

# PERCREPORTS

THE MAGAZINE OF FREE MARKET ENVIRONMENTALISM



## A Voice in the Wilderness

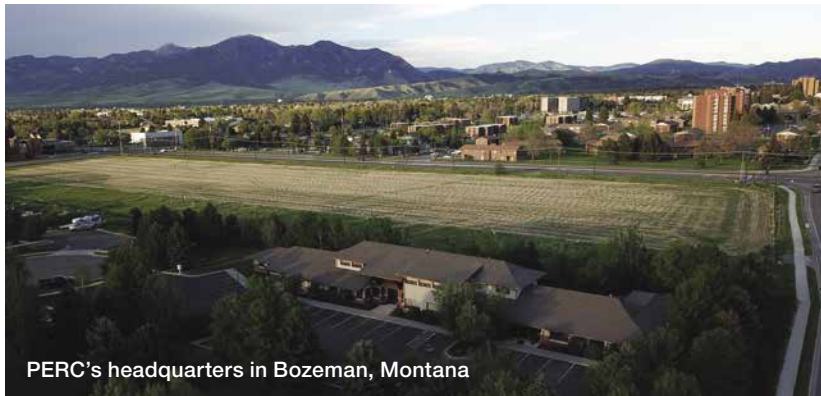
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PERC's headquarters in Bozeman, Montana

When PERC opened its doors in Montana in 1980, environmental problems seemed to only have one solution: more government regulation. For more than four decades, PERC has advanced a different approach that harnesses property rights, markets, and innovation to encourage environmental stewardship. Along the way, PERC has gone from being a voice in the Montana wilderness to becoming a leader in the world of environmental policy and conservation practice.

How did it happen? Part of the answer is that PERC's network runs far and wide. In addition to an impressive group of roughly a dozen staffers based in Bozeman, we have an extensive network of senior fellows, visiting scholars, and program participants that continually build on PERC's ideas and apply them to new environmental challenges. Each year, PERC hosts research workshops, visiting fellowships, landowner forums, "enviropreneur" camps, student seminars, legislative briefings, policy webinars, and more.

This issue of *PERC Reports* provides a glimpse of the broader reach of PERC's programs. It features the work of several past and present fellows and shows how their ideas are informing and shaping some of today's most pressing environmental issues.

Matthew Kahn (page 10) explores how markets help us adapt to climate change, based on work he developed during a recent summer fellowship at PERC. Rachael Young (page 18), a participant of PERC's enviropreneur programs, explains how her work on water markets helps manage competing demands for a scarce resource. Tate Watkins (page 34) uses research from several PERC visiting scholars to examine how the federal government responds to wildfires, which are already raging in parts of the West.

Eli Dourado (page 26) explores how policy reforms could unleash a revolution in geothermal energy production, drawing on ideas explored in a recent webinar with PERC scholars. Peter Karieva (page 42), an ecologist and former chief scientist at the Nature Conservancy, discusses research he conducted at PERC and his perspective on the state of conservation today. And the issue summarizes a new study by PERC scholars revealing some of the more inconspicuous economic benefits of gray wolf recovery (page 46).

This is just a sampling of the breadth of PERC's programs. This summer, we welcome another cohort of visiting fellows that will generate new insights and continue to expand PERC's reach—from our headquarters in Montana to the broader world of conservation.



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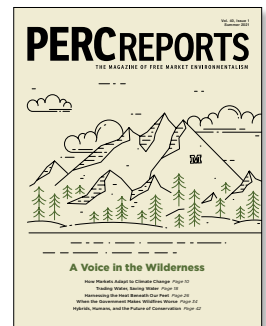
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# The Irreplaceable Leigh H. Perkins

A tribute to PERC's longest-serving board member

**T**he first time I met Leigh Perkins was in 2009 at Mays Pond, his hunting lodge. Nestled among the piney woods in North Florida, Mays Pond was exactly that—a humble lodge, inconspicuous, like its owner, in a region known for its plantation manors and estates. When we met that January morning to hunt quail, he offered me a cup of coffee and then proceeded to make the cowboy version of it using a soup pot on his kitchen stove. It was something you might expect from someone whose first job, I later learned, was as a rod man on a survey crew in the iron mines of Northern Minnesota.

In 1965, Leigh purchased the Orvis Company, a 109-year-old fishing rod manufacturer with only 20 employees. By the time he retired, Leigh had transformed Orvis—and fishing itself—into an outdoor lifestyle, an ethos of appreciation for nature more than any one product, with 700 employees and sales topping \$90 million. As important, if not more so, he was the pioneer of corporate conservation. Orvis gave 5 percent of its profits to environmental causes, paving the way for outdoor recreation philanthropic giants like Bass Pro Shops and Patagonia. Leigh was generous with his time too, serving on the boards of conservation organizations, including the Nature Conservancy, Tall Timbers, Trout Unlimited, and, of course, PERC.

Leigh was PERC's longest serving board member, joining the board in 1984 and continuing with only brief interruptions for the next 30 years. He was the anchor of a tradition of

fishing legends on the board (the others being John Bailey of Dan Bailey's Fly Shop in Livingston, Montana, and our current board member K.C. Walsh, the owner of Simms Fishing).

His indelible mark spanned nearly the entire 40-year history of PERC. Leigh was there at every critical juncture, a visionary who saw what many others might not. In PERC's infancy, having the CEO of Orvis as part of leadership provided the organization and free market environmentalism with much needed credibility in the conservation community. It's also how, more than three decades later, I ended up at the helm of PERC—through Leigh's unwavering faith and encouragement in elevating PERC's research from journals and books into real-world conservation policy and practice, a vision he inspired until his last days on the board.

Happy go lucky, generous, humble, and oftentimes a character, Leigh was unmatched in his outdoor prowess. I remember watching him effortlessly, almost nonchalantly, cast a flyline 70 feet across a spring-fed pond in Wyoming's Star Valley. Until the end, he hunted birds with a 20-gauge Winchester Model 21, given to him by his father when he was 16 years old. It was the gun he would let me use on my cross-country visits to hunt with him in Florida. To me, it was like holding King Arthur's Excalibur. In the field with Leigh in his 80s, I witnessed him take impossibly long shots at speedy quail and turn to walk back to the wagon as if he missed, not realizing that his strong wingshooting instincts still resulted in a downed bird.

Leigh was a dog man first and foremost. Having had the privilege to quail hunt many other properties in the Red Hills region of Florida and Georgia, hunting with Leigh was unique. Where others would keep score on how many quail were brought down and how many shots were fired, Leigh knew that was not what was important. Instead, he kept a clipboard in the wagon with a list of his dogs and noted with a pencil which ones found or pointed the coveys of quail. It was not about “meat in the wagon,” but the graceful, elegant dogs afield that were family to him. Many a duck hunter at Mays Pond would find themselves in a natural blind of brush, keeping company with the headstone of a loyal retriever who once sat years or decades ago in the early morning light by the side of Leigh Perkins.

One great memory of Leigh and his love of dogs was from a stay at a PERC board meeting in Big Sky, Montana. Leigh and his wife Annie would travel everywhere with their assemblage of English setters. But the hotel was a strict “no dogs allowed” establishment, as they learned at check-in, so Leigh asked for a room on the backside of the lodge on the ground floor. That night, when it got dark, he and Annie enlisted me and my wife to help them pop out the mesh screen in the window well of their room. Then, like a well-trained military operation, he proceeded to orchestrate a human bucket brigade to usher four English setters from their truck to the lodge room through that small window well. How quintessentially PERCian in spirit!

The boyish resourcefulness in Leigh didn't just extend to his beloved setters; it permeated his entire life. PERC board member Kim Dennis tells one story of a time she sat next to Leigh at a board dinner in Montana. Leigh had passed some fresh roadkill on the way to dinner but didn't have time to stop to pick it up. All through dinner he kept obsessing over the missed opportunity. By the time he showed up at breakfast the next morning, with a big grin on his face, he could report that he had returned to the site, and the deer's meat and organs were safely stored in his coolers.

Leigh was also defined by the women in his life. In the beginning, it was his mother, Katherine Perkins, a renowned sportswoman who fostered in Leigh a love of the outdoors,

wildlife, and nature, if not his sense of mischievousness. He would tell me stories of hunting alligators with his mother and watching her shoot turkeys on the wing. One of the most endearing photos he kept at Mays Pond was of an elderly Katherine walking after her son, finger pointed at him, clearly scolding him for some mischief, as a middle-aged Leigh walks away head down with hands in his pockets. He said it was a photo of his mom “advising” him.

In the end, it was his loving wife and hunting and fishing partner Annie—a strong, intelligent, and charming outdoorswoman in her own right and longtime friend of PERC. After Leigh's passing, I asked Annie if it was hard for them in his last year of life to be isolated from so many people because of Covid. On the contrary, she said. Though they missed family and friends, they got to spend an intimate year together fishing, hunting, watching wildlife, and taking in all the wonders of the outdoors until that magical hour of the day, when the soft evening light of the sun set on the legend, and man and nature merged into one. Leigh Perkins left us as he lived, the indomitable outdoorsman and conservationist.

After penning this tribute, I will head off to fish the evening hatch for colorful cutthroats in the pools and riffles of a tucked-away creek that empties into the Yellowstone River. Leigh would have surely encouraged that, and he probably would have suggested that I drop the writing and leave a few hours early. Mixing a love of the outdoors with meaningful conservation work is what Leigh inspired in so many of us who got to call him a friend. For the people at PERC, our passion is our work, and the work is a passion for the outdoors—that is the legacy of Leigh. PERC would not be what it is today without the friend we lost, the irreplaceable and immortal Leigh Perkins.



Leigh Perkins and Brian Yablonski



**Brian Yablonski** is the CEO of PERC. In “Frontiers,” he describes how PERC seeks to advance creative conservation through incentives, innovation, and cooperation.

# *PERC Remembers:* Leigh H. Perkins

The PERC family was sad to learn of the passing of longtime friend, board member, and ardent conservationist Leigh Perkins in May of this year.

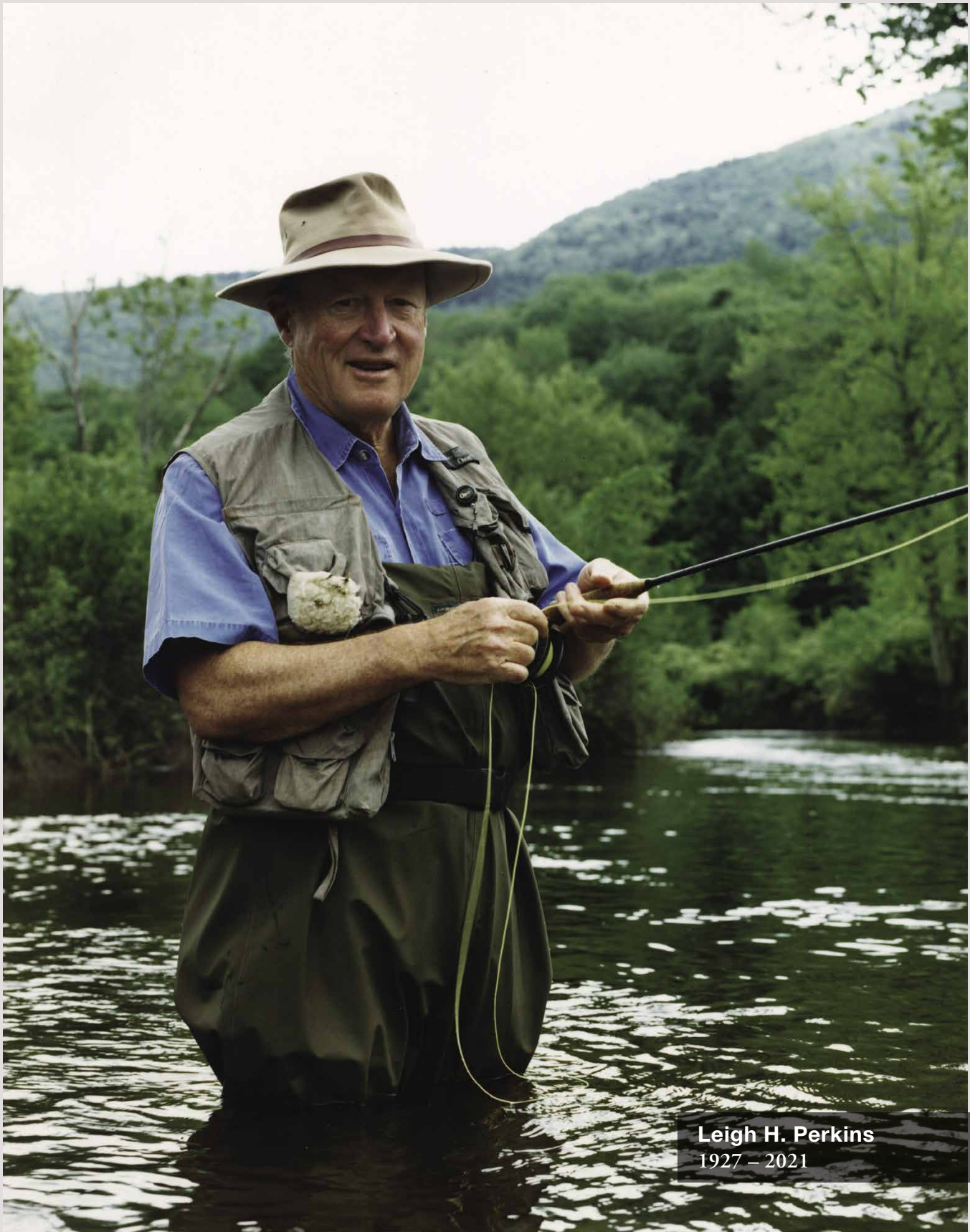
Leigh combined his love of sport with a sharp mind for business when he purchased the Orvis Company in 1965 and turned it into one of the largest and most respected outdoor stores in the nation. After handing the business over to his sons, he continued his love of the outdoors, doing the things he loved—hunting, fishing, and spending time with his grandchildren.

