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PERC REPORTS

FOR FREE MARKET ENVIRONMENTALISM

ENVIRONMENTAL POLICY IN THE ANTHROPOCENE

FROM THE EDITOR

Shawn Regan

Yosemite Valley is known for its scenic grandeur. But when Maria Lebrado returned 78 years after her tribe was driven out of the region, she was unimpressed. A guide described Lebrado seeing the valley for the first time since her childhood: "The wide open meadow of her day was covered with trees and shrubs. She shook her head, saying, 'Too dirty; too much bushy.'"

Throughout Yosemite, the landscape today is much different than the one seen by early white visitors. "The inviting openness of the Sierra woods is one of their most distinguishing characteristics," wrote John Muir in 1894. Frederick Law Olmsted's 1865 report on Yosemite described "miles of scenery" and "the most tranquil meadows." Since then, 75 to 90 percent of those meadows have been lost to larger and denser forests. What's emerged is a new landscape that would be in many ways unrecognizable to its earliest visitors.

"Much of the landscape in California that so impressed early writers, photographers, and landscape painters was in fact a cultural landscape, not the wilderness they imagined," writes ecologist M. Kat Anderson. "While they extolled the 'natural' qualities of the California landscape, they were really responding to its human influence." Native Americans regularly set fire to the region to clear forests, maintain open meadows, and grow food.

So what is the true character of Yosemite undisturbed by human action? Is it dense forests or open meadows? We cannot readily say. In many ways the only Yosemite we've ever known is one created by the actions—or deliberate inactions—of people. Even tougher is the policy question: If the Yosemite protected by early preservationists was the product of human influence, then to what state should it be managed today? In fact, the National Park Service recently established a controversial plan to cut thousands of trees in Yosemite in an effort to restore scenic vistas that have been obscured by the growing forest.

This example underscores a fact that is shaking the core of the conservation community: Virtually all of the world's landscapes have been shaped, and are continuing to be shaped, by human action. Scientists have even proposed a new word for this brave new world: the Anthropocene. The idea implies new questions for conservationists to consider. Chief among them: What does it mean for environmental policy?

In December, PERC hosted a two-day workshop to address the policy implications of the Anthropocene. Thanks to the Searle Freedom Trust, which funded the workshop, this special issue of *PERC Reports* explores the ideas discussed at the workshop. The articles challenge the conventional thinking about a variety of environmental policy topics and offer an ambitious vision for the future of environmentalism in the Anthropocene.

The featured articles in this issue are based on a larger volume entitled "Environmental Policy in the Anthropocene," available at **perc.org** or by request.

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PERC

The Property and Environment Research Center is a nonprofit institute dedicated to improving environmental quality through property rights and markets.

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TELL US WHAT YOU THINK
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The Three Ws and Beyond

We often say that research is what distinguishes PERC from most other organizations. But what is research and why is it so important?

To research a topic means to investigate it systematically, to test assumptions, establish facts, and ultimately to reach new conclusions. The research process—and it is a process—is not about advocacy. It is about *understanding*.

PERC's commitment to rigorous, intellectually honest research began with our founders, a small group of economists who challenged the conventional wisdom that free enterprise and unregulated markets inevitably caused environmental destruction. They dared to ask why markets failed to protect the environment, and they ultimately concluded that virtually all environmental issues boil down to two words: property rights.

When resources are unowned, there is little or no incentive to conserve them either in the marketplace or in an environmental bureaucracy. Research by PERC's founders showed that government regulations often wasted environmental resources and that, with clearly defined and tradable property rights, markets could foster environmental stewardship.

These discoveries became the principles of free market environmentalism, a paradigm born not out of ideological bias or partisan politics but out of curiosity, investigation, and honest research.

THE THREE Ws

Research at PERC has historically focused on what I call "The Three Ws": water, wildlife, and western lands.

Our recreational pursuits and Montana location only partly explain this concentration. "The Three Ws" are predominantly *public* resources, meaning that they are managed through a political process that is poorly understood, far from perfect, but regularly romanticized.

PERC scholars examined how restrictions on water trading discouraged conservation and created zero-sum fights between agricultural and environmental interests. The resulting research led to several policy reforms, most notably the classification of "instream flows" as a beneficial use of water in the West—a change that facilitates water trading and conservation today.

Our research has similarly informed wildlife management over the years and across continents. From the reintroduction of wolves to Yellowstone to the role of hunting endangered species, our scholarship helped demonstrate a universal truth of wildlife-landowner relations: "If it pays, it stays."

The third "W"—western lands—covers topics from public lands to American Indian reservations. For timely examples of this research, see PERC's new report "Access Divided" by Hannah Downey, Holly Fretwell, and Shawn Regan, or our brand new book, *Unlocking the Wealth of Indian Nations* (Lexington Press, 2016), edited by Terry Anderson.

NEW TOPICS, NEW PEOPLE

Few organizations, if any, can match the breadth or depth of PERC's research on these topics. We are proud of that history, but we recognize that new research topics and perspectives are needed to grow our audience and relevance.

Already this year we have launched new research initiatives on energy innovations and urban environmental issues. And we are hosting research workshops on both topics later this year.

These events and the publications they generate will mark a significant expansion in our research agenda. Of course, with new topics comes new people, and vice versa. The appointment of new senior fellows, including Spencer Banzhaf (see sidebar on right), will help fuel PERC's continued growth.

This issue of *PERC Reports* also showcases research on a new perspective: environmental policy in the Anthropocene. Though not focused on any particular resource, the Anthropocene perspective compels us to refute the "balance of nature" fallacy and ask how we can resolve competing human demands on an ever-changing natural world.

That is a question that free market environmentalism can surely help answer.

SAME COMMITMENT

Jean Briggs, a retired editor at *Forbes* and a former PERC board member who passed away this May, was recently celebrated by Steve Forbes for her "skepticism and the ability to look beneath the surface of things."

No doubt, Jean imprinted that quality onto PERC's genetic code. Hence, as we broaden PERC's focus to include new topics while maintaining our expertise on "The Three Ws," we will maintain our commitment to rigorous, intellectually honest research.

Reed Watson is the executive director of PERC. In "Frontiers," he describes how PERC is improving environmental quality through property rights and markets.

Meet PERC Senior Fellow Spencer Banzhaf

Spencer Banzhaf is a professor of economics at Georgia State University and a research associate at the National Bureau of Economic Research.

Q: What are your primary research interests?

A: My work focuses on how environmental quality is linked to private goods, which creates indirect markets for the environment. For example, you can't just go to the store and buy a nicer local climate or cleaner local air. But people can enjoy those things by living in a neighborhood with a nicer climate and cleaner air. Since many people like these things, demand for housing is higher in such areas, making housing prices more expensive. In this way, there really is a market for such goods—the market for housing which bundles them together.

Q: What brought you to PERC?

A: I first began reading some of PERC's research 20 years ago when I was working on my dissertation. Then I started using other PERC materials for teaching. Years later, I heard that PERC was a stimulating intellectual environment to visit and gave it a try. I've been happy to be part of PERC ever since.

Q: You are directing a PERC research workshop later this year with Matt Kahn on "Free Market Environmentalism in the Urban Environment." What does free market environmentalism have to do with urban issues?

A: PERC's work has focused primarily on natural resource issues. But most people live in cities, and many environmental problems are urban issues. Urban heat islands are part of the overall climate issue. Air pollution is worse in cities and affects more people. Transportation networks are overloaded, and so forth. Many of PERC's insights can be applied to these settings. For example, we know that pricing access to open-access resources helps address over-use problems, so how might congestion pricing work on roads and highways? Those are the type of questions we aim to explore in greater detail.

ENVIRONMENTALISM WITHOUT ROMANCE

BY SHAWN REGAN

In 1986, James Buchanan won the Nobel Prize in economics for changing the way we think about politics. Buchanan's key insight was that economists should use the same methods to analyze political behavior as they do to understand economic behavior. He helped establish a new form of economic analysis known as public choice theory, which Buchanan described in just three words: "politics without romance."

Public choice theory, Buchanan argued, "models the *realities* rather than the romance of political institutions." Politicians, bureaucrats, and voters, like people engaging in everyday market exchanges, are motivated primarily by their own self-interest rather than the public interest.

This was a simple insight, but it had important implications. There had long been a certain degree of romance in politics, even among economists. Politicians were modeled as selfless public servants promoting the public's interests, rather than their own. Bureaucrats advanced their agencies' missions, not their own budgets or authority. And voters sought to improve the public good, not to extract political favors for their personal benefit. By the time Buchanan was awarded the Nobel Prize, this idealized view of politics was no longer seen as a valid approach to economic analysis. "The romance is gone," Buchanan said in 1979, "perhaps never to be regained."

Politics is not the only area where we are subject to romantic tendencies. Environmentalism arguably elicits even greater romantic sentiments. Notions of a harmony with nature, pristine wilderness, and "Mother Nature" are prominent in modern discussions of environmental issues. Related ideas such as the balance of nature have dominated the science of ecology. And many environmental policies are based on the idea of restoring ecosystems to a historic baseline or preserving a perceived balance to nature.

But the romance of environmentalism is slowly fading, too. Today, there is growing skepticism about such idealized undertones to environmentalism, and in turn, to environmental policy. A new generation of ecologists is challenging the idea of an inherent balance in nature. Moreover, scientists are concluding that human action cannot easily be separated from the natural world. Research in paleoecology and other fields is revealing that landscapes once thought to be uninfluenced by humans were in fact dramatically affected by indigenous peoples. Conservationists are rejecting the idea of pristine nature as a worthy or practical conservation goal and adopting a more nuanced vision of the environment that includes human action. Scientists have even proposed the concept of the Anthropocene—the "age of man"—as a new geologic epoch to reflect the magnitude of human influences on the natural world.

These realities imply a very different—and less romantic—lens for viewing environmental challenges. Once we accept that nature is dynamic and profoundly shaped by human action, we can no longer view environmental problems as simply the consequence of human violations on the balance of nature, nor can they be solved by separating the natural environment from human influences. The notion of the Anthropocene suggests that doing so is impractical or even impossible. Instead, in the age of the Anthropocene, environmental problems become questions of how to resolve competing human demands on an ever-changing natural world.

In the age of the Anthropocene, environmental problems become questions of how to resolve competing human demands on an ever-changing natural world.

Moreover, science alone cannot resolve most environmental issues. Science does not tell us which ecological states are "right" or which environmental policies are best. Many ecological concepts are themselves normative; they offer little guidance for resolving conflicts over competing human values and preferences. Thus, most environmental problems are fundamentally questions of human values—of what landscapes we prefer, what elements of the natural world we want to preserve, and what aspects of nature we want, or do not want, around. This is "environmentalism without romance."

THE BALANCE OF NATURE

The romance of nature has deep historical roots. In particular, the idea of an equilibrium or balance of nature has long dominated environmental thought. George Perkins Marsh, one of America's first environmentalists, expressed the prevailing ecological view of the 19th century: "Nature, left undisturbed, so fashions her territory as to give it almost unchanging permanence of form, outline, and proportion." Any changes that do occur are so slow that for all practical purposes nature "may be regarded as constant and immutable." As long as it remains free from man's disturbances, nature "would have been constant in type, distribution, and proportion, and the physical geography of the earth would have remained undisturbed for indefinite periods."

In the early 20th century, the nascent field of ecology eventually rejected the notion of a pure, balanced nature. In place of Marsh's vision, early ecologists adopted the idea of ecological succession: Even if nature could be

affected by drought, fires, and other natural forces, it would always progress through various stages of succession until it reached a final "climax" state. Led by Frederic Clements, ecologists later expanded upon this line of thinking with the idea that entire plant communities evolved as collective, complex "superorganisms" of their own. These superorganisms eventually evolved into a mature adult form, which was ultimately determined by the local climate.

