RFF 70 | *Celebrating 70 years of Resources for the Future* | NO. 209 | WINTER 2022

Resources

The Legacy Issue

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A Note from RFF's President

70 Years of Resources for the Future

Resources for the Future (RFF) was founded on October 7, 1952. On October 7, 2021, we celebrated our first annual "Founders' Day" as an opportunity to honor our legacy. And this year, we celebrate our 70th anniversary—a milestone achievement for any organization.

Looking back at 70 years of this organization, I'm struck by the agility of RFF in adapting to meet the needs of a given moment. Time and again, we've responded nimbly to meet society's needs, delivering solutions that move decisions in a positive direction, improving the environment, human health, and our broader economic well-being.

I'll give just a couple of examples: RFF scholars Maureen L. Cropper and Wallace E. Oates (who offer their contemporary and historical insights, respectively, in this issue) in 1992 published one of the first surveys of environmental economics research, reflecting on its history and impact. In 1999, former RFF President Paul Portney (featured here in our "Supporter Spotlight" article) authored a formative RFF book about the continued evolution of economic thought on discounting, building on a legacy of RFF contributions to the topic. RFF scholars have engaged in work that addresses resource scarcity, air and water quality, energy markets, outer space and the radio spectrum, waste management, and more. Now and for the foreseeable future, the urgent challenge is climate change.

All in all, RFF has helped solve major environmental and resource challenges, and the classic *Resources* articles in this issue of the magazine demonstrate some of our landmark research. In the pages that follow, you'll find reprints from the *Resources* magazine archive, alongside contemporary reflections on that established work. You'll view various points in our "origin story" and follow along as we learn from our own history.

The next two issues of the magazine will look at the present and future of RFF, celebrating the people of our organization and the challenges we'll tackle in the coming decades. And throughout the year, we will have much to celebrate, and many opportunities to invite you to join us—perhaps even in person.

Thank you for being here with us at this point in RFF's 70 years. Thank you for all that you do in support of RFF. Our work is made possible by each of you who believes that today's environmental challenges require the best independent research and effective, efficient, and equitable solutions to protect the climate, enhance nature, and advance our well-being. I'm optimistic about our collective ability to take truly transformative action.

With high hopes for the near future,

Richard G. Newell
President and CEO, Resources for the Future

Resources

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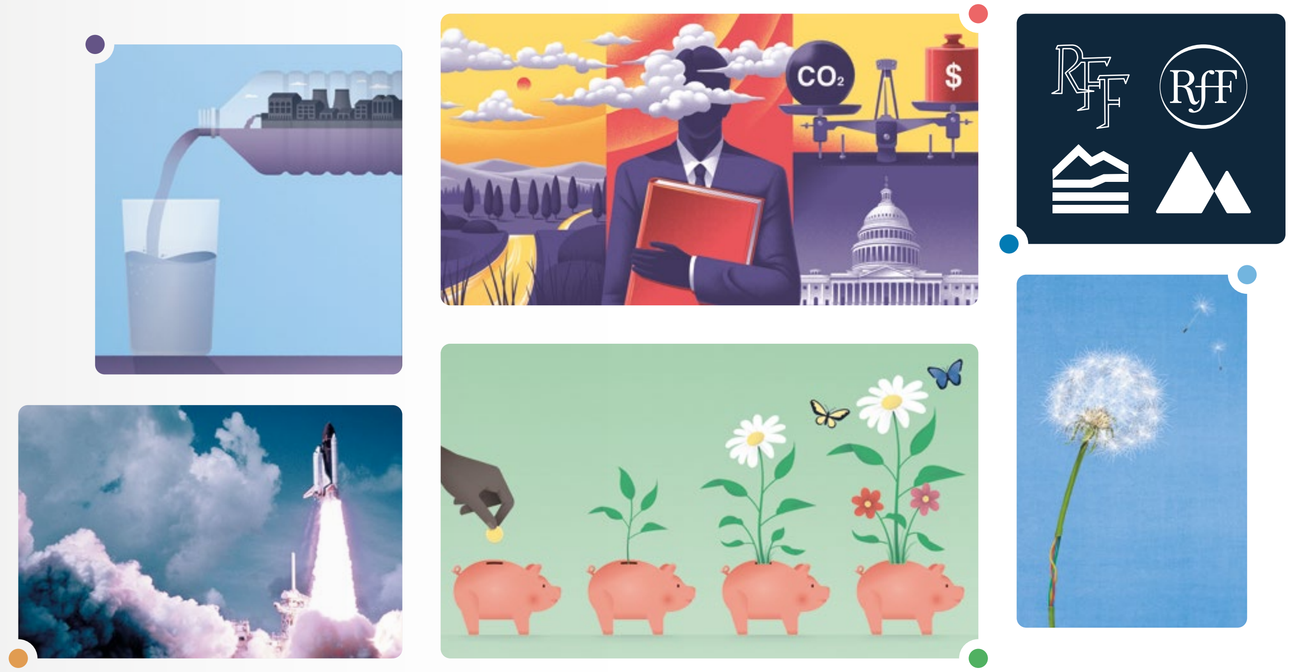

Editor's note: Some grammatical edits and other minor changes may appear in the reprints of these archived articles.

What's Nature Worth?

Using Indicators to Open the Black Box of Ecological Valuation

TEXT James Boyd
ILLUSTRATION James Round

“

Introduction by Raymond J. Kopp

Raymond J. Kopp is a senior fellow and director of the International Climate Policy Initiative and the Comprehensive Climate Strategies Program at Resources for the Future.

Jim Boyd's *Resources* article, more than 15 years deep in the magazine archive, aims to demystify the economic valuation of nature to decisionmakers—an ongoing task at Resources for the Future. To many, the question posed by the article's title, "What's Nature Worth," is meaningless. Surely it is the case that the air we breathe and the water we drink are priceless; life on planet Earth could not exist without these natural assets. No economist would argue with that line of reasoning. However, the question Jim poses is not directed at the value of air or water, but rather about the value of a small change in the quality or quantity of air and water. Jim describes these marginal changes in terms of changes to the services that natural assets provide. Marginal improvements in these services are the products of environmental decisionmaking, and the flows of these services determine the efficacy of environmental policies.

Economists face another challenge in communicating the notion of natural asset value. To the economist, value has a very particular meaning and is defined and measured only in terms of humans, i.e., from an anthropocentric perspective. At this point, the economist's definition of value comes in stark contrast to that of many conservationists who argue for the intrinsic value of natural assets; for example, Anne W. Rea and Wayne R. Munns Jr. say in their 2017 article, "intrinsic value reflects the perspective that nature has value in its own right, independent of human uses"—an ecocentric perspective. Economists are agnostic with respect to intrinsic value; it is a concept that simply cannot be measured by economic tools and analysis. ■

What is the value of nature? This difficult question has motivated much of the work done at Resources for the Future (RFF). If it seems odd that such a question could occupy an institution for half a century, consider both the importance and difficulty of the challenge. Nature and the services it provides are significant contributors to human well-being, and society makes decisions every day about whether we will have more or less of it. Knowing nature's value helps us make those decisions. The difficulty is that nature never comes with a convenient price tag attached. Ecosystems aren't automobiles, in other words. They *are* like factories, however. They make beauty, clean air, and clean water, and they feed and house species that are commercially, recreationally, and aesthetically important.

Over the past decades, economic approaches to the "value of nature" question have become ever more sophisticated and accurate. This sophistication has a downside, however: noneconomists rarely understand how estimates are derived and frequently distrust the answers given. To noneconomists, environmental economics presents a set of black boxes, out of which emerges the "value of nature," such as a statement that "a beautiful beach provides $1 million in annual recreation benefits" or "wetlands are worth $125 an acre."

How do economists arrive at such conclusions? For one thing, they examine the choices people make in the real world that are related to nature and infer value from those decisions. For instance, how much more do people spend to live in a scenic area as opposed to a less attractive one? How much time and money do they spend getting to a park or beach? The translation of such real-world choices into a dollar-benefit estimate is complicated and requires the use of sophisticated statistical techniques and economic theory.

Problems

Economic valuation is met with skepticism, in part because of the "black boxes" that are used by environmental economists—"black box" being useful shorthand for statistical or theoretical methods that require math or significant data manipulation, the stock-in-trade for economists and some ecologists.

FROM ISSUE 154 · PUBLISHED 2004

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The technical and opaque nature of economic valuation techniques creates a gulf between environmental economists and decisionmakers that fosters distrust.

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The technical and opaque nature of economic valuation techniques creates a gulf between environmental economists and decisionmakers that fosters distrust. Such studies can also be quite expensive and demand the expertise of a relatively small number of economists trained in ecological valuation. The complexity of the studies undermines the ability of economists to contribute—as they should—to the analysis of priorities, trade-offs, and effective ecological management.

Another criticism of economic valuation is that values are "created" through political and other social processes and are not something that can be simply measured or derived by "objective" experts. Technical analysis—the black box—fosters this criticism because it produces results that can be interpreted and evaluated only by an elite cadre of experts.

Opening the Black Box

RFF's mission is not only to advance the methodology of environmental economics and other disciplines but also to ensure that its technical research affects policymaking. RFF researchers continue to push the scientific frontiers of ecological valuation and always will. But an additional task is increasingly necessary: communicating to decisionmakers what we as economists and scientists already know and agree upon. As a group, environmental economists need to improve the ways in which they communicate the value of nature.

Unfortunately, better communication involves removing (or at least de-emphasizing) much of the technical content of economic methodology. We economists hate doing this. After all, much of the truth may be lost if the discipline of technical economic analysis is removed. But much of the truth is also lost when economists deliver answers that are not trusted or understood by the real-world audiences we must reach.

Here, I will talk about a method designed to make ecological valuation more intuitive and thereby address some of the criticisms of economic valuation. Working with colleagues at the University of Maryland Center for Environmental Science, we are studying environmental benefit indicators, which are a quantitative, but not monetary, approach to the assessment of habitats and land uses. Environmental benefit indicators strip environmental valuation of much of its technical content, but do so to reach a much wider audience and convey economic reasoning as it is applied to nature. Like purely ecological indicators, environmental benefit indicators summarize and quantify a lot of complex information. And like monetary assessment, environmental benefit indicators employ the principles of economic analysis. Our argument is that indicators can help noneconomists think about trade-offs.

We also believe that indicators can improve the way economists communicate ecological benefits and trade-offs. But it should be emphasized that we do not see indicators as a way to simplify assessment. The value of nature is inherently complex; rarely is there a clear-cut, "right" answer to questions such as which ecosystem is most valuable or which ecosystem service provided by a given habitat is most important.

What Are Indicators?

At the simplest level, indicators can be the number of individuals in a biological community or species present in a habitat. They may also be a measure of the number of days a piece of land is underwater or the presence of nearby invasive species that may threaten an ecosystem. These indicators tell us something about the health of a species or ecosystem.

Organized around basic environmental and economic principles, benefit indicators are a way to illustrate the value of nature. A collection of individual indicators about a given ecosystem can capture the complex relationships among habitats, species, land uses, and human activities, resulting in a more comprehensive picture. Regulators could use indicators to identify locations for ecological restoration that will yield large social benefits, and land trusts could use indicators to identify socially valuable lands for protection. Other applications include the evaluation of damages from oil spills or environmental impact studies.

The techniques we are developing will be relatively affordable and easy to use. Dozens of the indicators we have been collecting are readily available in geospatial data formats. States, agencies, and regional planning institutions increasingly have high-resolution, comprehensive data on land cover and land use, built infrastructure, population and demographics, topography, species, and other data useful for the assessment of benefits.

What Matters the Most?

Indicators should act as legitimate proxies for what we really care about: the value of an ecosystem service. For example, wetlands can improve overall water quality by removing pollutants from groundwater and surface water. This service is valuable, but just how valuable? To answer this question, we can count a variety of things, such as the number of people who drink from wells attached to the same aquifer as the wetland. The more people who drink the water that's protected by the wetland, the greater the value of the wetland.

