The Freshwater Trust and Upstream Tech

Aquifer conservation at scale for agriculture

Summary

Groundwater plays a significant role in supplying water for drinking and agriculture, as well as supporting many ecosystems. However, the underground aquifers that naturally store this water are slow to replenish, vulnerable to overuse from wells, and difficult to manage because so many different users draw upon them. The Freshwater Trust and Upstream Tech have worked together on various projects to conserve or restore freshwater ecosystems and related areas. Now, they have collaborated to create BasinScout® Platform, a tool to help identify the best places to improve groundwater and surface water quantity and quality. The BasinScout® Platform uses satellite imagery and machine learning to provide a holistic view of the farms within an aquifer basin and compare different possible conservation actions to see which would be most effective in terms of both cost and environmental impact. This enables targeted investments to achieve specific quantifiable improvements at a scale that makes a quantifiable difference for the environment.

Helping agriculture conserve aquifers through AI

The ground beneath our feet is generally not quite as solid as we imagine; it has many cracks and crevices. In most places this fractured ground is saturated with water, which we call *groundwater* to distinguish from water on the surface. Groundwater is estimated at less than 2 percent of the total amount of water on Earth, and yet it also includes 30 percent of all freshwater, while freshwater on (or above) the surface—such as in lakes, rivers, or clouds—is a mere 1.2 percent of all freshwater. And that groundwater is a vital natural resource. According to the U.S. Geological Survey, groundwater accounts for 40 percent of the public water supply and 39 percent of agricultural water usage in the United States. Wells drilled down into aquifers—the fully saturated zone underground—enable this use of groundwater. However, water moves slowly underground, sometimes taking centuries to move centimeters, which means people can and sometimes do withdraw groundwater from wells much faster than the aquifer can be replenished.

"Groundwater creates the capacity of rivers to flow, and the existence of wetlands and pools and riparian areas is dependent on groundwater," explains David Primozich, Conservation Director for The Freshwater Trust. The Freshwater Trust applies data analytics tools and technologies to help preserve and restore freshwater ecosystems, such as riparian areas. (Riparian areas are the riverbanks and transitional wetland zones between

rivers or streams and the surrounding land.) "Pound for pound, riparian and near-aquatic ecosystems create so much habitat and habitat diversity that we all depend upon," says Primozich.

But those ecosystems can be threatened by overuse of groundwater. As Primozich explains, significant pumping of groundwater can create a depression in the water table, the level at which the ground is saturated, and when that happens, more water from the surface sinks down to fill the depression, taking water away from the ecosystems above ground. Primozich warns, "Once the root zones of those riparian areas and the wetlands no longer have access to water, it's impossible for those ecosystems to sustain themselves." These aquifer depressions also affect both the quantity and quality of water available for drinking water as well as agriculture irrigation; in severe cases, wells run dry.

Collaborating to meet conservation challenges

Whereas it's not too difficult to focus on a small area like an individual farm and determine how to optimize it for particular outcomes like improved water management, it's a much greater challenge to plan effective ecological practices for a large-scale environmental system such as an aquifer—and all the ecosystems it serves—simply because of the sheer size. Considering agriculture alone, a river basin may support hundreds to thousands of individual farms, each with its own crops and farming practices. Knowing how the practices on these farms interact with each other and collectively affect the local aquifer requires not only massive amounts of data but also the capability to make sense of it. Consequently, governments and organizations have struggled to meet pressing conservation needs. "We have for decades seen tens of millions, hundreds of millions of dollars being spent on the environment, and with the absence of technology to guide those investments, they have lacked coordination to achieve a specific environmental objective," says Primozich.

> "We're able to translate the benefits of site-level actions to basin-scale objectives."—David Primozich, The Freshwater Trust