The idea of an equilibrium climax or "superorganism" left little room for humans other than as a disrupter of nature's final balance and had a far-reaching impact on conservation and environmental values in the 20th century. "The notion of a superior climax state gave a scientific validation to the conservationist's case against the machine and the farmer," writes environmental historian Donald Worster. The climax state served as "the yardstick by which man's intrusions into nature could be measured."

In the latter part of the 20th century, however, an internal critique emerged. Researchers began to discover that the equilibrium models theorized by earlier ecologists did not adequately explain the dynamic interactions that occur within ecosystems. A 1973 study of New England's temperate forests by William Drury and Ian Nisbet found that ecological succession did not lead anywhere in particular and never reached a point of equilibrium. Increasingly, ecologists began to focus on "disturbances," both natural and man-made, as part of an ever-changing mosaic of environmental conditions.

In his influential 1990 book, *Discordant Harmonies: A New Ecology for the 21st Century*, ecologist Daniel Botkin documents how the conventional view of a balance of nature apart from human action is unsupported by evidence. According to Botkin, "nature undisturbed is not constant in form, structure, or proportion, but changes at every scale of time and space." To the extent that there is a harmony of nature, it "is by its very essence discordant," he writes, "leading not to a simple melody but to a symphony at some times harsh and at some times pleasing." This sharply contrasts with ecologists' traditional faith in a predictable endpoint of succession, or what Botkin characterizes as the belief "that nature's melody leads to one final chord that sounds forever."

THE ANTHROPOCENE

In addition to recognizing that there is no balance of nature, ecologists are finding that humans have dramatically shaped ecosystems that we once considered pristine or relatively untouched. Recent evidence suggests that the American wilderness explored by Columbus, Lewis and Clark, and others had already been dramatically shaped by humans. As ethnologist Dale Lott explains, Lewis and Clark were "exploring not a wilderness but a vast pasture managed by and for Native Americans."

> If there is no true balance of nature to which we must restore environmental conditions, and if there is no pristine nature untouched by human action, then on what basis should we determine environmental policies?

Today, some archaeologists believe that humans may be responsible for the extinction of large mammals across several continents more than 10,000 years ago. Humans may also have affected the global climate for thousands of years. Carbon dioxide emissions increased significantly 8,000 years ago as people began clearing and burning large swaths of forests for agriculture, and methane emissions increased 5,000 years ago as humans began rice farming. William Ruddiman, a paleoclimatologist from the University of Virginia, estimates that these early anthropogenic effects may have been large enough to prevent another ice age from occurring.

Emma Marris succinctly describes the present-day reach of human influences in her 2011 book, *Rambunctious Garden*: "Every ecosystem, from the deepest heart of the largest national park to the weeds growing behind the local big-box store, has been touched by humans." Marris argues that conservationists should reject the idea of pristine wilderness and adopt a "more nuanced notion of a global, half-wild rambunctious garden, tended by us." Likewise, in 2012, a group of scientists led by Peter Kareiva, former chief scientist for the Nature Conservancy, criticized conservationists for viewing nature apart from people.

The scientists urged others to embrace "a new vision of a planet in which nature—forests, wetlands, diverse species, and other ancient ecosystems—exists amid a wide variety of modern, human landscapes."

In another 2012 essay, Kareiva and Michelle Marvier proposed a new framework of conservation science. "In the traditional view of conservation," they wrote, "people play one of two roles: The vast majority of people are a threat to biodiversity, and a relatively small number—mostly Western biologists—act as biodiversity's protectors and, one hopes, saviors." This is problematic, they say, because "conservation is fundamentally an expression of human values." Kareiva and Marvier's conception of conservation science seeks "a more integrative approach in which the centrality of humans is recognized in the conservation agenda."

THE ROLE OF SCIENCE

Although ecologists are discovering that the natural world is characterized by perpetual change and dramatic human influence, environmental policies remain based on assumptions of equilibrium and pristine nature. As Botkin writes: "If you ask an ecologist if nature never changes, he will almost always say no. But if you ask that same ecologist to design a policy, it is almost always a balance of nature policy." He goes on to say that "whether or not environmental scientists know about geological time and evolutionary biology, their policies ignore them. It is strange, ironic and contradictory."

If there is no true balance of nature to which we must restore environmental conditions, and if there is no pristine nature untouched by human action, then on what basis should we determine environmental policies? There is a growing recognition that science alone can be a lousy guide to environmental policymaking. Many key ecological concepts have normative foundations. For instance, as ecologist Robert Lackey describes, there is no universal definition of ecosystem health, yet many environmental policy issues are based on the idea of restoring or improving the health of ecosystems. Lackey calls ecosystem health a "value-based ecological concept" based on subjective assumptions that "masquerade as science." Ecosystems have no preferences; people do.

Entire ecological sub-disciplines, Lackey writes, "embrace normative science postulates as the core of their trade, maintaining that biological diversity is inherently good, extinction of populations and species is inherently bad, ecological complexity is inherently good, evolution is good, and biological diversity has intrinsic value." In reality, Lackey writes, "most scientific information is of a fine scale and narrowly focused and thus only indirectly relevant to many ecological policy questions." Thus, it is political institutions that must "balance competing values and preferences, a process in which the role of scientific information is limited."

THE CENTRAL QUESTION

Once we accept that nature is profoundly shaped by and connected to human action, we must consider environmental problems through a different lens. In this view, environmental problems cannot be thought of as simply the consequence of human violations of the balance of nature, nor can they be solved by separating natural systems from human influence.

Instead, environmental problems become questions of how to resolve competing human demands on an ever-changing natural world. Farmers want to use streams to water their crops, while anglers and rafters want to use the water for habitat and recreation. Ranchers want to use open landscapes to graze cattle, while environmentalists want to use them for wildlife habitat. The central environmental policy question, then, is this: Which institutions best allow humans to resolve their diverse and ever changing demands on an equally dynamic environment?

Protecting the environment is not simply a matter of preventing human violations on nature's balance. It involves making trade-offs, and doing so in a way that recognizes that nature is as ever changing as the demands that humans place on it. How those trade-offs are made in a world of diverse and conflicting human values ought to be the central environmental question in the age of the Anthropocene.

Shawn Regan is a research fellow at PERC and the executive editor of *PERC Reports.* His recent article "Austrian Ecology: Reconciling Dynamic Economics and Ecology" appears in the *Journal of Law, Economics & Policy.*

DESIGNING INSTITUTIONS FOR THE ANTHROPOCENE

Getting the incentives right.

BY JAMES L. HUFFMAN

Writing in 1990, Daniel Botkin observed that since the beginning of the modern environmental movement in the 1960s, environmental policymakers have had one core mission: restore the balance of nature. The laws and regulations intended to achieve this objective are designed to halt further human disruptions of nature or reverse the consequences of past disruptions. Recently, Emma Marris explained that this balance-of-nature paradigm leads virtually every scientific study of environmental change to use or assume a baseline. The baseline environmental scientists usually choose is the condition of nature before it was exposed to human influences.

This understanding of environmental problems easily translates into policy prescriptions for "healing a wounded or sick nature" and to ethical claims that "[w]e broke it; therefore we must fix it," writes Marris. Thus, baselines "typically don't just act as a scientific *before* to compare with an *after*. They become the *good,* the goal, the one correct state."

Both Botkin and Marris reject the balance-of-nature paradigm and its reliance on baselines. In their view, the natural environment is always changing, and humans have been an integral part of nature's story for millennia. There is no balance to be restored, just an uncertain future. Humans may be able to influence that future, but they and all other living things must adapt to it, or perish.

Yet a quarter century after Botkin labeled his theory the "new ecology," public policies trail behind. Policymakers are generally discouraged from adapting to new understandings of the world by those with vested interests in existing policies. And bureaucracies face constituencies more interested in stability and the benefits derived from existing regulations than in policy changes that respond to new knowledge.

But if Botkin and Marris are correct that nature is constantly changing and that humans are an integral part of nature, policy changes are needed. If nature is always changing, restoring it to some previous state—if that is even possible—makes no sense. In reality, what has been described as the balance of nature turns out to be only the state of nature preferred by those claiming it to be in balance.

Without a baseline of nature in balance, environmental policies, like all political decisions, ultimately come down to competing preferences. And if there is no single correct policy objective, centralized policymaking is unlikely to be the best approach. Given shifting human preferences, a steadily changing and highly variable natural environment, and a wide array of human actions that

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Irrigation districts are self-governing entities that perform functions of government at a local level.

affect nature, decentralized institutions allow for locally appropriate and timely decisions. We should, therefore, seek institutions that allow environmental policies to evolve along with changes in the environment and in response to shifting human preferences.

LOCAL PROBLEMS, LOCAL SOLUTIONS

Beginning in the 1980s, some economists began to argue that a greater reliance on private property rights, contracts, and markets would create ground-level incentives for people to make environmentally sensitive decisions. Free market environmentalists, as they became known, claimed that even if restoring the balance of nature made sense, it was a mistake for policies to treat all resources across a vast continent as if they were the same. Local property owners and resource users have knowledge that centralized regulators could never have. And unlike bureaucrats, private resource owners have strong incentives to make timely and informed adjustments when conditions change.

This justification for decentralized decision making was, of course, not entirely new. Europeans have relied upon the principle of subsidiarity as a guide for designing institutions that govern large regions. The idea behind subsidiarity is that problems should be addressed at the most decentralized level that is appropriate to their solution. Problems tend to be less complex on the local level, where knowledge about those problems also tends to be deeper. When local problems have regional, national, or global effects or causes, then there may be justification for governance at a more centralized level. Subsidiarity allows for diversity and adaptability in both policy priorities and the means to achieve those priorities.

The American federal system is also an illustration of subsidiarity. But it is far more complex than the relative powers of the national and state governments that we tend to focus on. Counties, cities, towns, school districts, zoning districts, irrigation districts, drainage districts, rural fire districts, and weed control districts all perform functions of government. From the perspective of subsidiarity, all of these governing entities and decision makers should be viewed as parts of the structure of American government.

HIERARCHY AND SELF-ORGANIZATION

If we embrace the principle of subsidiarity, two concepts in ecology theory—hierarchy and self-organization—suggest how we might think about the allocation of authority among this wide array of human decision makers.

Under catch-share management, a total allowable catch is determined by a centralized authority, and individual fishers are granted a form of property right known as an individual transferable quota to catch a share of the total harvest limit.

Hierarchy theory serves to isolate segments of highly complex systems for careful study. For example, to understand the role of a particular organism in a larger ecological system, there are two necessary reasons for things being as they are: the underlying parts of an ecosystem such as climate and habitat must allow for a given organism to exist, and that organism's existence must not be constrained by other organisms or factors. Take the lowly mouse as an illustration. Absent particular food sources, water, and temperatures, the mouse is not possible. Thus, mice are not observed everywhere on earth. But the prevalence of mice where they are possible is constrained by predators, disease, and even traps set by humans.

The existing combination of possibilities and constraints that allow the mouse to exist is not by design. It is the result of what ecologists call self-organization. What appears to be conscious coordination among organisms within an ecosystem is actually the result of spontaneous and fortuitous interactions among individual organisms. Thus, the mouse has a shot at, but is not assured, a role in a particular ecosystem at any given point in time.

What distinguishes humans from all other organisms in an ecosystem are the capacities to understand interactions among organisms and to consciously regulate effects on the ecosystem. These capacities can be employed through many different institutional arrangements. As the following examples illustrate, the ecological principles of hierarchy and self-organization are instructive in applying the concept of subsidiarity to the allocation of authority among various levels of government.

