backyard in Livingston, Montana I had the opportunity to connect with friends about what many are calling the “fifth season” in the West—an extension of summer marked by drought and wildfires. We sat around a headlamp attached to a nalgene bottle—a makeshift campfire to use during the all too frequent burn bans we observe in Southwest Montana. The grass in my backyard (that I choose not to irrigate given our situation) was crunching under our feet in early July. Like so many of us that live in the West, we asked ourselves “Is this the new normal?” and if so “how could we possibly adapt when it seems like things are happening so rapidly?” The historic drought in Montana and across the US West made big news, and for good reason. This impact on-the-ground

and in our own backyard watersheds are hitting home.

Albrecht et al. (2007) coined the term solastalgia to refer to feelings of hopelessness and isolation that we experience with environmental change; these feelings are deeply rooted in how we identify with our places—the landscapes that make up our sense of home. Solastalgia affects not only your sense of place, but also your sense of self and belonging. It’s destabilizing and disorienting to see the landscapes that make up your worldview change in response to both human and climate-driven impacts. I see these feelings in so many of my friends as we confront an uncertain future.

The summer of 2021 in Montana and across

the Western United States has highlighted not only the challenges we’re facing in our landscapes, but also the polarization around coming together for constructive outcomes—particularly in the complex social-ecological system that is the Greater Yellowstone Ecosystem (GYE). Climate predictions tell us that under the potential warming scenarios we face as a globe we should expect increased water deficits and wildlife impacts that portend not only large-scale ecological change, but also threats to the health of our communities; at the same time we are painfully aware that meaningful policies to address these threats are lacking in the GYE. We have two recent climate assessments, one for Montana and one for the GYE. In fact, the recent *Greater Yellowstone Climate Assess-*

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ment cited YERC's RiverNET as an example of a monitoring program that can help communities to adapt (Hostetler et al., 2021). These excellent works lay the groundwork, so to speak, on what we now must do.

So once we stare down the line at the overarching possibilities for our "new normal", how do we act? I recently posed this question as part of a conversation with a member of our Board of Directors, Jim Geringer. As a former Governor for the state of Wyoming and a founding member of the Western Governors Association, Jim has had to approach these questions from a policy standpoint, but has always relied on science to drive decisions. How? Through a methodical and risk management-oriented approach that can be applied to a variety of scenarios we face in the West. I apply it here to water resources in the Upper Yellowstone River Watershed.

**1. Identify the problem:** *What data do we have to quantify the impact to the resource? Who and what is affected by this impact?*

At this stage a community can identify what data exists and work towards establishing monitoring systems to address spatial and temporal gaps in knowledge; social and



YERC Board Member Jim Geringer. Photo: Kris Krüg. (Opposite page: Neal Herbert/NPS)



Wildfire smoke over Western Montana, Summer 2021. Peter Obermeyer

economic data as well as information from long-term ecological studies can support a more nuanced understanding of who and what (including our ecosystems and wildlife communities) are impacted by water deficits and how they are impacted.

### SO ONCE WE STARE DOWN THE LINE AT THE OVERARCHING POSSIBILITIES FOR OUR "NEW NORMAL", HOW DO WE ACT?

**2. Limit the impact:** *Is there a way to limit the damage being done to a resource?*

At this stage stakeholders ask themselves if there is a way to first limit the impact to a resource. In the case of drought in Paradise Valley, we know that we are facing a "tragedy of the commons" where upstream water rights holders have the ability to disproportionately

affect those downstream. And there is, too often, simply not enough water to go around for important activities like crop irrigation and cutthroat trout spawning. In Paradise Valley users could collaborate with the community to work towards limiting their impact, however trusted and transparent information - the data - is needed to quantify that impact as well as what to do, where and when.

**3. Adapt:** *How can we adapt to address the impact we've quantified in the above steps?*

Information and communication is critical in the final stages of assessment. In many cases good science can steer people towards land use practices that are a win-win for both water users and the environment.

**4. Advance science and understanding:** *What new technologies do we need to advance both the understanding of the problem and the ability to adapt to it?*

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Any adaptation strategy must be prepared to adapt both to changes in the understanding of the science behind a problem and the available technology to address that problem. In the case of water resources in Paradise Valley for example, RiverNET fills these gaps in data with tributary-level monitoring and in technology with our (soon to be released) freshwater forecasting system for the Upper Yellowstone River Watershed.

**5. Inform:** *What do stakeholders need to know about the impact to a critical resource and their community's ability to adapt to change?* At this stage information is used to empower individuals with the ability to look at both the data and the potential outcomes and be part of conservation decision-making from an informed position. This informed position includes not just how potential outcomes will affect their situation as a stakeholder, but also how outcomes will affect the community--including the ecosystem and wildlife community--as a whole.

It was fascinating discussing our water resources from a policy-making perspective and an interesting exercise to apply this approach to the challenges we're facing in the Upper Yellowstone River Watershed. In one of many conversations with landowners, one conversation with friend of YERC, Joe Phelps, stands out as an important, yet often forgotten message. It's about trust in the data and trust is built on the truth (the data).. Science and policy should not be decoupled, in fact they must and should go hand-in-hand because both measure success by successful outcomes whether an experiment in the lab or a smart water management decision on-the-ground. Yet efforts so often become decoupled and polarized in the current political climate of misinformation that we're in. Good policy is grounded in good science--it's just that simple. And that good science includes common sense and transparently sharing and communicating trusted data.