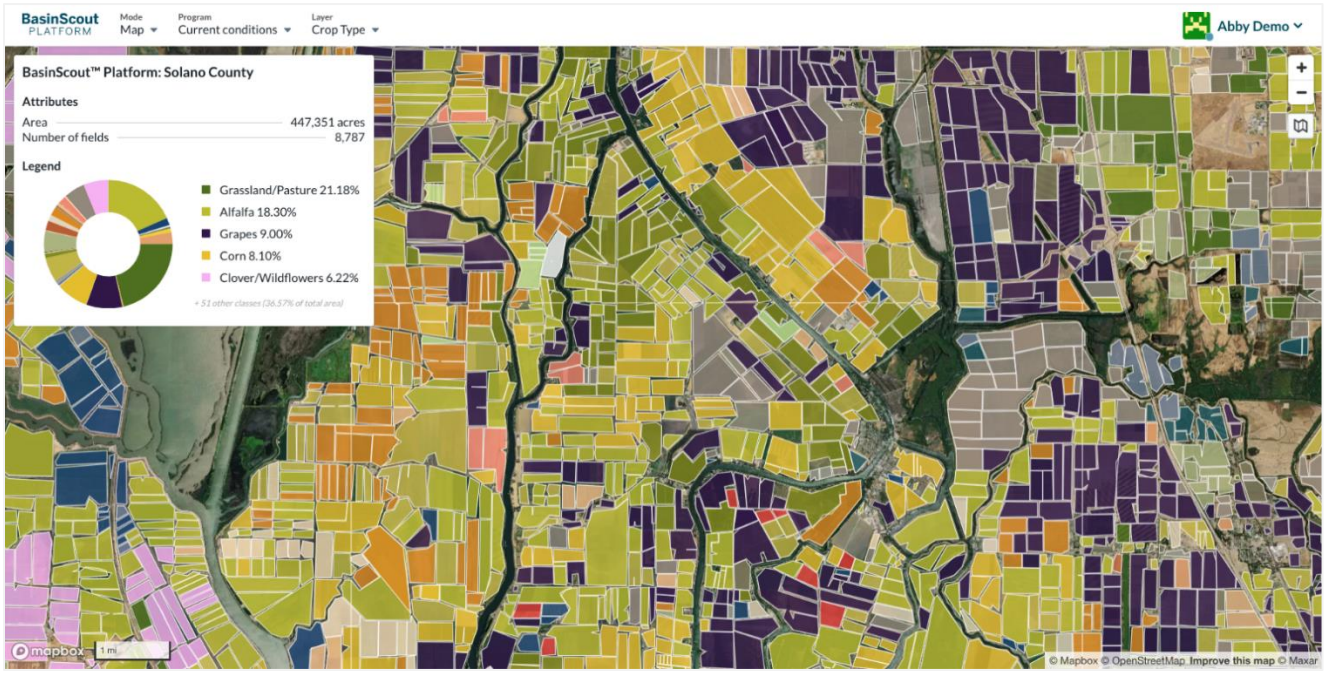
"Five to ten years ago, the limiting factor on scale was understanding where the farm fields were, what they were growing, and how they were growing those crops," says Marshall Moutenot, the Managing Director of Upstream Tech. "Because that's the equation that impacts freshwater, we're interested in designing programs to optimize resource use." Upstream Tech creates decision-support technologies for conservation and renewable energy. After reading *Quantified: Redefining Conservation for the Next Economy*, by The Freshwater Trust's president Joe Whitworth, the founders of Upstream Tech (including Moutenot) reached out to The Freshwater Trust, beginning a collaborative relationship.

"It came at a time when we at The Freshwater Trust were looking into a whole bunch of new optimization mechanisms," says Primozich. "With the data that were becoming available and with the computing capacity that was becoming available, we were starting to put together quantified environmental outcomes from individual projects on the landscape that we just hadn't been able to see before."

Moutenot adds, "The more we worked on the smaller projects together, the more we realized there was an opportunity to solve a much larger problem, which is how we arrived at the work we're doing now."

Targeting aquifer conservation actions at basin scale

That work includes BasinScout® Platform, a tool to overcome the challenge of developing feasible, cost-effective strategies for agricultural conservation. BasinScout® Platform combines the detailed ecological knowledge of The Freshwater Trust with the technical expertise of Upstream Tech to bring visibility to the larger picture of an aquifer ecosystem while also exploring the many possibilities for targeted field-level interventions that collectively can make big differences. "With application of new technology, we're able to translate the benefits of site-level actions to basin-scale objectives," says Primozich.