Marine Fisheries

When it comes to ocean fisheries, it is often not possible for local or even national governments to manage fisheries that are both widespread and transient. National regulation of fisheries will be limited by national jurisdictional boundaries, while also being constrained by various international agreements. This combination of restraints from below and above argues for some sort of international institution, yet the actual fishing is done by individual private entities who will be difficult to police given physical realities of the oceans. So the best solution in terms of both productivity and conservation may be one that is highly centralized in setting harvesting limits and highly localized in creating incentives to comply with those limits.

Land

The environmental successes and failures of land management regimes in the United States tend to confirm the validity of the subsidiarity prescription. Zoning by local governments is intended to protect wetlands, wildlife habitat, open space, scenic vistas, and other so-called ecosystem services. Although some of these values either can be or already are supplied privately, an absence of markets can limit the possibilities to solve environmental problems through the decentralized institution of private property. But the wide variation in ecological conditions across a large area of diverse communities constrains the effectiveness of zoning implemented on a state or national level.

Oregon, where a set of statewide goals and guidelines govern land use planning and regulation in every corner of the state, is illustrative. Because it is not possible for a statewide system to account for the preferences of every individual, and the state consists of a wide variety of communities with different shared values, the result has been an imposition of urban values on rural communities along with processes appropriate in some settings yet unduly burdensome in others.

Water

With water resources, ownership of the physical resource is not possible given the transitory nature of most

water bodies. In England, the institution of riparian rights emerged, likely as a result of self-organization among neighboring property owners. This riparian doctrine, under which owners of lands adjacent to a particular stream had correlative rights of use in the water, was received by the eastern U.S. states and initially adopted by new states heading west. But the naturally arid conditions of the American West imposed significant constraints on the effectiveness of the doctrine.

Once again self-organization among water users led to a new approach in the arid West: the first-in-time, first-in-right, prior appropriation system, which facilitated the beneficial use of scarce water. With a growing population and more water rights claimants, record keeping and permit systems were put in place to avoid conflict and inform potential users of existing rights. As water sources became heavily exploited, concerns about future water needs led state governments to impose conditions and limits on new permits. More recently, states have imposed restrictions on previously established rights, usually in an effort to protect fish and wildlife.

Today, there has been a strong push for more centralized planning and policy directives regarding water resources in response to increased urban demand, the requirements of policies like the Endangered Species Act, and extended droughts. Contrary to the principle of subsidiarity, the default has been toward greater centralization. Most notably, the efficiency advantages of market allocation have been abandoned to regional and statewide planning.

While some level of centralization in water allocation is needed to achieve certain policy goals, there is little reason to think we have the institutional arrangements correct overall. The fact that the system was, in its beginnings, self-organized is persuasive evidence that it served the needs of private users. Yet there is no doubt that public needs, particularly those of the modern environmental era, were neglected due to the constraints of the private rights system. Centralized authority, however, has its own constraints and possibilities that will not be evaluated and understood if the default is ever more centralization, whether toward policies that govern water or any other natural resource.

CONSTRAINTS AND POSSIBILITIES

Although environmentalists often prefer to view their causes as the pursuit of a higher good, environmental protection and preservation are really just an aspect of the larger challenge of allocating scarce resources. The fact of scarcity is what leads to concern about polluted air, endangered species, threatened wetlands, open space, and every other resource we might value.

> Environmental policies, like all political decisions, ultimately come down to competing preferences. And if there is no single correct policy objective, centralized policymaking is unlikely to be the best approach.

If we understand the objective of environmental policy to be the allocation of more resources to the satisfaction of environmental values, and we accept that this objective will influence the selection of institutions for resource allocation, "new ecology" provides some guidelines for getting the institutions right. The principle of subsidiarity holds that we should prefer the most decentralized approach that achieves our purposes. People closer to a problem usually have better knowledge of both the causes of the problem and the remedies likely to solve it. Self-organization also informs institutional design, Humans have a natural capacity for it, as happens in markets, where the force is no less powerful than in the self-organization of natural ecosystems. And while hierarchy theory in ecology seeks to explain why things are as they are, the concepts of possibilities and constraints can be helpful to institutional design. What is impossible should not be attempted, and constraints—both natural and human-imposed—will limit alternatives that would otherwise be possible.

It all seems rather obvious, but the tunnel vision of special interest politics too often leads to policy choices that are doomed to fail in the face of unrecognized or unacknowledged limits from below and above.

James L. Huffman is dean emeritus of the Lewis & Clark Law School and a PERC board member. His recent article "People-Made Law: Spontaneous Order, Change, and the Common Law" appears in the *Journal of Law, Economics & Policy.*

by Jonathan H. Adler

Accounting for Dynamic Nature

The environment is dynamic. Our regulatory state is not.

Most of today's environmental laws and programs are based upon outmoded assumptions about the relative stability of natural systems when free of human interference. Scientists have understood for decades that ecosystems are incredibly dynamic and change over time, often in unanticipated ways. To be effective, therefore, conservation policies must themselves be dynamic and adaptive, but they rarely are.

Noted ecologist Daniel Botkin argues that "solving our environmental problems requires a new perspective" of environmental concerns that incorporates contemporary scientific understandings and embraces humanity's role in environmental management. Recognizing a new perspective is but the first step, however. There is also a need to identify how this perspective can inform environmental policy, not just on the ground but in the very institutional architecture of environmental law and management. Then comes the really hard part, for even if it is possible to conceive of how environmental management should proceed, it may be devilishly difficult to put such ideas into practice. Old habits die hard. Legal and institutional norms die even harder.

The dominant approach to environmental protection in the United States has been a top-down, administrative regulatory model. Though often adorned with symbolic flexibility or market-oriented ornamentation, the system retains a relatively rigid and centralized structure at its core. Flexibility is rarely more than interstitial or on the margin. Existing environmental laws also implicitly, and

at times explicitly, presume an antiquated, static equilibrium model of natural systems. This is particularly true of those statutes which seek to conserve species or otherwise manage living natural resources.

This regulatory approach was adopted, in part, because Congress was wary of leaving agencies more discretion about how to handle certain types of environmental problems for fear that agencies would shirk their duties or devote resources elsewhere. Yet a consequence of this approach is that agencies do not have as much flexibility or discretion as might be desirable to match specific policy measures with specific problems, and abandon the "one-size-fits-all" approach embodied in much environmental law. Many environmental laws leave little room for marginal analysis or comparative assessment of alternative policy measures.

One response to the contemporary ecological understanding is the adoption of "adaptive management." Though much discussed, it is still relatively underutilized in environmental management. Some federal agencies have sought to implement forms of adaptive management—or what some might call "adaptive management-lite"—but there is not much to show for it.

There are opportunities to improve the adaptive and responsive nature of environmental protection efforts in the United States, but such opportunities are inherently limited so long as environmental protection is dominated by a relatively centralized, top-down administrative structure. Conventional regulatory and administrative systems are not particularly adaptive or responsive to changing environmental conditions, or even to new understandings of environmental needs. Bureaucratic systems change slowly and are rarely forward looking. This is due, in part, to legal constraints, but also due to the nature of monopolistic bureaucratic systems, and the inherent information limitations that hamper the ability of such systems to acquire and account for relevant information—let alone to encourage the discovery of such information in the first place.

If adaptive management is to be successful, there must be careful consideration of how to integrate it into the modern administrative state. The obstacles are both practical and political. Bureaucratic structures are resistant to change, and regulatory agencies do not go out of business when they fail to adapt. To the contrary, a failing agency is more likely to see a budget increase than it is to close its doors. The feedback mechanisms that force private firms to be adaptive and responsive to changing market conditions are largely absent from the administrative state.

The feedback mechanisms that force private firms to be adaptive and responsive to changing market conditions are largely absent from the administrative state.

Accounting for dynamic nature may require revisiting conventional notions of environmental protection and the underpinnings of environmental law and management. This presents an enormous challenge. Conventional approaches to environmental management may be unable to heed dynamic environmentalism's call so long as they are confined by contemporary notions of a fair administrative process, whether such constraints are the product of norms, statutes, or even the Constitution. The challenge of recognizing dynamic nature as such implicates the very foundations of contemporary environmental law and policy.

"Only political will and our basic perspective prevent us from moving constructively" toward sounder environmental policy, wrote Botkin in 1990. This remains true today.

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ECOSYSTEM SERVICES AND PUBLIC POLICY

Are ecosystem services really valuable enough to justify conservation?

BY R. DAVID SIMPSON

Ecosystem services have been a popular theme in conservation policy. By preserving or restoring areas of natural habitat, the argument goes, important goods and services such as clean air and water, flood control, and crop pollination will be provided to society. Those goods and services, if properly accounted for, may even be worth enough to justify the protection of the forests, grasslands, wetlands, and other ecosystems that provide them.

It's not surprising that the logic of ecosystem services has struck a chord. To some, the appeal is that all of the environmental benefits that "the market" has purportedly failed to account for could now be factored into public and private decision-making. To others, the possibility of structuring payments for ecosystem services that assign and respect property rights, and bringing the power of that same "market" to bear, may seem equally appealing.

But the situation is not as simple as these caricatures might suggest. If it is just a matter of structuring payments for the delivery of services of known and agreed value, it is difficult to explain why so much public-sector effort is being put into studying ecosystem services and enhancing their provision. Yet public agencies are deeply involved in such efforts. In the United States, for example, executive branch departments and agencies are now directed to "develop and institutionalize policies to promote consideration of ecosystem services… and, where appropriate, monetary or nonmonetary values for those services."

A fundamental question undergirds the issue, and policymakers and conservation advocates have yet to completely grapple with it and its implications: When are ecosystem services so valuable that an appreciation for them would motivate us to forgo alternative uses of the areas that provide them?

Despite the accumulation of writing on the topic, there continues to be a surprising dearth of reliable evidence on the value of ecosystem services. Furthermore, a compelling case has yet to be made that public intervention is required to assure adequate areas are set aside to provide ecosystem services. More research may not resolve the issue. Perhaps the most important public policy question is an even more fundamental one: What is it that we as a society wish to save of nature?

A LACK OF EVIDENCE

There are now thousands of published articles on ecosystem services, yet little has been settled regarding their values. Kate Brauman finds that a majority of 381 peer-reviewed studies relating water to ecosystem services "failed to adequately link changes in environmental conditions to human well-being, instead stopping at the point of suggesting that one was connected to the other." Concluding their review of ecosystem service studies, Ralf Seppelt and co-authors state that "less than one-third of all studies provided a sound basis for their conclusions." Taylor Ricketts and fellow researchers perhaps inadvertently

Forests or grasslands retained in a riparian buffer may remove some of the pollution that would otherwise enter streams. *Photo © National Agroforestry Center.*

The ecosystem services paradigm may mistakenly presume that the best way to conserve nature is to use it for its goods and services, rather than to find ways to leave it alone.

underscored an irony that persists: "Although the societal benefits of native ecosystems are clearly immense, they remain largely unquantified," they wrote—without explaining how we can be so sure that the benefits are "clearly immense" if they remain "largely unquantified."

Given the lack of robust work on ecosystem service valuation, it is not surprising that, as Yann Laurans and co-authors conclude, the literature "rarely reports cases where ESV [ecosystem service valuation] has been put to actual use, even though such use is frequently referred to as founding the goal and justification of ESV."

Since the information that is available now is limited, it may be instructive to consider what basic economic principles imply about the value of ecosystem services. The single most important thing to remember when thinking about economic value is that value is determined on the margin. This principle is fundamental, but it is often not appreciated by non-economists, who have been engaged in much of the research on ecosystem services. Nature may provide services of immense value to humanity in total, but marginal values are what matter. And in the case of many ecosystem services, marginal benefits are likely to be low.