Leigh supported many private solutions to land and water conservation and served on the boards of numerous organizations, including the Nature Conservancy, the National Fish and Wildlife Foundation, Tall Timbers Research Station and Land Conservancy, the Cleveland Museum of Natural History, and the Cleveland Scholarship Foundation. He also served as president of the Ruffed Grouse Society and founded the American Museum of Fly Fishing.

The contributions Leigh made to PERC over the years have been immeasurable. Not only was he a leader in promoting environmental solutions with business acumen, Leigh was also a friend and longtime PERC supporter, guiding generations of our leadership through nearly three decades of service on the board.

Leigh is remembered as a true outdoorsman who helped shape PERC's history through his invaluable commitment to the outdoors. We are grateful for everything he made possible at PERC and his enduring conservation legacy that will benefit generations of outdoorsmen and women to come.





**Leigh H. Perkins**  
1927 – 2021

**Mass timber rising.** Milwaukee will soon be home to the tallest timber structure in the world. At 25 stories, the unprecedented building, Ascent, heralds the rise of mass timber, a budding class of construction materials made by laminating strips of wood together. Mass timber is light and strong, and it offers a market for small-diameter trees that contribute to fire risk throughout the West. While Ascent’s engineering team at Thornton Tomasetti has paved the way for future “supertall” timber projects, reforms like those offered in PERC’s recent “Fix America’s Forests” report can promote innovative wood markets even more.



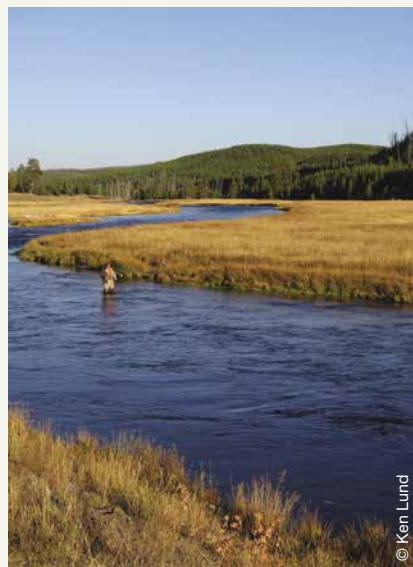
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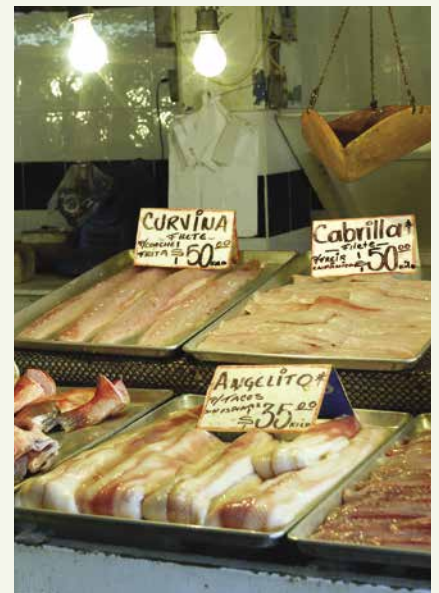
© Wildfire Defense Systems

**Private protection catching fire.** Wildfire Defense Systems, the largest private firefighting company in the United States, is the market’s response to ballooning property damage from wildfires. Partnering with insurers, WDS evaluates policyholders’ risk of fire damage. When wildfires break out, the company defends homes with its own fleet of fire engines and crews, saving dollars and property in a win-win for insurers and communities. This past year, as the Bridger Foothills Fire moved into Bozeman’s wildland-urban interface, WDS deployed three fire crews to protect homes and bolster public firefighting efforts. Not a single home defended by WDS burned.

**Straight outdoors.** The Covid-19 pandemic has upended lives in countless ways, but it’s also prompted a boom in hunting and angling. Utah recently set records for both pursuits, with total license sales up 28 percent, and many anglers were first-time purchasers. Colorado broke records for big-game applications in 2020—which have now been surpassed ahead of the 2021 season. And while Montana has seen spikes in permit applications for deer and elk, nonresident fishing licenses sales have truly surged, up by 60 percent. After years of sliding participation rates, Americans are getting outdoors in record numbers—a blip due to extraordinary circumstances, or a new trend?



© Ken Lund



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**One fish, two fish, prove how you fish.** Ten years after Mexico’s Gulf of California curvina fishery implemented catch shares, technological innovation and a new monitoring program are improving market-based fishery management there. The program, which employs mostly women, has transformed regulatory compliance with an app that allows community members to register their catch as they return to shore. The transparency and accountability allow fishers to demonstrate that they fish responsibly. The system also provides valuable information about when to fish to meet market demands and helps regulators make data-driven decisions to support the fishery.





**Wildlife trafficking gets a virtual hearing.** PERC research fellow Catherine Semcer recently testified remotely before the U.S. House Natural Resources Committee during a hearing on wildlife trafficking and its growth in online marketplaces. Semcer’s testimony focused on the need for development and conservation policies that provide better economic options than poaching or participating in other wildlife crime, thereby preventing illegal wildlife products from ever entering the marketplace. She also highlighted the need to consider the effects of Endangered Species Act decisions on wildlife law enforcement abroad.

**Property rights are for everyone.** PERC policy director Hannah Downey recently testified before the Montana House Agriculture Committee in opposition to a bill that would ban select nonprofit organizations from purchasing agricultural land. The intent of the bill’s sponsor was to stop American Prairie Reserve from purchasing ranchlands from willing sellers and putting those lands toward grassland and wildlife conservation. In effect, the bill destroyed the property rights of landowners and organizations, barring them from selling to or buying from whomever they want. The bill was ultimately voted down.



© American Prairie Reserve

**The garden is greener.** Dianna Rienhart joined PERC in 1984 and has contributed to the organization in about every way imaginable ever since—including helping produce *PERC Reports* as far back as the earliest issues. She retires this summer and will be missed by everyone at PERC. Not only has Dianna played an integral role as an editor, managed the office in Bozeman, and simply made sure things get done, but she represents the very best of PERC. Our loss will be her garden’s gain, as it will be even better tended than normal in the future.



© John Kakuk

**Conservation nation.** President Joe Biden has launched the America the Beautiful campaign, which aims to conserve 30 percent of U.S. lands and waters by 2030. Conservation is a worthy goal, but how it is done matters. In testimony before U.S. House Natural Resources Committee Republicans, PERC CEO Brian Yablonski emphasized the importance of private lands, property rights, and market-based solutions to achieving Biden’s goals. The administration later released a preliminary report on the guiding principles to reach the “30 by 30” goal, which embraced the PERC message of locally led conservation over restrictive regulations.



# How Markets Adapt to Climate Change

Market responses to emerging threats help cope with an uncertain future

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BY MATTHEW E. KAHN

**I**n 1980, the biologist Paul Ehrlich and the economist Julian Simon engaged in a famous debate. Ehrlich argued that ongoing population growth would lead to overconsumption of natural resources and a collapse in food consumption per person. Simon countered that rising scarcity creates incentives to unleash human ingenuity and address the challenge.

Flash forward to 2020, when we were confronted by a risk that again posed existential questions. The Covid-19 crisis was a wakeup call against complacency about our standard of living. The economic dislocation and disruption of daily life caused by social distancing and other measures rocked the global economy to its foundations. A silver lining was that we learned how quickly the world can adjust to shocks that we did not anticipate and for which we were unprepared. But it remains an open question how nimble we will be in responding to future threats.

During the Covid-19 pandemic, the challenge of climate change was temporarily displaced from the news. But the challenge has not gone away. As Julian Simon understood, human ingenuity will play a central role in reducing climate risks because our ability to adapt is accelerating over time.

## Coping with Change

We have two chief strategies to cope with the threat of climate change. First, we can mitigate the threat by reducing our production of greenhouse gas emissions. Second, we can adapt to the threat by changing how we live in response to new threats.

My work largely focuses on the second strategy. It explores how people, firms, and governments can adapt to the risks posed by climate change and how we can change our lives even as climate change grows more severe.

Given what we know, the rational strategy in the face of growing climate risk is to engage in both mitigation and adaptation. But at least in the short term, global greenhouse gas emissions will continue to rise as world per capita income increases. For the billions of people in the developing world who seek a better life, these income increases will be a good thing. However, given current technologies, continued emissions will exacerbate the climate change challenge, which will make adaptation even more important to guarantee future improvements in people's standard of living.

A great race is unfolding as global greenhouse gas emissions continue to rise but we become better at adapting to the emerging threat. The outcome of the race will depend on how people, firms, and governments cope with new risks.

In 1980, Julian Simon said that “discoveries, like resources, may well be infinite; the more we discover, the more we are able to discover.” Today, Simon's ideas about the role that human capital and ingenuity play in building our individual and collective resilience are as relevant as ever given the climate challenge.

## The Role of Induced Innovation

As millions of U.S. households and billions of people around the world seek new solutions to adapt to climate change, there is a huge market for firms that can devise products that help people cope. Our set of feasible coping strategies increases over time as innovation takes place. The next Elon Musk must choose what problems she will solve. The profit motive helps her prioritize.

Market demand drives the direction of innovation. Drug companies focus their efforts developing new drugs for diseases featuring a large market demand for cures. If few people suffer from a disease, then drug companies have much weaker incentives to pay the fixed costs and bear the risk of developing new medicines for that disease. Perhaps ironically, if climate

change is expected to cause significant aggregate damage to the population through increasingly intense heat waves, then this creates a profitable market niche for entrepreneurs who can devise solutions. For those new market products that require larger upfront fixed costs, for-profit firms will need to be convinced that the aggregate market is large. When entrepreneurs anticipate that there will be large future demand for an innovative climate adaptation solution, this creates the incentive for them to enter this market to design the new product.

This suggests that there is strength in numbers when it comes to adapting to climate change. If only one household experiences mold due to heavy rains, then no firm will develop a new solution to remove the mold. If millions of people face this challenge because of climate change-induced heavier rains, then it is profitable for firms to engage in the risky and costly search for solutions. The flooding in Houston caused by Hurricane Harvey created significant mold damage for thousands of homes. If entrepreneurs anticipate these emerging opportunities, then the power of human ingenuity is unleashed in the search for solutions.

In short, economics predicts that individuals will respond to the law of demand. If the price of adaptation-friendly goods declines, because of economies of scale and because of global supply chains lowering the average cost, then people will be more likely to adopt them.

Given the significant degree of income inequality in the U.S. economy, the super-rich play a special role in driving technological change. In June 2018, Bill Gates blogged about a new technology that guarantees that vaccines remain cold as they are transported to rural places. He funded this innovation in part because he anticipated that there is a crucial need for making sure that vaccines do not spoil as they are transported to those who need them. Such cooling transport technology is another example of an innovation that fuels adaptation. Due to his personal fortune and his ambition to improve the world's quality of life, Gates personally helped cause this innovation.

Development economists have been concerned that drug companies have much weaker incentives to design new drugs for people in poor nations because such drugs will generate less profit. The same logic applies in induced innovation for mitigating climate risk. If billions of people face similar challenges of extreme heat and sea level rise, new market opportunities will arise from this aggregate demand for solutions. In contrast, if hundreds of millions of poor people



face a location-specific challenge, for-profit firms have less of an incentive to solve this issue because aggregate demand for such a solution will generate less profit. In this case, nonprofit foundations such as the Gates Foundation and other development agencies can play a role in promising a financial payout to the firm that comes up with a solution.

As new goods are created and marketed, firms enter and compete against one another for market share. This competition benefits consumers as the price of such goods declines. Declining prices mean that even poorer people can afford these goods. We see this happening already. The quality-adjusted price of key adaptation-friendly products ranging from air conditioning to cell phones to refrigeration have all declined sharply over time.

The open research question here is how effective these goods are in offsetting the new risks we face. Research documenting the role of the widespread diffusion of the air conditioner in attenuating the outdoor heat and death rate correlation offers one optimistic example. The widespread ownership of cell phones represents another example of a new technology that plays a key role in keeping people current on their social network, trusted news sources, and local government actions. This real-time information helps people make informed long-term choices and short-term decisions during a crisis.

## The Zoom Boom

The meteoric rise of Zoom software and other technologies during the Covid-19 pandemic showcase just how quickly technological solutions can proliferate in response to massive demand. In early March 2020, every university in the United States closed down and went online to protect people from the virus. Professors gave lectures from home using Zoom, and students learned online.