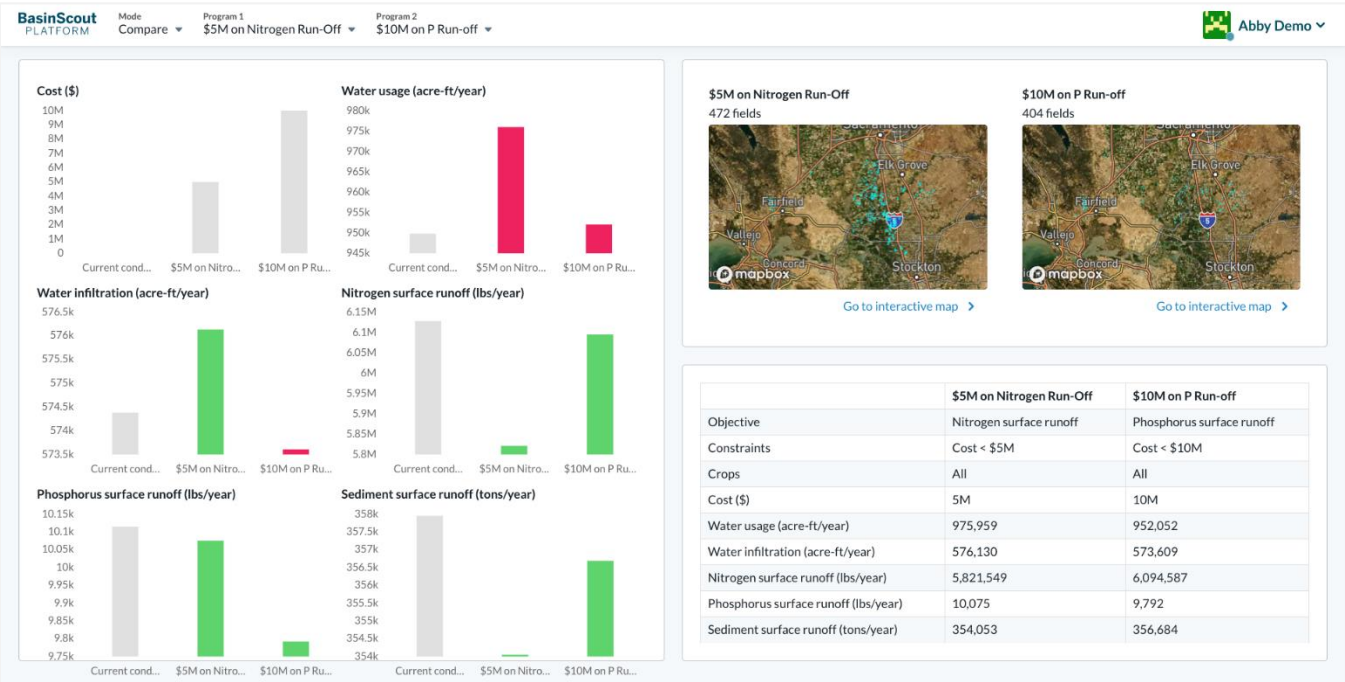


BasinScout® Platform assesses the current conditions on a landscape, including remotely identifying crops. (BSP includes imagery from Mapbox OpenStreetMap, and Maxar.) Image courtesy of The Freshwater Trust.

Although many factors can affect the health of an aquifer, the ones under control by farmers include what crops they're growing and what farming practices they're following—irrigation, fertilizer use, and tillage. Attempting to monitor and measure those practices manually is impractical at best even for one farm, all but

impossible for a whole basin, but in the past decade, advances in computing and artificial intelligence have brought this information within reach. “Our background at Upstream Tech is in leveraging satellite imagery and algorithms, oftentimes machine learning, to automatically do those types of analyses,” explains Moutenot. “The Freshwater Trust had the context of understanding which models mattered and the environmental context to run those models in.”

Through those capabilities, BasinScout® Platform can automatically delineate from satellite imagery all the different fields in a given aquifer basin and identify the farming practices and environmental effects (such as water consumption and nutrient runoff) in each. With an overall basin mapped out and detailed this way, it’s then possible see how various targeted actions in particular areas will affect the overall basin and to devise, quantify, and compare potential conservation programs. Multiple constraints can be chosen, from specific objectives (such as reducing water use) to resource limitations (such as an annual budget), individual crops, and specific actions (such as irrigation improvements). Scenarios can then be generated to not only quantify the benefits to be gained from particular actions, but also specify the fields where actions should be taken to realize those environmental gains.



Basin Scout Platform compares different scenarios to prioritize actions and achieve conservation outcomes. (BSP includes imagery from Mapbox OpenStreetMap, and Maxar.) Image courtesy of The Freshwater Trust.