As an example, think of wild bees. A bee's economic value is determined by the value it adds by pollinating flowers that eventually produce fruit. If adding an additional bee to an orchard means that many more fruits will grow, then that bee could be extremely valuable. When bees are abundant, however, most flowers are likely to already be pollinated, so additional bees would add little to the expected value of the crop.

Similar considerations determine the value of other ecological assets. Forests or grasslands retained in a riparian buffer may remove some of the pollution that would otherwise enter streams and cause environmental damage. This service can be quite valuable if such areas are very effective at removing pollution. But the wider the existing buffer, the less pollution remains for the marginal meter of buffer to remove.

These examples highlight an interesting phenomenon, which we might call the "If-a-little-goes-a-long-way, you-don't-need-a-lot" principle. If wild bees are prodigious pollinators, a small number of bees might be enough to perform the service of crop pollination. If riparian buffers are very effective at removing pollution, a narrow buffer might be all that is needed. And if a little bit doesn't go a long way, substitutes may be more feasible than maintaining ecosystem services. For example, rather than devoting productive farmland for pollinator habitat, farmers instead might grow one of the numerous crops that do not require insect pollinators. Or rather than preserving large areas of riparian buffer, treatment plants may become a more attractive alternative. These basic economic principles suggest that the value of ecosystem services might be limited in many cases, and an appeal to ecosystem services would not motivate large-scale conservation when opportunity costs are significant.

So what does this mean for the question of whether public funds should be allocated to estimating the value of ecosystem services? And why is the ecosystem services framework often used to suggest that society is conserving too few native habitats?

THE VALUE OF NATURE

Ecosystem services may seem to be a modern development in conservation policy, but current debates retrace a century-old conflict over the value of nature. In the early 20th century, John Muir, the founder of the Sierra Club, championed a vision of preserving nature for its own sake. Muir clashed with Gifford Pinchot, who would become the first Chief of the U.S. Forest Service. Pinchot promoted conservation as a means of enhancing the flow of nature's more tangible benefits to society, and, in some instances, advocated more intensive uses of public lands.

Over recent decades, the latter vision has been ascendant. Conservation advocates have often argued that nature can essentially pay for itself, if we would only recognize its value. Natural areas might support sustainably harvested products, provide genetic models for new pharmaceutical compounds, offer recreational destinations for "eco-tourists," and a host of other valuable goods and services.

In practice, however, the economics of such ventures often do not make sense. In some respects, nature is too generous—some of the goods and services nature provides are so abundant that people are willing to pay very little for them. Others fail because ancillary infrastructure is lacking. The world may be filled with natural wonders,

but many are located in places that are too inaccessible and dangerous to attract many tourists. Moreover, low-intensity use of natural systems can only exist as long as the products or services being provided are of relatively little value. At higher prices, more intensive exploitation displaces sustainable use of diverse systems.

But what if the economics did make sense? If nature-based ventures would be profitable, why would the public sector have to subsidize them, as we often see? In particular, why would national governments need to be involved to induce local and regional decision-makers to do what is in their own interest? There does not seem to be a compelling answer. So why, then, is there renewed enthusiasm among ecosystem service advocates for the idea that nature can be made to pay for itself?

The likely answer is that conservationists perceive a mismatch between their goals and the means to achieve them. Conservation can be an expensive proposition. Preserving natural areas that shelter biodiversity requires amassing sufficient funds to compensate their owners for the opportunity costs of not converting forests, wetlands, and other areas to alternative uses. It may also require ongoing expenses to monitor natural areas and assure that they are kept intact. Conservation advocates and their funders seek ways to motivate more habitat conservation without bearing the full cost. It's not surprising, then, that when it comes to ecosystem services, some conservation advocates have promoted public policies aimed at incorporating ecosystem services into regulatory decision-making.

CONSERVATION IMPLICATIONS

Many advocates speak and write as if it were an established fact that ecosystem services are undervalued and that public policies should be enacted to assure that the ecosystems providing them are sufficiently protected. But these propositions are not, in fact, well established on a broad basis.

That is not to say that there are not important reasons to be concerned with the decline of natural ecosystems. There may well be, as many have suggested. Many of us feel ethical or even spiritual obligations to be good stewards of the natural world. However, the ecosystem services paradigm may mistakenly presume that the best way to conserve nature is to use it for its goods and services, rather than to find ways to leave it alone.

This underscores a fundamental issue with ecosystem services. If taken literally, ecosystem services-based arguments are not appeals for conservation in some generic and universal sense so much as for the conservation of particular types of areas. Many of the arguments for ecosystem services are, implicitly, exhortations to create checkerboard landscapes consisting of numerous small pockets of "natural" habitats situated within areas devoted to less-intensive cultivation, production, or settlement. But if land is used less intensively in production, it means either less will be produced or more land must be used elsewhere, causing human activities to expand further into the remaining "wild" areas of the planet.

Do we as a society want a world with many small areas devoted to conserving a limited suite of native species, or one in which production and human habitation are more intensive in some areas while more of the landscape is left relatively untrammeled? Current research on ecosystem services has little to say about these questions. Instead, it seems intended to create the impression that technical calculations can inform conservation choices. Such a view would fit neatly into a paradigm in which regulators would determine the proper land-use choices and restrict property rights accordingly. In our society, however, we rightly set a high bar to such "takings." At present, there is simply not enough reliable information about the value of ecosystem services to justify this sort of regulatory approach.

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MISSION

PERC is dedicated to improving environmental quality through property rights and markets.

VISION

We envision conservation policies and practices that focus on results rather than rhetoric and replace conflict with cooperation. Our goal is to foster a culture of environmental entrepreneurship.

APPROACH

PERC's team:

- conducts research to advance understanding of complex environmental issues;
- disseminates ideas through publications and educational outreach; and
- empowers enviropreneurs by providing skills and training to scale up entrepreneurial efforts that improve the environment.

Help us identify, cultivate, and celebrate demonstrations of free market environmentalism.

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PERC SCHOLARS examine how property rights create incentives for conservation and how markets give people with conflicting environmental values a way to cooperate rather than fight.

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PERC RESEARCH appears in scholarly journals, the popular press, and PERC publications.

STUDENTS AND SCHOLARS explore our ideas to prepare for the environmental issues we face in the future.

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PROPERTY RIGHTS help turn liabilities into assets and provide the right incentives for environmental stewardship.

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PERC offers alternatives to blunt policy instruments which often limit both economic and environmental benefits.

How Humans

We conserve nature by using less of it—but to do so we must embrace modern technology.

BY LINUS BLOMQVIST

Spare Nature

If current trends continue, it is possible that human impacts on the environment will peak and decline this century, even as the global population approaches 10 billion. “Peak impact” offers an inspiring vision for global conservation. Here is how it works.

Humanity has, by most measures, done extraordinarily well over the past century. People on average live longer and eat better. The share of the global population living in poverty is lower than ever before. But supplying food, energy, materials, and water to a growing and increasingly wealthy population has come at a steep cost for the natural world. Humans today use at least half of all ice-free land, mostly for farming and forestry. Habitat loss, overexploitation, pollution, and other environmental impacts have on average reduced wildlife populations by more than half since 1970. Hundreds of species of birds and mammals have gone extinct over the past few centuries, and many more are threatened today.

But there are glimmers of hope. Even as biodiversity continues to be lost, there are signs that economic growth and human welfare are becoming increasingly decoupled from environmental impacts. While many of humankind's environmental impacts have grown in absolute terms, several have started to flatten out or even decline. Per-capita impacts have in many cases gone down, in large part because the technologies used to produce goods have become less environmentally harmful. If these decoupling trends continue, it is possible that human impacts on the environment will peak and decline this century, even as the global population approaches 10 billion and people around the world become more materially rich and secure.

"Peak impact" offers an inspiring vision for global conservation. It can be achieved by accelerating beneficial economic and technological processes while continuing to use protected areas, payments for ecosystem services, and other conventional conservation tools at a landscape levels. Here is how it works.

TAKING A BURDEN OFF

While population and per-capita consumption have added to humanity's overall burden on the environment, technological shifts have for the most part reduced it. These shifts can be reduced to two mechanisms: substitution and intensification.

The substitution of tractors for horses eliminated the need to dedicate about one-quarter of all U.S. farmland to feed draft animals. The introduction of synthetic nitrogen meant farmers no longer needed to keep as much as half of their cropland in fallow to replenish soil nutrients. Together with agricultural intensification in the forms of rising crop yields and greater efficiencies in meat production, these technological advances have allowed the area of farmland per capita to fall by half over the last half century, even as diets have gotten richer. While global farmland area has increased by about 10 percent since 1960—causing widespread habitat loss—it has barely grown since the early 1990s. During that period, global population rose by more than 20 percent and GDP per capita nearly doubled.

The transition from fuelwood to fossil fuels, nuclear power, and hydro as sources of energy has also contributed to flattening global demand for wood. In fact, per-capita wood consumption has declined so much as to offset the concurrent increase in food consumption, such that the total per-capita demand for biomass has stayed constant for more than a century. Today, it takes on average less than one hectare to provide food, energy, and living

The forests of New England, once cleared for marginal farming operations, have now returned. Dioramas produced by the Harvard Forest depict changes in the landscape over the past 300 years.

space per person, compared to an estimated four hectares per person among early agriculturalists some 7,000 years ago.

Through similar mechanisms, farmed meat and fish have taken pressure off wild populations. Petroleum- and plant-based substitutes for whale oil spared global whale populations—not just in the 19th century when kerosene replaced whale oil in lighting, but also in the 20th century when innovations made whale products unneeded for lubricants, soap, and margarine. Shifting from coal to natural gas to nuclear and hydro—and wind and solar power more recently—has gradually reduced the amount of carbon emissions per unit of energy, even as total global carbon emissions have continued to rise. As humans shift from harvesting goods in the wild—such as bush meat hunting or whaling—to farming them, or to producing goods in factories, the amount of environmental harm per unit produced tends to fall.

In other words, in most cases, the more synthetic our consumption, the less nature we destroy. We spare nature by using less of it.

So far, in most cases, technological improvements have not fully offset the increasing pressure from a growing population and higher consumption, so most environmental impacts have grown in absolute terms. Indeed, increasing efficiency has often enabled greater consumption. But as population growth slows and demand for material goods saturates at high levels of income, the peak and subsequent decline of human impacts on the environment is a distinct possibility this century.

THE CHALLENGE

To understand what decoupling means for conservation, we need to focus on the micro level. Here, the fate of conservation boils down to an evolving race between consumptive uses of the environment, such as conversion of forests to farmland, and non-consumptive uses, such as the preservation of land or wildlife for aesthetic or recreational purposes. Put differently, the conservation of natural habitats and wildlife is ultimately a question of opportunity costs. In the words of ecologist John Terborgh, as long as a forest is "worth more dead than alive," conservation is an uphill battle.

In most cases, the more synthetic our consumption, the less nature we destroy. We spare nature by using less of it.

Conservationists have devised several strategies to deal with opportunity costs. Protected areas—one of the cornerstones of global conservation—exclude some or all ecologically harmful activities by legal means. They allow constituencies to identify and protect the most unique and highly prized places for their biodiversity, scenery, or other values. When adequate resources are available, such legal designations can be backed up by interventions to save threatened species or landscapes. Yet protected areas face a number of limitations.

Societies and communities are often not willing to make big economic sacrifices for the intrinsic or aesthetic value of biodiversity or landscapes, especially—and understandably—in poorer countries. The vast majority of protected areas are located in places where there are no

Photos provided by Harvard Forest Archives, Harvard Forest, Petersham MA. Modern forest photo (far right) by David Foster.