But other things matter, as well. For example, is that wetland the only one providing this service, or are others contributing to the aquifer's quality? The more scarce the wetland, the more valuable it will tend to be. There may also be substitutes for wetland water-quality services provided by other land-cover types such as forests or by human-made filtration systems. Mapping and counting the presence of these other features can further refine an understanding of the benefits being provided by a particular wetland. Does mapping and counting these things give us a dollar-based estimate of the wetland's value? No. But it does lead to a more sophisticated, nuanced appreciation of the wetland's value than we would get if we ignored socioeconomic factors and economic principles. Traditional regulatory and ecological ecosystem assessment techniques typically ignore socioeconomic factors, such as the number of people who benefit from an ecological function. And the techniques never include an assessment of concepts like economic scarcity or the presence of substitutes. These omissions highlight the second important function of benefit indicator systems—they can be used to convey basic economic concepts that speak to value.

Ecosystem Services and Economic Principles

Ecologists and economists have identified a wide variety of very important ecological services, including water-quality improvements, flood protection, pollination for fruit trees, recreation, aesthetic enjoyments, and many others. Indicators should be organized around these specific services to help convey a deeper understanding of the service itself. Also, from both an ecological and economic standpoint, services should be analyzed independently. A typical ecosystem will generate multiple services, but not all services should be assessed using the same data or at the same scale.

The analysis of a service's scarcity and the importance of substitutes are important economic concepts that can be conveyed. Another is the role of complementary assets, which is particularly important to the assessment of recreational benefits. Access via trails, roads, and docks is often a necessary—or complementary—condition to the enjoyment of recreational and aesthetic services. These things can also be counted and relate intuitively to value.

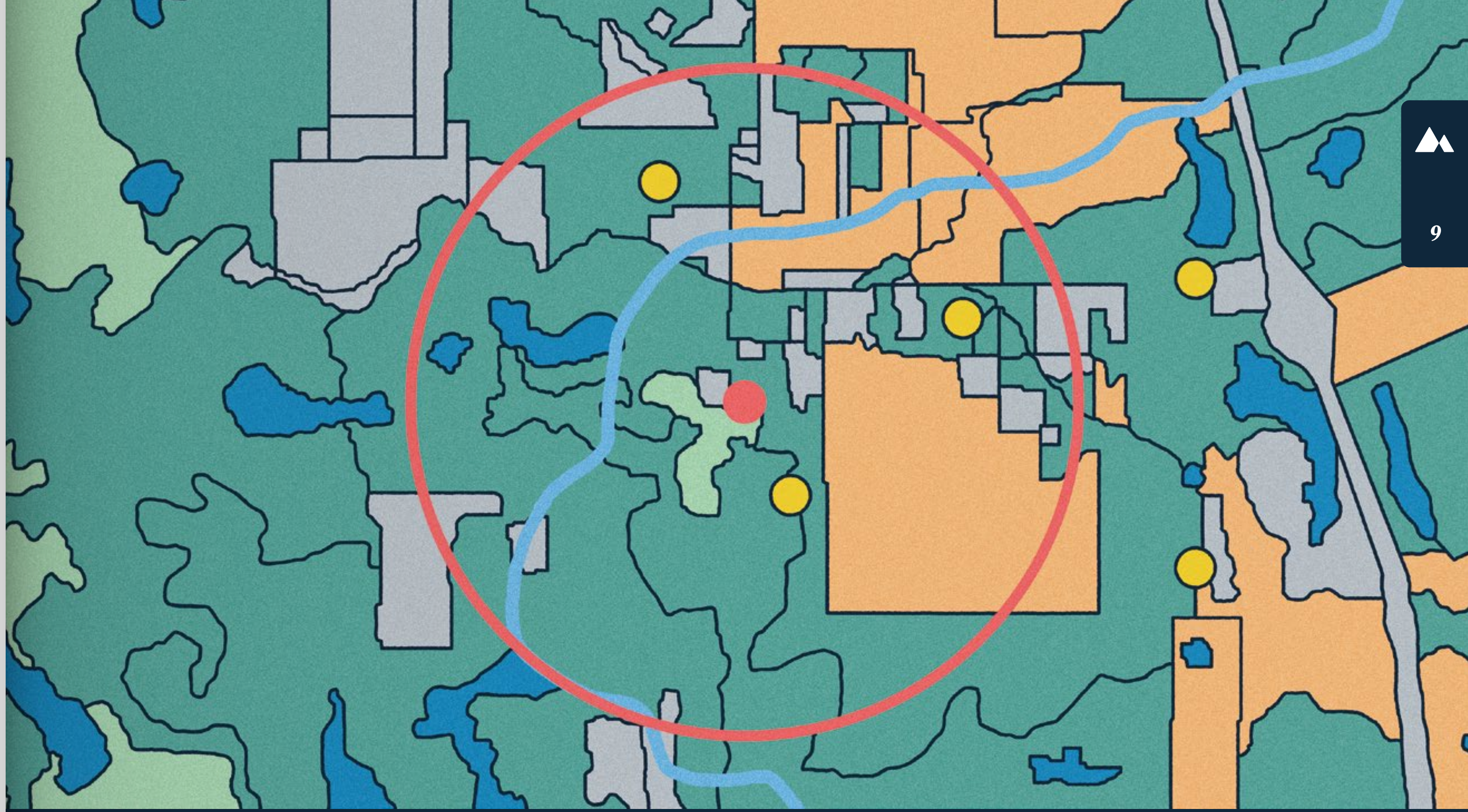
Finally, an indicator system can also feature proxies for risk to an ecosystem service. For example, an ecosystem service may be threatened by an invasive species that can overwhelm more valuable native species—whether by a rise in sea level if the habitat is in a low-lying area, or by human encroachment if the ecosystem is sensitive to the human footprint. To foster a disciplined communication of results, we are developing indicators for demand, scarcity, substitutes, complementary assets, and risks that are specific to particular services.

The Importance of Landscape and Scale

Ecology emphasizes the importance of habitat connectivity and contiguity (or proximity) to the productivity and quality of that habitat. Terms like connectivity and contiguity are inherently spatial and refer to the overall pattern of land uses, surface waters, and topographic characteristics in a given region. Species interdependence and the need

The figure on the right is rendered from the original image, first published in 2004.

> "To foster a disciplined communication of results, we are developing indicators for demand, scarcity, substitutes, complementary assets, and risks that are specific to particular services."



How Do Environmental Benefit Indicators Work?

- Impervious
- Agriculture
- Forest
- Water
- Wetlands
- Well
- Study Area Boundary
- Aquifer Boundary

This map illustrates how a wetland can contribute to drinking water quality. The wetland in question is hydrologically connected to nearby drinking wells. It is also in an area where wetlands are scarce and where water quality may be impaired by agricultural activity.

Environmental benefit indicators (EBIs) are a way to illustrate the value of nature in a specific setting. An individual EBI might be the presence of invasive species or the number of acres under active cultivation. A collection of indicators about a given area can portray the complex relationships among habitats, species, land uses, and human activities. EBIs are drawn mainly from geospatial data, including satellite imagery. Data can come from state, county, and regional growth; land use or transportation plans; federal and state environmental agencies; private conservancies and nonprofits; and the US Census.

Regulators and planners can use EBIs to address specific questions, such as which wetland site, among many, is the most valuable? Coming up with an effective answer requires looking at many factors: on-site characteristics, such as the type of wetland; off-site characteristics, including the presence of wetlands in the larger area; and socioeconomic indicators, such as the number of people who depend on wells in the area for their drinking water.

The map above graphically portrays how these types of factors may relate to one another in the target area. One of the great virtues of this approach is that unforeseen relationships—such as the amount of *A* in relation to *B*—is quickly made apparent.

> Instead of burying the principles of economics in their methodology, economists need to better communicate those principles in ways that resonate with 'normal' people.

IMAGE (LEFT)
A man hikes between giant sequoia trees in Three Rivers, California.

Jordan Siemens / Getty Images

James Boyd *is a senior fellow; the Thomas Klutznick Chair in Environmental Policy; and the director of the Land Use, Forestry, and Agriculture Program at Resources for the Future.*

for migratory pathways are additional sources of "spatial" phenomena in ecology. The health of an ecosystem cannot be assessed without an understanding of its surroundings.

From an economic standpoint, ecosystem benefits depend on the landscape for an additional reason: because the social and economic landscape affects the value of nature. Where you live, work, travel, and play all affect the value of a particular natural setting. And the consumption of services often occurs over a large scale; examples include recreation and commercial harvests of fish or game, water purification, flood damage reduction, crop pollination, and aesthetic enjoyment.

To ignore or minimize the importance of off-site factors misses much that is central to a complete valuation of benefits. How scarce is the service? What complementary assets, such as trails or docks, exist in the surrounding landscape that enhance the value of a service? These questions relate to the overall landscape setting and are, accordingly, spatial in nature.

What the Audience Wants

Some audiences who are interested in the value of ecosystems crave the answer that's typically provided by economists: a dollar value. Government agencies are regularly called upon to demonstrate the social value of programs, plans, and rules they oversee. Generally speaking, the higher the level of government, the more demand there is for a bottom-line dollar figure for the costs and benefits of regulations. Such results allow politicians and high-level bureaucrats to wrap themselves in a cloak of legitimacy and objectivity.

Less cynically, putting things in dollar terms makes it easier to analyze trade-offs. The dollar benefit of program *A* can be directly compared to the dollar benefit of program *B*. Assuming the dollar figures are correct, we know which program is better, and this is why economists prefer this approach. Only by expressing benefits in a consistent framework can the apples of ecological protection be compared to the oranges of alternative actions.

Conclusion

Environmental economists need to better communicate trade-offs and the value of nature in a way that educates and confers legitimacy on their own economic arguments. Environmental benefit indicators are an underutilized way to do this. Because indicators avoid technical complexity and the expression of value in dollar terms, however, too many economists reflexively dismiss their value. But the alternative—formal econometric benefit analysis—is unlikely to ever generate results that are holistic enough, transparent enough, credible enough, and cheap enough to get widespread practical use. Scientifically sound, econometric analysis should continue to be conducted, of course. But agencies and planners should know that there are alternatives.

Instead of burying the principles of economics in their methodology, economists need to better communicate those principles in ways that resonate with "normal" people. Benefit indicators can help do this by concretely and quantitatively illustrating the relationships that are important to economic analysis. Communicating even a qualitative understanding of economic principles and relationships would be a huge advance for economic thinking in regulatory decision contexts.

Indicators can also be used to track the performance of environmental programs, regulations, and agencies over time—something that gets surprisingly little attention from environmental agencies or economists. To do so would require consistent and large expenditures of time, money, and expertise. But instead of trying to calculate the dollar benefit of a regulatory program over time, agencies could more easily measure things like the number of people who benefit from the ecosystem services that are protected by the programs. This type of measurement doesn't yield a dollar benefit, but it does yield an intuitive number that conveys valuable information.

Given these benefits, indicators are underutilized in local, regional, and executive-level environmental decisionmaking. ■

IMAGE (RIGHT)
A scenic road in Olympic National Park, Washington State.

Carmen Martínez Torrón / Getty Images

Introduction by Ann M. Bartuska

In his 1967 article from the *Resources* archive, John Krutilla poses some key questions regarding whose voice should be heard in land management decisions and how much weight these voices should carry. This issue has continued to be refined through administrative direction, as well as in court decisions, driven in large part by the public notice and comment provisions of the National Environmental Policy Act. One of the challenging aspects of public engagement that carries Krutilla's thinking further is the question of whose voice carries more weight—that of someone from the local community who uses the resource, or that of someone 2,000 miles away who values just the knowledge that public lands exist in their natural state? As scientists and policymakers have better understood that these are functioning ecosystems, with interconnections among all components (i.e., plants, animals, water, soil, and humans), we are asking who speaks for nature and the intrinsic value of natural systems. ■

Ann M. Bartuska is a senior advisor at Resources for the Future.

Backwoods Economics

TEXT John V. Krutilla

Large and in many cases irreversible changes in the American landscape and its plants and animals have taken place in the process of wrestling a modern industrial society from the wilderness. And there are reasons to fear that additional and unnecessary degradation of natural environments may continue. Public action to preserve places of extraordinary scenic beauty can in itself raise problems which neither the market nor the government is equipped to handle adequately.