Many for-profit firms are now switching to remote working and conferencing via the web. As firms learn how to create teams from remote locations, this opens up several adaptation possibilities. For one thing, it can help workers avoid traffic congestion and the delays associated with it, while also reducing local air pollution. By unbundling one's place of work from one's place of residence, workers will have much more freedom to choose where they live based on criteria other than commuting. This will help them to adapt to those risks and opportunities that they prioritize.

Improvements in information technology such as teleconferencing allow for a physical separation of a firm's headquarters

A great race is unfolding as global greenhouse gas emissions continue to rise but we become better at adapting to the emerging threat. The outcome of the race will depend on how people, firms, and governments cope with new risks.



Given the physical size of the United States, there are many places to build our productivity hubs given that cities take up little physical space. There are many possible places to build future cities if our current productivity hubs face significant climate risk.

from its back offices and production centers. A firm can keep a few workers in a coastal center city location and send factories and back offices to distant locations. If coastal cities are especially prone to climate risks, then production activity can move to safer locations. If a firm can coordinate across its various functions without them being physically near each other, then this opens up many more possibilities of where they can locate. This increased menu of locations facilitates adaptation.

More jobs now feature work that does not require face-to-face contact. Thus, people can be productive during extreme weather events that limit their ability to travel away from home. Future snowstorms in Chicago, for example, will cause less short-run disruption for worker productivity because workers can engage in remote work on such days.

### Could Wall Street Leave Wall Street?

Our economy features many sectors, but our most productive firms are concentrated in a handful of high-tech industries, and these industries tend to cluster in specific cities. Given the place-based threats that climate change poses, could our major firms and key productivity hubs be significantly damaged by climate shocks?

In 2012, I was called by a reporter from *The Economist* who was writing a story about the risks that climate change poses for coastal cities. I was asked, “Isn’t it true that Wall Street is a major center of finance in the United States?” I replied, “Yes.” “Is it true that sea level rise could flood Wall Street as Hurricane Sandy recently demonstrated?” I said, “Yes.” “Thus, couldn’t climate change, by accelerating sea level rise, decimate the U.S. economy by destroying Wall Street?” The reporter’s argument was that damage to key productive places could greatly injure our overall macroeconomy.

Building on the work of Gary Becker and Julian Simon on human capital, I reject this place-based theory of economic growth. The human capital approach argues that any geographic area that has a pool of talent will experience economic growth. In the modern economy, places are productive if skilled people and well-managed firms locate there. The great financial





cluster of Wall Street would become a less productive place if ambitious, young finance workers stopped moving to New York. Consider an extreme example: If sea level rise threatens Wall Street, and firms take no preventive actions, then we certainly could suffer a major productivity shock. Given that Wall Street firms make their money from anticipating market trends, such firms have strong incentives to be aware of the new climate risks they face due to where they have located their key workers and assets.

If the place called Wall Street is threatened by sea level rise, major firms will anticipate this threat and move to higher ground. Such firms will have strong incentives to find areas that face less future climate risk. If Goldman Sachs exits an increasingly risky southern Manhattan, then other firms will follow, so that the economic agglomeration re-forms in a safer, more resilient area. If this dynamic plays out, New York City loses a major employment center and apartment prices nearby will fall in value, but there will be new wealth creation on relatively safer land. This optimistic scenario implicitly assumes that current clusters of productive firms can coordinate together and quickly re-form on higher ground.

This process will play out through a trial-and-error learning process. Given the physical size of the United States, there are many places to build our productivity hubs given that cities take up little physical space. This means that there are many possible places to build future cities if our current productivity hubs face significant climate risk. This

transition would incur costs and time. A silver lining of forming the new productive cluster on higher ground is that this would provide a new opportunity to reconsider what economic activities should cluster together, and thus the new productivity center may be even more productive than the original cluster.

## The Bet, Round II

These are just a few of the examples that I explore in my new book, *Adapting to Climate Change: Markets and the Management of an Uncertain Future*. The upshot of the book is that markets and human ingenuity help us adapt to new risks that we face. We are not passive victims. Humans have substantial ability to cope with emerging risks, whether from Covid-19 or climate change. Each day we grow stronger in our ability to withstand the changes that Mother Nature throws at us. As rational economic agents, we are increasingly aware of these risks, and our individual demand for solutions adds up to sufficient aggregate demand to unleash innovations that enable us to adapt.

The possibility that we are growing ever better at adapting to climate change evokes the older debate between Julian Simon and Paul Ehrlich. Back in the 1980s, they debated whether the growth of the world's population would harm our standard of living. Ehrlich argued that a growing population would increase demand for scarce resources and bring about a Malthusian collapse.

It is important to recognize that the unintended costs of these government policies will rise over time due to climate change; thus, it is in our best interest to consider policy reforms that allow the price system to signal emerging scarcity.

Simon countered by focusing on the role that market price signals play in directing behavioral change. He argued that prices would rise to reflect the rising scarcity of resources, and this would trigger conservation and supply-side innovation to search for substitutes. Simon also argued that population growth raises the possible set of innovators whose ideas would increase the abundance of resources. Ehrlich bet that natural resource prices would rise, while Simon bet that prices would fall as human ingenuity would identify substitutes and people would respond to the incentives embodied in price signals. Simon won the bet.

The ongoing climate adaptation challenge poses a similar high-stakes contest. Given that the world has finite land and many people, which regions will remain livable as climate change grows worse? An extension of Simon's logic posits that our growing human capital will allow us to discover ways to offset the new environmental pressures we face. Critics will ask whether we have sufficient time to discover these innovations. But innovators are always looking for the next big profit opportunity. The anticipation of future demand creates an incentive today to research potential solutions. If enough entrepreneurs enter this competition, the probability of a significant breakthrough rises sharply. Although we must avoid wishful thinking that technological advances alone will protect us, the technological frontier is shifting thanks to the rise of the global middle class seeking new products to help them cope with new risks and financed by the global capital market.

Today, we are adapting to the new risks posed by Covid-19. We face both contagious disease risk from the virus and fiscal risk associated with the economic shutdown. In the midst of the pandemic, the federal government has changed its rules and policies several times, and this has contributed to uncertainty and planning challenges for firms and households. The private sector can play a more productive role in facilitating

adaptation to such shocks—as long as federal policy creates credible incentives for experimentation, innovation, and investment.

## New Rules of the Game

My book discusses new “rules of the game” that would accelerate our progress on climate adaptation. For example, I believe that the United States needs to remove policies that subsidize homeowners, thereby encouraging more renting, and we need more “upzoning” that allows for taller and denser construction.

Such issues may not seem related to climate adaptation, but they are. Homeowners hold an undiversified asset portfolio—they have put all of their “eggs in one basket.” Climate change increases the risk of such place-based bets. If the federal government no longer subsidized home ownership, as it currently does through a variety of policies, then more people would choose to rent, helping them hedge climate risk.

Other policy solutions relate to classic PERC land-use themes. For instance, phasing out farming subsidies would reduce moral hazard concerns as farmers would have a greater incentive to adjust their activities to adapt to the emerging profit opportunities created by climate change. If an area faces greater drought risk and the price of water is rising, farmers would substitute away from water-intensive crops. To take another example, by subsidizing living in flood or fire zones and consuming natural resources, federal and state governments often slow down the adaptation process.

It is important to recognize that the unintended costs of these government policies will rise over time due to climate change; thus, it is in our best interest to consider policy reforms that allow the price system to signal emerging scarcity. Unleashing price signals dovetails with Julian Simon's vision for building a more prosperous nation and a more resilient economy—and, ultimately, increasing our ability to “take a punch” from Mother Nature, no matter what she ends up throwing at us in the future.

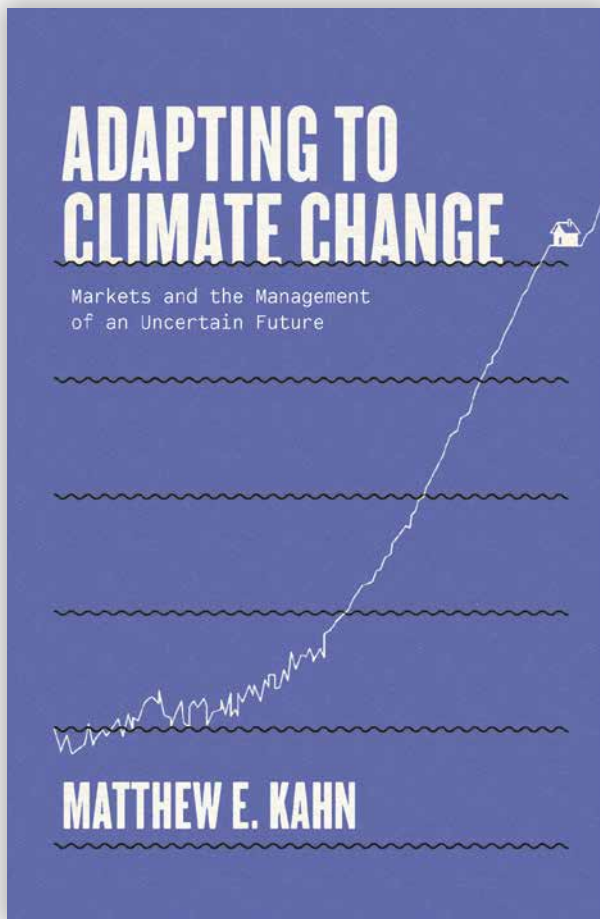


**Matthew E. Kahn** is a professor of economics at the University of Southern California. He was a PERC Julian Simon Fellow in 2016-17. This essay is adapted from his new book *Adapting to Climate Change: Markets and the Management of an Uncertain Future* (Yale University Press).



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# TRADING

# WATER,

# SAVING

# WATER

Water markets help the West cope with supply-side shocks and evolving demands

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BY RICHAEAL YOUNG

**A** drought swept through California in the early 1990s. I remember my second-grade teacher painting a bleak picture to our class about how we could literally run out of water, and that there might not be enough for people and fish alike. As a young child, what I took away was apocalyptic: images of fish stranded ashore because people were using too much water.

That day, I ran home from school, on a mission. I didn't even bother dropping off my backpack inside. I went straight to the hose in our front yard and dragged it to the street, where there was a storm sewer with a sign that read, "No Dumping, Drains to Bay." A fish was painted alongside the warning to emphasize the point. I stuffed the hose into the storm sewer and turned it on full blast. I was giving some of our water to the fish. While I didn't know it at the time, that was the first of many water transfers I would facilitate.

Decades later, droughts continue to plague the West. They've become so normal that they now require new terms like "megadrought" and "aridification." When the West faces water shortages, no one is spared: habitats degrade, food and electricity production take hits, communities are choked by relentless wildfires. The repercussions of droughts will intensify as they occur more regularly and with more severity amid climate change.

Today, as a water economist, my job is to help customers stretch their limited water resources. This means managing supplies wisely and getting a handle on collective demands. Fortunately, one of our available tools is an old one: water markets that can help reallocate the resource to the places it's needed most.

I've learned a lot more about water and water markets since I was a second-grader determined to help fish in the San Francisco Bay. One lesson is that even well-intentioned water markets can have bad outcomes if poorly designed or executed, as was my first water transfer. After a decade in this industry, I've seen great water markets and failing ones. They're often grouped together, mischaracterized, and misunderstood, muddling the record on water markets in the western United States.

## What Water Markets Are

In the arid western United States, there simply isn't enough water to meet every water demand. For decades, water markets have been an important tool that helps westerners reallocate their limited water to higher-value uses through voluntary, compensated agreements. Importantly, there is no single water market in the West—there are hundreds, ranging from informal to formal, operating at a hyperlocal level.

Voluntary, market-based transfers reallocate water to where and when it's most needed, in the process helping to produce more with less, facilitate better environmental outcomes, and cope with drought and climate change.

At its core, a water trade entails transferring some or all of a water right to another party, typically in a way that changes its place or purpose of use. Voluntary, market-based transfers reallocate water to where and when it's most needed, in the process helping to produce more with less, facilitate better environmental outcomes, and cope with drought and climate change.

The concept of "most needed," however, is always evolving. Drought and climate change are altering the timing and quantity of western water supplies. Water demands change as a result of shifting community needs, global market conditions, and cultural values. For example, urbanization has led many municipalities to acquire water for city use. Consumer demand for high-value crops like tree nuts, hops, and apples has led to shifts in water use within the agricultural sector. Increased public support for healthy ecosystems has led to more purchases that keep water in rivers and streams to support wildlife habitat. Demands for water use change within and between sectors; the ability to reallocate water to adapt to those changes is imperative. Without trading, water would be locked into a particular place, time, and purpose that could not adapt to meet changes in supply, local community needs or values, or global market conditions.

I first got the chance to learn all about water markets in graduate school. As part of my research, I interviewed some 100 farmers and water managers across the West over eight weeks, traveling many less-traveled dirt roads. I learned that there was much more activity and breadth in water trading than our research team had previously known. I also learned about the very real barriers that formal water markets erect for farmers, and how those barriers—not the price of water—can make water trading unaffordable to the average farmer. Eventually, my thesis advisor and I started Mammoth Water, the company we now run in an effort to make water markets more affordable, accessible, and equitable.

Seven years later, I still travel many dirt roads, working closely with farmers and water managers from Kansas to



The author (right) with a customer, a farmer whose water allocations are monitored with meters.

