Microsoft

AI for Earth Grantee Profile

Yellowstone Ecological Research Center
Powering smart ecological decisions with real-time data insights

Summary

Our ecosystems are changing rapidly as the ripple effects of a warming planet take hold. Climate change has revealed the degree to which we are all interconnected in a vast web of life. As such, adapting to a changing climate will take coordinated action across all decision makers, from policy makers to scientists, ranchers and farmers to concerned citizens. Yellowstone Ecological Research Center (YERC) recognizes that information is at the heart of coordinating this adaptive alliance. With the 22-million-acre Greater Yellowstone Ecosystem as its laboratory, YERC strives to gather vast stores of field data into a single source of truth trusted by all stakeholders as a reliable and actionable representation of the local ecosystem. The next frontier in YERC's ambitious project is to bring this data to life through accessible reporting, visualization, and analytics. Microsoft Azure cloud processing and machine learning are among the tools YERC is using to help land stewards to interpret signals from across the ecosystem—rivers, land, and wildlife—and to take action for a sustainable future.

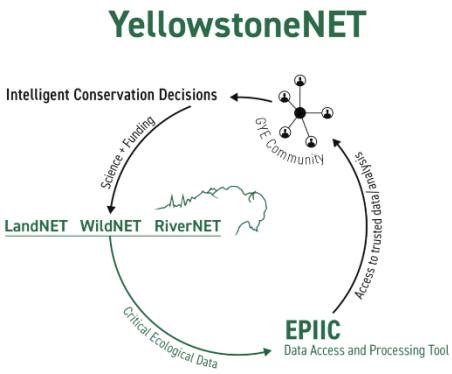
Tackling the climate crisis through collaborative conservation

Ecological stewardship in this time of climate crisis calls for reliable, timely information and coordinated action by an array of land stewards across the private and public sectors. The US federal government has set a goal of conserving at least 30 percent of the nation's lands and waters by 2030. Critical to this conservation effort are efforts to support carbon sequestration, to minimize biodiversity loss, to reduce air and water pollution, and to remove obstacles to animal movement and migration.

Tackling this climate crisis is, as Secretary of the Interior Deb Haaland put it, an "all-hands-on-deck effort." The US Department of the Interior's May 2021 report "Conserving and Restoring America the Beautiful" and the Executive Order on Tackling the Climate Crisis call for "collaborative conservation," uniting public leaders and private citizens in a common cause. This coalition includes federal, state, local, tribal, and territorial officials; agricultural and forest landowners; ranchers and fishermen; scientists and conservation activists alike. The Nature Conservancy echoes the call for collaborative action: the 2030 goal "will require an expansive approach that leverages science and collaboration with Indigenous peoples, landowners, and others to deploy a full suite

of conservation tools. To succeed requires better science and large-scale spatial planning to identify, conserve, restore, and protect climate-resilient habitats."

Yellowstone Ecological Research Center (YERC) is putting this national vision into practice in the Greater Yellowstone Ecosystem. Collaborative conservation has been at the core of YERC's mission since its inception in 1993. Systems ecologist Bob Crabtree founded the Center to "put science to work"—to connect people across the greater Yellowstone community with the information they need to make prudent land-use decisions. YERC's flagship program YellowstoneNET "brings people, data, and technology together to solve Yellowstone's most pressing ecological problems," Crabtree explains. YellowstoneNET is a way for "everyone to engage as concerned citizens, conservation stewards, and the scientists we are."



Building community through shared data

Crabtree realized that coordinating diverse decision makers in land stewardship is essentially a data problem. At the heart of collaborative action is a shared, trusted nexus of diagnostic information accessible to all. "How we respond and react to environmental issues is largely dependent on how data is collected and shared," he explains. "How can we create change or act preemptively to preserve our ecosystem without the specific knowledge of how to do so?"

> "YellowstoneNET brings people, data, and technology together to solve Yellowstone's most pressing ecological problems."—Bob Crabtree, Founder and Chief Scientist, YERC

YERC brings together scientists, land producers, recreational users, and concerned citizens to collect data and, with the help of technology, to transform these field data sets into a system for monitoring and predicting the complicated dynamics of a biosphere. In turn, these stakeholders gain access to a robust data processing system to support informed decision making in their domains.