When an agency of the public undertakes to resolve conflicting interests, a decision favoring the predominant viewpoint is often regarded as necessary, since it reflects the principle of majority rule. But when improvement in the allocation of resources is at stake, to follow the preference of the majority can sometimes lead to an uneconomic allocation not justified by the original purpose of public intervention.

An economic allocation would require provision to be made for the entire spectrum of individual tastes in proportion not only to their representation in the population but also to the intensity with which they are experienced. That even an exclusive taste may be gratified in the private sector is clearly shown by the existence of custom shops and individual services of all kinds. Why, then, should a public agency, confronted with a choice between providing a good or service that appeals to many or an alternative that pleases a small minority, necessarily choose what is favored by the many? Taken to a logical conclusion, if such decisions come up *one at a time*, and if each decision favoring the commonly held preference preempts one of the remaining opportunities for indulging an esoteric taste, in due course all of the resources or configuration of landforms and biota considered by many to offer unique experiences will have been extinguished, one by one.

Since the government is deeply in the resources field and to a large extent dominates the remaining wildlands, much of the grand panoramic landscapes, and all navigable streams, allocative machinery is required if we wish to safeguard rare natural environments.

It is not merely a question of, say, adjusting the margins between hydropower production and more water-based recreation. Catering to the mass demand for lakes for swimming, boating, and water skiing is not enough. Provision should also be made for those who prefer to canoe in whitewater or fish in free-flowing streams.

I can visualize an explicit policy to ensure that the dominant tastes are indulged only in proportion to their representation, while the minority tastes are accommodated in proportion to their representation, taking into account also the intensity of the demand as well as the number of individuals nurturing each. This will require viewing resource configurations as parts or systems, not as individual cases, with an appropriate allocation of resources within the system to accommodate the widest range of demands in proportion to their representation. ■

When this article was first published, **John V. Krutilla** *was a senior research associate at Resources for the Future.*

Air Quality and Electricity

What Competition May Mean

TEXT
Dallas Burtraw, Alan J. Krupnick, and Karen L. Palmer

ILLUSTRATION
Andrea Ucini

FROM ISSUE 123 · 70 · PUBLISHED 1996

Although the likely breakup of the US electricity industry is heralded as an economic boon to businesses and consumers alike, the downside to more competition is debatable, especially since the uncertainties involved are many. Whether the air we breathe improves or worsens will depend on choices that consumers, producers, and policymakers have yet to make. Economic analysis of alternative regulatory options offers insights into what could happen.

For a number of reasons, including advances in technology favoring smaller-sized power plants, the natural monopoly status of electricity generation is coming to an end in the United States. In the next ten years, most analysts anticipate, the generation component of the industry will open up to competition. As a result, different approaches to the regulation of transmission and distribution will also have to be found.

The move away from tightly regulated electricity generation promises efficiencies that will benefit consumers, whose energy prices should be lower and whose array of options should expand to include, for example, time-of-day pricing and interruptible service.

Yet, other considerations besides efficiency enter into the thinking of policymakers as they decide what form a restructured and more competitive industry should take. One of these considerations is the need for environmental protection. From the standpoint of society as a whole, the benefits of increased market competition could be a bad bargain unless air quality is maintained at current or improved levels.

> **"The move away from tightly regulated electricity generation promises efficiencies that will benefit consumers."**

Introduction by Karen Palmer

Karen Palmer is a senior fellow and director of the Electric Power Program at Resources for the Future.

In August 1996, RFF Press published the book *A Shock to the System: Restructuring America's Electricity Industry*, a primer that explains how the US electricity system was expected to evolve in the coming decades as competition was introduced in the sector. This essay, printed in *Resources* magazine in the same year, draws from the chapter of the book that looks at the air quality implications of electricity restructuring.

While the essay, in retrospect, is overly optimistic about some of the consequences of electricity restructuring—such as the anticipated increased use of cost-reflective time-varying electricity prices, which failed to materialize—the main message remains true. The environmental consequences of electricity supply in the years after restructuring depended importantly on choices about environmental regulation, energy policy, and new sources of electricity supply, all of which were difficult to predict. In the 25 years since we wrote this article, emissions of criteria pollutants from the electricity sector have declined by 80 to 90 percent, and most of those changes came about due to regulations that were put in place by the US Environmental Protection Agency under the Clean Air Act. Unanticipated declines in the price of natural gas also played an important role; the restructuring likely enabled the industry to take better advantage of this cost trend. As the electricity sector faces its next big transition of substantial decarbonization over the next 15–20 years, policy, market design, and technology will be important. In addition, the choices made by independent actors—including producers, consumers, and new market players such as demand aggregators and smart-device manufacturers—will shape the new transition in similarly unpredictable ways over the coming decades. ■

The electricity industry is and will continue to be subject to numerous federal and state laws, regulations, and initiatives to reduce air pollution and its consequences. What isn't clear yet is whether current environmental policies are likely to be more or less effective when the generation segment of the industry is opened to competition. Nor is it clear how many existing laws and policy initiatives will have to be revamped or replaced. The environmental effects of restructuring ultimately will depend on choices that producers, customers, and especially policymakers have yet to make. As they weigh options, an economic analysis of alternative regulatory approaches—and the likely effects on consumption and investment—offers some insights into what could happen.

Cleaner Air vs. Dirtier

Power plants now produce more than a third of the country's annual nitrogen dioxide (NO_2) and greenhouse gas emissions, and about three-quarters of its sulfur dioxide (SO_2) emissions. These emissions also include the soot, dust, and aerosols that, together with secondary forms of NO_2 and SO_2 emissions, make up particulate matter.

Some analysts have suggested that restructuring the industry could reduce air pollutants and their effects by hastening new investments and growth in the construction and use of new plants that run on cleaner fuel (i.e., natural gas). However, if, as expected, restructuring reduces the price of electricity, an upswing in use is likely. Whether an upswing in use is accompanied by an upswing in emissions depends on the vintage of plants and the type of fuel used to meet the increased demand.

Because new, cleaner plants are not expected to dominate the industry for some time, there is concern about increased use of existing facilities. Such concern is raised most often by states in the Northeast, who fear that more open access to electricity transmission will increase coal-fired generation in the Midwest. These downwind states fear that the added use of coal will cause them to experience higher concentrations of ozone and particulate matter (and more acidic deposition), making it more difficult for them to maintain current ambient air quality levels.

> **"Some analysts have suggested that restructuring the industry could reduce air pollutants and their effects by hastening new investments and growth in the construction and use of new plants that run on cleaner fuel."**

> **"Current incentives to trade allowances are not as strong as they could be, since the states often create disincentives for using utility compliance plans that rely on trading."**

However, the Federal Energy Regulatory Commission (FERC) takes a different view. FERC's recent analysis of its own open transmission access regulation predicts only trivial increases in NO_2 emissions, implying small changes in ozone concentrations and particulates in the northeastern states. Several limitations of this analysis argue for caution in its interpretation, however. For instance, FERC's analysis does not account for changes in prices once access to transmission is more open, nor the effects that changes in prices will have on consumer demand, operation of the electricity system, or new investment in generation and transmission.

Impact on Current Environmental Policies

Whether or not competition in electricity generation markets increases or reduces air pollution, it certainly will affect the many policies that regulators have devised to deal with power plant emissions thus far. Since the passage of the Clean Air Act in 1970, a wide range of federal regulations has been implemented, with a growing reliance on incentive-based methods to force accountability for environmental damage. Competition could give some of these programs the boost they need to succeed in even more significant ways. One example is the US Environmental Protection Agency's SO_2 emission allowance trading program, under which coal-fired electric power plants receive annual allowances for SO_2 emissions, which the plants can transfer to other plants within their own systems, sell to other utilities, or save for later use to meet the annual emissions cap.

Current incentives to trade allowances are not as strong as they could be, since the states often create disincentives for using utility compliance plans that rely on trading. For instance, in every important coal-producing state, regulators reward the use of in-state coal over other "strategies" that may cost less. The incentive to use trading should become stronger in a deregulated market where generators are penalized by the market for incurring unnecessary costs.

On the other hand, industry restructuring will likely weaken policies that state regulators have adopted to factor environmental damage into the cost of doing business, encourage consumers to conserve energy, and promote renewable energy sources. What is broadly described as "social costing" could become one of the casualties.

Social Costing

In use by seven states and under consideration by several others, this type of policy requires utilities to estimate the environmental damage that could result from alternative generating technologies and, for each option evaluated, to incorporate the results into the estimated private cost of producing electricity. The power plants that the utilities invest in (or contract with) must be chosen based in part on the results of this exercise.

Broader access to electricity transmission could undermine state efforts to encourage generators to reflect social costs in investment or operating decisions. And, if competition were to extend to the consumer level, social costing as it is now practiced would become virtually unworkable. Electricity suppliers would be able to bypass social costing regulations by operating as independent generators and by marketing power directly to large customers or to power aggregators, who would then contract directly with electricity consumers.

In the short run, the demise of social costing would be of little consequence. The emission rates of new facilities are relatively low, so social costing programs have had minor impacts on investment decisions for new plants. Over time, however, social costing programs could take into account a broader range of factors in estimating the environmental damage of producing electricity. Many analysts, including researchers at Resources for the Future (RFF), envision extending social costing beyond investment considerations to encompass the operation of existing facilities, which often have emission rates that are several times higher than new plants.

What analysts hope is that, if social costing were to become more comprehensive, utilities could make business decisions that would lead to dramatic environmental gains at relatively low costs. For instance, suppliers could switch from

> Little doubt exists that renewable energy sources like hydroelectric, wind, solar, geothermal, and combustible resources will suffer in an environment where the cost of generating electricity is expected to fall.

IMAGE (LEFT)
Power lines in San Bernardino, California.

Bill Stevenson / Getty Images

When this article was first published, **Alan J. Krupnick** *was a senior fellow and* **Dallas Burtraw** *and* **Karen L. Palmer** *were fellows at Resources for the Future.*

Currently, Alan Krupnick is a senior fellow and director of the Industry and Fuels Program, Dallas Burtraw is the Darius Gaskins Senior Fellow, and Karen Palmer is a senior fellow and director of the Electric Power Program at Resources for the Future.

one generating technology to another, depending on the effect of prevailing atmospheric conditions. (They could use older, dirtier plants when breezy conditions would disperse emissions, and clean but expensive new plants when temperature inversions would create stagnant air.) Regulators will have opportunities to incorporate a broadened application of social costing into the workings of the new institutions that will arise to regulate transmission and distribution.

Alternatively, imposing a tax on emissions throughout the economy could make the cost of environmental damage part of the cost of doing business. Some experts consider this approach superior because no distortions would arise between the prices of electricity and other forms of energy.

Conservation Programs

Despite skepticism about the overall effectiveness of so-called "demand-side management" programs for consumers (e.g., free energy audits or subsidies to purchase energy-efficient heating and air conditioning systems), many states insist they be maintained as restructuring moves forward.

Yet, how such conservation programs can be funded in a restructured industry is open to question. States may find it unfair to continue to impose the costs of such programs on incumbent utilities in a competitive environment. To do so may make such utilities less competitive because of the offsetting prices they have to charge for transmission or distribution.

One way around this difficulty might be to enhance the ability of electricity suppliers to base their prices on time-of-demand and power load conditions, thus limiting the need for conservation programs. Another way is for states to charge a fee for demand-side management programs, which all generators (or their customers) that connect to the transmission or local distribution grids have to pay. Such a fee would prevent customers from taking their business elsewhere solely to avoid paying for such programs.

Renewables

Little doubt exists that renewable energy sources like hydroelectric, wind, solar, geothermal, and combustible resources will suffer in an environment where the cost of generating electricity is expected to fall. If it does fall, firms that use renewables to produce power may not be able to cover their (generally higher) costs. Moreover, the costs and operating characteristics of renewables often do not compare favorably with those of fossil-fired facilities.

Nevertheless, through proper pricing of electricity transmission, the advantages of using renewables may still be recognized in a restructured industry. For example, industrial and commercial users could take advantage of wind and solar generation, which often are available at times that coincide with periods of peak electricity demand.