California to understand the particular challenges they face. Farmers struggle to find interested trading partners, negotiate prices, and navigate complex regulatory frameworks—tasks for which they typically hire real estate agents, engineers, and attorneys. Regulators, on the other hand, spend substantial time and effort reviewing applications to trade water. Trading rules are complicated enough that, in some instances, we found regulators had made mistakes and approved trades that did not conform to their own rules, potentially harming other water users or the environment.

All of these reasons were the impetus for us to create the first “smart markets,” or electronic clearinghouses, for water trading in the United States—centralized hubs for trading activity that automate the process of matching parties by both price point and regulatory constraints. We’ve helped customers transfer water to more productive lands, with lower environmental impact, at a fraction of the time and cost than before. Matching many parties with one another is difficult to organize by hand; with a smart market, it’s effortless.

While smart markets for water are new in the United States, water markets are not. Yet in the West, they’re usually informal and decentralized, as we documented in a 2019 report. Many trades are done at the local level and sealed with a handshake between farmers. Formally reported water trades

represent a fraction of the total volume and value of water traded annually. We have little idea about how much water is being traded in aggregate, or what value water markets are creating, across the country. And while we don’t know the exact breakdown, the bulk of water trading happens between agricultural producers, who trade water to manage irrigation requirements and cope with shortages.

## What Water Markets Are Not

Despite their long history in western management, water markets are plagued by pervasive misconceptions and are regularly misrepresented in the media. They’re dubbed new tools for the rich to speculate on water, manipulate its value, and sell to the highest bidder. The truth couldn’t be further from this mischaracterization. In reality, water markets help communities cope with scarcity, allowing users to reallocate a limited resource as needed.

In December 2020, the Nasdaq Veles California Water Index futures launched. The idea, similar to commodity futures, is to hedge risk in price volatility by locking in a price today. In this futures contract, the price would be that of the index. If the index price goes up, the holder of the futures contract would pocket the difference and could put the proceeds toward the purchase of real, wet water. If the index price goes down, the holder would owe the difference but would be able to purchase real, wet water at a lower going market price.

Unlike commodity futures, however, the Nasdaq “water futures” do not require delivery of the commodity—wet water. Instead, the futures contracts are financially settled based on the index. The use case above presumes that the price of wet water that the user would need is closely correlated with the Nasdaq Veles California Water Index. But water pricing is idiosyncratic, depending on location, purpose of use, infrastructure, reliability, and other characteristics. For instance, the direction and magnitude of price shocks felt in some areas are different than in others, even within the same state or region. Further, the index is based on partial and proprietary pricing data from only five of California’s many dozens of local water markets. It’s unlikely, therefore, that the futures will be a useful tool for participants in real water markets in California or across the West. In reality, the futures market is not a wet water market at all—it’s more a tool to make “paper water” bets on California’s drought conditions.

A month later, in January 2021, an article from *The New York Times* portrayed investors attempting to financially exploit water rights in the Colorado River Basin. Among other things, the reporting pushed the idea that hedge funds were buying up undervalued agricultural water rights, which they could hoard

in federal reservoirs, eventually selling water to the highest bidder once its value peaked in a time of distress. It's not a new storyline about water markets. While such sensational stories generate buzz and clicks, they fail to acknowledge the pillar of western water policy that was built to prevent speculation: the beneficial use doctrine.

In the United States, water is the property of the people of each state, held and administered in trust by the appropriate state agency. No one “owns” water; instead, the ownership right is in the use of the water, called a usufructuary right. Western water law was further built on the beneficial use doctrine—rights to use water come with the caveat that they must be *beneficially* used. Using water rights in a way that is not considered beneficial could subject them to relinquishment. Of course, the definition of beneficial use is an evolving concept. Leaving water instream to improve habitat, for instance, is not recognized as a beneficial use everywhere, a regulatory reality that can hamper conservation efforts. Yet while definitions of beneficial use vary state to state, holding water for future financial gain is not a recognized beneficial use across the West. Speculating on water in the West is illegal.

## Trading Friction

In the trading of real, wet water, farmers, conservationists, or anyone else looking to trade is likely to come across plenty of challenges. At practically every step in the process, a person looking to trade water will encounter an obstacle that imposes transaction costs in time, money, or effort. They'll need to determine how much water to trade, an increasingly difficult task given the effects of climate change.

In the trading of real, wet water, farmers, conservationists, or anyone else looking to trade is likely to come across plenty of challenges. At practically every step, a person looking to trade water will encounter an obstacle that imposes transaction costs in time, money, or effort.

They'll need to identify an interested party with which to trade. Most contact their neighbors, family members, and friends, although some work with specialized water attorneys and brokers. Some areas have legal pads, or bulletin boards, that act as water listings. Some even post their water for sale on Craigslist.

After finding one another, the parties will negotiate contract terms, sometimes a prickly task as both sides typically know one another. And finally, in a formal transaction, they'll submit a transfer application to the appropriate regulator—a loose term that, depending on the community or basin, could refer to a state or local public agency, a court, or a water or irrigation district.

While each of these steps adds costs for water market participants, the last step—the one involving regulatory review—has a huge amount of variability. A potential transfer not only depends on the review process of the applicable regulatory agency, but also whose desk it lands on.



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Water trading regulations should be as complex as necessary. After all, our watersheds, aquifers, and the activities they support are complex. They are also unique, so there is not and cannot be a one-size-fits-all solution for water trading regulations. The groundwater trading programs in the Platte River Basin of Nebraska, for instance, where stream depletion is the primary concern, look much different than the program being developed in Rosedale-Rio Bravo in California, an area with significant potential for groundwater recharge. Even within the Platte River Basin, trading programs differ from one district to another.

While local considerations are crucial, complexity does make it difficult for water users to understand and navigate the regulatory process for transfers. This is particularly evident when regulators fail to clearly define the criteria for approving transfers. Many still rely on case-by-case evaluation, which can lead to arbitrary and inconsistent rulings.

At Mammoth Water, regulatory unpredictability makes our work difficult. We match buyers and sellers in customized smart markets that consider both price point and regulatory constraints—but we have to know what the regulations are. The rules must be specific and clear, lending themselves to automation. Otherwise, we cannot tell a computer how to evaluate potential trades. We're leveraging automation to reduce transaction costs, but we need the public sector to do its part.

Codifying water transfer criteria, which we constantly advocate at Mammoth Water, is the single thing that regulators could do to lower transaction costs most. Clear and specific

criteria provide more transparency to water market participants from the outset, formalizing the legal and technical standards for a thumbs-up or a thumbs-down. Such clarity would increase the quality of transfer applications that a regulator receives, as well as streamline and systematize decision-making.

## Markets for Conservation

Stewardship is Mammoth Water's primary company value. And well-designed water markets are an important tool for water stewardship. To begin with, water markets create a new revenue stream for water savings and conservation, rewarding good stewardship. This encourages more efficient water use, putting scarce and under-utilized water to better, more productive purposes.

An active and successful participant in western water markets is a seemingly unlikely one: the environmental sector. Water trusts and nonprofits across the West—in Arizona, California, Colorado, Nebraska, Oregon, Washington, and elsewhere—regularly acquire water through a combination of temporary and permanent transfers. Their leases and purchases supplement and retime instream flows, creating better environmental outcomes through voluntary, market-based transactions.

In Nebraska, the Platte River Recovery Implementation Program has acquired a combination of surface water and groundwater rights for the benefit of endangered species, including the whooping crane, piping plover, and pallid sturgeon. In recent years, the program has adapted its strategy to lease surface water rights that can be stored



A customer talks to the author (right) about potential solutions to water use challenges.

© Jack Kent Cooke Foundation/Nick Ciorogan

in Lake McConaughy, a federal reservoir, giving greater control to retine releases in a way that most improves habitat downstream. This year, the program is leasing nearly 40,000 acre-feet of water.

Since 1978, the Arizona Land and Water Trust has used market-based transactions to improve holistic land and water management practices in southern Arizona. Its agreements with landowners include conservation easements, short-term water leases that encourage fallowing, conversion to crops that use less water, and modernization of equipment and infrastructure. The trust has a long track record of preserving land with particular importance to wildlife, protecting more than 60,000 acres.

In Washington State, Trout Unlimited has developed an impressive portfolio to boost streamflows for two federally listed species: steelhead in the Yakima River and Chinook in the Methow. The group has worked with landowners on a range of agreements, from drought-year leases to permanently repurposed water rights for instream flows. It has also worked collaboratively with growers and irrigation districts to boost efficiency and update operations that improve conditions for fish.

Mammoth Water is supporting Trout Unlimited, Kittitas Reclamation District, and the Yakima Basin Integrated Plan to build on their joint success creating multi-benefit water management practices in the Yakima Basin. Our ongoing project, funded by the Bureau of Reclamation and Washington Department of Ecology, will develop a smart market strategy that would generate benefits to both farmers and fish by streamlining downstream trades.

These are a handful of success stories that have many parallels. Local, state, and national environmental organizations are not just active but innovative participants in water markets. And they are well versed in what it takes to make water trades happen: deep expertise at the local level, boots-on-the-ground engagement, and pure grit.

## Coping with the Future

Well-designed water markets help manage changing water supplies and demands. They help communities cope with water scarcity in the short term and evolving demands in the long term. They create a new revenue stream for water users, who can monetize their water savings and invest in conservation practices and technologies. Those who decry or wish to do away with water markets ignore the important role they play in adaptation and resilience, including to supply-side dynamics that we've felt through drought, aridification, and climate change.

But water markets are not foolproof. They rely on good governance from regulators, which requires transparency, trust,



© Michael Jeffries

If you asked me today, “Are water markets good or bad?” I would ask you, “Which water market?”

and inclusivity. They must reflect community needs and local hydrologic relationships, preventing harmful if unintended impacts to third parties. Unfortunately, not all water markets meet these criteria, which could make them unfair or vulnerable to abuse or exacerbate scarcity conditions.

If you asked me today, “Are water markets good or bad?” I would ask you, “Which water market?” There’s a lot of nuance in what makes good water market design. In many instances, tracking how water markets perform is lacking. Better analysis of water trading volumes and outcomes could identify which rules are making an impact, good or bad, on environmental and socioeconomic outcomes. Local communities and water professionals could learn from that analysis and leverage the insights to improve market design and performance.

Stories about communities running out of water or Wall Street buying up the West’s water make our anxiety spike—as they should. We should desire to be fierce stewards of the water our communities depend on; after all, that’s the story of my first water memory. But my hope is that, like with my own journey, others will dive deeper to explore the real water scarcity issues on the horizon and what we can do to start to resolve them. People should be informed about and empowered in water governance, whether they’re farmers who irrigate their crops, households who want clean and reliable water from their taps, or children who simply want to share their water with fish.



**Michael Young** is co-founder and CEO of Mammoth Water, a public benefit corporation that makes water trading more affordable, accessible, and equitable. In 2017, she participated in several PERC programs for environmental entrepreneurs, or “enviropreneurs.”



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# Harnessing the Heat Beneath Our Feet

How lessons from the shale oil revolution could help us access geothermal energy—and provide clean power—virtually anywhere on the planet


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BY ELI DOURADO

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Steam rises from geothermal plants near the Salton Sea in California.

© Geothermal Rising/Janet Harvey



**I**magine an energy source that is cheap, compact, safe, non-polluting, reliable, inexhaustible, and unconstrained by geography. What if this energy nirvana has been right under our noses—and beneath our feet—all along?

Our planet holds a tremendous amount of heat. The center of the earth has a temperature that is about the same as the sun's surface. Scientists have estimated that the band from the surface to a depth of 10 kilometers contains about 50,000 times more thermal energy than the chemical energy in all of the planet's oil and gas reserves. Furthermore, this heat is continually replenished. The decay of radioactive elements in the earth's interior creates an estimated 44.2 terawatts of heat flux—about twice humanity's primary energy consumption today.

Humans have produced electricity from the earth's subsurface heat since 1904, when Italians first harnessed geothermal steam at Larderello, in Tuscany. Today, the same site produces enough power for 10 million Italian households, about 10 percent of the world's geothermal electricity. This high share concentrated in one place reflects the small installed base of current geothermal technology. In the United States, today's geothermal power plants represent a tiny sliver of total energy output, supplying about 0.4 percent of the country's utility-scale electricity. Conventional geothermal technology is only deployed at sites where subsurface heat makes itself evident through visible features like hot springs, geysers, and fumaroles. The main geothermal field at Larderello is called *Valle del Diavolo*—Valley of the Devil—because it contains springs of boiling water. The largest geothermal field in the world, in California, is called the Geysers, although the features for which the area is misnamed are actually fumaroles.

Thanks to recent technological advances, accessing geothermal energy is becoming feasible even in places where the planet's heat does not appear at the surface. But to harness our planet's innate energy to the fullest extent—in the process, cutting greenhouse gas emissions and making our economy boom—we need much more experience with new concepts for geothermal energy production. In many domains, proficiency inexorably increases with experience—you get better at doing something the more you do it—a phenomenon illustrated through learning curves. Learning curves have been essential in energy, where researchers have made rapid improvements in solar power and battery technology as cumulative production has increased.

For geothermal energy, perhaps the closest analogue to past learning curves is the shale oil revolution. That revolution not only dramatically advanced the state of the art in drilling and subsurface engineering, but its advances are also

now helping push frontiers in geothermal energy. A repeat of the shale revolution with next-generation geothermal would promise clean and inexhaustible energy, but it requires gaining experience and getting started along the learning curve. While the shale industry benefited from Congress simplifying rules around leasing permits and access to land, these policy obstacles remain for geothermal exploration and production on federal lands—and threaten the next potential revolution in energy.