*Low flows in Pine Creek, Paradise Valley, July 2021. Frank Dean.*

While I see YERC's contributions at all of these stages, perhaps our most significant niche in this risk-management approach is to advance science and understanding towards positive conservation outcomes. Along these lines, when I joined the team in the spring of 2021 I was excited to learn about the work of Dr. Dean Koch, data scientist, ecological modeler, and post-doc at YERC, and how his work fits into our growing RiverNET program.

Dean's work involves the further development of an open-source USDA model called SWAT+ (Soil Water Assessment Tool) combined with a belowground model called [gwflow](#) to provide a full-on total water budget specific for each tributary of the entire Upper Yellowstone Watershed from the headwaters at Yellowstone Lake to Carter's Bridge in Paradise Valley. Because this model includes all of our monitoring and sensor inputs as well as impact

factors such as NWS data, it is capable of not only short-term (36-hour and 5-day) forecasts of discharge, temperature, and turbidity), but also what we're calling "What-if-Scenarios (WIS)" for land-use planning and action.

To build off of Dean's work, we are building a user-friendly interface on the RiverNET platform that allows landowners, planners, students, etc. to change a variety of input parameters to evaluate and quantify the impact of both climate and human activity. For example, an end-user will be able to change the amount of timing of precipitation and surface temperature, vegetation moisture stress, evapotranspiration, and other factors that affect the water budgets of each tributary. Most importantly, our program will provide the ability to create and test WIS for simultaneous impacts of both natural and human impacts; this will specifically allow for drought

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adaptation/mitigation and explore options for optimal water allocation under a wide variety of scenarios. You can watch a presentation from Dean on our [RiverNET](#) page if you'd like to dive deeper into this topic--we're pretty excited about it.

So let's return to that feeling of solastalgia—rooted in hopelessness and uncertainty. As a millennial I've grown up in the context of eco-anxiety and the climate crisis. In biology class in 2004 I firmly remember my first exposure to that iconic J-shaped graph of atmospheric CO<sub>2</sub> and the increasing temperature increases over time since the industrial revolution—a chart I would use over a decade later when I found myself teaching high school biology. As first a scientist and then an educator I've been pleasantly surprised to see that my students (proudly identifying themselves as "Gen Z") often don't share the same learned helplessness that my generation and those before me often identify with in the face of environmental change. Inspired by youth

activism from individuals like Greta Thunberg, they're looking for solutions and ready to adapt. Moreover, they expect policymakers and organizations with the power to influence conservation outcomes to be accountable—to look at the data, fill in the gaps, and push our communities to adapt. My former students would roll their eyes—trust me, I've seen it—at the thought of a bunch of millennials sitting around lamenting environmental change.

So perhaps the more fitting question we should be asking ourselves is "What does resilience mean for our landscapes and for our communities without adaptation and restoration?" We know that we're facing some "new normals"—particularly when it comes to water in the West—but if we arm ourselves with data-driven technology and communities that are empowered by information we're well-positioned to adapt—that's what we call Adaptive Ecology, a mainstay at YERC.

### Resources Cited:

Albrecht, Glenn Sartore, Gina Connor, Linda Higginbotham, Nick Freeman, Sonia Kelly, Brian Stain, Helen Tonna, Anne Pollard, Georgia. 2007. Solastalgia: The Distress Caused by Environmental Change. *Australasian psychiatry : bulletin of Royal Australian and New Zealand College of Psychiatrists*. 15 Suppl 1. S95-8. 10.1080/10398560701701288.

Hostetler S, Whitlock C, Shuman B, Liefert D, Drimal C, Bischke S. 2021. Greater Yellowstone climate assessment: past, present, and future climate change in greater Yellowstone watersheds. Bozeman MT: Montana State University, Institute on Ecosystems. 260 p. <https://doi.org/10.15788/GYCA2021>.

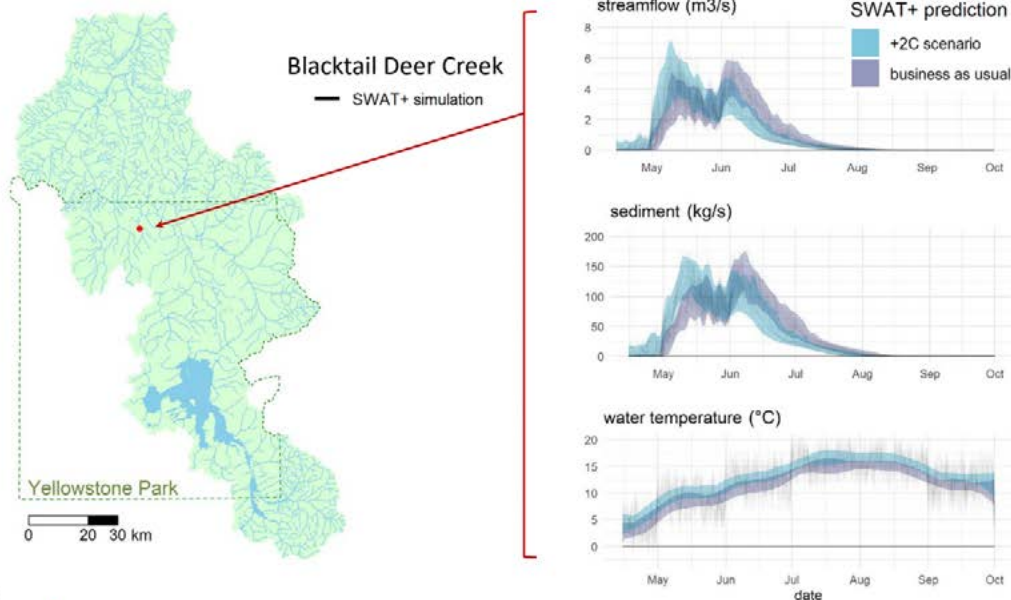
**Tory Dille**

*YERC Development & Communications Coordinator*



[Join YellowstoneNET today.](#)

## Our vision: simulate past, present, and future watershed behavior





*YERC is using a data-driven approach to help write the next chapter of human-wildlife coexistence in the Greater Yellowstone Ecosystem. Photo: NPS*

## WILDNET: CARNIVORES AND COEXISTENCE

Coexisting with carnivores has been a central focus at YERC for nearly four decades. In fact, YERC's chief scientist did graduate work in the early 80s to test how improved habitat characteristics and provision of alternate food sources, deterred mammal predation on waterfowl nests in Utah. Such coexistence programs have a deep history both in our society and in our science.