Whether concern about pollutants from fossil fuels will stimulate policies to increase the use of renewables is likely to depend on concern about global warming. (Renewables emit few, if any, greenhouse gases.) Since any related national policies will take time to shape, expanding and increasing the renewable electricity production and investment tax credits authorized in the 1992 Energy Policy Act may be an appropriate interim way to sustain the development of renewable technologies.

Putting Change in Perspective

Within the larger context of the country's regulatory structure, changes in the electricity industry may have more limited implications for the environment than might be inferred from this article, which merely throws the possible consequences into rough relief. Cities will still have to meet air quality standards, power plants will still be subject to an SO_2 emissions cap, and other policy initiatives for preserving or improving air quality in national parks and rural areas will continue.

As with many issues associated with restructuring, whether society will be the worse off if demand-side management programs and social-costing activities diminish or take on new forms remains a subject for further study. In any case, current state efforts to tilt electric utility investment decisions in favor of the environment have not been widespread nor particularly forceful. If law and public policy do have to be reconfigured, the quality of the environment may actually benefit as a result of the industry's new structure. ■

NO. 209 | WINTER 2022 | *"Things have changed in some quite dramatic ways."*

Forty Years in an Emerging Field

Economics and Environmental Policy in Retrospect

FROM ISSUE 137 · 70 · PUBLISHED 1999

Economics was missing in action during the environmental revolution of the late 1960s, but eventually made its mark on policy. How the discipline became an agent of change in environmental law is a story that isn't over yet.

TEXT
Wallace E. Oates

ILLUSTRATION
Kouzou Sakai

Introduction by Maureen L. Cropper

Maureen L. Cropper is a senior fellow at Resources for the Future.

In 1999, when Wally wrote this article, he was reflecting on the state of environmental economics since the 1960s, when most environmental economists did not have allies among environmentalists, regulators, or corporate leaders. The *Journal of Environmental Economics and Management* had yet to appear, and many environmental economists did not yet recognize the importance of working with legislators and others in government. Wally put forward the idea that, for environmental economists to be effective, they would need to work with policymakers and find out the information that policymakers want. Responsiveness to the needs of policymakers is reflected in the contributions that Resources for the Future (RFF)—and, more broadly, environmental economists—have made since the 1960s.

RFF and its scholars have taken environmental policy seriously for the past 70 years, and we've grown in our contributions—in large part through direct interactions with policymakers. Since Wally wrote this article, RFF has provided insights on carbon taxes, pollution permit markets, and the functioning of electric utilities—all of which policymakers have used to formulate policies. A recent example is RFF's Social Cost of Carbon Initiative, which has advanced the estimation of the social cost of carbon during times when the federal government's focus has been elsewhere. On the related topic of intergenerational discounting, our researchers have worked with federal agencies to help ensure that the discount rate reflects the latest economic research on this issue.

Wally discusses the progress made by environmental economists over the last four decades of the twentieth century. We've advanced even further in the 20 years since his article was first published in *Resources*. RFF has been part of this progress, and RFF will continue to promote economic research that informs policy design. ■

We have seen a remarkable transformation in the role of economics in environmental policymaking over the past three decades. Coming out of the environmental revolution of the 1960s, the early federal legislation—notably the Clean Air Act Amendments of 1970 and the Clean Water Act Amendments of 1972—essentially ignored economics. In the "command-and-control" tradition, this legislation directed environmental agencies to set air and water quality standards with little regard to their economic consequences, and then to issue directives to firms for the control of their waste emissions into the environment, often specifying the technologies that were to be used.

Since those early days, however, things have changed in some quite dramatic ways. To take one example, the US Congress under the 1990 Clean Air Act amendments has adopted a wholly different regulatory strategy to tackle the troubling acid rain problem: a market for tradable sulfur emissions allowances. Sources throughout the nation are buying and selling entitlements to a limited quantity of sulfur discharges into the atmosphere. This approach is achieving our objective of cutting aggregate emissions in half, but it does so in a way that gives emitters discretion to determine their own levels of both emissions and abatement technology.

More generally, benefit-cost analyses of proposed environmental standards have become a routine part of the regulatory process. Although their role in the establishment of regulatory standards is, in some cases, rigidly circumscribed by existing statutes, such benefit-cost studies figure in important ways in the debate over proposed measures (and in ex post reviews of policy, as well).

How has environmental policymaking evolved from a process in which economics had so little relevance into one in which economics plays a significant role? And what did economists have to do with this transformation? These are fascinating questions—if not easy ones—to answer. But let me at least offer some reflections.

Environmental Economics Early On

If we didn't know better, it would be natural to suppose that economics had been important in the design of environmental policy from the outset. After all, economists were, it might seem, well positioned upon the arrival of the environmental revolution. They had a coherent view of the problem of environmental degradation—one that indicated clearly the nature of the "market failure" that takes place when economic agents have free access to our scarce environmental resources. Such free access leads quite naturally to an excessive use of resources, resulting in a polluted environment. Moreover, this view of the environmental problem carries with it a direct policy prescription: government needs to introduce the correct "price" in the form of a tax on polluting waste emissions. Such a tax would represent the surrogate price that would induce polluters to cut back their emissions to the socially desired levels.

This perspective on environmental regulation, developed in the first half of the century by A. C. Pigou and others, was embedded in the academic literature by the time the amendments to the Clean Air and Water Acts were under consideration. Basic textbooks provided a standard description of the smoky factory spewing fumes over nearby residences and went on to prescribe taxes on the emissions of the offending pollutants as a corrective measure.

But this approach was completely ignored in the initial round of environmental legislation, both in the United States and abroad. Why? My answer to this question comes in three parts. First, there was no constituency for whom the economist's view and policy proposal had much appeal. Environmentalists were decidedly hostile. The market system was the reason we had pollution in the first place, they said. The idea of putting a price on the environment was morally repugnant. Moreover, they argued, it wouldn't work: polluters would simply pay the tax and go on polluting. Environmentalists thus flatly rejected an economic approach (as I learned personally and painfully on several occasions) and called for direct controls on polluting activities.

Industry was not very sympathetic, either. The idea of a new tax was, of course, not very appealing. Beyond that, some firms found that environmental controls could actually work to their advantage, because such controls were often much stricter on new industry. Many established firms welcomed the barriers to entry that command-and-control regulation was creating.

> "If we didn't know better, it would be natural to suppose that economics had been important in the design of environmental policy from the outset. After all, economists were, it might seem, well positioned upon the arrival of the environmental revolution."

Finally, the fraternity of regulators was less than enthusiastic about discarding traditional methods of regulatory control for a largely untried system of taxes on pollution. There really was no one to champion the cause of the economic approach to environmental policy.

The second part to my answer turns to the state of environmental economics itself in the late 1960s and early 1970s. Economics had a view of the pollution problem, but it did not go much beyond a general conceptual level. It is a long way from an equation on the blackboard—stating that a tax on each firm's emissions should be set equal to "marginal social damages"—to the design and implementation of a workable system of pollution taxes. And few economists were working on these issues. Today, there exists an active Association of Environmental and Resource Economists with a membership approaching one thousand and with a large and energetic sister organization in Europe. But thirty years ago, only a small number of economists was seriously addressing the hard issues of policy design.

Several of these economists were at Resources for the Future (RFF). Allen Kneese and Blair Bower, for example, published a pathbreaking study of water quality management in 1968 that explored the scientific character of water pollution, studied the actual institutions for regulating water quality, and then turned to the design of a feasible system of fees for the control of waste emissions. But these studies were exceptions. Economists really were not in a position at that time to offer much guidance on the actual design and implementation of systems of environmental taxes.

The third part of my answer (closely related to the second) is the pervasive ignorance of the economic approach to environmental policy outside the economics profession itself. Even as late as 1981, Steven Kelman's survey of the environmental policymaking community turned up virtually no one who could explain even the basic rationale for incentive-based policy measures! Finally, it is probably a fair criticism to say that few of those who *did* understand the power of incentive-based approaches were willing to make the effort to educate legislators, regulators, and their staffs about this radical alternative.

> "The story of the growing role of economics in environmental policymaking is a complicated one, only imperfectly understood."

Economics and the Evolution of Environmental Policy

The story of the growing role of economics in environmental policymaking is a complicated one, only imperfectly understood. Indeed, its chapters contain both serendipitous and more purposeful elements.

One important facet of this story in the United States (but not in Europe) is the emergence of an alternative incentive-based policy instrument. Economists surely knew that, in principle, it is possible to attain the objective of cutting back waste emissions either by a tax or by a system of tradable emissions permits (TEP). It is straightforward to show that emissions can be reduced to the target level either by setting a sufficiently high tax on emissions or by issuing the requisite number of emissions permits and allowing trading activity to establish the market-clearing price. The outcome in the two cases is, in principle, identical.

But in the early dialogue, discussion focused primarily on the tax approach. My recollection is that most of us, in our assessments of the prospects for various policy measures, assumed that the so-called quantity approach involving a TEP system would encounter overwhelming opposition inasmuch as it involved literally putting the environment up for sale. Polluters would buy and sell "rights to pollute." There seemed to be little hope for such an audacious proposal.

We were wrong, of course, partly, I believe, by reason of historical accident and partly because of a failure to understand the political economy of instrument choice. With the prospect of a tumultuous political confrontation in the mid-1970s over nonattainment of clean air goals in many

regions of the country, the US Congress introduced in 1977 a provision for "pollution offsets." Under this provision, new sources of pollution could enter nonattainment areas if existing sources cut back their emissions by more than those of the entrants. Somewhat unwittingly, I suspect, federal legislators had opened the door to what eventually became the Emissions Trading Program, under which the trading of emissions allowances for air pollutants has been taking place in many areas.

TEP systems turn out to have much more appeal than their tax counterpart in the policy arena. Environmentalists are much more sympathetic to them because, by restricting the number of available permits, the environmental authority can directly and unambiguously achieve its objective. Industry is also receptive. Instead of paying a tax, firms typically receive (under some kind of grandfathering provision) a valuable asset: emissions permits, which they can use either to validate their own emissions or sell for a profit. Regulators much prefer TEP systems to taxes. They can achieve their goal simply by issuing the requisite number of permits; they don't have to worry about setting and then adjusting tax rates to induce the needed reductions in pollution. It is interesting

IMAGE (ABOVE)
Margaret Walls presents at an RFF event as Alan Krupnick listens with rapt attention.

Ankers, Anderson & Cutts Photographers

"The evolution of environmental policy is best seen as part of a larger movement for the fundamental reform of regulatory policies, a movement that actively seeks to employ market incentives for social programs."

Wallace E. Oates *was a university fellow at Resources for the Future and a professor of economics at the University of Maryland. He passed away in 2015.*

that the TEP approach has not caught on in Europe; there, the use of incentive-based instruments has primarily taken the form of taxes on pollution.

The work of environmental economists has, I think, been important in this evolution. Ideas can be a powerful force in the policy arena, and economists were able to provide a compelling conceptual rationale for the new tradable-permit approach. In addition, economists carried out a substantial number of careful empirical studies that documented the large cost savings available through the use of incentive-based policy instruments. Over the last thirty years, the educational void has been filled. In response to environmental concerns, courses in environmental economics have sprung up across the country. At the graduate level, the field of "Environmental and Natural Resource Economics" has emerged; PhD students have written dissertations and gone on to teach, carry out research, and take positions in environmental agencies. As mentioned earlier, there now exists a large and energetic organization of environmental economists; the Association of Environmental and Resource Economists has its own journal and holds frequent conferences to help organize research efforts and disseminate the findings. At least as important has been the growing presence of economists in law schools and schools of public policy. Here, many future policymakers have received a firm grounding in the economics of environmental policy.

RFF has played an important role in this evolution. From the beginning, RFF reached the policymaking community not only through research, but through determined and patient efforts to make available and accessible to the general public not only research findings but, more generally, the basic economic principles of policy analysis and design. Indeed, this very publication, *Resources*, has a long history of doing precisely that.

Lest we go overboard with self-congratulation, however, it is important to recognize that there has been a growing receptivity in the Western world to market-based forms of regulation. The advent of Reaganomics in the United States and Thatcherism in Britain signaled the arrival of what John Kay has called a new "faith in market forces." Over this period, we have seen a basic change in the intellectual setting for social and economic policy—one that is at least as concerned with "government failure" as with "market failure." From this perspective, the evolution of environmental policy is best seen as part of a larger movement for the fundamental reform of regulatory policies, a movement that actively seeks to employ market incentives for social programs.