## Learning by Fracking

Both the shale industry and the next generation of geothermal energy are premised on subsurface engineering and exploration, although applied to different ends and with differing characteristics. Indeed, it is mainly because of the advances learned in the shale fields that next-generation geothermal energy has become a possibility.



Fumaroles, like these near a geothermal plant cooling tower in Italy, are features that emit hot gases and steam. While conventional geothermal energy systems rely on rare areas with special geology that makes heat easy to access, technology perfected in the oil and gas industry is unlocking the potential of heat found much deeper in the earth. © Geothermal Rising/Fabio Sartori

Like geothermal, tight oil and shale gas started from tiny bases. U.S. tight oil production grew from 0.42 million barrels per day 15 years ago to over 8.30 million barrels per day before the Covid-19 pandemic. Likewise, shale gas production increased from 5.4 billion cubic feet per day to more than 73.6 billion.

Getting oil and natural gas out of shale formations is tricky. Producers first have to decide where to drill based on data and educated guesses about where shale resources might lie. Then, they drill thousands of feet until they reach a shale formation. Next, they drill horizontally through the formation to increase the surface area of the well in contact with oil-rich resources. Finally, they frack—they use a fluid at high pressure to create vertical cracks in the shale to increase the flow of oil and gas into the borehole and up the well.

Horizontal drilling and hydraulic fracturing had been done for research purposes by the 1970s, but to become commercially viable, cost was key. Oil and gas producers needed to explore, drill, and frack cheaply enough to compete in the unforgiving global commodity market. In addition, they needed to compensate for the risk of wells that come up dry. Over the course of a decade, the accumulation of experience, best practices, and technology—including adoption of new drill bits and well casings—made the United States a player in global energy markets. One energy policy paper estimated that the price of natural gas at the wellhead fell by 13 percent for every doubling of natural gas output from the shale fields between 2005 and 2015.

When America became a net energy exporter in 2019, many commentators felt that it came out of nowhere. Politicians had for years prattled about energy independence without anyone believing that it was a realistic prospect. Yet the country's newfound energy self-sufficiency was the result of policy choices, particularly the Energy Policy Act of 2005, which contained numerous provisions that addressed unconventional energy resources. Critically, the act's Section 390 established a presumption that small-footprint oil and gas wells on federal lands need not go through a lengthy environmental review before permits or leases are granted. Substantive environmental laws like the Clean Water Act still apply to oil and gas drilling, but the cumbersome, often multi-year process to obtain a permit is streamlined.

In a nascent field where learning curves rule, removing obstacles to getting the learning process started is paramount. In this regard, streamlining permitting was a boon to the industry. It's difficult to imagine initial, experimental drilling

The most attractive element of advanced geothermal is the ability, in principle, to place such systems anywhere—even next to or underneath major cities.

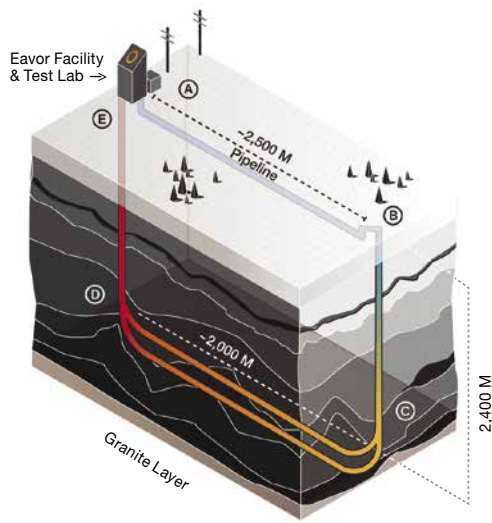
on public lands with still-high costs and no guarantee of finding oil when it is preceded by months or years of environmental paperwork. But with the major policy obstacles out of the way, the industry got rolling, leading to the very breakthroughs that now make geothermal energy a possible game changer.

## Next-Generation Geothermal

Conventional geothermal wells are technically hydrothermal—they work by extracting steam from a production well. Typically this steam flows upward through hot porous rock, acquiring heat energy along the way, but then gets trapped under impermeable caprock. Placing a production well where the steam is trapped gives it only one way to go—up the well, where, at the surface, it can power a turbine to produce electricity. A second well, called an injection well, is used to put water back into the system, without which the supply of steam would eventually dry up and lose pressure.

Producing hydrothermal energy is pretty simple, and it would be very cheap at scale, but it requires this subsurface configuration—hot porous rock topped with impermeable capstone—to work. It is impossible to scale it because of these subsurface requirements. Next-generation geothermal technology moves beyond these geographical limitations to access heat that is available even when it is not immediately evident at the surface, and even when subsurface rock configurations don't make it so easy.

There are many concepts for how next-generation geothermal could work, and they span a spectrum from evolutionary to revolutionary. On the evolutionary end of the technology spectrum, so-called enhanced geothermal systems work a lot like existing conventional geothermal systems, applying advances in subsurface engineering gained from the shale oil revolution to make more resources viable. Like conventional systems, enhanced ones use production and injection wells to generate steam, but there are two key differences. First, they access deeper sources of heat discovered through analysis and exploration. In principle, heat is everywhere if you drill



Note: Fluid flows from A to E



Eavor is one company developing advanced geothermal energy technologies. It has completed a closed-loop geothermal system (illustrated above) as a demonstration project in Alberta, Canada (pictured at right). © Eavor

deep enough, but nascent enhanced geothermal firms look for resources that are in a sweet spot that balances ubiquity and depth.

Second, in addition to enabling the use of deeper thermal sources, enhanced geothermal technology makes energy extraction possible in areas where rock formations aren't optimal for transferring heat energy. For example, if the production and injection wells sit on two sides of hot, solid rock with a network of fractures between them—created using fracking techniques perfected in the shale fields—then water can flow between the wells, absorbing heat and turning to steam. Subsurface engineers are quick to point out that the purpose of fracking in such cases is different than in oil and gas extraction. Enhanced geothermal frackers don't use proppants like sand because the purpose isn't to hold the fractures open to extract resources. Rather, they aim to create a network with a lot of surface area through which water can flow. Furthermore, oil and gas fracking occurs in sedimentary rock, whereas geothermal applications like the one described above create fractures in igneous or basement rock formations. Many engineers say that these differences slash the risk of seismic events.

On the revolutionary end of the technology spectrum are closed-loop geothermal systems, also called advanced

geothermal systems. A closed-loop design is different from conventional and enhanced methods in that a working fluid flows only within a set of pipes that is closed to the subsurface. Water or another fluid introduced at the surface flows in a downward pipe segment until it reaches the bottom of the system, absorbs heat, and then returns to the surface in an upward segment. A turbine converts heat into electricity at the surface, and the fluid continues its circular course back underground. Some projects use working fluids that become supercritical—acting as a liquid and a gas at the same time—at the temperatures and pressures inside the well. This allows them to absorb more energy with fewer losses from circulation.

The most attractive element of advanced geothermal is the ability, in principle, to place such systems anywhere—even next to or underneath major cities. No assumptions about subsurface rock structures need to be made. If you can drill deep enough, you will find heat, guaranteed. If you can drill cheaply enough—vertically to reach heat and laterally to increase surface area—the system will be economically viable. Advanced technology, then, transforms the viability of geothermal energy everywhere on the planet into a simple question of how low drilling costs can go. If they were to go low enough, advanced geothermal systems could supply the entire planet with electricity. We would reach energy nirvana.



## Drilling for Steam

Limited by today's drilling costs, many of the ex-oil-and-gas veterans now turning to geothermal energy are adopting concepts in the middle of the technology spectrum—using a closed loop, but also applying other subsurface engineering methods. One company, Sage Geosystems, has a design that uses a downward-facing fracture network at the bottom of its well that is filled with conductive and convective fluid. This approach draws heat from deep rock formations toward the base of the loop, reducing the depth producers have to bore and economizing on drilling costs. Sage is currently developing a demonstration well using this approach. “Once we get through a successful pilot these next few months,” company CTO Lance Cook said in early 2021, “we are off to the races.”

While various enhanced and advanced geothermal concepts are likely viable with current technology, near-term breakthroughs could make the sector boom. Progress in subsurface engineering has been primarily focused on needs of the shale industry, which are subtly different from those of next-generation geothermal. This means that the new geothermal sector still needs a repeat of what happened in the shale oil boom—incremental, iterative improvements focused on specific needs that arise from experience. Geothermal needs to work up its own learning curve.

The new geothermal sector still needs a repeat of what happened in the shale oil boom—incremental, iterative improvements focused on specific needs that arise from experience.

One set of new technologies needed for some geothermal projects centers on resource characterization—figuring out where exactly the best underground heat resources are located, how hot they are, and what sort of rock formations are nearby. This problem can be tackled to some extent with big data and machine learning. Combining data from industry partners who, until now, have had no need to identify heat resources could yield a better understanding of the subsurface and save on exploration and drilling costs. Ultrasound techniques could also be applied to map the subsurface.

Next come drilling advances. An underappreciated driver of the shale oil revolution was the polycrystalline diamond compact drill bit, invented in 1971 but perfected by the end of the 20th century. Although the bit has been a game changer



A geothermal well at the Utah Frontier Observatory for Research in Geothermal Energy, an underground field laboratory for developing and testing enhanced geothermal technologies. © Utah FORGE/Eric Larson

in the shale fields, no manufacturer currently outfits their bit with the circuitry necessary to operate in the temperatures, pressures, and shock levels needed for deep geothermal applications. Suitable electronics exist in the space sector, but they would need to be ported over to the drilling industry to decrease costs in geothermal conditions.

Less incremental drilling technologies are also on the horizon. Non-rotary concepts such as water hammers could work much faster in hot, dry rock. ARPA-E has even funded development of a millimeter-wave directed energy beam capable of melting and vaporizing rock. When commercialized, it could lead to deeper wells and access to hotter temperatures than currently available.

Finally, new generation technologies could make turning heat into electricity more efficient. A popular idea in closed-loop geothermal is to use carbon dioxide as a working fluid. Supercritical fluids can transport more heat from a given well, and CO<sub>2</sub> reaches supercritical conditions at relatively low temperatures and pressures compared to alternatives.

So far, there is no turbine generator appropriate for supercritical CO<sub>2</sub>, although in principle there could be, and it would increase power output significantly for some well types. Another technology that could be promising is thermoelectric generators, solid-state devices that turn a temperature gradient into electricity. Today's thermoelectric generators are optimized to produce tiny amounts of current from small temperature differentials, but if the technology were adapted for geothermal energy, it could someday even be used down-hole to produce large amounts of power directly where the hottest temperatures emanate.

With today's technology, most of the startups pursuing enhanced and advanced geothermal concepts reckon they could produce electricity at or below four cents per kilowatt-hour. That is for electricity that runs 24/7, whether the sun shines or the wind blows. With new technology, the cost could fall by half or more. Like the geothermal fields at Larderello that have been producing electricity for more than a century, wells drilled today will produce heat for eons. Once the



drilling costs have been amortized, the only significant cost of electricity production will be to maintain and occasionally update the generation equipment—the primary energy will be effectively free.

## Policy Predicaments

How do we achieve a geothermal future? The most important step is simply to get started, so that the industry can work up the learning curve of geothermal-specific problems and the technologies that address them. Here, policy barriers play a role. Although the goal should be to eventually support geothermal energy generation anywhere, simply by drilling deep enough, the best place to get started is still where heat resources lie closest to the surface. Scientists at Southern Methodist University's Geothermal Laboratory have shown that the most accessible resources in the country lie in the West, and they overlap considerably with federal lands.

To get started in earnest, then, the industry needs permits to drill wells and produce geothermal energy on lands leased from the federal government. Section 390 of the Energy Policy Act of 2005 streamlined the permitting process for oil and gas wells, but that provision does not include geothermal wells. At issue is a categorical exclusion from environmental review under the National Environmental Policy Review Act, or NEPA. Congress provided a rebuttable presumption that, within certain limits on surface footprint and other criteria, oil and gas wells are excluded from NEPA review. Congress's failure to include geothermal wells within the same parameters means that geothermal permits face a multi-year environmental assessment process while oil and gas permits do not.

Tim Latimer, CEO of Fervo Energy, has noted the unequal treatment that his geothermal company has faced relative to the oil and gas industry:

I've been astounded as I've entered this industry coming from the oil and gas space, where we have very responsive regulators that work with us to tell us what to do and where to do it, and we were able to get projects permitted very quickly. ... A common experience for me in geothermal is we submit all of the necessary paperwork, regulations, environmental impact assessments to the regulatory bodies, and it sits there for months and months and months, and we actually can't even get a response.

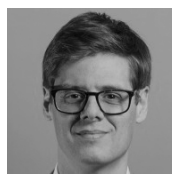
The overlap between federal lands and the most accessible sources of heat in the United States means permitting

The overlap between federal lands and the most accessible sources of heat in the United States means permitting obstacles may be even more important in geothermal than they were for unconventional oil and gas.

obstacles may be even more important in geothermal than they were for unconventional oil and gas. As it turned out, there are vast shale resources accessible from private and state land for which federal permitting requirements did not matter—because they do not apply. Removing federal permitting obstacles was important to get the shale industry going, but ultimately, it may have only sped up an inevitability. In contrast, it is difficult to see how enhanced geothermal systems can get off the ground without some permitting flexibility, given the reality that so much of the West is owned by the federal government.