If agricultural yields across the world come closer to their potential, crop production on existing farmland could more than double.

competing land uses, either because the land is too infertile, rugged, or remote. Where farming, logging, or mining is viable, and where population densities are higher, protected areas are much less common, or they are poorly enforced or dismantled altogether when pressures become too high. Where protected areas make a difference, they tend to displace the harmful activities to other places, rather than eliminating them altogether. When logging or farming is banned from an area, the wood and food will still be produced somewhere—either close by or in a different region. For this reason, local successes do not necessarily add up to less habitat loss globally, even though they have helped many individual species and populations to survive.

Another way to win the race between consumptive and non-consumptive uses is to identify and capture value from conserved land or wildlife. Ecotourism, as well as ecosystem services like purification of water and air by plants, flood control by wetlands, and crop pollination by wild insects, are examples of how benefits might match or exceed the value of developing land for farming or housing. Several of these have proven effective conservation tools at local levels. Buffer strips, which capture pollutants from agricultural runoff, have helped restore riparian ecosystems across many parts of the United States and Europe. Ecotourism tips the balance in favor of conservation in some scenic or biodiverse parts of the world, notably the tropical forests of Costa Rica and many wildlife reserves in Africa.

Yet these tools, too, face certain limitations in achieving conservation at larger scales. Ecotourism can bring large incomes in accessible places with unique qualities, but is often not feasible in areas lacking these features or at wide geographical scales.

As for ecosystem services, many of the most biologically rich ecosystems are so far from cities, farming, and other human activities that their services do not really have economic value. For instance, riparian vegetation only serves humans if there is a nearby source of pollution, like farming, and a downstream population to benefit from cleaner water. Trees only provide an air quality service when there are humans nearby to benefit from cleaner air.

In other cases, it can be more profitable to develop land for farming at the expense of natural habitats and their ecosystem services, and instead rely on substitutes. Rather than use large amounts of cropland for legumes to supply nitrogen to the soil, for instance, farmers could use the land to grow other crops and apply synthetic fertilizer.

In places where farming or housing is not profitable, the opportunity cost of setting aside land is often much lower. But if the land was not under threat of conversion anyway, relying on the ecosystem services does not result in more land for nature. This presents a paradox: We might benefit from ecosystem services the most in the areas where they make the least difference to conservation outcomes.

Finally, if ecotourism, ecosystem services, or other economic benefits of conservation really do alter the use of land and other resources, these activities tend to be displaced elsewhere rather than eliminated.

By no means does this imply that we should abandon protected areas or ecosystem services. Nor does it mean that paying people to protect their land or provide ecosystem services is not beneficial. But the effects on land use and conservation may not be able to stem the global tide of habitat and species loss, as long as demand for land and material goods keeps increasing. Conventional conservation tools are necessary, but not sufficient, for global conservation to succeed.

TOWARDS PEAK IMPACT

Decoupling through intensification and substitution can pick up where conventional conservation leaves off. Decoupling can reduce the consumptive value of land and wildlife, so that their exploitation becomes less profitable—in other words, so that the opportunity cost of conservation falls.

For example, once kerosene was widely adopted, there was little reason to continue whaling, since no one would buy the more expensive whale oil. As intensive farming in the American Midwest combined with better transportation networks to lower food prices across the country, marginal farming operations in places like New England became a losing proposition, and much of the farmland was left to resurgent forests. This process was reinforced by the fact that a growing

manufacturing sector offered better uses for people's time and capital. A similar phenomenon is now playing out across other regions, including Latin America.

Substitution and intensification generally follow economic growth and modernization, but they are not entirely spontaneous or natural processes. They can be accelerated through targeted policies, investments, and institutional reforms by governments, civil society, and entrepreneurs. Four priorities stand out.

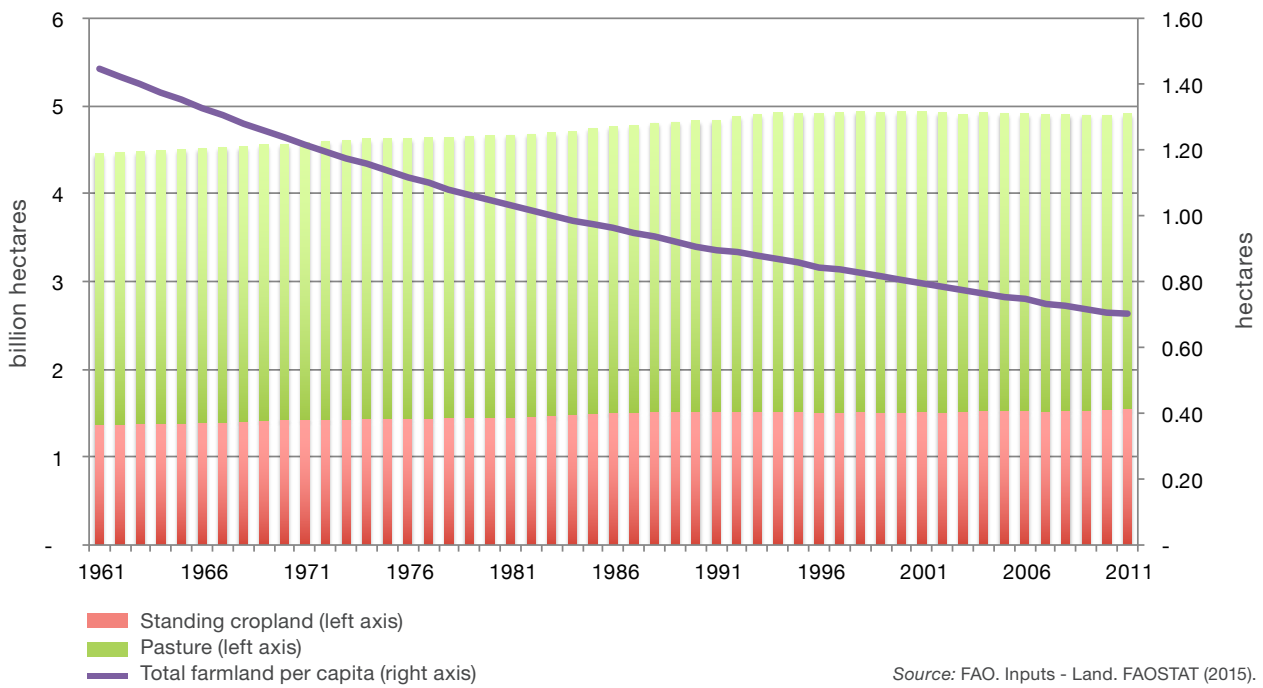
The first is to spread existing technologies to spur substitution and intensification in more places. Perhaps the most important part of this is to enable farmers, especially in poor countries, to adopt modern agricultural technologies. This is an urgent priority that can halt the expansion of farmland as food demand continues to grow globally. And we know that it is possible: If agricultural yields across the world come closer to their potential, crop production on existing farmland could more than double.

Along with agricultural modernization, moving up the energy ladder can make a big difference for conservation. Modern energy, mostly fossil fuels, has substituted for fuelwood, organic fertilizers, and horses, resulting in "land sparing." But decoupling is not just about changing the source of energy; it's also about using larger amounts of energy in order to reduce impacts on wildlife and habitats. So the second big factor in decoupling is energy—and lots of it. Aquaculture takes more energy than capture

Grand ball given by the whales to celebrate the discovery of the oil wells in Pennsylvania. *(Vanity Fair, 1861)*

Global Farmland Area

The amount of farmland used in food production per capita has declined by about half since 1960.



Source: FAO. Inputs - Land. FAOSTAT (2015).

fisheries, and feedlot systems use more energy than bushmeat hunting. The impressive yield improvements we have seen in agriculture would be impossible without huge energy inputs in the form of fertilizers, pesticides, machinery, and irrigation. Abundant modern energy is also needed to power the industries and cities that allow decoupling to happen.

So we save nature with energy, but since our energy has so far mostly come from fossil fuels, sparing land and wildlife also releases large amounts of carbon dioxide into the atmosphere. This presents a huge trade-off. The only way to reduce our impacts on land and wildlife while also avoiding the worst impacts of climate change is to decarbonize our energy supply. Renewables like solar and wind will play a part in this, but they are far from sufficient. We need energy sources, such as nuclear power, that work when the sun is not shining or the wind is not blowing, and that can provide baseload power for cities and industries.

Neither agricultural modernization nor energy transitions, however, are purely about technology. Both are fundamentally underpinned by broader social and economic shifts, including urbanization, income and consumption growth, and a shift from subsistence farming to manufacturing and services. These shifts not only lift people out of poverty and increase their choices and freedoms, but they are also associated with lower population growth, which can reduce pressure on the natural environment. Therefore, accelerating these processes in a just way is our third priority.

The fourth and final priority for decoupling is innovation, which creates more opportunities for substitution and intensification. For example, the improved seeds that were part of the Green Revolution are estimated to have saved an area half the size of France from conversion to farmland. Looking forward, if clean energy sources like nuclear power are to diffuse more rapidly, we will need innovations that lower their costs.

NECESSARY, NOT SUFFICIENT

Even as decoupling takes pressure off forests and wildlife, it does not solve every conservation problem. It does not guarantee that the landscapes conservationists care about most, such as old-growth forests, will be preserved, or that land that remains in production will be concen-

trated in areas where ecological impacts are least significant.

There are places where consumptive values are virtually non-existent and conservation is the highest use by default. This is referred to as passive protection, and it includes parts of the Amazon basin and the Siberian Taiga. But in many places, consumptive values will remain significant, making passive protection insufficient. As a result, conventional conservation measures like protected areas or direct payments remain essential. Decoupling is a complement, not an alternative, to these strategies—it is a means of making them more feasible. Only when the two are combined, especially at a landscape level, can the scales be tipped in favor of conservation.

The role of conventional conservation approaches in the context of decoupling is highly contextual. In many temperate regions, and on marginal lands in the tropics, pressures are easing and land prices are falling as a result of decoupling. In these cases, governments and conservation organizations can step in to make the most of these opportunities.

For example, competition from agriculture in more productive regions led to the abandonment of marginal farming operations in parts of the Mississippi basin. But it took a concerted effort by governments and conservation groups to restore floodplains such as the Oachita River. Likewise, greater efficiencies in cattle production have made ranching less profitable in some regions, but it still requires the work of conservation organizations to purchase marginal ranchland, tear down fences, reintroduce wildlife, and create nature reserves—as the American Prairie Reserve has done in Montana, for instance. In some cases, such as in Mexico, payments for ecosystem services have accelerated the abandonment of marginal agricultural land.

In fertile lowlands in the tropics, agricultural intensification can be a double-edged sword. Higher yields in these regions are essential for the global land footprint of agriculture to peak and decline. However, higher productivity in these lowlands makes farming more competitive and can bring even more pressure to expand agriculture locally. In this situation, protected areas and strategic, landscape-level strategies can help concentrate production on lands that are already cleared, while ensuring protection for the most biologically rich areas.

A VIBRANT FUTURE

Decoupling through intensification and substitution, modernization, and innovation can combine with conventional conservation approaches to offer a practical strategy to achieve peak impact and leave more room for nature. But decoupling also presents tough choices and trade-offs. Further intensification of farming, including the use of biotechnology, will be needed to shrink humanity's footprint. Dense and abundant (but sometimes unpopular) energy sources like nuclear power must be a part of our energy future to spare land and decarbonize our economies. Large amounts of meat and fish will have to be farmed instead of harvested in the wild.

Decoupling can combine with conventional conservation approaches to offer a practical strategy to achieve peak impact and leave more room for nature.

Yet these technologies can also enable us to find greater spiritual and aesthetic connections to nature. If food and energy production take up less land, there will be more space for nature, both near and far from cities. Less demand for wild meat might bring wildlife back in many regions. Substitutes have helped bring the whales back, giving people a better chance of seeing these spectacular creatures in the wild. To put it differently, decoupling from nature in material terms might give us more of the beauty, diversity, and other immaterial benefits that nature has to offer.