Much Left to Accomplish

The role of economics in environmental policy has clearly come a long way over the past thirty years. Prospective environmental programs are routinely subjected to benefit-cost assessments, and at least some attention is often given to the use of incentive-based instruments for the attainment of our prescribed standards for environmental quality. But this progress should not be exaggerated. Most of our regulatory measures, for example, are still of the command-and-control variety. Often, it is not easy to design a workable and effective incentive-based mechanism. In fact, the design and implementation of such measures for different kinds of environmental problems are real challenges. An especially fascinating and difficult case is how to design a system of tradable carbon allowances on an international scale to address global climate change. This problem is the subject of widespread interest and current research. Meanwhile, plenty of more mundane and localized cases of environmental management need to be addressed. We have a long way to go!

While we economists can take some real satisfaction in our contributions to environmental policymaking, we must retain a certain humility. Benefit-cost analyses are a valuable component of program assessment, but we should never base decisions about environmental standards solely on the bottom line of a benefit-cost study. Likewise, command-and-control programs will continue to be a fundamental part of our regulatory landscape. But even here, there is plenty of room for economic analysis that's aimed at making such command-and-control programs more effective in attaining their environmental targets at relatively low cost. ■

Making a Legacy of Independent and Innovative Research

Resources magazine recently spoke with former RFF President and current University Fellow Paul Portney, who reflected on his time in the RFF family. His wife, Chris Portney, also has been involved at RFF, including five years as a member of the staff. Below are excerpts from the conversation with Paul, covering what's changed over the years, what hasn't, and the couple's longstanding commitment to the organization.

Supporter Spotlight

In this RFF Supporter Spotlight feature, we hear directly from donors about their commitment to issues in climate, energy, and the environment; how they make a difference; and why they support Resources for the Future—all in their own words.

What originally brought you to RFF?

I won a dissertation fellowship from Brookings and came to Washington in 1971. My intention was to go into academia and get a teaching job, but I liked Washington so much that I wanted to find a way to stay. RFF was, at that time, located in the Brookings building, and we shared the cafeteria. One day at lunch, someone from RFF said, "We're looking for somebody to help us on a project. Would you like to spend a year at RFF?" So, I joined in September of 1972—and that one year turned into 33, with the last 10 as RFF's president.

How has RFF evolved since you first became affiliated with the organization?

When I came to RFF, for all intents and purposes, we could have been an economics department at a university, with the goal of just doing research and publishing in journals. Over time, the Board of Directors and several of my predecessors decided that, for the work to have an impact, RFF needed to better communicate results to businesspeople, environmentalists, and particularly policymakers. As president, I asked the staff to think of themselves as faculty members who both published research and taught. But they weren't teaching college students—they were sharing with Hill staffers, people at companies, and people in the environmental advocacy community about how our tools and research could inform the design of energy, environmental, and natural resource policy.

We're now in the 70th year since RFF was established. What do you think the organization's greatest impact has been over its longstanding history?

> "I was lucky to have mentors and friends at RFF who helped shape me."

In the 1970s, RFF researcher Allen Kneese found a way to address pollution without command-and-control regulation, by structuring regulation in a way that creates incentives for people to clean up pollution. During that same decade, John Krutilla said that if you want to turn a mountain into a ski resort, for example, you can't just look at how much money the resort would make—you have to look at the value the land provides as wilderness. Later, RFF researchers developed techniques to put a value on the environment, in part by asking people in surveys how much they would pay to preserve an area. Those accomplishments all have made a big difference in the way people think about and value environmental protection.

You and your wife Chris have been donors to RFF for 20 years now. What keeps you engaged?

I have an emotional answer and a more cerebral one. The emotional answer is that I've stayed connected because RFF gave me a wonderful career. I learned so much from the colleagues I worked with and was lucky to have mentors and friends at RFF who helped shape me. On the cerebral side, it's because RFF researchers can go into a project without needing to arrive at a predetermined conclusion. RFF truly has remained independent and nonpartisan, particularly during a period when nonpartisanship has all but disappeared. I think what I admire most about RFF is the fact that it has strived to remain independent, and I hope it always will.

You and Chris have chosen to make a legacy gift by including RFF in your estate plan. What motivated you to support RFF in this way?

Twenty years ago, RFF was getting ready for its 50th anniversary, and as president of the organization, I was asking for significant contributions. I felt that, if I was going to ask people for big gifts, I ought to make a pledge or donation myself. Over time, Chris and I have been fortunate enough to be in a position to contribute. This type of legacy gift is a way we can give at the end of our lives, even if we haven't necessarily been in a position to make big annual cash gifts *during* our lives. We've just felt a responsibility to do that. ■

Four Ways You Can Support RFF

1 Give through our website

Visit www.rff.org/donate to make a one-time donation, or to set up a monthly recurring donation.

2 Give through the mail

Send your check to Resources for the Future | 1616 P Street NW, Suite 600 | Washington, DC 20036

3 Give through a donor-advised fund

Donate through a DAF account at a community foundation or financial institution to support RFF while receiving favorable tax benefits.

4 Give through a will, trust, or gift plan

Include RFF in your estate plans to provide meaningful, long-lasting support.

Discover other ways to give at www.rff.org/donate/ways-giving or contact Tommy Wrenn at twrenn@rff.org

Our Legacy in Logos

In February 2019, Resources for the Future (RFF) unveiled a new logo—the sixth brand iteration since the institution's founding in 1952. What follows is a brief history of RFF's visual identity.

TEXT
Ross van der Linde

Ross van der Linde *is the vice president for communications at Resources for the Future.*

"When I became RFF's vice president in 1989, I told Bob Fri—the president at the time—that I wanted to change the logo. He let me run with it but made clear to me that if everyone hated it, I would have to take the blame! I remember saying that I wanted something that looked more modern and that conveyed the fact that we're an analytical organization. I thought that what the artist came up with was terrific. It looked like a graph, but conveyed a mountain range, as well. Originally, the uppermost of the two straight lines at the bottom was blue, connoting a river.

Paul Portney
RFF CEO and president, 1995–2005
RFF vice president, 1989–1995

A Half Century of *Resources* Magazine

Over the course of RFF's 70 years, and its six logo iterations, *Resources* magazine also has seen a number of different logotypes appear on its cover. Throughout more than 60 years in print, the magazine's masthead has adapted to reflect changing design trends, moving between a variety of serif and sans serif typefaces. The latest update launched in early 2020, with the use of *Acta Poster*, an attractive serif with heavy letters that feature an elegant flourish on the letter *R*.

1 Starting with Serifs

1952–1961

For its first nine years, RFF's logo featured sharp serifs at discordant angles—a design that would have stood out as much to 1950s audiences as it does to our modern-day sensibilities. RFF's founders might have been inspired by the distinctive 1950s wordmark of the Ford Foundation, whose initial funding was crucial in establishing RFF. Another possibility is that the design was inspired by the ornate typographies of the pre-Raphaelite movement, whose artists attempted (like any good RFF scholar) to capture the natural world with the greatest degree of objectivity.

2 Loopy Lettering

1962–1975

During the 1960s, RFF scholars developed not only new ways of thinking about the environment, but also entirely novel areas of study—including the fields of environmental economics and urban economics. The 1962 revisions to RFF's logo may have reflected the mood of those days—at an institution that was rapidly maturing and consistently producing highly visible and authoritative work. Thus, gone were the harsh and jagged forms, replaced by elegant, looped lettering.

3 Font Futurism

1976–1983

RFF's 1976 logo adopted a strongly geometric typography popularized by European type foundries of the 1960s—showcasing the precision of new printing technologies and symbolizing the emergence of a new technological age. This type of distinctive geometric typography became widely used in the 1960s and 1970s, including in the Star Trek universe. While the font may have reflected a similar spirit of futurism at RFF, the branding was destined to date itself—and indeed, it became the shortest lived of RFF's past emblems.

4 What the Font?

1983–1992

Perhaps the most peculiar evolution of RFF's logo took place in 1983, with the adoption of "Resources for the Future" text that used an ambitious combination of uppercase, lowercase, italicized, and normal lettering. Were the lowercase *e* letters an homage to the *e* words that animate RFF's research: "environment," "energy," the "economy"?

5 Reaching New Peaks

1992–2018

In 1992, RFF adopted its first distinctive "double-mountain" logo. The branding succeeded in combining two key themes in RFF's work—a mountainous skyline depicting the natural world, alongside three lines that might be interpreted as trend lines on a chart. There was much to like about this elegant combination of ideas, and the logo persisted for more than a quarter of a century—rendering it the most durable in the institution's history.

6 Looking Forward

2019–Present

Early 2019 marked the sixth, and current, iteration of RFF's logo. Our goal was to refine the best of RFF's historic brands into a memorable, elegant, and timeless identity. We decided to redeploy the double-mountain design, while smoothing out some of the harsher elements. Inset at the base of the mountains in the new design is a cutout triangle: a placeholder for rivers, transportation networks, energy infrastructure, or other natural and human elements that make up RFF's work.

1950 1960 1970 1980 1990 2000 2010 2020

In Pursuit of a Sustainable Space Environment

Economic Issues in Regulating Space

TEXT Molly K. Macauley PHOTO NASA

Debris resulting from human enterprises in space could seriously hinder space activities in many orbital locations within a few decades. It may be useful to conceptualize management of such debris in terms of sustainable development on Earth. Like a sustainable Earth environment, a sustainable space environment would meet the needs of the present generation without compromising the ability of future generations to meet their own needs.

Accordingly, some debris may be endurable as long as its effect on future generations can be offset. Given that entities engaged in space activities may not be motivated to cover social losses resulting from the proliferation of debris, and that such losses may be much greater than private losses resulting from the collision of spacecraft with debris, regulation of debris-generating activities may be desirable.

In light of uncertainty about the proliferation characteristics of debris and the difficulty of specifying the benefits and costs of space activities, regulation must be considered carefully. However, regulation that incorporates economic incentives for debris control may be promising.

“

Introduction by Michael A. Toman

Molly’s analysis of the seemingly arcane topic of space debris anticipated, by many years, a problem that now receives routine press attention. She deftly applied environmental economics principles to the issue of a sustainable space environment in ways that also reveal analogies with the economics of climate change. In both cases, the problem worsens as the negative side effects accumulate (whether debris or greenhouse gases). As a consequence, space vehicle manufacturers adapt to increased debris by adding costly shielding. Moreover, individual users of space underinvest in costly debris reduction and avoidance, because most of the benefits of those expensive efforts would accrue to other space users. International cooperation is needed to create agreed-upon norms and incentives that induce debris reduction or removal—but achieving broad participation in major debris prevention or reduction is difficult because of the incentive to leave it to others. Molly’s foresighted analysis of the challenges with space debris exemplify her skill in researching frontier topics. Her thought leadership remains sorely missed today.

Michael A. Toman is a senior fellow and director of the Earth Observation for Policy Initiative at Resources for the Future.

Debris resulting from human activities in space is a growing concern. Ranging from used rockets and derelict satellites to particulates from propellant fuels, such debris can collide with and destroy operating spacecraft. Even small pieces of debris can cause substantial damage.

For example, an aspirin-sized piece of aluminum that orbits at a typical velocity of about 10 kilometers per second has the same destructive energy as a 400-pound safe moving at 60 miles per hour. While most experts agree that the current level of debris is manageable, they caution that, at the rate at which it is accumulating, debris could render many orbital locations unusable within twenty years.

The amount of debris in space is estimated to be doubling every decade. This rate of accumulation is in part due to the self-propagating behavior of debris. Even without encountering any artificial objects, debris can proliferate in a chain reaction of collisions with other debris, including natural debris such as micrometeoroids. In response to the growing threat posed by debris, decisionmakers have begun to consider strategies to slow the increase of debris resulting from human activities and develop techniques to protect spacecraft from debris. While the magnitude of the cost of such strategies has not been estimated with certainty, it is expected to be large.