YellowstoneNET targets five goals that get to the core of YERC's adaptive ecology:

1) Involve all stakeholders as community scientists, where landowners, scientists, and citizens alike collect data using sensors.

2) Aggregate ecological data from YERC's three programs—RiverNET, LandNET, and WildNET—and other publicly available sources.
3) Provide transparent open access to that data via the cloud-based platform EPIIC.
4) Supply a vast array of analysis tools for intelligent decision making and preventative stewardship of the landscape.
5) Offer short-term forecasting and modeling through "what-if" scenarios for problem solving and planning.

Building trust through grassroots data collection

Critical to YERC's success is the common ground the nonprofit identifies across disparate stakeholders. Ecologists and ranchers might not see eye to eye on conservation. They don't share the same objectives or incentives and they operate on different time horizons—decades or centuries for an ecologist; hours, days, or a season for ranchers. Even among land producers, priorities vary. Some ranchers view wildlife conservation as a holistic goal while others are concerned specifically with short-term impacts such as elk foraging on their alfalfa fields. But as Crabtree observes, ranchers share an interest in reliable information and in the long-term resilience of the land, whether the end goal is conservation per se or production yield. "They are very interested in smart, sustainable land use practices. What we call resilient ranching or regenerative ranching practices. This is becoming a big win-win situation." It is by appealing to that shared interest that YERC is able to enlist different interests in a common cause.

> "We think the real key to what we're doing is that if all the stakeholders bear witness to the data collection process, then and only then will it be trusted. And if it's not trusted, it won't be used to make smart decisions."—Crabtree

Involving all stakeholders in data collection—the first goal of YellowstoneNET—builds the trust necessary for collaborative action. "We think the real key to what we're doing is that if all the stakeholders bear witness to the data collection process, then and only then will it be trusted. And if it's not trusted, it won't be used to make smart decisions," says Crabtree. YERC's Chief Technology Officer Roby Roberts explains the power of grassroots data collection: "When all parties are involved in and bear witness to the collection, analysis, and dissemination of data, it becomes trusted information." YellowstoneNET, says Roberts, "gives everyone access to verifiable ecological information to make educated decisions."

Transforming field data into conservation strategy

YERC is able to involve diverse stakeholders in its program because its system is flexible enough to meet different members where they are, with the insights they need, when and how they need them. Using cloud services, AI, machine learning, and data processing, YERC has developed its YellowstoneNET program to help transform unstructured data into usable insights. Those usable insights serve myriad short- and long-term goals—increasing carbon sequestration on ranch land; managing the trout population; predicting bison migration; increasing crop yield—but all further the broader objective of creating climate-resilient habitats.

The cornerstone of YellowstoneNET is the open-access cloud-based platform EPIIC, an Ecosystem Prognosis, Impacts, and Information Cooperative built on Microsoft Azure. EPIIC achieves an "Internet of Things for Nature," bringing together a vast array of sensor datastreams, diagnostics, planning tools, and forecasts from YERC's own field research projects—RiverNet, LandNet, and WildNet—alongside data from many other sources like academia, public agencies, and private companies.

Aggregating data for ecosystem-wide visibility

YERC's goals to collect and aggregate crowdsourced data align with the goal of Microsoft AI for Earth to help preserve earth's ecosystems by creating a Planetary Computer, a multi-petabyte catalog of global environmental data stored in analysis-ready formats. With support from AI for Earth including access to Azure AI tools and services, YERC is building its own aggregated data collection across many different sensor types, in a more accessible format and at a larger scale than would otherwise be possible. Some of the data ingressors YERC uses include HOBO link sensors to measure water throughput and soil moisture, drone data, wildlife camera images, satellite images, and even human sensors—that is, citizen scientists armed with a cell phone field-data recording app. YERC aggregates data from these sources in containers within Microsoft Azure Cosmos DB. In addition, YERC uses Azure Event Hubs to automate the processing of real-time raw data into a more usable format for analytics. YERC's field researchers are utilizing machine learning to process some data—for example, as part of RiverNET, scientists are using computer vision to process images for the detection and classification of aquatic insects.