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Better Bred Than Dead

Is wildlife breeding an acceptable conservation strategy?

BY MICHAEL 'T SAS-ROLFES

© Pete Oxford

A black rhino is flown to an undisclosed location in South Africa in hopes of establishing a viable breeding population.

Wildlife breeding raises many pivotal questions and concerns. Are wildlife breeders interfering with nature? To what extent is the practice justified as a legitimate conservation tool? And to what extent can we condone modern techniques of genetic manipulation and even potential de-extinction of species using emergent DNA technologies? All of these issues revolve around questions of "wildness" and traditional views of conservation, which are increasingly being challenged in this Anthropocene era, in which human activity dominates over nature.

South Africa is a world leader in endangered species breeding. The country's experience dates back to 1837, when Alexander van der Byl enclosed an area of about 6,000 acres on his farm near Bredasdorp in the Cape region to protect a herd of 27 bontebok. Without Mr. van der Byl's intervention, the bontebok would most likely have met the same fate as the blaubok, a smaller relative of the roan and sable antelopes that was exterminated by hunters in the late 18th century in the same area.

Two other examples of South African species that were reduced to single populations are the Cape mountain zebra and the southern white rhino. In both instances, the species had become confined to a single state-owned protected area in which their numbers could increase through natural breeding. But subsequent expansions relied on a more strategic approach to establish new, genetically viable founder populations in additional areas of suitable habitat, with the

cooperation of private landowners. Other examples from around the world include Przewalski's horse, Père-David's deer, the American bison, and the Arabian oryx.

Whereas wildlife breeding efforts such as van der Byl's bontebok initiative and white rhino protection in South Africa's Hluhluwe-Umfolozi Park may have started as a passive activity, the gradual emergence of new technologies that allowed sedation, translocation, and other genetic and veterinary interventions has led to an increasingly sophisticated suite of options.

Mark Stanley Price, former chair of the IUCN's Reintroductions Specialist Group, played a key role in returning the Arabian oryx to the wild. In "Fall of the Wild," a recent article he co-authored with antelope specialist David Mallon, Stanley Price argues that most animal populations today are subject to some form of human intervention, and that rather than question whether they are "wild," it makes more sense to consider simply whether they are managed "lightly" or "intensively." According to Yolan Friedmann of the Endangered Wildlife Trust, many large mammal species in South Africa effectively exist under fairly intensive management, especially those that are rare and endangered.

The spectacular growth of South African game numbers since the 1960s is well documented, including the recovery of threatened species such as white rhino, black wildebeest, and roan and sable antelope—largely thanks to the efforts of private breeders.

Mallon and Stanley Price point out that the question of wildness is not just of theoretical interest; it has practical implications for international agreements such as the Convention on International Trade in Endangered Species and Convention on Biological Diversity, as well as for meeting objectives under national legislation and monitoring by the IUCN's Red List. They cite the example of the Arabian oryx, whose upgrade from "extinct" in the 1970s to "vulnerable" in 2011 has drawn criticism, as most of the animals now survive in fenced enclosures under active management. They share Friedmann's observation that most South African wildlife ranching takes place in fenced enclosures and note that regarding these situations as "non-wild" would have massive implications for Red-List assessments.

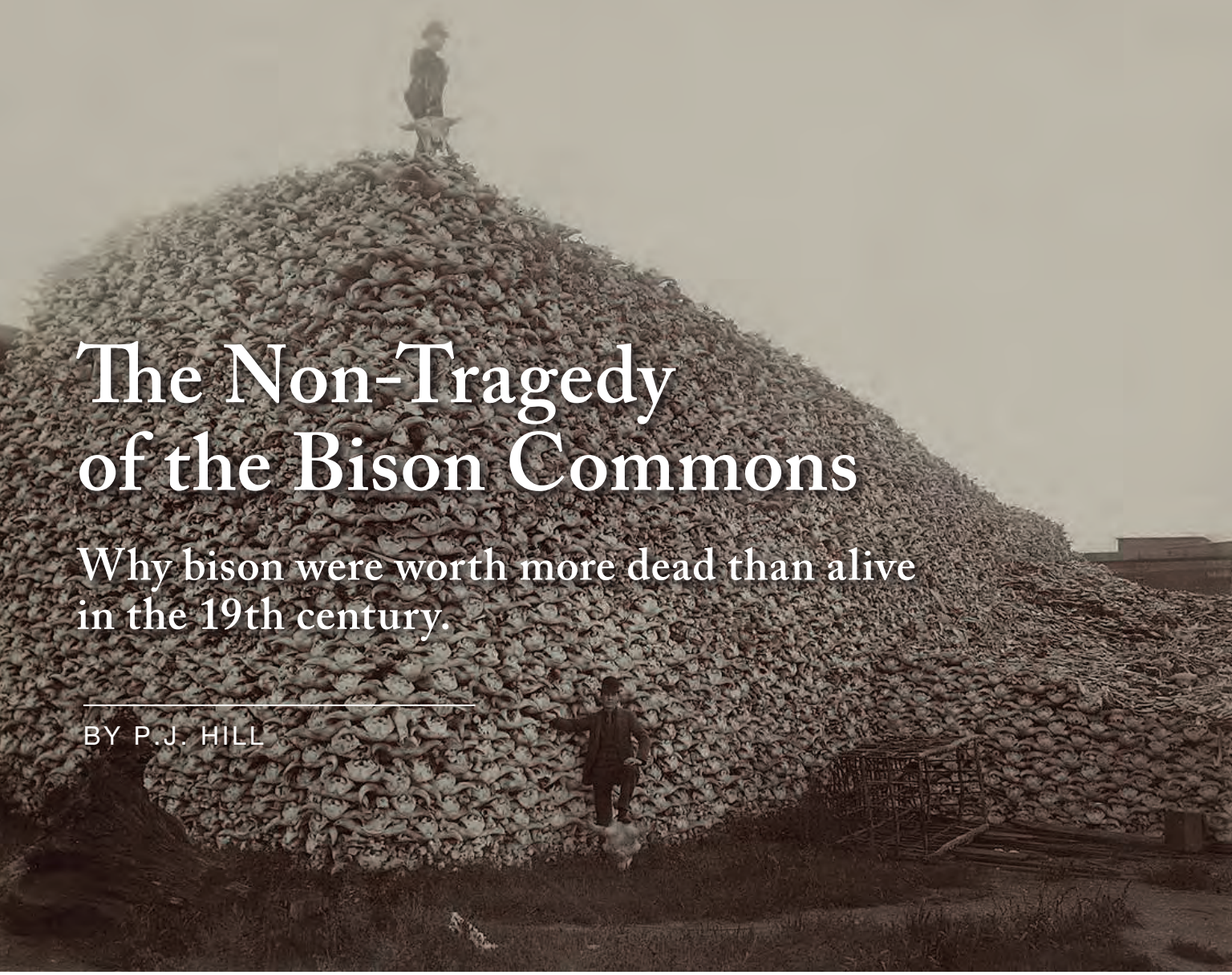
The spectacular growth of South African game numbers since the 1960s is well documented, including the recovery of threatened species such as white rhino, black wildebeest, and roan and sable antelope—largely thanks to the efforts of private breeders. Apart from the issue of enclosure, conservationist concerns also relate to the use of non-native subspecies such as the roan and sable antelopes from other parts of Africa and the introduction of species such as nyala and blesbok to areas outside their historical ranges.

To what extent should we be concerned about the genetic purity and historical ranges of species, especially when we have already modified them so much? This question is especially relevant in Africa, where projected forecasts of human population and economic growth—coupled with needs of food security—suggest that the pressure on wildlife will soon intensify. It is also instructive to look at examples of the addax, dama gazelle, and scimitar oryx—antelope species known collectively as the "three amigos." These species were mostly exterminated from their home ranges in North Africa for food by hungry locals during times of civic unrest. Off-site commercial breeding for trophy hunting in Texas has provided a hedge against extinction for these species and provides a possible source for reintroduction, but remains controversial in the United States and elsewhere.

White rhinos are being bred in China, and there are proposals to move some rhinos to Australia and Texas for breeding and safe-keeping. Does this make more sense than applying further intensive and assisted breeding strategies within southern Africa? And to what extent can we accept that motivations for breeding are not based solely on pure "conservation" goals, but also the commercial potential of tourism viewing, trophy hunting, and production of commodities such as rhino horn?

Opinions on such questions will vary widely between animal welfarists, conservationists, and commercial wildlife breeders. But there is no doubt that wildlife breeding will continue to play a vital role in both species conservation and the broader land-use economy.

Michael 't Sas-Rolfes is a PERC research fellow based in Cape Town, South Africa, and a doctoral student at the University of Oxford.



The Non-Tragedy of the Bison Commons

Why bison were worth more dead than alive in the 19th century.

BY P.J. HILL

A pile of bison skulls prior to being ground into fertilizer in the mid-1870s. By 1886, less than 1,000 bison remained in North America.

North America was once home to massive herds of bison. Approximately 30 million bison roamed the plains during the 19th century, and in 1870, there were still at least ten million bison on the continent.

But by the mid-1880s, that figure had fallen to less than 1,000. Entire herds were wiped out in a matter of years. "In 1880, the country was practically uninhabited," wrote early rancher Granville Stuart, describing the plains of Montana. "One could travel for miles without seeing so much as a trapper's bivouac. Thousands of bison darkened the rolling plains."

That all changed in just a few years. "In the fall of 1883 there was not one bison remaining on the range" in Montana, according to Stuart.

The story of how this massive "slaughter on the plains" occurred with such speed and ferocity has been well documented. The near extermination of bison and the massive harvesting of them by white hunters continues to hold great interest among historians of the American West. The species has recently garnered renewed interest: In May, President Obama signed a bill designating the bison as the U.S. national mammal. The question of why the historic bison slaughter happened, however, has received less attention. And the explanations that exist often lead to incorrect conclusions about this era.

AN ALTERNATIVE EXPLANATION

The usual explanation of this rapid depletion of the bison—at least among economic historians—was the lack of ownership of them. Because no one owned the bison, the story goes, no one had an incentive to protect them, resulting in a "tragedy of the commons." Although some Indian tribes had loosely defined claims to certain areas to hunt the animals, those claims were virtually extinguished as settlers moved westward. In essence, bison were taken on first-come, first-served basis, with no incentive to account for the future of the population. Anyone could kill bison on the plains as rapidly as they wished.

This lack of well-defined and enforced property rights is the root cause of virtually all environmental problems. But upon closer examination, it does not adequately explain the demise of the bison during this period. In a recent academic article, published in the *Independent Review*, I offer an alternative explanation: The bison were slaughtered not because of a lack of property rights to them, but because there was a higher-valued use of the land on which their massive herds thundered. In other words, even if property rights could have been established to the bison herds, settlers would likely have slaughtered them anyway. The plain fact was that, during this period, a bison was worth more dead than alive.

The most valuable resource on the plains at the time was not actually the bison, but the grass beneath their hooves. The prairie grasses on the Great Plains were the bison's primary food source. As railroads ventured westward, however, that grass became increasingly valuable for another purpose: meat production. But not just any meat—specifically beef, which would require grazing lands to run cattle.

Bison, of course, are also a source of meat. But for a variety of reasons, bison meat was extremely expensive to deliver to market during this time period. Domesticated cattle, on the other hand, could produce beef from the grasses of the plains much more efficiently. Since bison were in direct competition with cattle for space, their demise was inevitable. The result was a massive slaughter of bison over little more than a decade.

The bison were slaughtered not because of a lack of property rights to bison, but because there was a higher-valued use of the land on which their massive herds thundered.