In fact, the love-fear relationship with large carnivores starts with Teddy Bears and Little Red Riding Hood. They elicit a wide range of deep emotions, beliefs and values in all of us. Today, management strategies range from control programs (that often bear resem-

blance to predator bounties) to successful applications of coexistence programs and practices like livestock guarding dogs, habitat improvement, and other deterrents that may or may not work. All of these strategies are contested and politicized in a way that brings us further from coexisting as a community - this is certainly the case with the current legislation targeting Northern Rocky Mountain wolf and bear populations. YERC's 28 years of research on carnivores in the northern Yellowstone region using our multiple field stations in Park County, both above and below Yellowstone's northern range, have witnessed the recovery of these contested carnivores. We've been working on data-driven solutions

for conservation of wildlife and wildlife habitat for decades and are excited to build upon those successes.

We believe that with community science, coexisting with carnivores will be successful but how did we get into the current situation in the first place?

### **SCIENCE AND BASIC BIOLOGY WERE THE FORCES THAT FOUGHT OUR WAY OUT OF THE PREDATOR ERADICATION ERA AND PAVED THE WAY TO THE RISE OF MODERN CONSERVATION.**

In the Greater Yellowstone Ecosystem (GYE), our native carnivores - from wolverines and mountain foxes to wolves and grizzly bears - face threats exacerbated by a long history of moving between states of recovery and eradication. Across the US and even in Yellowstone National Park, the predator eradication era (~1850 to 1950) aimed to increase valuable prey populations like elk. Then in the late 30s, Adolph Murie conducted a landmark study in Yellowstone that is attributed to turning the tide against indiscriminate killing of predators (mammals and raptors). Published in 1940, "Ecology of the Coyote in the Yellowstone" used basic science to chronicle the strong ecological role and value of predators. Throughout history our beloved and hated carnivores have been excellent bellwethers for concern and action. In our backyards of the GYE, wild herbivores may invade rangelands for forage and carnivores may seek out domestic livestock, especially if their habitats are degraded and their wild prey reduced. We have cases of successful coexistence programs to address human-wildlife conflicts





*Bob Crabtree, YERC's Chief Scientist, observing predators near Soda Butte Creek with YERC Board Member, Dr. Carly Vynne-Baker, Yellowstone National Park*

like these, but is that enough when conservation is so often politicized?

We now find our society in an era of misinformation where science is ignored, common sense is marginalized, and fiction becomes fact. Yet science and basic biology were the forces that fought our way out of the predator eradication era and paved the way to the rise of modern conservation led by the likes of Teddy Roosevelt and Aldo Leopold. The old saying is still appropriate today: “Politics usually trumps science”, but does it have to? We’re not sure it does, and we need your support at this 21st century crossroads.

We can contest long-held and diverse values and beliefs or we can engage with science. Respectful discussions and constructive criticism can and should necessitate actionable outcomes - that’s why YERC works with agencies, landowners, other NGOs, private busi-

nesses, and individual citizens to seek ideas that result in action. We seek win-win solutions and we take a critical step: bringing stakeholders together to learn from our decisions. Both scientists and practitioners measure success by their ability to predict the consequences of their actions - so why shouldn’t we be working together and bear witness to meaningful change in the GYE? With so many tools at hand - both tried-and-true traditional methods and the latest technologies - we can better learn to coexist with carnivores if we learn together.

We have the opportunity to depoliticize how we manage carnivores and return to a fact-based approach where diverse stakeholders work together to reduce conflicts and learn to trust data that was collected, processed, and communicated together in an open, transparent manner. In what’s now called the digital age, YERC is leading the way to apply the best

science, technologies, and information (data science) to promote healthy carnivore populations, restore ecosystems, and reduce or eliminate conflicts. We invite you to consider this adaptive learning approach; we’re proud to facilitate information gathering in what we call community science cooperatives that together produce trusted data that is resistant to mis- and disinformation campaigns.

Grab a seat around the table or gather around the campfire.

**Robert Crabtree**  
YERC Founder and Chief Scientist



**Tory Dille**  
YERC Development & Communications  
Coordinator



Consider [donating to WildNET](#) and supporting of science-based coexistence strategies for carnivores—we can’t do this without you!



## A WALK ON THE WILD SIDE

“Move.... Now!” Paige yelled when we were surprised by three panting bison bursting through the high willows behind us as we emptied water out of our soggy boots. I was a long way from Silicon Valley on the fourth morning of rising at 4:30 a.m. to measure bird populations in Paradise Valley and in Yellowstone National Park. I was thrilled to have the opportunity to accompany Paige on her daily transect hikes identifying bird songs in return for keeping an eye out for wildlife while she took rapid notes at each return to preassigned GPS points. In this case, I wasn’t doing my job as a lookout very well. That day we were surveying in Yellowstone’s Lamar Valley where we were challenged to stay 100 meters from wildlife and the bison were consistently on the move.