The prize that awaits us if we can fix this permitting obstacle is cheap, clean, scalable baseload electricity for the country and—once we get the technology right—the world. A number of new companies, generally started by ex-oil-and-gas executives, have emerged to take advantage of the opportunity. Houston-based Fervo is developing enhanced geothermal wells. Eavor has completed a closed-loop demonstration system in Alberta, Canada. Sage Geosystems, also founded in Houston, is pursuing a hybrid model. Quaise is commercializing millimeter-wave drilling invented at MIT.

If these companies and others like them are given a chance, geothermal know-how could become a major export industry by the 2030s. If we want to convert the world to non-fossil energy, removing technical obstacles through practice is essential. It would be a shame if something as obscure as a permitting asymmetry on federal lands delayed the global transition to clean energy.



**Eli Dourado** is a senior research fellow at the Center for Growth and Opportunity at Utah State University.

# When the Government Makes Wildfires Worse

Federal policies are subsidizing people's choices to build homes in harm's way

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BY TATE WATKINS

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Wildland firefighters respond to a fire in Colorado in 2020. As residential development has expanded into fire-prone western areas over recent decades, more people and property have been put in harm's way.  
© National Interagency Fire Center

**A**s long as humans have had fire, they have tried to bend it to their will. Native Americans set small fires for centuries to clear underbrush from forests or open up pasturelands. Later, European settlers purposely burned perimeters around their settlements to protect them from unexpected wildfires. In the late 19th century, private timberland owners organized the first groups to fight wildfires, often structured as cooperatives. In the American West, members paid dues based on acreage owned, the proceeds of which were used to protect timber stands from flames. By the turn of the century, more than a dozen states had programs devoted to fighting wildfires.

But by the early 20th century, the federal government had become entrenched as both forest owner and wildfire fighter. In 1905, President Theodore Roosevelt led the charge to establish the U.S. Forest Service. During his two terms, Roosevelt used presidential power previously granted by Congress to drastically increase the size of federal forests, setting aside tens of millions of acres. A large and lethal fire season in 1910 brought political salience to the destructive potential of wildfires, and the government stepped in. An agency publication summed up its stance at the time: “Protecting the Nation’s wildlands from fire was one of the new agency’s greatest responsibilities since, in the words of the new Forest Service, only the Federal Government can ‘give the help so urgently needed.’” More than a century later, wildfires remain an urgent problem, and the feds’ help simply isn’t doing the job.

Wildfires are getting bigger and more devastating, and muddled incentives are making a bad situation worse. The root of the problem is the idea that the federal government will show up virtually anywhere, anytime, to try

to put out wildfires, regardless of the cost or effort required. Federal spending on wildfires has doubled in real terms over the past decade and grown fivefold since the late 1990s. Wildfire-related costs have consumed the majority of the Forest Service’s budget for years, prompting the common quip that the agency should be renamed the “Fire Service.” The implied federal guarantee of firefighting-no-matter-what signals to residents that it’s perfectly fine to build and live in fire-prone areas. Yet nudging more people to live in high-risk places has actually increased the potential for catastrophe.

### Fires Are Getting Worse

For most of the 20th century, the prevailing stance of the federal government was that fires should be extinguished as aggressively and quickly as possible. It pursued this goal with lookout towers and networks of fire detectors that even included rural mail carriers. In the 1930s, the approach was embodied by the “10 a.m. rule”—the idea that all wildfires should be under control by that time the day following detection. By 1939, the Forest Service had developed units of parachuting smokejumpers to rapidly respond when fires did ignite, and by 1944, it had rolled out Smokey Bear to educate everyday Americans about fire prevention. The idea that all wildfire should be snuffed out held sway through much of the second half of the 20th century and remains a popular notion today.

But decades of demonizing fire hasn’t always helped. For various types of forests and landscapes, fire is a positive force, rejuvenating grasses and soils and keeping vegetation in check. Ponderosa pine trees need regular fire to thrive, for example. But while frequent, low-intensity fire brings ecological benefits—something well understood by countless

timber owners in the Southeast who carry out controlled burns annually—a landscape that hasn’t seen fire regularly is much more likely to suffer a large and intense one once it finally comes. Decades of suppression have left many western forests choked with dense stands of small-diameter trees, underbrush, and other growth. This has contributed to high fire risk in many places today and partially accounts for why wildfires in the West are getting worse over time.

Before 2000, wildfires generally destroyed a few hundred structures in the United States each year. From 2000 to 2010, that rose to roughly 3,000 or 4,000—a big jump. Then in 2018, nearly 25,000 structures burned. According to insurer Munich Re, economic damage from western wildfires has surged for several years, now totaling \$10 billion to \$20 billion annually. In California, seven of the 10 most destructive fires in state history have occurred in the past five years. In 2020, fires in the West killed 47 people, destroyed 18,000 structures, cost \$3.6 billion in suppression efforts, and caused \$16 billion in damage. The season was notable for how much damage extended beyond California to Oregon, Colorado, and Washington.

Unfortunately, many predict the bad trends will get worse. Climate change has contributed to making many forests and other western landscapes drier for longer. (About 40 percent of the acreage burned by wildfires since 1984 has been in forests, while the majority has been shrublands or grasslands.) western fire seasons have lengthened by an average of 60 to 80 days over the last three decades. In some places, the fire “season” is no longer a season at all but a year-round concern. Insect and disease infestations have also left dead trees on millions of acres of forests, compounding the risk created by a century of striving to zealously put out every fire.



But the most fundamental reason wildfires are becoming a bigger problem is that there are now more homes and people in harm's way. In recent decades, the area where houses meet forests and other wild vegetation has grown by one-third—and it's not because the forests are encroaching. The footprint of such areas, which researchers call the “wildland-urban interface,” represents the fastest-growing type of land use in the contiguous United States. By 2010, it contained more than 43 million homes covering a total area larger than Texas.

The rapid growth in residential development not only puts more property and lives in fire-prone areas; it also increases the chances that new wildfires will ignite. People cause approximately eight in 10 wildfires, and human ignitions—whether from escaped campfires, burning debris, power lines, railroads, arson, or something else—threaten 30 times more homes in the wildland-urban interface

than do fires caused by lightning. People are also responsible for helping to extend the wildfire season, which would be limited mainly to summer months if not for human ignitions.

Economists Dean Lueck of Indiana University and Jonathan Yoder of Washington State University have studied the evolution of wildland firefighting in the United States as visiting Julian Simon and Lone Mountain Fellows at PERC, respectively. They have noted that the federal government has essentially had a “blank check” to suppress wildfires since the 1908 Forest Fires Emergency Act. They describe wildfire fighting today as a “highly structured, hierarchical, military-style” effort. The National Interagency Fire Center in Boise, Idaho, spearheads responses from the federal level and coordinates with state and local agencies, moving specialized firefighting crews and equipment from one active fire to the next.

“This network comprises a bewildering array of laws, policies, and contracts that create a complicated mix of incentives and outcomes,” Lueck and Yoder wrote in a 2016 *PERC Policy Series* on wildfire. “Scholars and other commentators suggest that inefficiencies abound in the system, leading to over-investment in suppression and under-investment in pre-fire risk mitigation.”

The most egregious thing about this blank check to suppress wildfires seems to be the fruitlessness of most suppression efforts. “There is well documented evidence,” the economists have written, “that fire suppression on large fires, especially when they are active, is often exceedingly ineffective.” Consider that tanker drops of fire retardant that seem to be made for cable news often have little effect on large fires. Likewise, “backfires” set purposely by firefighters to try to contain a wildfire often fail to accomplish that objective but end

up destroying valuable timber or other property. Still, these tactics continue to be funded year after year. “Even when suppression of large fires may be effective,” Lueck and Yoder continued, “there are many cases in which the suppression costs far exceed the value of the protected resources.”

The biggest wildfire-related legislative action of recent years was when Congress formalized in 2018 the blank check by providing federal agencies with disaster-account funding for fires, a model akin to the one used to fund flood and hurricane responses. The reform separated disaster funding for fires from main budgets, ultimately making it simpler and easier for agencies to devote money to firefighting. Dubbed the wildfire “fix,” it did nothing to address the muddled incentives at the heart of the problem: Homeowners don’t pay for the government’s all-out efforts to put out fires and protect their lives and property; tens of millions of taxpayers do. The blank-check approach dulls people’s incentive to prepare for fires—including when it comes to choosing where to build and live.

### Government Creates Noise

Prices contain information. A sky-high insurance premium to live on the edge of a western forest, for instance, might inform you that the wooded lot is extremely risky and you should build your house elsewhere. But interference often drowns out the price message.

When the federal government spends seemingly limitless amounts to put out wildfires, it signals that it’s OK to move to riskier areas. As Patrick Baylis of the University of British Columbia and 2019 PERC Lone Mountain Fellow Judson Boomhower, of the University of California San Diego, have pointed out, “the guarantee of federal government protection” from wildfires creates what’s known as a moral hazard. “Homeowners do not

internalize the expected costs of future fire protection when choosing where to live or how to design and maintain their homes,” they’ve written. “Perhaps just as importantly, local governments do not internalize these costs in zoning, land use, and building code decisions.” The economists concluded that government spending to suppress fires has created implicit subsidies, borne by the rest of us, for people who live in high-risk places.

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The idea that all wildfire should be snuffed out held sway through much of the second half of the 20th century and remains a popular notion today.

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The hazard comes from the expectation that the feds will swoop in to help out once flames are raging. Baylis and Boomhower estimated that these implicit subsidies to property owners can be more than 20 percent of a home’s value. In Montana and Idaho, they find that the subsidies exceed the total value of federal transfers to those states for the Temporary Assistance for Needy Families program.

The expectation of federal assistance also likely undermines incentives for property owners to take preventative actions. “The promise of aggressive firefighting at no cost may reduce private incentives to choose fire proof building materials and clear brush around homes, actions that can decrease the threat to homes during a wildfire,” they wrote. “Similarly, federally financed firefighting limits incentives for cities and states

to create and enforce wildland building codes and defensible space regulations.”

Essentially, all-out federal firefighting transfers wealth from taxpayers to homeowners in risky areas. It also blunts the incentives to organize and prepare at lower levels of government—or on an individual level.

The distortions created by federal wildfire policy share similarities with ones created by federal flood insurance. The National Flood Insurance Program offers plans to homeowners in floodplains, hurricane alleys, and other areas prone to inundations. But legislation requires that it aim for “affordability” for premium holders, rather than set premiums based on underlying risk. “Any insurance pricing structure that is not based on the risks associated with a home in a given location creates distorted incentives,” Arizona State University economist and former PERC Julian Simon Fellow Kerry Smith has said.

An implicit bailout when disaster hits makes it much easier to justify staying in a risky place. It’s how one Mississippi home in the flood program, valued at \$69,000, ended up flooding 34 times in 32 years, resulting in \$663,000 worth of claims. It’s little surprise that a program that makes rebuilding affordable, or even possible, in such a risky place would end up \$20 billion in debt—after Congress recently wiped away \$16 billion from the program’s balance sheet. To top it all off, Smith’s research suggests that in some areas it may not actually be low-income households who are benefiting from federally discounted insurance. Along the Gulf Coast, research findings by him and coauthor Matthew E. Kahn, another previous PERC Julian Simon Fellow, “imply that in many locations we are subsidizing higher income households and not the ones envisioned by equity concerns.”



The blank check for wildfire fighting from the federal government clearly distorts incentives for homeowners. In California, policies regarding insurance markets have compounded the issues. After bad fire seasons resulting in record insurance payouts in recent years, insurers began to raise rates or even get out of the market altogether. In response, the state has sought to freeze policies and rates in what was already the most stringently regulated insurance market in the country. It is essentially encouraging

people to remain or rebuild in places almost certain to burn again.

“People are used to paying, say, \$1,600 a year of property cost for insurance,” Michael Young, a vice president at Risk Management Solutions told *Bloomberg Businessweek* last year. “But if that goes up to \$4,000 or \$5,000 per year, that might not be something that they’re interested in or capable of doing.” Nobody roots for their insurance premium to triple, but nobody wants their house to burn down either.

And a trebling of insurance rates in fire-prone areas may be just the price signal needed to keep new residents away.

California clearly doesn’t see the situation that way. Its legislature passed a bill in 2018 that allows the state to prohibit insurance companies from canceling or refusing to renew policies for up to a year after a wildfire emergency. Regulators invoked the measure in 2019, when it covered 800,000 homes, and then renewed it in 2020, when it applied to 2.1 million homes—fully 18 percent of California’s residential insurance market. The upshot is that the premiums for homes in risky areas will be subsidized by policyholders in other areas, at least until the insurers now shouldering huge losses can withdraw from the market. Choosing to risk having your home destroyed by a wildfire is one thing. But other policyholders or even taxpayers shouldn’t be forced to subsidize you to take that risk.