> "We can see the response from our impacts in real time in order to make decisions."—Crabtree

Community partners can tailor EPIIC's data visualization to their own needs with tools such as what-if scenario forecasting, which lets users model the cascading effects of any number of counterfactuals, such as temperature, rainfall, or animal migration. The system enables both long-term forecasting and short-term precision ecology tailored to specific needs. For example, YERC's RiverNet program has three years of data on water turbidity and discharge—the quality and quantity of freshwater, both input and output. EPIIC brings this

data together to form a picture of a water budget. Made available alongside such public data resources as USGS weather data or the USDA's SWAT-MODFLOW groundwater hydrological model, decision makers can move from analyzing past data to forecasting or modeling different use scenarios.

Powering proactive land management with AI

It's this AI-enabled approach that allows ecologists and producers to make the leap from reactive conservation to proactive land management. For example, what-if scenarios could help ecologists predict the effect of a 5-degree rise in temperature on the trout population. Ranchers might query the system to predict how lower rainfall could affect their soil moisture levels and vegetation, or to model how different grazing practices could affect soil moisture, plant cover, or carbon content of the soil. YERC has partnered with the Western Sustainability Exchange, a nonprofit that works with ranchers to pioneer resilient ranching practices. As part of this partnership, YERC developed a rancher dashboard application that ranchers can use to track their soil carbon. The nonprofit runs a carbon credit trading program that routes corporate carbon credit donations to ranchers who can demonstrate success in sequestering carbon from the atmosphere through responsible land-use practices. The program incentivizes ranchers in the short term to learn through AI how to improve their carbon sequestration; long term, they win again through improved soil health and vegetation and we all win with a healthier ecosystem.

It's this type of collaboration—born of alignment among diverse intersecting interests rather than policy or persuasion—that AI and machine learning tools enable. Features in its success include trusted, co-produced data streams; real-time open access via user-friendly dashboards and apps; and a scale of computational power only possible in the cloud.

Looking ahead

EPIIC promises to transform ecology from a siloed academic endeavor in which scientists publish papers over years to a collaborative enterprise in which flexible data models power decisions in real time. In the past, academic scientists, public agencies, private companies, and land producers maintained their own data and decision-making tools. Timeliness of the data prevented insights from transcending the academic, private, and public sectors. An academic paper is of little use to a farmer making tactical decisions in response to emergent changes. Even agricultural consulting companies offering periodic drone data analysis are ill-aligned to the use case of a farmer responding to unpredictable factors like drought or elk herd migration.

YERC's cloud-powered technology, by contrast, makes scientific data accessible in time to be useful in practice. Using predictive analytics, a rancher can query what effect a change in agricultural practice would have on soil carbon, for example. "We can see the response from our impacts in real time in order to make decisions," Crabtree comments. "It's kind of like getting back to gathering around the campfire back when decisions were made together face to face." Next steps for YERC include developing its data platform with user interfaces and

analytics tools for specific purposes, with the help of technology partners like Topcoder, Amphora Data, and Azure services like Power BI.

Yellowstone Ecological Research Center's EPIIC powers the type of collaboration that might once have taken place over a campfire, but it does so in an unprecedented and powerful way—it arms the decision makers with access to real-time information at a scale and immediacy prior generations could not have imagined.

About Yellowstone Ecological Research Center

Yellowstone Ecological Research Center has developed a data-driven, adaptive approach to ecological stewardship of the Greater Yellowstone Ecosystem. YERC collects long-term datasets to capture real trends over years, analyzes these data at appropriate spatial scales (from genes to ecosystems), and collaborates with agencies, universities, and other NGOs so that its scientific research supports sustained solutions for adaptive decision-making.

Resources

Website

Yellowstone Ecological Research Center, https://www.yellowstoneresearch.org/

Documentation

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