Every morning during sampling, Paige goes to specific GPS waypoints within the valley and park to study which birds are active in the willows. She applies her well-honed ornithology skills from her studies at Montana State University and terrific knowledge of birdsongs to collect important data on how many breeding pairs of different species of birds have returned to the willow habitats in the riparian areas of the Greater Yellowstone Ecosystem (GYE). In a previous role, Paige was the field crew leader for the Mexican spotted owl study in Capitol Reef. Aside from getting up at O dark 30, the mornings were beautiful with incredible listening experiences - songbirds broadcast their territorial songs from dawn to late morning each day. We didn’t talk at all when she was actively measuring, or walking

between points, but she would give me a rollup each time we finished. Some birds stood out, Lazuli Buntings, MacGillivray’s Warblers, Belted Kingfishers in Paradise Valley along with Meadowlarks, Brewer’s Sparrows, and Spotted Sandpipers in the Park. Ten minutes was spent at each repeatable GPS point, then we quietly walked 100 meters to the next—exactly the same locations as in previous years. Her dedication and patience to collect this important data really impressed me

Why is this important? Like so many ecological phenomena in the park, it relates back to the reintroduction of the wolves to the GYE back in 1995. By then, the elk population had grown to the point where it was negatively impacting the riparian ecosystem and, more specifically,

## WILDSIDE

the growth of willow communities. Also, the reduction in habitat for beavers had a negative effect on river erosion.

Redistributing the elk population through top-down effects by wolves lowered their numbers in some riparian communities dominated by willows. This combined with decreases in elk population levels due to a variety of factors including wolves, helped conserve the willow populations and in some cases, willows reestablished where there had been significant grazing before wolf reintroduction. The willows are an important home to many bird species, and mammals both large and small that browse on willow. Turns out the dense growth provides cover and nesting sites. Even the willow pollen is an important source of food for honeybees early in the spring.

It's been my pleasure to serve on the board of YERC for the past three years, but this was my first time out in the field where I could experience what our researchers do on a daily basis. I currently work for Cisco, and the company has a program called Time2Give Back. This program enabled me to spend a



*Joan getting her feet wet conducting field work*



*Horned Lark. Joan Sherlock  
(Opposite Page: Joan Sherlock)*

week assisting Paige in measuring the biodiversity response to willow revegetation courtesy of the wolf reintroduction as well as time with other field researchers measuring the tributaries feeding into the Yellowstone River through YERC's RiverNET program.

Mornings were filled with assisting and viewing what our researchers do, and afternoons I spent time with Tory Dille, our new Development and Communications Coordinator. We were able to work together on marketing, development plans, and prepping materials for our upcoming Board of Directors meetings.

It was a great experience and the biggest take-aways for me were:

(1) You can take corporate experience and effectively apply it to nonprofit growth that matters

(2) Our environment is in crisis and we each

need to pick at least one meaningful project to get behind and make change happen

(3) The people who do the "on the ground" research that give us scientific evidence of how humans are affecting the earth and how we can correct problems NOW - are folks of dedication and patience. They are definitely unsung heroes. Here's to you, YERC staff, who pulled it all together and work tirelessly for what matters - to protect and sustain the Yellowstone Greater Ecosystem! At its core is the world's first national park - Yellowstone - and what Wallace Stegner said was America's best idea.

**Joan Sherlock**  
YERC Board of Directors



[Volunteer to help with field work!](#)



## BEYOND ENVISION YELLOWSTONE

Four years ago at the tail end of the elk mating season called the ‘rut’, YERC dug in its heels to craft a new vision for the Greater Yellowstone Ecosystem (GYE) and sponsored a strategic scoping and planning summit at Mammoth Hot Springs, the headquarters of Yellowstone National Park. The Envision Yellowstone summit targeted many of the top private sector thought leaders from across the country (and Canada!), to forge a new way of doing business that empowers communities with data-driven science and technology to activate land, water, and wildlife stewardship across the GYE and beyond. As homework, attendees were asked to read several chapters of the book *Half Earth* by EO Wilson and think about how we could enact his plan to save the planet’s living systems in the GYE and make it, once again, a model for the world. The

group also did an evaluation of what YERC has accomplished in over 20 years and we evaluated the state-of-the-ecosystem (GYE). We were briefed by agency biologists and managers to understand important issues threatening Yellowstone as we reviewed dozens of surveys specific to the major watersheds surrounding the GYE. I went back to the roots of the pioneering conservationist Teddy Roosevelt and challenged attendees to “bring Teddy Roosevelt conservationism into the 21st century”. We knew that nearly all recent successful conservation efforts were the result of public-private partnerships. As such, we embraced Aldo Leopold’s land ethic as we knew that successful conservation had to also be evidence-based and involve private landowners. How could we get private landowners involved, gain their trust, and

restore ecosystems bottom up, one parcel or one watershed at a time?

**WE NEED TO RAISE THE BAR, EMPOWER STEWARDSHIP OF THE LAND, AND SOMEHOW BRIDGE THE GAP BETWEEN SCIENTISTS AND PRACTITIONERS.**

We shared stories about how YERC and other organizations had forged successful relationships with state and federal agencies to provide them ‘decision-support’ through long-term research and monitoring, something YERC has specialized in since 1993. We talked about the real ecological and political lessons

## ENVISION YELLOWSTONE

learned from our research on natural and policy experiments like the great fires of 1988, the reintroduction of the wolf, the '100-year' drought from 2001-05, the shifting migration and movements patterns of bison, elk, and pronghorn, the decline of the northern range elk herd, and the spread of invasive pathogens like white pine blister rust. We also identified barriers to progress and why politics usually trumps science.