A second factor fueled the slaughter: growing demand for bison hides as a result of technological innovations in tanning. Economist M. Scott Taylor of the University of Calgary recently documented this phenomenon, arguing that English and German tanners were the first to discover a workable process for tanning bison hides. By 1871, technological change in tanning meant that bison hides had become almost identical to cattle hides for commercial use. Demand for bison hides boomed over the next decade as a result.

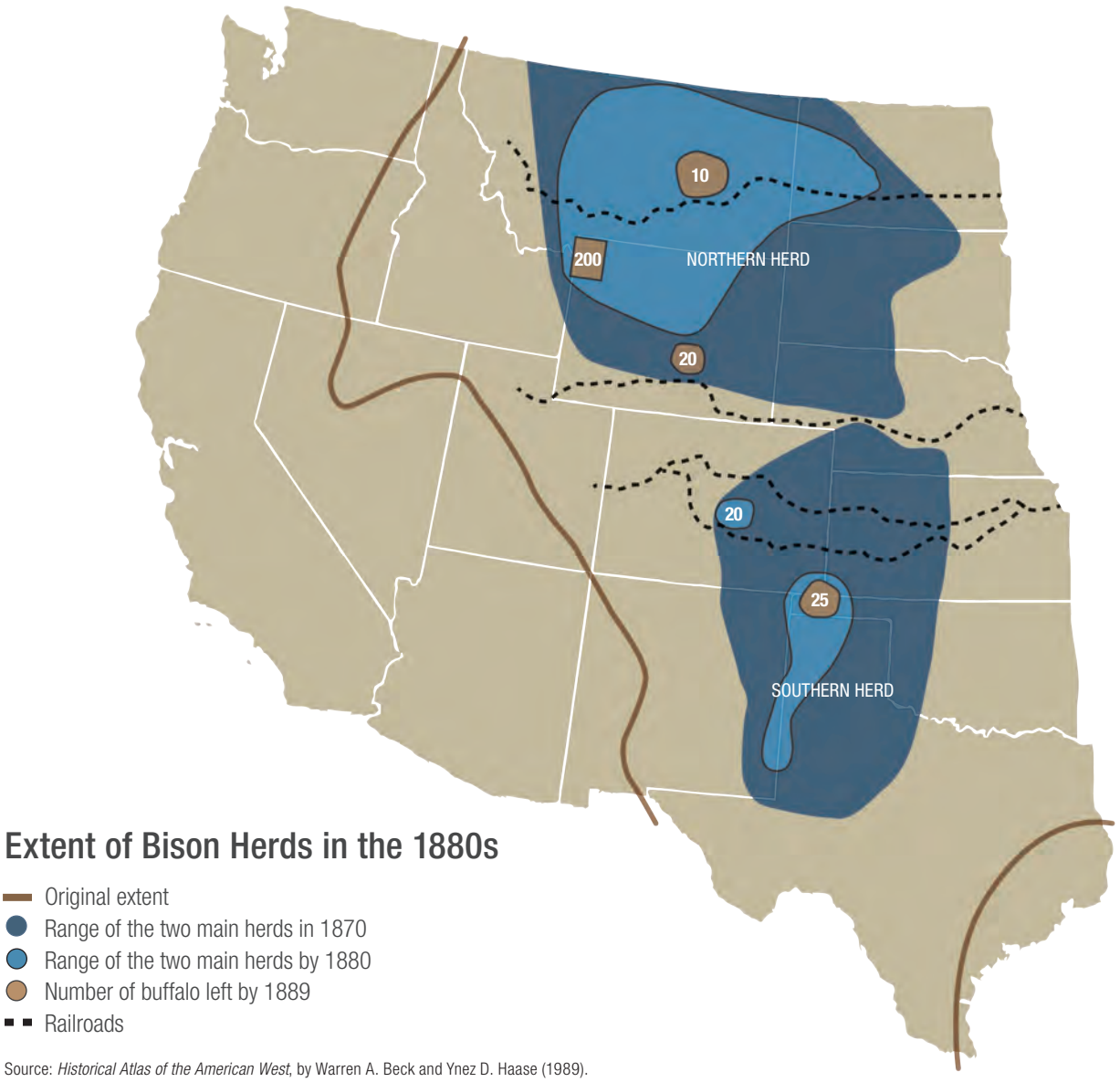
With bison hides fetching between $3.00 and $3.50 apiece at railheads, thousands of hide hunters outfitted themselves with wagons, rifles, and crews of skinners. These groups could kill several hundred bison in a day. The hides were stacked, bundled, and hauled to railroads where they were shipped east for tanning.

The hide trade sped up bison harvesting remarkably. The Western Kansas herd was eliminated in less than four years (1871-1874), the herds in western Texas were exterminated in five (1875-1879), and the bison of eastern Montana were killed off between 1880 and 1883.

If bison represented a viable form of production over the long run, either for meat or for hides, one would expect to see efforts to establish rights to bison and attempts to raise them for market. Yet there is no record of ranchers attempting to do so during this period.

THE BISON COMMONS

After 1870, with the railroads expanding and the gradual pacification of Native American tribes, ranchers began to exert a new set of economic values upon the western landscape—one that did not include millions of bison roaming the plains. In fact, the bison herds presented a challenge for ranchers in the West: Bison consumed grass



Extent of Bison Herds in the 1880s

- Original extent
- Range of the two main herds in 1870
- Range of the two main herds by 1880
- Number of buffalo left by 1889
- Railroads

Source: *Historical Atlas of the American West*, by Warren A. Beck and Ynez D. Haase (1989).

and disrupted cattle production, so their removal was virtually an economic necessity, not necessarily a tragedy or waste of resources.

In this sense, the true economic cost of having bison around was rising dramatically. Herds of bison meant less room for cattle, and less grass for them to eat.

Compared to cattle, bison were not a practical means of converting grass to meat. This was not because the meat was unpalatable. Railroad crews depended heavily on bison for their sustenance, and early residents of forts often engaged in meat trade with Indians. The major problems with bison had to do with production—they are difficult to confine, difficult to raise, and difficult to bring to market.

Bison cannot be gathered and trailed like cattle. "Bison is nothing at all like a cow critter," as one participant in a 1906 roundup put it. "A bison ain't afraid of nothing and don't stick with the herd like a cow will." Ten cowboys could easily trail 3,000 head of cattle. But ten cowboys could hardy herd ten bison to a common point.

Indeed, bison are one of the large animal species that Jared Diamond, author of *Guns, Germs, and Steel*, lists as incapable of domestication. One bison historian reports that, even when raised from calves and gentled over a long period of time, "they have almost always sooner or later turned on their trainers, and some of these later have been killed by them." When Michel Pablo, who owned 800 bison on the Flathead Reservation, contracted to sell his herd to the Canadian government in 1906, it took five years of intense effort to get the bison captured and transported.

Because of these challenges, bison had to be killed on-site, dressed, loaded onto wagons, and then moved to a railhead. After 1872, refrigerated cars were available, so

it would have been possible to slaughter bison and move them by wagon to the railroad, where they could be transported to eastern markets. But the cost was prohibitive. As economist John Hanner describes, "Even in cold weather when meat could easily be saved, overland carriage across the plains was so demanding of time and effort that only bison killed within a short distance of a rail depot were normally butchered." In contrast, cattle could be trailed directly to a railhead, so moving a cattle herd was much cheaper than transporting bison.

At the time, based on my estimates, hauling one ton of bison carcasses a mile toward a railhead cost approximately 30 cents. Trailing cattle to a rail line, on the other hand, cost less than two cents per ton-mile. Given such a large difference in costs, it is not surprising that ranchers were loathe to even consider bison as a viable alternative to cattle production on the plains.

Transporting cattle had yet another advantage: They could be moved live to a slaughterhouse, eliminating any danger of spoilage. In contrast, bison could be transported only in the wintertime, by refrigerated car, or after preservation, as with the pickling of tongues. Each of these were much higher-cost alternatives than delivering cattle to market.

The hide market, therefore, performed a useful function for cattle ranchers arriving on the scene. Because hides were valuable, at least some economic gain could be captured by the slaughter of the bison. In the absence of the hide market, bison would have, in all likelihood, simply been killed and left to rot.

Almost as quickly as bison were removed from the plains, cattle began to flourish. "In 1880, no one had ever heard tell of a cowboy in 'this niche of the woods,'" wrote Granville Stuart, "but in the fall of 1883, there were 600,000 head of cattle on the range." Hanner estimates that by 1890 there were more cattle on the High Plains than there had been bison 20 years prior.

BISON TODAY

But what about other values? Didn't the simple value of their existence mean that killing several million bison represented a tragedy?

It is difficult to calculate how many bison it would take to satisfy the non-commercial demand for them. But it is clear that once bison numbers dwindled to a small amount, entrepreneurs recognized that each additional bison became more valuable and took steps to preserve them.

In the winter of 1872-1873, a Pend d'Orielle Indian captured eight orphaned bison calves. By 1884, his herd had grown to 13 head, and he later sold them to Charles P. Allard and Michel Pablo. The purchase price showed how much the value of bison had risen—$154 per head, at a time when cattle went for just $25 per head. The bison were run on the Flathead Reservation in northwestern Montana and grew to 300 head by 1896. When Allard died, his share of the herd was sold to several buyers, but Pablo kept his herd intact. In 1906, Pablo tried to sell his herd to the U.S. government but was unsatisfied with the price offered. He later sold the herd to the Canadian government for $200 a head.

Once the bison's value as an ecological curiosity increased, efforts to preserve the species became successful. Today, there are numerous bison ranches, some of which produce bison for the meat market. Herds also live on public preserves such as Custer State Park in South Dakota, Yellowstone National Park, and the National Bison Range in Montana. The National Bison Association reports that there are 450,000 bison in North America, with about 220,000 of those in the United States. Approximately 90 percent of U.S. bison are in private hands, with the remainder in public parks and preserves.

The story of the American bison is one of rational individuals operating under an institutional framework that did not necessarily create a tragedy of the commons. It is true that property rights were not well defined and established for bison on the open prairies, but since they were not viewed as a valuable resource at the time, people put little effort into establishing rights in the first place. Even if there would have been well-defined and enforced property rights to bison, it is likely that cattle would still have replaced them as the primary converter of grass on the Great Plains.