By contrast, Colorado has taken a more prudent tack: allowing premiums to be adjusted to reflect different levels of fire risk. If a homeowner loses his policy because an insurer decides not to cover his area anymore, he can take risk-mitigating actions such as modifying the home or managing the trees around it and get a certification for having done so. In turn, various insurers agree to cover certified homes. Letting risk dictate the price of insurance gives property owners clear incentives to do the preventative work that reduces fire risk in the first place.

In California, rather than allowing the insurance market to continue to innovate, develop new wildfire models that are more precise, and price risk more accurately, regulators seem hell-bent on making sure insurance prices will be based on anything except for underlying risk. But whether the disaster threat is flood or fire, the last thing

policymakers should be doing is allowing people to disregard risk on other people's dime.

## A Better Response

Even if California's insurance markets were allowed to function based on risk, the federal approach to suppressing wildfires—and implicitly subsidizing risky homebuilding—would remain.

Lueck and Yoder have pointed to two reforms that could help. One is to let more fires burn more widely, especially in areas where few structures are at risk, and concentrate resources on protecting life and property. Until the 20th century, the approach to fighting wildfires was usually not to fight at all—a “let it burn” stance. Even today, fires covering many millions of acres are generally allowed to burn out in parts of Alaska every year.

A much more targeted approach to suppression makes economic sense.

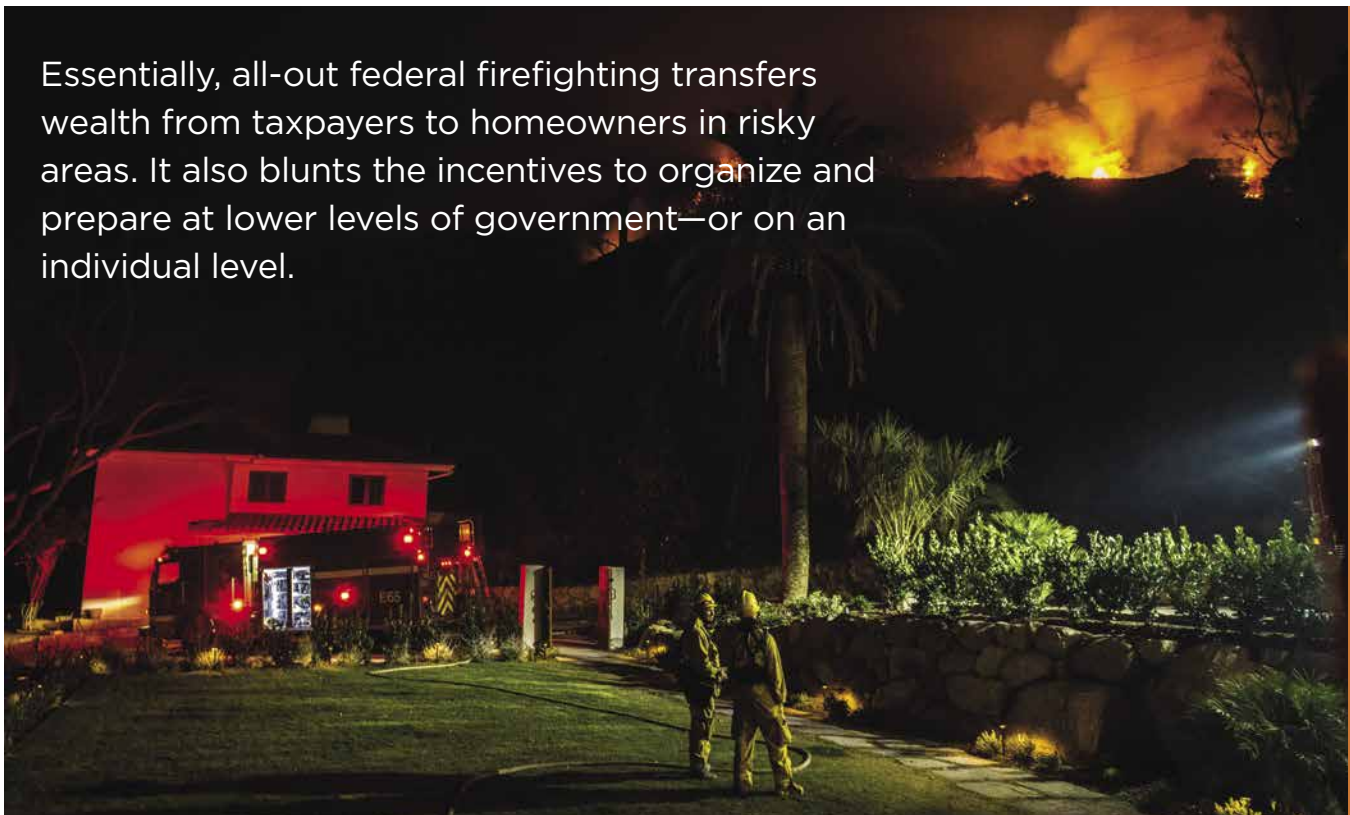
Every acre is not equally valuable, and every acre burned is not equally damaging. Here, the private sector is already helping. Wildfire Defense Systems is an example of a business that's concerned not so much with acreage burned—as federal efforts to fight fires often are—as with structures protected. Working for insurers, it preemptively evaluates policyholders' fire risk and advises actions to mitigate it. It also responds to active fires with equipment like water tankers or fire retardant to protect homes of covered policyholders. For nearly a decade, the company, which now serves 20 states, has been honing its system to judge a property's fire risk based on vegetation, topography, climate, history, and various other factors. Of course, these sorts of efforts depend on insurers being able to charge rates that at least keep them in business.

The second reform would be to set federal wildfire funding at a base level,

and then let agencies “bank” unspent funds from one year to the next. If that were the case, total public spending devoted to fires might actually go down, and the demand for services from private pioneers like Wildfire Defense Systems might go up—meaning homeowners and insurers rather than far-flung taxpayers would foot more of the bill for wildfire risk. That would, in turn, give property owners more incentive to use fire-resistant designs and materials and to prepare their homes and environs for fires by doing things like spacing trees appropriately, enclosing eaves, and screening vents.

Beyond the home, various actions could be taken in forests to try to reverse the current state of overinvestment in suppression and underinvestment in prevention. The idea would be to reduce ignition risk and limit the intensity of wildfires when they do break out. Prescribed burns and selective

Essentially, all-out federal firefighting transfers wealth from taxpayers to homeowners in risky areas. It also blunts the incentives to organize and prepare at lower levels of government—or on an individual level.



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Every acre is not equally valuable, and every acre burned is not equally damaging.



harvesting are two ways to reduce property damage and suppression costs from wildfire. Both aim to reduce the amount of fuel available to a potential fire—either by preemptively burning it or removing it mechanically. But there’s often a great deal of political and environmental opposition to such efforts, and when they do get off the ground, bureaucratic and legal obstacles often limit their scope.

Still, wildfires have become so salient that Sens. Dianne Feinstein (D–Calif.) and Steve Daines (R–Mont.) have been willing to reach across the aisle to argue that much more needs to be done to proactively manage forests. The two legislators have co-sponsored a bill to speed up efforts to decrease fire risk with measures like prescribed burns and mechanical thinning. Such projects are often delayed or derailed by environmental reviews, which take an average of nearly three years to prepare for large-scale forest projects—meanwhile, wildfires do not wait for paperwork to get done. The senators’ legislation aims to streamline such requirements for certain projects, as well as cut through some of the additional red tape that the Endangered Species Act can impose. PERC’s

recently released public lands report, “Fix America’s Forests,” suggests similar regulatory reforms and advocates other innovative approaches to expand and expedite forest restoration and reduce fire risks.

If bureaucratic obstacles can be flattened, then communities will be better positioned to invest in forest management themselves. One path to do that is through forest resilience bonds, a financial tool piloted by the Blue Forest Conservation nonprofit in 2018 and described in detail in PERC’s “Fix America’s Forests” report. The effort raised \$4 million in private capital from insurance groups, private foundations, and other investors to restore 15,000 acres in Tahoe National Forest through activities like thinning trees, carrying out prescribed burns, and clearing brush. A local water utility and the state of California, both of which will ultimately benefit from reduced fire risk in the project area, will repay the bond. The Forest Service had projected the work to take a decade or more, but the upfront financing and novel partnership has accelerated the timeline to just four years. This model could even conceivably be applied to residential communities and insurers who seek to decrease fire risk.

Today, government wildfire policy often seems to promise the wrong kind of help, given how much of the spending aimed at putting out large fires is ineffective. Even if there’s been little appetite to reform the blank check approach to fighting wildfires, various private actors are taking matters into their own hands, from companies providing insurers with sophisticated risk models, to financial innovators decreasing the likelihood of catastrophic fires breaking out in forests, to individual residents deciding to make their homes more firewise. Still, nudging people to dismiss risk by making it cheaper and easier for them to live in fire-prone areas helps no one—least of all those in harm’s way.

## reason

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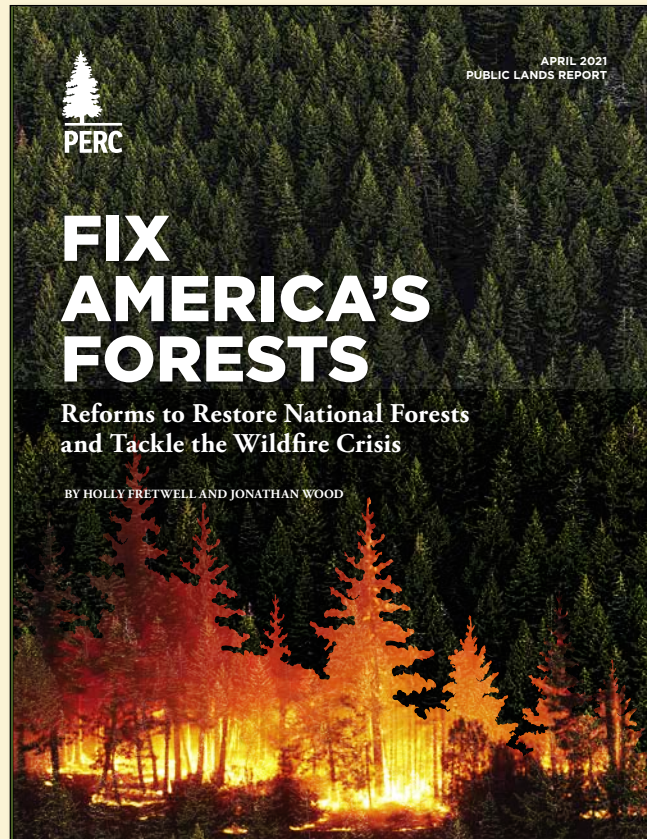


**Tate Watkins** is a research fellow at PERC and managing editor of *PERC Reports*.



# FIX AMERICA'S FORESTS

Reforms to Restore National Forests  
and Tackle the Wildfire Crisis



As wildfires proliferate, the Forest Service lacks resources to address millions of acres of national forests in need of restoration. Fortunately, partnerships with states, tribes, industry, and environmental groups are unlocking new support for projects that improve forest health and reduce fire risk. PERC research fellows Holly Fretwell and Jonathan Wood recently outlined reforms that would spur more investment in forest restoration, helping slash wildfire risk in the West.

Now available at  
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Peter Kareiva  
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# Hybrids, Humans, and the Future of Conservation

A conversation with ecologist Peter Kareiva

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**H**e's been described as “one of the most innovative and provocative thinkers in conservation today”—a “myth-busting scientist” who “pushes greens past reliance on ‘horror stories.’” *The New York Times* called him “the most prominent critic of the conservation movement from within its own ranks” for putting forth a more optimistic version of environmentalism and urging scientists to follow data, not dogma.

Peter Kareiva is the author of more than 150 scientific publications and author or editor of eight books, including a text-

book on conservation science. In 2019, Kareiva was a Julian Simon Fellow at PERC, researching hybridization and reexamining assumptions about species “purity.” He is a past director of the Institute of the Environment and Sustainability at UCLA and former chief scientist at the Nature Conservancy. In 2020, Kareiva became president and CEO of the Aquarium of the Pacific in Long Beach, California. We asked him about his research on hybridization, the role of humans in conservation, and his views on the future of the field.

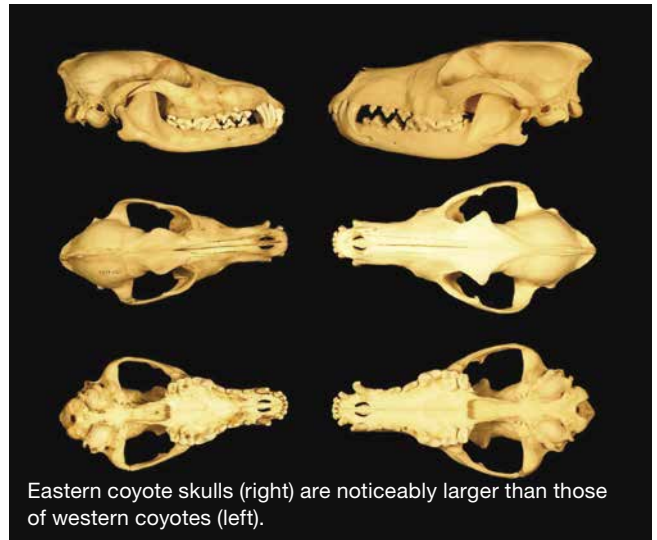
**Q: Some of your recent work focuses on “hybridization events.” What do biologists mean when they use this term?**

**A:** Hybridization is the process of producing offspring by mating two parents from different species. It can occur naturally—meaning without any active human assistance—or it can occur because humans facilitate it, as was the case when ranchers crossed American bison with cattle to create “beefalo.” Plant breeders have often crossed different crop varieties to produce hybrids with special properties or “hybrid vigor.” For example, Meyer lemons are the result of crossing traditional lemons with mandarin orange trees to get a larger and sweeter lemon.