Retrospectively, had we sufficiently involved private landowners, agencies, businesses, universities, and NGOs? Could we provide them better access to the key vital signs - health diagnostics - of the landscape in a timely manner to prevent negative impacts on the very ecosystem that economically supports a vast, 20 million-acre, three-state region? How could we envision what the future would look like if we made the right or wrong decisions at the right or wrong time or in the right or wrong place?

It was clear that we need to raise the bar, hurdle the barriers to success, build trust between stakeholders, empower stewardship of the land, and somehow bridge the gap between scientists and practitioners. We all agreed that what scientists and practitioners do should go hand-in-hand because both measure success by the ability to predict the consequences of their actions. That defines anyone as a scientist as long as they contribute new knowledge. So how were we going to proceed with a new way of doing business to make ecosystems - both protected areas and working landscapes - resilient to the impacts of climate, land-use activities, and market economies when they are all interacting and changing in unpredictable ways? Yes, this is chaotic and complex! It is rendering traditional management and policy decisions ineffective. So what do we do now?

Along these lines, we proceeded with two things. First, we tried to better bridge the

communication gap by translating the complexities and chaos of the changing ecosystems we live in so that we not only communicate the science of nature better, much better, and involve all people in it so that we build trust in the evidence - data - during an epidemic of mistrust and mis- and disinformation. Further, what if we worked together, side-by-side to bear witness to the collection, storage, and processing of important natural resource information - ecological indicators and vital signs that we call diagnostics? As our society was becoming more polarized, we sought pathways to consilience. We also adopted what we call the 'human medicine model' to better communicate how we monitor, diagnose, and provide prognoses for healthy landscapes and watersheds. For example, we drew close analogies between air and water and the human circulatory system, 3D habitat structure and the skeletal system, and equated the health of our immune system to ecosystem resilience and how a landscape might bounce back after a large impact or disturbance. Second, we looked to other disciplines: military science, medical science, and the history of weather forecas-

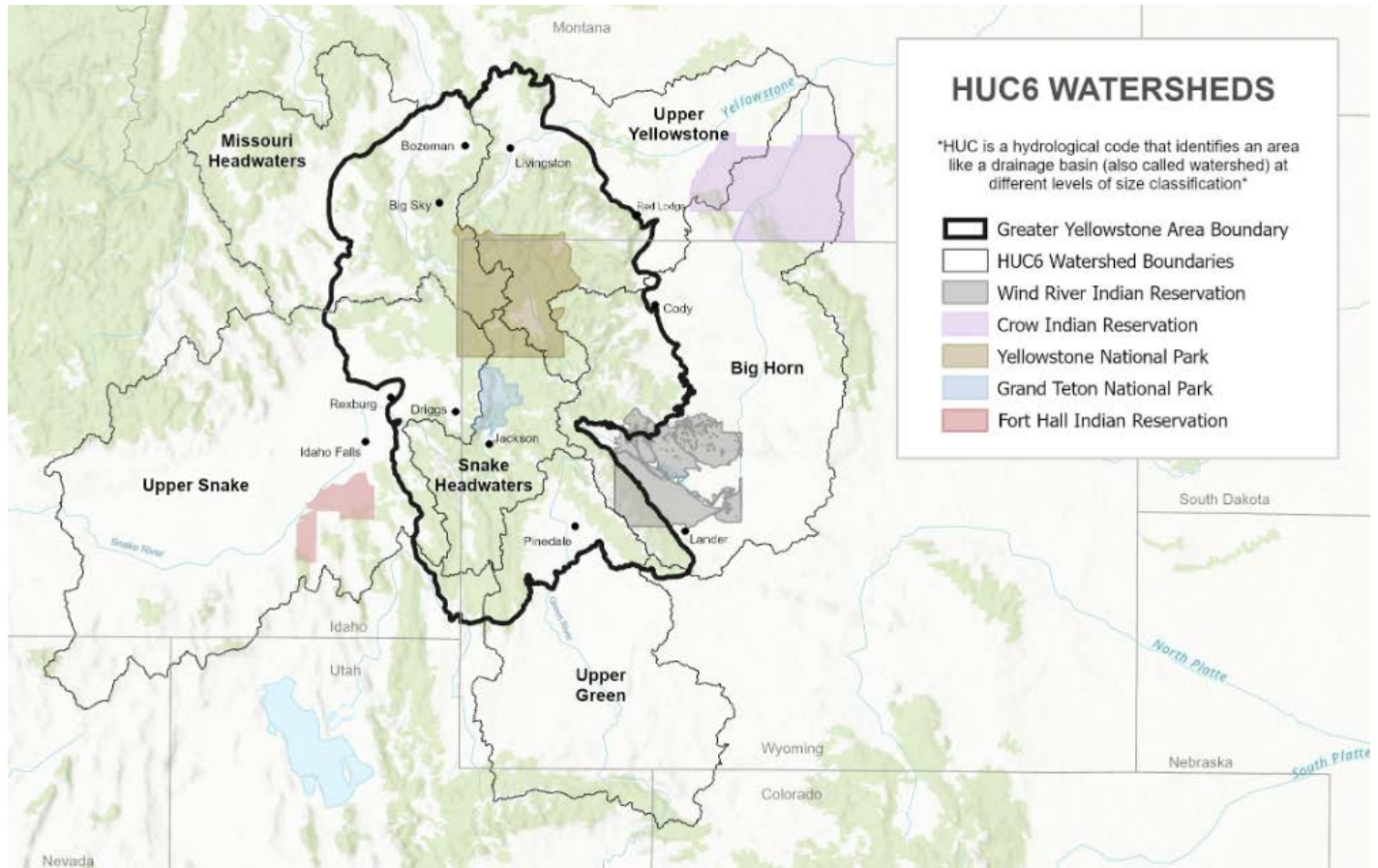
ting. An odd mix? We thought not. The basis of scientific revolutions (Thomas Kuhn) usually always involved a breakthrough technology as well as borrowing ideas from other disciplines. Indeed technology has changed the world.