Although the space debris problem will loom larger in the future than it does in the present, it must be addressed today if near-Earth space is to be preserved for the use of future generations. Viewed in this context, the issue of space debris is comparable to the issue of sustainable development on Earth. Sustainable development could shed light on how to conceptualize the space debris problem. Moreover, international support of economically oriented strategies for achieving sustainable development—such as debt-for-nature exchanges and transactions to commercialize biodiversity in tropical areas of the world—suggests that similar strategies for mitigating space debris may be politically acceptable. International support for economically oriented strategies is crucial, because debris in space is an international problem.

A Sustainable Space Environment

As a concept for preserving Earth’s resources, sustainable development is generally taken to mean no net loss over time in the global stock of human and natural capital associated with environmental quality, atmospheric integrity, natural resource adequacy, biodiversity, and other desiderata. Such development would meet the needs of the present generation without compromising the ability of future generations to meet their own needs.

With regard to space, an analogous concept might be a “sustainable space environment.” According to one interpretation of this concept, the environmental impacts of present-day space activities need be moderated only at the point at which they unduly compromise future generations. Just as sustainable development does not require the cessation of all polluting activities, a sustainable space environment would not necessarily require the absence of debris in space. Some amount of debris may be endurable. The amount may be large or small, depending on whether technologies exist to offset the effects of space debris on future generations’ ability to meet their needs.

Ascertaining the point at which present-day space activities unduly compromise future generations is challenging, because it requires us to presume to know the preferences of future generations and to make judgments involving the moral, legal, and economic values of these preferences. Individuals who contend that it is immoral or unfair—or both—to presume to know the preferences of future generations or to choose a discount rate with which to link present-day and future space activities might suggest that no space debris generated by people is endurable unless it can be fully cleaned up. This means that humans would be permitted to generate debris only if the effects of that debris on future generations are fully reversible.

As virtually every space activity generates some debris, eliminating debris would be tantamount to ceasing space activity. This is why decisionmakers have generally recognized the desirability of minimizing or reducing debris, rather than eliminating it. Assuming, then, that a sustainable space environment is one in which there is some socially optimal amount of debris, several questions arise: To what extent should debris in space be reduced? How much should be spent to reduce debris? I will argue that the costs of reduction need to be balanced against the benefits of reduction. Weighing these costs and benefits will indicate the desirability of adapting to debris and pursuing some combination of debris reduction and debris adaptation actions.

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An aspirin-sized piece of aluminum that orbits at a typical velocity of about 10 kilometers per second has the same destructive energy as a 400-pound safe moving at 60 miles per hour.

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An Endurable Amount of Debris

Debris in space is a by-product of activities that provide many benefits. Satellite communications, for example, enhance the quality of life. Remote sensing of Earth from space contributes to national defense and provides information about weather conditions and the quality of the environment. Interplanetary exploration and experiments conducted in space augment our stock of knowledge. If we are to continue to reap these and other benefits from space activities, we must be willing to endure some debris generated by these activities. If we are, we must determine what amount of debris is endurable and how we can control debris so that it does not exceed this amount.

The problem of debris in space is somewhat different from the problem of pollution on Earth. When pollution is unregulated, polluters will pollute excessively because they can generally enjoy the benefits without bearing the costs of polluting activities. These costs are borne, for the most part, by third parties—that is, parties other than the polluters. However, the costs of debris generation can be borne by generators of the debris (spacecraft owners, for example) as well as by third parties. One aspect of this mutual harm is that, by taking actions to protect their spacecraft from debris, spacecraft owners can reduce harm to both themselves and third parties. For example, if they place shields on their spacecraft, spacecraft owners would reduce the likelihood that spacecraft would be harmed by debris and therefore the likelihood that spacecraft themselves would be a source of debris.

This reduction in mutual harm—or increase in mutual benefit—is not guaranteed, however. Because the vastness of space and the way in which debris propagates and migrates through various orbital planes complicate predictions about who or what will be affected by debris, spacecraft owners are likely to shield their spacecraft to the extent that it benefits themselves, rather than to the extent that it benefits third parties as well. Indeed, they may have an incentive to pollute excessively—that is, to contribute proportionately more to the total amount of debris in space than they may expect to benefit from their own efforts at debris reduction.

Given the costs associated with debris prevention, is there any situation in which the socially optimal level of debris resulting from human activities might be close to zero? The answer is yes, but only if the benefits of debris-generating activities never exceed the costs of debris reduction. In orbits that have no atmospheric drag to remove debris, and in orbits that are highly traversed by spacecraft, the optimal level of debris resulting from human activities may be close to zero.

At the other extreme, is there any situation in which the socially optimal level of such debris is unconstrained? Again, the answer is yes, but only if the benefits of space activities increase at a faster rate than the costs of debris reduction. In the early days of spacefaring, benefits did increase faster than costs. This is generally no longer the case.

Benefits and Costs of a Sustainable Space Environment

In addition to controlling the amount of debris generated in space, there may be other desiderata associated with preserving the environment of space. One objective might be to improve the capability to accommodate increases in the amount of space debris. This might be achieved by developing technological innovations—such as shields for spacecraft and debris “vacuum cleaners”—to adapt to debris, as well as by ensuring that increases in the amount of debris occur gradually, rather than abruptly, such that future generations have time to develop their own techniques for adaptation.

Another objective of a sustainable space environment might be to improve our ability to specify the location, rate of proliferation, and other parameters of debris. Present-day technology allows us to detect and track only those pieces of debris that exceed 10 centimeters in diameter. The probability, size, and economic consequences of collisions of artificial objects with debris too small to detect are difficult to model and quantify, as is the rate at which debris proliferates as a result of collisions that create additional debris. Advances in modeling and quantifying these parameters of debris could significantly increase the ability of present and future generations to adapt to debris.

A risk-based setting of priorities for remediating the hazards of debris resulting from human activities is another possible goal of a sustainable space environment. Presumably, the highest priority would be given to remediating the most egregious hazards, unless remediating less egregious hazards would contribute as much to overall remediation at lower cost. Priorities might range from the removal of the upper stages of rockets to the venting of excess propellant from these stages, which would reduce the potential for and the severity of chemical explosions.

Another objective of a sustainable space environment might be some notion of fairness in terms of who wins and who loses, both now and in the future, as a result of space activities and efforts to mitigate debris hazards. Issues of fairness could pit spacefaring nations against non-spacefaring nations, or developed countries against developing countries. They could also pit commercial entities against government entities, if the latter do not assess the relative burdens of the cost of collisions of spacecraft with debris and the cost of debris control on the former. If commercial launch vehicles or payloads are harmed by debris, commercial space companies would lose revenue and face increased insurance rates. However, efforts to control debris raise the cost of space activities. What is needed are policies that adroitly balance the benefits and costs of debris control.

The cost of mitigating debris includes several direct costs: the cost of mitigation activities; the cost of monitoring these activities; and, if the activities are undertaken in response to government regulation, the costs of enforcing the activities. These costs are privately borne by aerospace firms and by the budgets of government's defense and space agencies. The cost of mitigating debris also includes indirect costs arising from the effects that the direct costs of controlling debris have on the pace and direction of long-run technological innovation and from the effects of the self-propagating nature of debris on future space activities. These costs are more generally borne by society.

Individual governments or companies are likely to ignore socially borne costs. If these costs are larger than privately borne costs, it may be desirable for governments, industry consortia, or other centralized entities to regulate debris generation. However, the costs of regulation must be smaller than the social costs of debris control for regulation to make economic sense.

Potential Economic Impact of Debris

Before focusing on strategies for mitigating debris, the potential economic impact of debris on space activities warrants some consideration. The monetary loss associated with a space activity not completed as a result of the collision of a spacecraft with debris can be experienced not only by the agent who is carrying out the activity—a corporation, a particular scientific community, or an agency such as the National Aeronautics and Space Administration—but by society, as well. Thus, expected monetary loss should be distinguished as "private expected loss" and "social expected loss."

One way to measure private expected loss is to multiply the cost of a space activity by the probability that a spacecraft in the orbit in which the activity takes place will collide with debris during its average operating lifetime. The assumptions implicit in this calculation are that the collision completely curtails the activity and that the cost to replace the activity can be approximated by adjusting the original cost of the activity for inflation.

One way to measure social expected loss is to estimate the costs that would be imposed on society by the collision of spacecraft with debris. These costs might reflect the contribution

"A risk-based setting of priorities for remediating the hazards of debris resulting from human activities is another possible goal of a sustainable space environment."

IMAGE (ABOVE)
Reusing spacecraft is one way to reduce the amount of debris in space.

Spacex / Unsplash

of a collision to debris in different orbits or in various longitudinal locations—some of which are more valuable and populated than others—along the geostationary orbit. (The geostationary orbit is the orbit in which most communications satellites that transmit live sports events, news, and other information are located.) These costs might also reflect the contribution of the debris to delays in a space program—for example, delays due to special investigations of or public concerns about the loss of a space shuttle as a result of the shuttle's collision with debris.

The relative (rather than absolute) magnitudes of private losses and social losses suggest that losses for private agents may be significantly smaller than losses for society at large. Consequently, private agents—who confront only private expected losses—may not find it worthwhile to take actions to mitigate the impact of debris on space activities. Consider the following scenario: A commercial communications satellite is nearing the end of its operating life, at which point it will be debris. A few months' to one year's worth of the satellite's fuel supply is needed to boost the satellite out of its geostationary orbit. If a year's worth of fuel is needed, the satellite would cease operation one year earlier than planned; consequently, the satellite operator would forgo several million dollars in revenue. To induce the satellite operator to boost the satellite out of its orbit, another spacecraft operator would have to compensate the satellite operator in this amount. However, the spacecraft operator is unlikely to do so, as he or she faces a private expected loss due to damage caused by debris of only $500,000.

This private loss is small because the estimated probability that the satellite will be damaged by debris is low. The probability that a space shuttle will be damaged by debris is also likely quite low, given the brief amount of time a shuttle is in orbit. While the estimated cost of a shuttle flight—which is based in part on imputed value-of-life estimates for the shuttle crew—is on the order of $1 billion, the private expected loss due to a shuttle's collision with debris can be much smaller.

The social expected loss values for space activities may be much larger than private expected loss values, as the risks posed by debris are increasing. Debris experts estimate that the probability of a geostationary satellite colliding with debris will increase from 0.001 to 0.4 by the year 2000. Based on this estimate, private expected losses will increase from $500,000 to $200 million in 1992 dollars. The difference in these losses—about $200 million—reflects the costs imposed on operators of satellites in the year 2000 by today's satellite operators, given current launch rates, the operating parameters of today's satellites, and the potential of today's satellites to contribute to debris in space. Thus, some fraction of the $200 million could be ascribed to each of today's satellites to represent its social loss.

Parties engaged in space activities may be motivated to take actions to cover their private expected loss values—to use insurance to cover losses due to debris or to place shields around spacecraft to protect their payloads, for example. However, they may not be motivated to cover social expected loss values by taking actions to prevent debris generation, such as using lanyards to secure external components of spacecraft or boosting spent spacecraft out of the geostationary orbit. If so, and if the differences between private and social expected losses are large, regulation may be desirable to compensate society for losses resulting from the proliferation of debris resulting from human activities.

“Parties engaged in space activities may be motivated to take actions to cover their private expected loss values—to use insurance to cover losses due to debris or to place shields around spacecraft to protect their payloads, for example.”

Debris Mitigation Strategies and Techniques

The most desirable types of strategies for mitigating debris are those that would minimize the sum of debris control costs and damage costs, thereby allowing the widest range of opportunities to achieve given debris mitigation goals. Limiting the ways that entities directly involved in space activities can contribute to a given overall reduction in the level of debris would probably increase the costs of complying with regulations to control debris. Therefore, flexible strategies, which would allow such entities to implement least-cost debris mitigation techniques, are desirable. This means that debris mitigation techniques should probably not be limited to reducing debris at the source—for example, by designing and operating spacecraft in such a way that their potential to explode or break up is reduced, venting excess propellant, using lanyards to secure external spacecraft components, or boosting geostationary satellites into so-called disposal orbits. Rather, they should also include recycling, changes in the production or operation of spacecraft, and "end-of-pipe" controls. Recycling would involve the capture and reuse of spacecraft or spacecraft components. Production and operation changes would involve the attachment of shields to and the incorporation of redundant components in spacecraft, and the modification of a spacecraft's orbital parameters. End-of-pipe controls would involve the removal of human-made debris from space and improved and increased monitoring, modeling, and measurement of debris, which would allow spacecraft to avoid debris.

