Research Brief

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Stanford | Woods Institute for the Environment

Beaver ponds: A new old tool for water and wildfire resilience

Stanford researchers have developed a novel mapping system which can give land and watershed managers a more comprehensive understanding of how beaver dams reshape landscapes. The approach could help ensure beaver restoration projects maximize benefits and minimize risk through more precise site selection.

Background

Across North America, watersheds are under growing pressure from climate change, land degradation, and unsustainable water management. Wetlands in particular—crucial ecosystems for storing water, filtering pollutants, recharging aquifers, and supporting biodiversity—have declined in area by over 50% in the lower 48 states and losses continue. In recent years, government agencies and conservation groups have invested in expensive engineered solutions to recuperate these ecofunctions, such as installing artificial wetlands, retention basins, and stream re-wilding structures.

A dramatically more affordable and efficient alternative: the North American beaver. Through dam-building, beavers create complex, dynamic wetland systems that store water, slow runoff, trap sediment, recharge groundwater, and reduce downstream flood risk. Their ponds also act as natural firebreaks, helping landscapes retain moisture and providing critical refugia during wildfires. Beavers provide many of the same hydrological services that human-built infrastructure aims to replicate—but with lower costs, self-maintaining structures, and ecological co-benefits such as increased habitat complexity and biodiversity support.

However, beaver-based restoration remains underutilized in part due to limited understanding of where and how beaver ponds develop, how large they become, and under what conditions they are most effective. The ponds created by beaver dams can also lead to nuisance flooding, crop damage, and tree mortality, making them unpopular with some landowners

POINTS FOR POLICYMAKERS

- **Beaver restoration is a promising, affordable, and efficient nature-based solution for enhancing water storage, increasing drought and wildfire resilience, improving water quality, and supporting biodiversity:** The broader ecological and hydrological benefits of beaver restoration extend beyond dam construction to include pond and wetland formation, which enhance water retention, habitat creation, groundwater recharge, and carbon sequestration
- **Beaver reintroduction becomes tricky when landowners and water managers are concerned about nuisance flooding, crop damage, or unwanted tree kills:** Being able to make-data driven site selections that maximize benefits and minimize undesirable flood risks is critical to the success of beaver reintroduction programs.
- **Site-specific hydrologic and natural landscape features are important considerations for selecting restoration sites:** Knowledge of which natural features exert the strongest controls on how beaver dams will impact a landscape provides a foundation for policymakers and land managers to design effective, targeted conservation strategies.
- **A new dam mapping framework better predicts the ponding that would result if beavers or manmade beaver dam analogs were reintroduced to a given landscape.** This information, when combined with sociopolitical considerations, can assist watershed managers in selecting reintroduction sites with greater confidence that they are creating the most benefit with the least risk.

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and infrastructure managers. Without accurate mapping and predictive tools, water and land managers struggle to incorporate beaver impacts into water budgets, restoration strategies, and climate adaptation plans. Better quantification of beaver pond extent and environmental drivers is essential for leveraging this natural infrastructure in place of—or in strategic complement to—engineered solutions.

A team of researchers, led by Luwen Wan, a postdoctoral fellow at the Stanford Institute for Human-Centered Artificial Intelligence, Kate Maher, a professor of Earth system science at the Stanford Doerr School of Sustainability, and Emily Fairfax, an assistant professor of Geography, Environment, and Society at the University of Minnesota, has developed easier and faster techniques to map surface water area across different beaver habitats and quantify key factors that drive variations in beaver dam length and pond area. These tools could arm watershed managers with the ability to make informed selections for the best reintroduction and translocation sites, minimizing unwanted flooding by predicting pond size, while maximizing the desired ecological benefits of bringing beavers back to the land.

Existing models are used to predict where beavers could build dams and how many dams a stream could support. This new research improves on these predictions by assessing how environmental variables normally considered separately (e.g., stream permanence, valley width, and soil permeability) interact to affect dam length. The team found this intersectional approach can explain 81% of variance in dam size—which means analyzing a mix of key factors in a pre-beaver environment could help predict the scope and scale of damming that would result from reintroduction. Additionally, this work identifies key variables—dam length, woody vegetation height and stream power—that have the biggest impact on pond size.

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ABOUT THE RESEARCH

This brief is based on **Factors influencing surface water accumulation in beaver pond complexes across the Western United States** published in *Communications Earth & Environment* and **Smokey the Beaver: beaver dammed riparian corridors stay green during wildfire throughout the western USA** published in *Ecological Applications.*

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FOR MORE INFORMATION

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