For example, after WWII the public demanded a weather forecasting system so that people could better plan their day, the next day, and the coming week. Even possibly avert natural disasters. We also saw a revolution in medicine and social programs whereby preventative health care was finally supported by insurance companies to realize a triple win for patients, medical professionals, and even insurance companies. We saw the success of military science by processing real-time or near real-time intelligence from multiple sources all at once, both on and off the battlefield. Finally, we realized that Stephen Hawking was right when he defined intelligence as the "ability to adapt to change". And we joked some about a conservation intelligence agency or C-I-A.

So how could we forge a new way of doing business by developing and delivering an



*Above: Peter Obermeyer (Opposite page: Pat Byorth, Trout Unlimited, speaks about the importance of collaboration for conservation at a recent YERC-sponsored event. Tory Dille)*



Credit: Greater Yellowstone Climate Assessment

ecological forecasting system that adopted and applied the successful elements of these disciplines and applied them to our natural resources? How were we going to translate all this scoping to a new plan that involved all these concepts and ‘lessons learned’, primarily in the GYE. We applied the concept of a ‘home ecosystem’ from Terry Tempest Williams. We wagered that people might find common ground within and between home ecosystems through what we call community science cooperatives. After all, most people care about their home ecosystem (clean air, water, and soils) like they care about their own health and the health of their loved ones. Is the hippocratic oath that doctors take similar to our stewardship of the land around us?

In light of these concepts, lessons learned, evaluation of surveys, expert opinions from agency biologists and academics, we develo-

ped the start of a new way of doing business in the GYE starting with the assessment step for planning. At the Envision Yellowstone Summit, YERC divided the GYE into major watersheds (divisions of the upper Yellowstone, Green, Snake, and Missouri river watersheds), and identified pressing issues in each. Freshwater resources made the top of the list in each watershed of the GYE. Furthermore, because YERC researchers have done so much long-term work over 30 years in the Upper Yellowstone watershed (UYRW) - from the headwaters near Cooke City and Yellowstone Lake to Livingston, Montana - we chose RiverNET for our signature program in the inaugural UYRW. We also laid out the elements of the next two steps - monitoring and prediction - for RiverNET and the other two land and wildlife programs, we call our LandNET and RiverNET programs. So the Summit ended with a resounding message: **It’s time to move**

**beyond assessments and focus on solutions.**

RiverNET recognized the protection, supply, and critical need for cold, clean water and lots of it, not only for humans, but the many species that rely upon freshwater like trout. In my 32 years of ecosystem research, I describe the main discriminating attribute for the GYE as “snow-sensitive semi-arid region”. And indeed, the vast majority of biodiversity hotspots are in what we call riverine floodplains which include rivers, streams, wetlands, and riparian vegetation. Water is everywhere and often in short supply for humans and thousands of other species. The movie “A River Runs Through It” ends with the famous, and appropriate ending, ““Eventually, all things merge into one, and a river runs through it. The river was cut by the world’s great flood and runs over rocks from the basement of time. On some of the rocks are timeless rain-

## ENVISION YELLOWSTONE

drops. Under the rocks are the words, and some of the words are theirs. I am haunted by waters.” At the end of the Envision Yellowstone Summit we added this: “information rivers are the words we need to hear” and we crafted the basics of YellowstoneNET, a network of people working together in ‘community science cooperatives’ to capture those trusted information streams - from land, water, and wildlife - and ingest them into an open-source, cloud-based internet data platform for ‘intelligent’ decision-making called [EPIIC](#).

In addition to the new RiverNET program, other pressing issues around the GYE were used to define projects within the LandNET and WildNET programs. Each needed a strong, standardized monitoring program that was inclusive for all stakeholders and ecological forecasting - the predictive component analogous to weather forecasting. These are the main reasons that a 36-hour forecast went from 27% accuracy in 1955 to 90% in 2020. For weather, it was deployment of thousands of weather stations that broadcast meteorological information in near real-time and a mechanistic, processed based models that ingested those sensor data streams. Thus, the evidence-based (empirical) models became adaptive and ‘learned’ from iterative cycles of comparison between model predictions and real-world observations from sensors and people. With this adaptive two-pronged strategy based on the public need, trust was built to where the weather itself became a standard social discussion topic and extremely popular weather channels on the internet.

**FOR RESTORATION AND COEXISTENCE EFFORTS TO BE SUCCESSFUL, THEY MUST BE ADAPTIVE AND BASED ON DATA GATHERED BY STAKEHOLDERS.**



*Photo: Eric Ian*

We’re now in a period of strategic growth for our field-based community conservation cooperatives that fuel our programs - RiverNET, LandNET, and WildNET - as they move past (1) Assessment and on to, (2) Monitoring, and (3) Predictions. We started with RiverNET in the Yellowstone Headwaters, our incubator watershed for the GYE that provides a template for how we apply our programs to the social-ecological systems in the other five GYE watershed units. Like weather stations, we deployed and maintained sensor stations and human-powered cell phone apps that transmit critical diagnostics on water quantity and quality. We’ve just built a total water budget for the entire UYRW that is producing 36-hour and 5-day forecasts for water flow, temperature, and turbidity - available on our just released (v1) RiverNET data platform with public access. We are now expanding RiverNET to the Madison River Valley and the Upper Snake

River in Wyoming. As we grow RiverNET into all of GYE’s six major watersheds, we engage with all stakeholders of each watershed for each program. We emphasize local pressing issues and then conduct an overlap and gap analysis so there is ground for collaboration - filling in the remaining gaps with community science engagement. This builds trust in the data so that stakeholders move forward with conservation action that is data-driven and evidence-based.