Strategies for reducing debris can be evaluated on the basis of their expected costs and their expected benefits, which are defined as the objectives of a sustainable space environment. A number of strategies may garner these benefits. These strategies include actions that parties may voluntarily and unilaterally take to reduce debris and other actions in response to moral suasion, such as exhortations from governments, industry associations, or others to reduce debris. Both types of action would foster a sustainable space environment, but might not be as likely as other actions to garner all four of the above-noted benefits.

Command-and-control regulation, in which government would specify the technologies and methods to be used in mitigating debris, would attain these benefits. However, if the general experience with command-and-control regulation of polluting activities on Earth is any indication, it would do so at a fairly high cost, given that it does not allow regulatees to take what for them would be the least-cost approach to complying with regulation.

Other potential regulatory alternatives include economic penalties for debris generation, including compensation that might not be strictly financial but might consist of transfers of in-kind resources (such as technology transfer) to non-spacefaring nations or to other parties harmed by debris, and taxes or fees levied on particular stages of space activities. The latter could include deposit-refund schemes whereby deposits made on the launch of spacecraft, for example, are refunded when components of the spacecraft are boosted to disposal orbits, excess propellant is vented, and so on. Yet other regulatory alternatives might include tradable permit schemes, in which commercial space firms and other entities would be allowed to trade permits to generate some specified amount of debris; reliance on insurance markets and liability law to assign financial responsibility for debris generation and thereby reduce it; and bonds purchased for space activities. Such bonds, which would be redeemable upon proof of compliance with overall debris reduction goals, would be similar to insurance but would be specifically linked to debris mitigation actions. Like deposit-refund schemes and insurance, performance bonds would likely be less difficult to monitor and enforce than other debris control alternatives because they would encourage self-policing.

Regulatees' perceptions of the fairness of the above debris control strategies would be based on compliance costs and on other factors that operate to shift distributions of wealth or that affect a party's technological prowess or prestige. Actions taken voluntarily, actions taken in response to moral suasion, command-and-control regulation, financial penalties, insurance, and performance bonds might be perceived as fair by regulatees for whom compliance costs and distributional effects are small, but perceived as unfair by those who face high costs and large redistributions of wealth. Financial penalties for debris generation that explicitly compensate regulatees who face higher compliance costs than other regulatees, or deposit-refund and tradable permit schemes that seek to minimize the cost burden, might be seen as fair. Taxes might be considered unfair unless the tax revenues are redistributed to regulatees, or fees are graduated according to some generally agreed-on bases.

None of the above debris control strategies appears to outperform the others on all bases. However, the economically oriented strategies—especially those that encourage self-enforcement—may be promising.

Need for International Cooperation

To be effective, debris mitigation actions will probably require the consensus of those currently using space, those who will be using space in the future, and those who may never use space directly but who benefit indirectly from space activity. If the record of global environmental cooperation on Earth is any blueprint, however, reaching consensus on space debris policy may require an explicit resolution of the potential clash between environmental protection of space and the development of spacefaring capability by nations not presently active in space. With respect to sustainable development on Earth, accommodating global environmental protection and individual countries' economic development has been difficult, due to the lack of or argument over the specification and sharing of property rights.

Similarly, the muddled specification of rights in space is bound to complicate space debris policy. Assigning property rights may be viewed as contrary to international law. However, assigning countries responsibility for minimizing debris in specific orbital locations—such as the geostationary orbit—could be tried, particularly as countries that are geographically positioned to best use various geostationary orbits already have incentives to boost spent satellites to disposal orbits in order to make room for their own next-generation spacecraft. Nations or regions might also be assigned responsibility for tracking and monitoring debris generation and for enforcing compliance with debris control regulation in various orbits. As an inducement to take on this responsibility, they could be given assistance in developing their own tracking and monitoring technology. ■

“Similarly, the muddled specification of rights in space is bound to complicate space debris policy. Assigning property rights may be viewed as contrary to international law.”

When this article was first published, **Molly K. Macauley** *was a senior fellow at Resources for the Future. She passed away in 2016.*

One Strategy for Pollution Control

FROM ISSUE 34 · PUBLISHED 1970

The idea of effluent charges as a possible method of controlling water pollution is less familiar in the United States than the alternative approaches of either subsidies or standards, with which we have had more experience. The article that follows is adapted from the testimony of Allen V. Kneese before the Committee on Government Operations of the US House of Representatives on February 6, 1970.

TEXT Allen V. Kneese **ILLUSTRATION** James Round

Introduction by Catherine L. Kling

Catherine L. Kling is a university fellow and a member of the board of directors at Resources for the Future.

Alan V. Kneese is commonly regarded as one of the founding intellectual pillars of environmental economics; he helped cement its relevance for policy. Reading the article reproduced here, more than 50 years after it was published, reminds us why. The fundamental insights Kneese clearly articulates about waste discharge into our nation's waterways, and the need for economic incentives to address the problem, are as true today as in 1970. While the enforcement of point source pollution eventually became consistent enough to force emitters to reduce their pollution, growing evidence suggests that these reductions may have come at a higher cost than necessary. Further, the lack of requirements on so-called "nonpoint" sources of pollution, such as agricultural runoff, has had the sorry but expected result of increasing pollution problems, which in turn has resulted in risks to safe drinking water, increased prevalence of toxic harmful algal blooms, beach closures, and risks to anglers. ■

Editor's note: The US House Committee on Government Operations no longer exists in the same form as in 1970.

Although a number of legislators have made great and sustained efforts to bring about effective water pollution control in the United States, the results have been disappointing. Many authorities seriously doubt that the present strategy can lead to effective management of our water resources.

The strategy is based on two main elements. The first, financial support for the construction of municipal waste treatment plants, was authorized by the Federal Water Pollution Control Act of 1956 and has been continued under subsequent legislation. In 1966, grants totaling $3.4 billion were authorized for the period 1968–1971, and it became possible for municipalities to cover up to 55 percent of the costs of treatment-plant construction.

The second element is federal enforcement action against individual water dischargers, reinforced by the Water Pollution Control Act of 1965. This act requires that all states set quality standards for their interstate and boundary waters. These standards were to be reviewed by the Secretary of the Interior by mid-1967. Understandably, there were some delays, but for the most part, the requirement has been met.

Each state also was responsible for proposing a program for achieving the standards. These programs were to serve as benchmarks for judging the need for federal enforcement actions. Actually, the government has had authority to bring enforcement proceedings against interstate polluters in the past, but its record of imposing direct regulations on large industries has been dismal, partly because it is difficult and costly to institute enforcement proceedings, and partly because of the political power of the larger industries.

The construction of municipal waste treatment plants has been lagging, since appropriations have fallen far behind authorizations. It has also been asserted that municipalities are holding up construction until federal funds become available.

A recent report by the General Accounting Office is a devastating critique of the scattershot way support has been provided to municipal treatment plants, poor operation of the plants, and overwhelming growth of industrial discharges. In every major river system studied by the General Accounting Office, the conclusion was the same: we have failed to mount a significant attack against the major contributors to pollution. Relying exclusively on the tool of enforcement to remedy this situation would be awkward, expensive, and effective at best only in the short run.

Most of the many proposals to provide federal subsidies for the construction of industrial waste treatment plants have not been put through. This may be fortunate, since subsidies for industrial waste treatment could be less effective than incentives to adopt other waste reduction procedures, such as recycling and byproduct recovery. Moreover, subsidies would diminish the extent to which the costs of using the common property resource are reflected in consumer goods, thus leading to overconsumption of the goods relative to the social cost of their production.

Some industrial plants are connected to municipal systems and benefit from the subsidies for municipal treatment plant construction. Furthermore, the tax reform bill recently passed by Congress would provide for five-year tax amortization of pollution control facilities and, according to recent testimony, would cost the government $400 million a year in forgone revenues.

A weakness of rapid tax amortization is that it cannot help those marginal firms which often serve as the excuse for granting subsidies. In effect, tax write-offs provide most assistance where it is not particularly needed and, unless counteracted by other provisions, permit the death of industrial plants legitimately needing aid.

Several years ago, an alternative strategy for dealing with national water pollution problems received support from economists who had studied the matter. Had it been adopted, our efforts to improve the quality of our national waters would be much further advanced than they are now, and we would be moving into a position to achieve desirable levels of water quality at the least cost to society.

> **“In every major river system studied by the General Accounting Office, the conclusion was the same: we have failed to mount a significant attack against the major contributors to pollution.”**

IMAGE (RIGHT)
A stream deposits sediment into Skaneateles Lake in New York.

Matt Champlin / Getty Images

Allen V. Kneese *was a senior fellow at Resources for the Future in 1961–2001 and served as the first president of the Association of Environmental and Resource Economists in 1979. He passed away in 2001.*

This strategy is based on two main elements. The first rests on the concept that, as far as possible, the waste discharger should bear the cost of the damages his disposal activities impose on the environment, which is the common property of all citizens. The second stems from the knowledge that, in many of our highly developed basins, where pollution problems are concentrated, great savings in costs can be obtained by carrying out a systematic, well-integrated plan of water quality management on a regional basis. This regional plan would extend beyond the treatment of waste waters at particular outfalls.

We must devise ways to make the costs of using national resources a factor in the decisionmaking of industries, local governments, and consumers. The waste-assimilative capacity of our rivers is a valuable asset, but these rivers have alternative uses which conflict directly with waste disposal. Watercourses are essentially unpriced and treated as free goods. This unhappy state of affairs cannot be remedied unless we put a price on waste discharge to watercourses and on the use of other common property resources.

Accordingly, one element of the proposed strategy for water quality management is what may be termed an “effluent charges system.” The proceeds—rental income from a scarce resource—could be used by society for improvement of the environment or in various ways that are beneficial to society. Even more important, the effluent charges would provide an incentive to conserve the use of watercourses for waste discharge.

Careful studies have shown that industries often can reduce waste discharges enormously—and usually at low cost—if they are given a proper incentive to do so. In many instances, the best means of reducing waste discharges are by internal process changes and the recycling of materials that otherwise would be lost.

Similarly, under our present setup, municipalities are paying only a portion of the social costs of disposing waste to streams. The distribution of their payments reflects how much wastewater treatment they have implemented. The effluent charges system would give municipalities an incentive to proceed expeditiously in the treatment of waste.

Another point of some importance is that our present policies put heavy emphasis on the construction of treatment plants, but do not follow through with equal emphasis on operations. Experts point out that most plants operate far below their capabilities. Since the effluent charges system has a deterring effect on what is put into a stream, such a system offers an incentive for the effective operation of existing facilities.

A number of persons have dubbed the effluent charge “a license to pollute”—a cliché which has not contributed to the cause of effective water quality management. It is also sometimes said that effluent charges cannot be implemented because industries do not know precisely what they discharge into watercourses. The latter part of this statement, unfortunately, is true. But it is high time to remedy the situation. ■

RESOURCES IN AMERICA'S FUTURE

Text
Hans H. Landsberg,
Leonard L. Fischman,
and Joseph L. Fisher

"Can the United States, over the balance of the twentieth century, count on enough natural resource supplies to sustain a rate of economic growth sufficient to fulfill all of these aspirations?"

Introduction by Richard G. Newell

Richard G. Newell is president and CEO of Resources for the Future.

This 1963 article—based on the formative book *Resources in America's Future: Patterns of Requirements and Availabilities, 1960–2000* by Leonard Fischman and longtime Resources for the Future (RFF) scholars Hans Landsberg and Joseph Fisher—posed an important question: "Can the United States, over the balance of the twentieth century, count on enough natural resource supplies to sustain a rate of economic growth sufficient to fulfill all of [its] aspirations?" The authors answer with "a qualified yes," and 60 years later, it's clear that the authors were largely correct—at least with respect to their focus on material resources and aspirations for increased living standards.