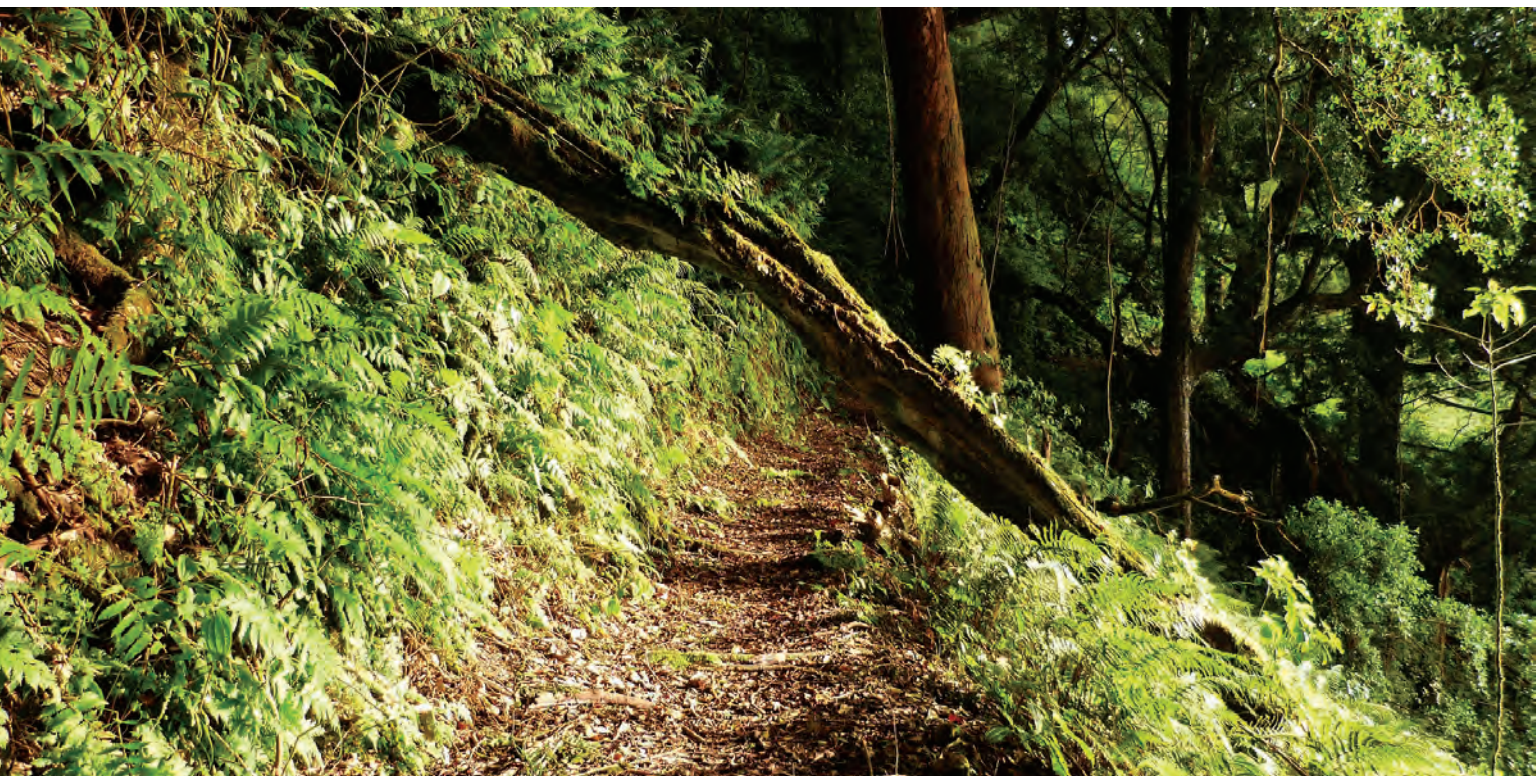
The shift from bison to cattle may not have been perfect, but there is not evidence of large-scale resource waste, as some claim. When bison became more valuable as they came close to extermination, and as new amenity values emerged, entrepreneurs did exactly what you would expect them to do: They established rights to the animals and prevented their demise. Today, thanks to these private individuals, hundreds of thousands of bison thrive once again in the United States—this time with the prestige of being our national mammal.

P.J. Hill is a senior fellow at PERC and professor emeritus of economics at Wheaton College in Illinois. His article "Are All Commons Tragedies? The Case of Bison in the Nineteenth Century" was recently published in *The Independent Review*.

Are Ecosystems Self-Organizing?

A species walks into a bar...

BY MARK SAGOFF



Once "entirely destitute of trees," according to Charles Darwin, Ascension Island has become richly vegetated and produced a cloud rainforest as humans introduced plants from all across the world. *Photo © Ascension Island Government.*

Ecosystems self-organize. At least that's what ecological theory often assumes. Simon Levin, a prominent theoretical ecologist, refers to ecosystems as "prototypical examples of complex adaptive systems, in which patterns at higher levels emerge from localized interactions and selection processes acting at lower levels." Ecologists Eric Schneider and James Kay agree. "We must always remember that left alone, living systems are self-organizing; that is, they will look after themselves," they write. "Our responsibility is not to interfere with this self-organizing process."

A widely used textbook on ecological modeling reiterates this assumption, stating that "evolution has created very complex ecosystems with many feedback mechanisms, regulations, and interactions." Because of these processes "of coordinated evolution... rules and principles have been imposed for cooperation among the biological components. These rules and principles are the governing laws of ecosystems."

The problem is that none of this makes sense. In saying this, I do not mean to refer simply to a vast literature that debates whether ecological theory has established general

rules, principles, and even unifying concepts. Instead, I mean to ask how someone would test whether a given ecosystem is self-organized. I do not think it can be done.

Ecosystems, according to Levin, "self-assemble from components shaped by evolution, and self-organize as those components reproduce and express phenotypic plasticity," that is, express new traits in response to environmental conditions. Even if this is true, could an ecologist tell by observation or experiment whether a specific site represents 1) a self-assembled ecosystem shaped by evolution or 2) a collection of species that happen to occur together at a time and place each there for its own reasons? These sites have different kinds of natural histories, but do they have different kinds of ecological properties?

To see the problem, assume that only heirloom sites in which many or most species share a co-evolutionary history possess the characteristics of self-organized ecosystems. Let us also assume that hodgepodge sites—those that are filled with introduced species that share no evolutionary history—lack these kinds of characteristics.

Ascension Island in the middle of the Atlantic near the equator, which Charles Darwin described in 1839 as "entirely destitute of trees," became richly vegetated and produced a cloud rainforest over the next century because of plants people brought there from the four corners of the Earth. If there were a difference in the ways in which heirloom and hodgepodge ecosystems behave or are organized, an ecologist should be able to tell that the Ascension Island cloud forest is a novel, man-made ecosystem and not a co-evolved, self-assembled one. But ecologists cannot do this. The only way ecologists can tell that a site is a self-organized ecosystem rather than a hodgepodge of species that happen to occur together is to determine or to assume that the site has a certain kind of history, and then conclude that it therefore has a certain kind of organization. The inference is conceptual, not empirical, and it is based on the presumed history of a place and not on its present characteristics.

Other than by documenting the history of a site, ecologists apparently have no way to tell whether an ecosystem represents an ancient, co-evolved community or an agglomeration of colonizing species brought together as the result of human activity. If ecologists cannot tell by observation or experiment which ecosystems are co-evolved and which are novel, or which species are old-timers and which are newcomers, then how do they know which, if any, are self-organized? Self-organization is not an observed empirical property of an ecosystem but an inference based on an assumption, which may or may not be true, about how it was produced.

If ecologists cannot tell by observation which ecosystems are co-evolved and which are novel, then how do they know which are self-organized?

One ecologist, Dana Phillips, likens the species that co-occur at a certain place and time to people at a crowded bar. "Like strangers in a bar," he writes, "they were there at the same time, but they weren't really there *together*." There are often couples and sometimes small groups. But most arrive and leave at different times, and many ignore each other altogether.

Ecologist Daniel Simberloff has described a "long-standing controversy" among ecologists "over whether a plant community is anything other than the assemblage of populations co-occurring in a specific place at a specific time: that is, to what extent are communities integrated, discrete entities, and, if they are, what is the nature of the integration?" Historically inappropriate hodgepodge ecosystems and historically correct heirloom ecosystems seem to be equally self-assembled or integrated—which may be not at all. There is no way to tell, other than by knowing their history, which is which.

Mark Sagoff is Senior Fellow at the Institute for Philosophy and Public Policy at George Mason University in Fairfax, Virginia, and author of *The Economy of the Earth*, 2nd Edition (Cambridge University Press, 2008) and *Price, Principle, and the Environment* (Cambridge University Press, 2004).

by Wendy Purnell

Life in the Plasticene

Crowdsourcing data to remove plastic from waterways—and (one day) earn a profit.

"There's a great future in plastics. Think about it." Mr. McGuire's career advice to Dustin Hoffman's character in the 1967 film *The Graduate* was spot on. By 2007, the average American was purchasing more than 220 pounds of plastic each year.

Invented to replace natural occurring substances like ivory and rubber, plastic might once have been seen as a means of relying less on nature for material goods. Now plastic is considered one of the worst offenders among pollutants in waterways. It's so pervasive that some scientists briefly flirted with the notion of the Plasticene era, imagining future geologists unearthing evidence of an age dominated by the presence of plastics.

Those who have participated in beach clean-ups are acutely aware of the pervasiveness of plastics. Frustrated by floating plastic debris, a group of surfers, swimmers, and marine conservationists came up with a plan to crowdsource pollution data and identify hot spots. Launched in April, the Global Ocean Alert System geotags floating debris, maps pollution, and helps prioritize clean ups.

The idea is for plastic recyclers to use the data to determine profitable locations to drop booms in waterways and harvest plastic before it makes its way to sea. With oil prices down, recycled plastic can't compete with new plastic, so we are unlikely to see thousands of booms drop soon.

But the technology is ready. In Baltimore's Inner Harbor, a floating installation known as Mr. Trash Wheel uses good old-fashioned riverboat technology to scoop up floating debris and drop it on a dumpster barge. Since May 2014, Mr. Trash Wheel has prevented 257,070 plastic bottles and 173,600 plastic bags from reaching the Chesapeake Bay.

In Guatemala, AGEXPORT collects plastic from landfills and industries and then recycles it at a profit. The group is currently developing a new source in the Lake Amatitlan basin, where two million residents produce 1,800 tons of solid waste per day. In the future, they hope to also harvest debris from the Motagua river delta, stopping plastic before it reaches the Atlantic. So perhaps there is a great future in plastics after all.

Mr. Trash Wheel scoops up floating debris in Baltimore's Inner Harbor. To geotag litter in your local waterway or download the Global Ocean Alert app, visit **GlobalAlert.org.**

Fighting Fire with Fire

Innovative financial tools allow land managers to address wildfire risk.

© Samuel Roberts Noble Foundation

Humans have used fire to shape the environment for millennia. Around the world, fire is an important tool for managing forests and preparing fields for crops.

Fire also plays an ecological role. Many forests evolved with frequent, low-intensity fires that remove trees damaged by storms or insects. Forest or field, ash from burned vegetation also returns valuable nutrients to the soil.

In the United States, as development creeps into the wildland-urban interface, fire is increasingly seen as a threat. At the same time, drought and decades of fire suppression and reduced timber harvests on public forests have led to a fuel build up that contributes to catastrophic wildfires.

Precisely because humans have managed fire for thousands of years, we know how to mitigate wildfire risk. Prescribed burns are used by ranchers, farmers, and foresters to clear vegetation and create buffer zones to protect property. When a land manager determines there is a fire risk on or adjacent to her property, she can apply for a prescribed burn permit from local or state agencies.

But there's a problem: Landowners are often deterred by the potential cost of a fire that burns out of control. To help Oklahoma landowners manage liability, the Samuel Roberts Noble Foundation teamed up with the Oklahoma Prescribed Burn Association and brokers at the Bramlett Agency to provide prescribed burn insurance. If an insured landowner follows prescribed burn protocols but the fire accidentally spreads, Bramlett will cover the costs of fire damage. By sharing best management practices and pooling risk across the state, prescribed burn insurance is helping landowners reduce fire hazards. The Foundation is also working to make prescribed burn insurance available across the country, but scaling up means navigating legal and regulatory environments that vary by state.

On public lands, the story is similar. Public land agencies often lack funding to conduct prescribed burns or manage for fire. PERC Enviropreneur David Groves has designed an Environmental Impact Bond (EIB) allowing the Forest Service to borrow against future wildlife suppression funds. In a pilot project in California last year, private investors provided capital for restoration practices to make forests more resilient to wildfires. The future of the project is unclear, but given that much of the fire risk in the West comes from public lands, innovative solutions like the EIB are critical.

STAY TUNED for PERC's forthcoming wildfire policy report and Wildfire Solutions Summit on July 22nd in Bozeman by visiting perc.org/wildfire.

Wendy Purnell is PERC's outreach director. Before joining PERC, she organized beach and harbor clean ups in Nicaragua and was a member of the Global Ocean Alert System's advisory committee.

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