Like WildNET and RiverNET, our LandNET program has provided opportunities for collaboration that are a win-win for working lands and the ecosystem as a whole; it is a community science coop for monitoring and predicting landscape health including providing information on soil moisture, carbon, and drought adaptation that often utilizes remote sensing technologies and sensor stations,

similar to RiverNET sensors, to support resilient and conservation-minded ranching. Through a partnership with the Western Sustainability Exchange we design, built, and launched - a dashboard app - a multi-faceted tool to monitor diagnostic of the health of working lands based on their grazing practices and climate impacts on-the-ground. Our approach is all about empowering individuals in the stewardship of the places that are important to them - whether it is their own ranch or critical wildlife habitat in their backyard ranchland ecosystem. WildNET follows in this same vein by working towards developing new applications for wildlife monitoring through the combination of emerging technologies, community partner involvement, and landscape ecology. This diverse program includes everything from camera traps to songbird surveys - which adds to our three decades of research and monitoring of mammal populations.

As we strategically grow our three community science cooperative programs, we are determined to stay focused on the “them” not us and remember our role. So the essential key in our strategy is a clear goal (trusted data-driven decision-making with a focus on transparency in communication and data sharing) but more importantly the process to get there: building the community based on trust. Trust is built on the truth. And that truth operates within what is called a ‘social-ecological system’ which integrates people’s needs and roles in working, managed, and protected landscapes. This is where humans are the major players because we deal the blows - the impacts - both good and not-so-good. And there is no better, and urgent, time to focus almost entirely on the good - the methods, practices, and strategies that restore health and build resiliency through restoration ecology and wildlife coexistence programs. **For restoration and coexistence efforts to be**

**successful they must be adaptive and those adaptation strategies must be based on the data - the information and evidence gathered by stakeholders and then shared** - that’s why we like the term shareholders because that defines the ethic of stewardship. And if this is successful, then those information streams must be used in a way where iterative learning occurs, both in our research (i.e., models) and in the true stories we tell as the tribal humans we are. EO Wilson was once asked, “what is the greatest threat to biodiversity”. He answered “tribalism”. Humans are now the greatest destructive force on Earth but also the greatest potential to restore it

**Robert Crabtree**  
*YERC Founder and Chief Scientist*



Learn about [Envision Yellowstone](#)



NPS/Diane Renkin



## NOTES FROM THE FIELD

**Notes from the EPIIC Team, by Roby Roberts, YERC Chief Technology Officer:** It's been a productive summer for the EPIIC Platform. The release of Beta version 1.0 of our RiverNET Application this summer was a significant milestone for the EPIIC platform. Users can now sign up to view near real-time data on the health of the Upper Yellowstone Watershed at the tributary level. Visit [www.yellowtsoneresearch.org/rivernet](http://www.yellowtsoneresearch.org/rivernet) to get on the platform!

As part of our LandNET program I have been leading an effort with one of our key partners, the Western Sustainability Exchange, to develop an application to enable landowners with the diagnostics needed for resilient ranching practices. Stay tuned for the public release of this application.

EPIIC was built on collaboration. EPIIC is an open-source software project meaning anyone that is interested can contribute. Developers throughout the world (Brazil, India, Vietnam, Malaysia, Belgium) contributed working with another key partner TopCoder (part of Wipro). Their unique and diverse skill sets played a key role in the stewardship of the Greater Yellowstone Ecosystem.

To develop applications using the EPIIC platform, YERC also works with MSU Computer Science students for their senior capstones as part of the Bobcat Software Factory

(<http://www.bobcatsoftwarefactory.com>). Under the direction of Dr Clemente Izurieta, students played a key role in the development of the platform and this academic year students will be participating to develop additional functionality. We also work with other departments on campus for their career gain and our mutual innovation. Students in engineering, marketing, statistics, ecology, and film/photography have worked on past projects. We now sponsor 6 projects with MSU students!

**Meet John Jubenville:** Hello! My name is John Jubenville, I am from Eagan, Minnesota and am studying Computer Science at Montana State. I enjoy mountain biking, skiing, and exploring our public lands. I'm currently working on YERC's database and developing mobile web apps to get data streaming into EPIIC. It's been great to work with such a driven and passionate team that does so much for my education as well as the community and ecosystem.

**Notes from WildNET Field Tech Piage Cresswell:** "Hey, there's a wolf behind you!" - the words everybody wants to hear while they are in



*John Jubenville exploring the GYE with his trusty companion*

Yellowstone. Let's rewind back to 4:00 am that morning. A friend and I were tucked into our sleeping bags, catching the last bit of shut eye before my alarm went off. As a field ornithologist, your hours tend to be very weird--you're either fully nocturnal (as I was 3 years ago for a spotted owl study down in southern Utah) or awake before dawn (as I was this summer for songbird vocal ID). Hence the 4am wake up call. After the blaring cell phone, the sleepy-eyed confusion, and the scrambling to grab packs, we headed off to Yellowstone around 4:10 AM. We drove in companionable silence as we watched the glowing sun peak over the Absarokas.