That quantified, targeted planning can mean huge savings in time, effort, and costs—and can make a real difference to the environment. By providing better focus on what can be done, where, and how, BasinScout®

Platform brings ecological conservation from an abstract ambition to a concretely achievable and cost-effective plan of action.

Primozich says, "What we have seen in every single case where we've applied these analytics is that when you focus your attention on the places that deliver the highest value, it's not only less expensive, but we can get there on a timeline that is meaningful for the ecosystem."

Meeting larger goals with machine learning

"The value of bringing machine learning into this is that the agricultural landscape changes on an ongoing basis," says Primozich. "So the dynamism that comes with advanced technologies and things like machine learning enable us to continue to adaptively manage and change our recommendations based on the land management changes that are happening from year to year." The flexibility provided by machine learning also means BasinScout® Platform can be readily adapted to new aquifer regions. Moutenot says, "Where machine learning comes into play is that it really automates that process of hand-designing and hand-calibrating models, and that is the key piece of speeding up that process."

> "It's hundreds of thousands of scenarios being evaluated among tens of thousands of fields simultaneously. That's the innovation."—Primozich

The core advantage of BasinScout® Platform is the scalability it enables, moving beyond the constraints of acting on a site-by-site basis to considering all the interconnected parts of an ecosystem as a whole. Primozich says, "It's hundreds of thousands of scenarios being evaluated among tens of thousands of fields simultaneously. That's the key, that's the innovation." And not only does scalability mean taking action holistically, but also it means bringing people and organizations together to address the larger needs of the environment. Again, Primozich: "BasinScout® Platform gives us the ability to scale in a way that we just have not seen before. When you can scale, then you can start talking about not just the single investment from an individual company, but what that means in combination with dozens of companies coming together around a common ecological objective."

About The Freshwater Trust

The Freshwater Trust (TFT) is a nonprofit with a mission to preserve and restore freshwater ecosystems. The 36-year-old organization develops data analytics applications and methodologies to support strategic watershed restoration project planning, tracking, and reporting. Since 2011, TFT has used its patented StreamBank® suite

of tools, including its BasinScout® methods, for assessing watersheds, prioritizing restoration actions and monitoring long-term benefits. In addition to technology, TFT has a solid track record of implementing projects in and along rivers throughout the Pacific Northwest to benefit native species habitat, water quality and streamflow goals.

David Primozich is the Conservation Director at The Freshwater Trust. He is a leading expert on water quality trading and environmental accounting in the United States. He has more than fifteen years of experience working with private and public entities on regulatory compliance related to water quality and endangered species. David leads efforts to quantify environmental improvements that result from land and water management actions, making it possible for regulated entities to secure permits for water quality trading and grant makers to improve the effectiveness of watershed conservation investments. His experience also includes shaping emerging measurement science and tracking procedures around ecosystem services to achieve better conservation results.

About Upstream Tech

Upstream Tech designs and develops decision-support technologies for scalable environmental conservation. As a public benefit corporation, Upstream Tech leverages innovations such as satellite data and machine learning to transform data into efficient actions for land conservation, agriculture, and water management.

Marshall Moutenot is the co-founder and Managing Director of Upstream Tech, overseeing the product development, growth and partnerships. He was awarded Forbes 30 Under 30 in Energy and has served on panels for the United Nations Economic and Social Council. Marshall holds a BA in Computer Science from Tufts University.

About the BasinScout® Platform

The Freshwater Trust and Upstream Tech partnered in 2019 to co-create the BasinScout® Platform. BasinScout® Platform combines TFT's analytical conservation expertise and BasinScout® process with Upstream Tech's machine learning capabilities. This new, automated platform can more rapidly and efficiently assess agricultural practices and restoration actions, and develop feasible, cost-effective scenarios across large, complex geographical areas.

Resources

Websites

BasinScout® Platform: https://basinscout.org/
The Freshwater Trust: https://www.thefreshwatertrust.org/

Upstream Tech: https://upstream.tech/

Documentation

"FAQ: What is groundwater?" U.S. Geological Survey. Accessed August 24, 2020. https://www.usgs.gov/faqs/what-groundwater

"Water Science School: Groundwater" U.S. Geological Survey. Accessed August 24, 2020. https://www.usgs.gov/special-topic/water-science-school/science/groundwater-what-groundwater