Natural hybridization among plants has played a significant role in creating new plant species. Until recently, natural hybridization among animals was thought to be rare, but that view has changed with access to molecular genetic data. Even if new species are not created by hybridization, a less dramatic result of hybridization can be the introduction of novel genes into populations. That has been the case with eastern coyotes, which have hybridized with wolves, and as a result are larger than western coyotes and able to take down larger prey.

**Q: You’ve critiqued a belief, widely held by conservation biologists, that hybridization is a threat to biodiversity. How does your perspective differ?**

**A:** Conservation biologists have tended to assume hybridization is a threat to biodiversity for two reasons: 1) hybrid offspring may have reduced fitness, which reduces the average reproductive rate of the species in question or 2) hybridization may swamp out locally adapted and unique genotypes, and produce populations that are no longer genetically distinct. On the other hand, genomic data has also linked hybridization to adaptive radiations of groups such as Heliconius butterflies. Especially salient to a world experiencing rapid climate change, studies of evolution in contemporary time have suggested that hybridization can be essential to rapid evolution at a pace commensurate with swift environmental change. For example, there is evidence that hybridization in Darwin’s finches on the Galapagos Islands has facilitated rapid adaptive changes of beak shape over a 30-year period.



“While I agree that hybridization can imperil species, I would never assume this was the case without evidence.”

While I agree that hybridization can be a threat to species and can imperil species, I would never assume this was the case without evidence. I am willing to consider a wide variety of conservation interventions that others may reject out of fear of hybridization. The dusky seaside sparrow went extinct when the U.S. Fish and Wildlife Service abandoned captive breeding. The agency abandoned the effort because the birds available to initiate the captive breeding program were not pure representatives of the species due to previous hybridization events. If it had not been abandoned, the program might have saved the species.

**Q: Do conservationists need to reconsider their stance on hybrids? If so, in what ways?**

**A:** For sure, conservationists need to reconsider their assumptions about hybridization in light of recent research findings. Data documenting hybridization as a cause of species extinction are extremely sparse. Natural hybridization is much more widespread than previously thought, and we have several examples of hybridization contributing to diversity. We also live in a world with rapid environmental change that places a premium on species adapting in the face of that change. Several recent studies document how hybridization can help species adapt rapidly in this challenging world.

“We have learned that making people the enemy of conservation is no solution. Durable conservation requires buy-in from local communities.”

**Q: People sometimes talk about Yellowstone bison as being “genetically pure.” Should the bison population be glad about that? Should we?**

**A:** Yellowstone bison are the only bison in the United States that have no cattle genes. For this reason, they are valued as the only pure bison, and the hundreds of thousands of bison outside Yellowstone are devalued because they have some cattle genes. Cattle and bison do not mate or hybridize in nature. These cattle genes in bison are a relic of early 20th century forced matings between bison and cattle intended to incorporate some beneficial bison genes into cattle.

The “impure” conservation bison herds outside of Yellowstone all have less than 1 percent cattle ancestry. Without DNA analysis, no one can tell the difference between bison with cattle ancestry and “pure” bison that lack cattle genes. Worrying about 1 percent cattle ancestry, especially given the fact these cattle genes are gradually disappearing from one generation of bison to the next, does not make sense. One way of seeing clearly the foolishness of this obsession with pure bison is to take note of the recently discovered Neanderthal ancestry in humans. The Neanderthal ancestry of humans is as high as 1.4 percent in Asia and 1.22 percent in America—substantially higher than the cattle ancestry in bison. Are we less human for that Neanderthal ancestry?

**Q: How did so many conservationists come to champion concepts such as “genetic contamination” and “genetic purity” that, when applied to humans, seem plainly abhorrent?**

**A:** First, there is no escaping that many prominent early conservationists were racist and thought in terms of genetic purity. For example, Madison Grant, co-founder of the Bronx Zoo and the Wildlife Conservation Society, was an ardent supporter of eugenics to maintain the purity of the human

race. Grant authored a book entitled *The Passing of the Great Race*, which Hitler referred to as his “Bible”; it was the first foreign book published by the Nazis after they took power. While such overt racism has no place in modern conservation, ideas of genetic purity and a tendency to want to maintain the status quo and an uncontaminated world persist.

Second, because conservation is a field with very few people of color, conservation biologists tend to have little contact with colleagues who would point out how offensive are ideas like genetic purity and genetic contamination. This is changing now—but one cannot change the language of already published research articles, and words have a life of their own as cultural memes.

**Q: The work of the late economist Julian Simon has led many to reevaluate their views on the relationship between human progress and the natural environment. Similarly, you have put forth a vision of “conservation science” that seeks to maximize the preservation of biodiversity and the improvement of human well-being. How is this done in practice?**

**A:** Traditional conservation maps species distributions and biodiversity and sets priorities and strategies for saving those species. If public investment or policy is needed to achieve the resulting conservation, input may be invited from stakeholders. A more inclusive approach is to include human well-being (jobs, health, economic growth) up front, and design a conservation plan that jointly serves nature and people. By explicitly embracing multiple objectives (biodiversity, access for people, jobs, and no extinction), conservation plans can jointly maximize all of the objectives. If this is done well, armed guards and tanks will not be needed to protect natural areas—instead the local population will embrace protected areas as long as their livelihoods can also be enhanced.

**Q: You’ve written that “conservation is fundamentally an expression of human values.” What role should human values play in conservation policy and practice?**

**A:** Conservation science examines how ecosystems function and how they are changing. Conservation science also seeks to understand and predict the consequences of human



A Darwin's finch on the Galapagos Islands. © Pedro Szekely

activities and the effectiveness of management interventions in achieving some conservation goal. However, conservation goals and objectives are set by people, and those goals reflect our values. Humans tend to care more about animals than plants, for instance, and hence the Endangered Species Act extends more protection to animals than to plants.

Conservation requires money, and the dollars we spend to recover endangered species reflect differences in how we value different species. One person's conservation success might be viewed by a different person as a conservation failure. The conservation that gets done is a human choice—how successful we are at doing that conservation is a subject for conservation science.

**Q: More than a decade ago, you challenged conventional approaches to conservation with this kind of thinking. How have these ideas been received?**

**A:** In 2007, [biologist] Michelle Marvier and I published an article called “Conservation for the People.” At that time, all of the major conservation organizations were still focusing on biodiversity hotspots, wilderness areas, and habitat protection, with minimal concern for people. Photos of people on their websites were few. Our article, and several others like it, argued that for conservation to succeed it must also be concerned with benefits to people. Now, if you go to the homepage of any major conservation organization, you can find statements about protecting nature because doing so

will enhance our personal well-being. We have learned that making people the enemy of conservation is no solution. Durable conservation requires buy-in from local communities.

**Q: You have encouraged conservationists not to focus solely on “pristine” landscapes, but to look to human-altered landscapes as sources of conservation value as well. Has there been a shift in the way people think and approach conservation?**

**A:** Most conservationists and members of the broader scientific community would now admit that there is no “pristine” left on the planet. Having accepted that fact, there has been a growing willingness to see conservation value in urban parks, novel ecosystems, ranches, altered rivers, logged forests, and other “non-pristine” landscapes. Some have argued that to include these sorts of landscapes in conservation is to surrender. I think it is the opposite—it is a strategy for winning. We have to deal with the world we live in—which is a world filled with people. We do not have to empty half the world of people to secure biodiversity. Instead we can devise strategies that protect biodiversity in human landscapes.

Private landowners have a huge role to play since the majority of threatened and endangered species in the United States have most of their habitat on private land. Conservation easements, which are permanent restrictions on land use associated with a property deed, are one especially powerful tool for promoting conservation on private lands. The idea is that these restrictions preserve critical habitat, while allowing private landowners to own, use, sell, and bequeath the land subject to easement restrictions. Thus, easements allow land to remain private, yet also be protected in perpetuity for biodiversity. A recent study of easements in Alabama showed that a portfolio of 49 easements secured many more high-priority species per acre than public lands—partly because the easements targeted specialized habitats and high-diversity regions.



**Peter Kareiva** is the president and CEO of the Aquarium of the Pacific and was a 2019 Julian Simon Fellow at PERC.

# Cars Get Safer in a ‘Landscape of Fear’

New research shows how wolves are generating large benefits by keeping deer out of headlights

BY ADDISON DEL MASTRO



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**B**y the early 20th century, gray wolves had nearly gone extinct in North America, a decline fueled partly by government-sponsored efforts to control predators. Since the U.S. Fish and Wildlife Service listed the species as endangered in the 1970s, gray wolf numbers have begun to rebound. Wolves are now found in national parks and human-inhabited areas throughout much of the American West, including several midwestern states such as Wisconsin. The recovery story is an obvious win for conservation.

The politics of wolf recovery, however, has tended to come down to a rural-urban divide, with farmers and ranchers lamenting livestock fatalities and environmentalists and outdoor enthusiasts prizing wolves for natural beauty or what’s known as “existence value.” This state of debate turns wolf reintroduction into a zero-sum issue, in which wolf advocates’ gain comes at the expense of the private landowners who bear the costs of wolf recovery.

Economists Jennifer L. Raynor (2021 PERC Lone Mountain Fellow), Corbett A. Grainger (2015 PERC

Lone Mountain Fellow), and Dominic P. Parker (PERC Senior Fellow), however, have produced evidence for a hypothesis that offers a new framing for wolf reintroduction. Their study, published in the *Proceedings of the National Academies of Sciences* in June, focuses on a unique aspect of wolf recovery in Wisconsin: its impact on deer-vehicle collisions. “There’s no question wolves cause economic losses,” Raynor explains, but “they also generate really large economic benefits.” Why? Because they considerably reduce vehicle collisions with deer, a seemingly intractable problem that the study notes is responsible for “29,000 human injuries, 200 human fatalities, and nearly \$10 billion in total economic losses” in the United States every year.

What about ranchers and farmers, who fear livestock losses due to predation by wolves? Based on the research team’s findings, Raynor argues that the measurable, concrete economic benefits of wolf recovery—in addition to whatever existence value it creates—greatly outweighs the losses caused by wolf predation, by as much as a factor of 63 to one.

The issue, then, is compensation. “Wolves are generating large economic benefits that can be quantified and potentially transferred,” Raynor says. In many states, ranchers and farmers can already receive compensation for livestock deaths if they can prove a wolf was responsible. But Raynor suggests that, with the right policy, the compensation process could be simplified, and even enhanced, given the overall savings from reduced vehicle collisions. Essentially, it isn’t just wildlife enthusiasts and motorists who would benefit from more wolves—if the policy is right, even farmers and ranchers could benefit, too. Because deer-vehicle collisions are such a widespread problem, they can affect anybody who drives.

How, exactly, are wolves reducing vehicle collisions with deer? Perhaps surprisingly, deer kills by wolves are only a minor driver of the reduction. The bulk of the effect points to a unique ecosystem function of wolves: what ecologists have called a “landscape of fear.” Wolves—like deer—often travel along or near linear, man-made landscape features, including roads. The presence of wolves along roads wards off deer, thereby reducing the likelihood and number of collisions.

“Most of the reduction is due to a behavioral response of deer to wolves, rather than through a deer population decline

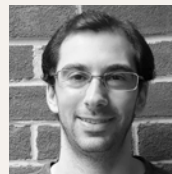
from wolf predation,” Raynor says. “Wolves control economic damages from overabundant deer in ways that human deer hunters cannot.” It’s a simple but crucial dynamic that points to two realities rarely considered in deer control policy. First, human hunters, because they only operate a few weeks or months per year, cannot produce a long-term “landscape of fear.” Second, deer-vehicle collisions can be slashed without meaningfully reducing the absolute deer population.

The benefits of wolf recovery could be far reaching. Raynor suggests that car insurance providers might reduce rates, and help fund wolf-loss compensation programs, with their own savings. Insurance companies may not care about wolves per se, but they certainly care about collisions. Aligning their incentives with those of the predator could transform the wolf debates from zero-sum arguments into positive-sum opportunities. An increased pool of compensation funding could make whole farmers and ranchers who suffer livestock losses. People who value wolves for recreational or existence value could enjoy them. And deer hunters could still pursue large populations of deer, even with the presence of wolves.

The possibility of linking deer control with wolf conservation is an intriguing one for policymakers to consider, even if the particulars are a question for the future. While these findings are limited to deer in Wisconsin—Raynor notes that their study did not examine other species, such as elk—they are likely to hold true in other states. In any case, to make wolf recovery sustainable, policymakers should make sure that the economic benefits of wolves are enjoyed broadly, including by the farmers and ranchers who have disproportionately borne the costs of living with wolves. If that can be done, groups previously at loggerheads—from ranchers to hunters to motorists to environmentalists—can share in conservation benefits and economic savings alike.

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**Addison Del Mastro** was a visiting impact fellow at PERC in 2016 and a participant in PERC’s 2012 student seminar. He writes with a focus on land use and the built environment.

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