No one was at the gate when we got to the north entrance of the park so we drove on through. About 30 minutes later, we arrived at Soda Butte. It was 6 AM and hardly anyone else was in the parking lot--a rare respite from the steady stream of tourists common to mid-June. Research permit proudly displayed on my windshield, we began the trek down to my first survey point. In Yellowstone, all research technicians are required to bring along a volunteer in order to keep an eye out for animals (bears, bison, wolves, you name it). My good friend Amy volunteered to go along this time. Amy and I made it through the first 5 points without incident. I jotted down the birds I heard while they scanned the horizon. After each point, we would look at each other and nod--the signal that it was time to move on. During birding, you must stay as quiet as possible. Between points I try to maintain the silence,

## FIELDNOTES

but it's also not a good idea to sneak up on any wild animals. During the transitions, there might be some hushed conversation about how beautiful the morning is or how yummy our scones will be from the Wonderland Cafe in Gardiner (a post-survey treat).

At point 6 we made it through 4 out of the 10 required survey minutes when a massive bison poked his head out of the willows about 75 meters from us. If you've ever been 75 meters from a massive bull bison, you know it is too close. The official park guideline is ~25 meters so we knew we were in the clear, but more than just startled as the bison started to approach us. That is an alarm to move; whenever a wild animal walks towards you instead of away, they want you to leave and a bison wants to see that. Experiences like these are common in the park as the bison herds are very habituated towards people, particularly around the roads. When this happens, researchers put their safety above the data and remove themselves from the situation. I realized that there was a herd across the river and this particular bison wanted to be reunited with his companions. By all means, sir! Amy and I moved along to our next point, shaving about 4 minutes off the required time with a shakily written note in my book to the head biologist about our close encounter.

At the next two survey points, Amy was laser focused on the bison--that bison would not make any moves without Amy knowing. Unfortunately, a laser focus in front means a blind eye behind. So Amy was doing her job as a safety sentinel in a 'buddy system' to focus entirely on that bison until we were well into the safe zone. I seemed to count the 50th Brewer's Blackbird when someone called from the road, "Hey, there's a wolf behind you!" I looked towards the road (about 100m from us) to see a man with two kids and a set of binoculars. At first I didn't believe him. My head snapped around to see her- a beautiful slate-grey juvenile, scraggly from recently losing her winter coat, with a collar around her neck. She was barely 100 meters from us.

As I mentioned before, the official rule of distance between you and a bison is 25 meters but for wolves, it's 100 meters. As we both looked at the wolf and then looked at each other, the wolf stared right at us, assessing whether we were a threat. I then realized that this wolf was not here for us, it was here for our previous friends. Amy and I sighed with relief as the wolf trotted towards the river and jumped in. As it swam across, more and more people stopped along the road and got out of their vehicles to see.

By the time the wolf was across the river, time was up for my survey point. All the noise of folks slamming their car doors and telling their parties about the wolf scared off the birds. I looked at Amy and said "Well, there goes my bird survey this morning." Amy said to me with wild eyes "Are you not incredibly excited that we just saw a wolf?" I replied with some irritation, "yes, but all the birds flew off and now I have to



*Paige Cresswell collecting field data. Photo: Joan Sherlock*

take note of this sampling bias!". Amy looked at me like I was crazy.

We finished the last point and hiked back to the car about 30 minutes later. As we clicked our seat belts and chatted about the day ahead, I turned to Amy and mumbled, "Alright, that wolf was actually really cool and part of the reason we have birds in the riparian vegetation in the first place." We drove away with massive grins on our faces and a story to tell our families for years to come.

**Notes Frank Dean, RiverNET Field Research Coordinator:** One of the best parts of a field season for RiverNET is building community with local landowners and getting to know the tributaries of the Upper Yellowstone through their experience. This was highlighted for me on a recent trip up Upper Mill Creek.

Part of our field team met a landowner on Mill Creek that informed Paige that fish were dying as soon as they left the main stem and started swimming up a small stream flowing through his property. When she arrived back at the field station, Kyla (RiverNET Field Technician) along with myself, were just getting our day of RiverNET field work ready and were informed of the situation on Mill Creek. We made contact with that landowner and quickly made our way to his property



*The RiverNET team, Kyle, Frank, and Kyla, in action. Photo: Joan Sherlock*

to investigate. Upon arriving, we were greeted and given a great layout of the amazing piece of property where this incident was occurring. Taking out our water quality sampling gear and supplies we made our way to the creek where the fish were dying. Sure enough, right as I got to the edge of the water I spotted two dead fish about 6-8 inches long laying across the rocks.

After seeing the dead fish, Kyla began recording diagnostics, (temperature, pH, and a water sample for later analysis), I waded into the stream to scoop up a sample of the water. Once in the middle of the small stream, I unscrewed the lid of the sample collection jar and bent down to scoop a sample of water into the jar. The second my hand touched the water, I felt a strange tingling sensation in all of my fingertips and pulled my hand out to inspect my fingers. Thinking the water was just cold and I was still tired, I bent back down to finish grabbing the sample when I felt the sensation again. It felt like the prank packs of gum that give you a comedical zap or a hand buzzer, but this was much stronger and throughout my whole hand and lower arm! I turned to Kyla and asked if the water felt weird to her at all, still thinking I must be imagining this feeling in my hand. She put her fingers into the water

and quickly pulled them out with a frightened look on her face, agreeing the water did feel strange.

Quickly getting out of the moving stream, the landowner and our team exchanged information and determined there may be some loose electrical lines affecting the stream. Our water quality analysis--conducted back at the YERC lab in Paradise Valley--confirmed that this stream is typical of the cold, clean water to typical of headwaters flowing out of protected areas. By the time I let him know the water quality was normal, he let me know he had already called his electrician and figured out the issue.

Moments like these (albeit less electrifying) are common when we are in the field. Expect the unexpected. It's truly a pleasure to connect with landowners and other stakeholders through our community science programs!



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