The past 60 years have seen a continuance of many of the trends highlighted in *Resources in America's Future*. The US economy has grown threefold in real terms since 1963, and the US population hit 330 million in 2020—up from 180 million in 1960. Less than 1 percent of the workforce is now engaged in farming, mining, logging, and other direct production of raw materials—down from 10 percent in the 1960s when the article was first published. And more than 80 percent of the US population now lives in cities or suburbs. Large-scale exploration of space has accelerated and now has substantial private-sector engagement. As the article highlights, market forces that encourage increased productivity and efficiency, substitution to less scarce inputs, technology innovation, and world trade all have underpinned this continued ability to resource the US economy.

Yet, the authors' qualification—which relates more to what they call the "quality" as opposed to the "quantity" of resources—has taken a different turn than they expected almost six decades ago. They understood that management and protection of the environment and natural resources is a more difficult challenge than privately traded commodities, and they raised a warning flag over the deterioration of the environment, such as "burned-over forestland," "abandoned strip mines," and "pollution of water."

Other scholars at RFF would continue to highlight the importance of addressing the worsening problem of air pollution, offering up innovative policy approaches for doing so. And of course, the need to protect global atmospheric resources from climate change was unappreciated at the time this article was written—it has since emerged as, by far, the greatest environmental challenge of our time. Nonetheless, the solutions remain the same: increased efficiency, substitution to clean energy and other processes that don't emit greenhouse gases, and technological innovation that enables a net-zero-emissions global economy. Moreover, past success in delivering material resources for economic activity demonstrates that human ingenuity—guided by enlightened policy, market, and financial forces—can deliver the necessary solutions that will help stabilize the climate. This realization should leave us optimistic, despite the hard work in store for us ahead. ■

FROM ISSUE 13 · 70 · PUBLISHED 1963

At first glance, natural resources may not seem to be as important in the US economy as they used to be. The resource industries like farming, mining, logging, and other direct production of raw materials represent a steadily shrinking share of the total economy. Less than a century ago, half the working population of the United States was engaged in such pursuits. Today, one-tenth of the working force performs these tasks (and turns out five times as much). More and more Americans—already two-thirds of the population—live in cities or suburbs.

The country is well along in the change-over from a "products" economy to a "processing and service" economy. But this does not mean that natural resources become less necessary. It suggests, rather, the magnitude and diversity of activities that now rest on the base of natural resources—manufacturing, transportation, marketing, government, education, national defense, the arts, and the many other aspects of modern society. Natural resources—land and its products like timber, crops, and livestock; water; the mineral fuels; and metals and other nonfuel minerals—are still the indispensable physical stuff of which civilization is built.

For a long time, the United States has used more resource products than any other country. In 1952, the President's Materials Policy Commission noted with some awe that, since the beginning of the First World War, consumption of most of the fuels and other minerals in this country alone had been greater than total world consumption for all the preceding centuries. That was eleven years ago. The national appetite for source materials has grown since then. And it will keep on growing. A much larger number of people—perhaps around 330 million by the year 2000 as against 180 million in 1960—will want an even higher average level of living than today's: better diets, better housing, more cars and consumer goods of all kinds, better educational and cultural opportunities, more facilities for outdoor recreation, and so on. At the same time, they will insist on a strong defense establishment, and apparently they will want to continue large-scale exploration of outer space and programs of assistance to less-developed countries.

Can the United States, over the balance of the twentieth century, count on enough natural resource supplies to sustain a rate of economic growth sufficient to fulfill all of these aspirations? That is the central question behind Resources for the Future's broad inquiry into the future domestic demand for natural resources and the goods and services derived from them, and into the prospects for meeting such requirements.

> **"The country is well along in the change-over from a 'products' economy to a 'processing and service' economy. But this does not mean that natural resources become less necessary."**

The answer is a qualified yes. With due regard to the requirements of other countries, the indications are that the American people can obtain the natural resources and resource products that they will need between now and the year 2000. Whether or not they will depends on how hard and how well they work at it.

"Neither a long view of the past, nor current trends, nor our most careful estimates of future possibilities suggest any general running out of resources in this country during the remainder of this century … The possibilities of using lower grades of raw material, of substituting plentiful materials for scarce ones, of getting more use out of given amounts, of importing some things from other countries, and of making multiple use of land and water resources seem to be sufficient guarantee against across-the-board shortage.

"There is, however, great likelihood of severe problems of shortage (or, as in the case of agriculture during the next decade or two, of surplus) from time to time in particular regions or segments of the economy, for particular raw materials. Deficiencies either of quantity or quality in the environmental resources of land and water undoubtedly will also occur in some instances."

These conclusions, qualified as they are, relate almost entirely to the physical side of resource problems. Problems of quality, touched on only briefly in the study, are equally important and probably more difficult.

"Simply having enough oil, metals, land, and water would not spell a satisfactory life for most people. For example, there is surely enough land for urban expansion for many years to come and probably for outdoor recreation, also, but the quality of it could be allowed to deteriorate to the point where it would yield unsatisfactory services. Similarly, burned-over forestland and abandoned strip mines lie ugly and useless for many years unless treated and restored. Pollution of water does not usually prevent its use, but it does make use less pleasant and more costly. The relationship of people to resources, which usually has been expressed in terms of quantity, needs to be restated for modern times to emphasize what is happening to the quality of resources."

Questions of resource quantity alone give one plenty to think about; since Malthus's time a century and a half ago, the fear that the earth's material riches will run out has preyed on people's minds. In recent years, especially since the President's Materials Policy Commission brought out its report, scarcity has been thought of more in terms of cost than of physically running out. While this refinement modifies the problem of scarcity, it is not in itself a solution. If the costs of obtaining scarce natural resource products or developing substitutes should rise significantly in relation to other costs, society would be devoting increasing shares of capital and manpower to their production; this would be a drag on the continued rise in average levels of living that is hoped for.

The estimates of possible US needs for the next four decades developed in the new Resources for the Future (RFF) study suggest resource requirements of unprecedented size. The projections indicate a tripling of requirements for both energy fuels and metals by the year 2000, almost a tripling for timber, and almost a doubling for farm products and for withdrawals of fresh water. Other important uses of water, such as recreation and dilution of wastes, cannot as yet be statistically measured.

The conclusion that such amounts can be available—plus the quantities needed in the years between—depends on three assumptions: continuing gains in technology, improvements in political and social arrangements, and a reasonably free flow of world trade. Two other assumptions on which the whole system of projections rests are that there will be no large-scale war or widespread economic depression like that of the early 1930s.

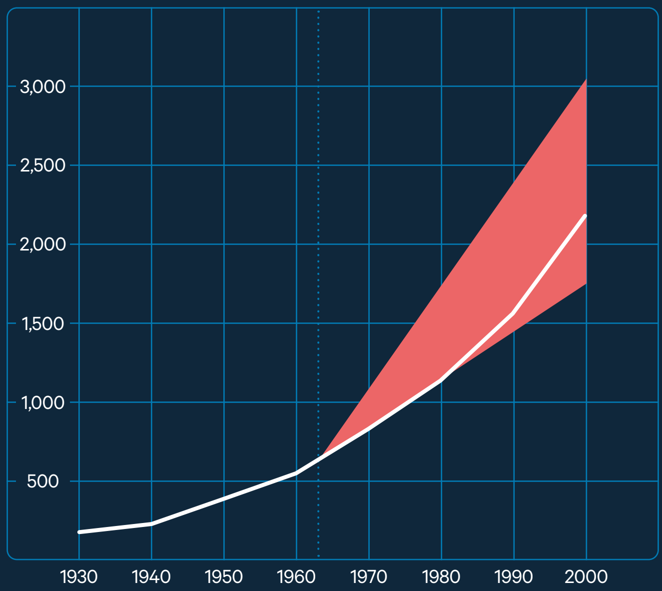
Undoubtedly, there are limits to particular natural resources in particular places, but this has

Growth in the Economy

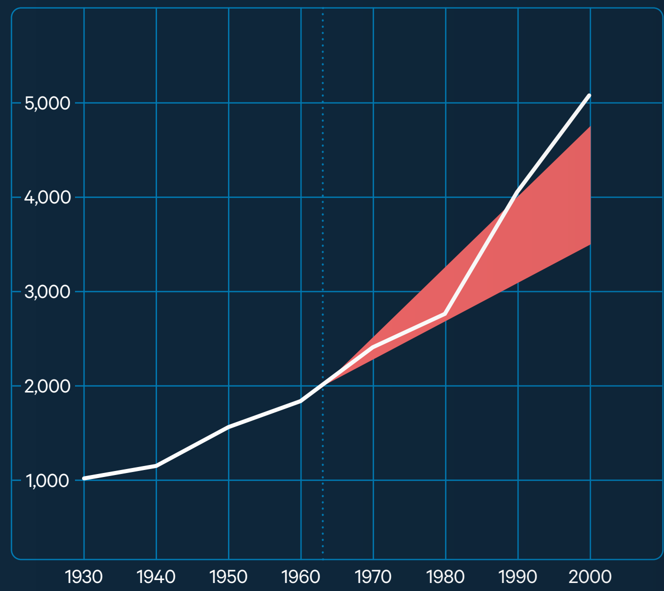
When this article was first published in *Resources* magazine in 1963, a set of graphs illustrated projections for growth in various economic sectors for the rest of the century. Since then, the *Resources* team has updated the data to indicate what actually transpired. The graphs below show the projected and actual growth for several economic metrics throughout the twentieth century.

Actual growth
Range predicted in 1963
Year of publication

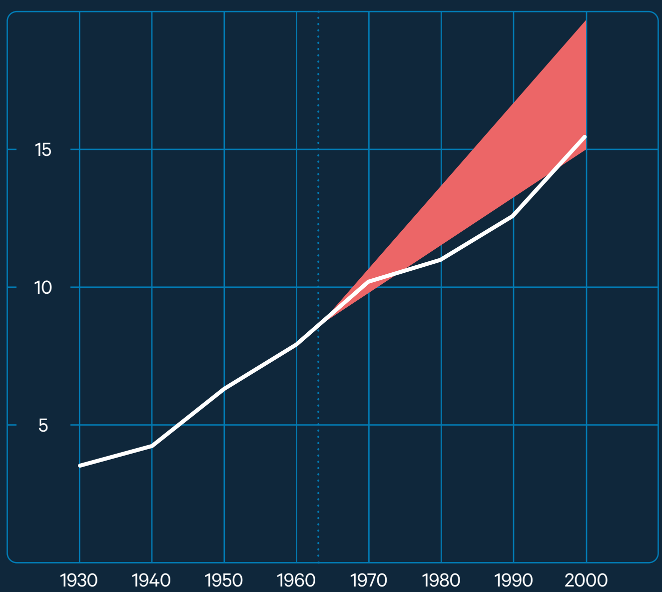
Annual Gross National Product
(1960$ billions)



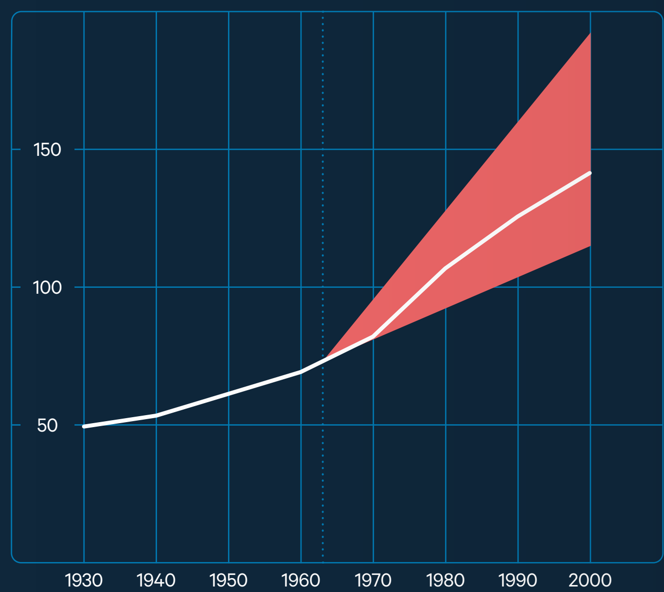
Personal Consumption Expenditure per Capita
(1960$)



Gross National Product per Worker
(1960$ thousands)



Labor Force
(millions)

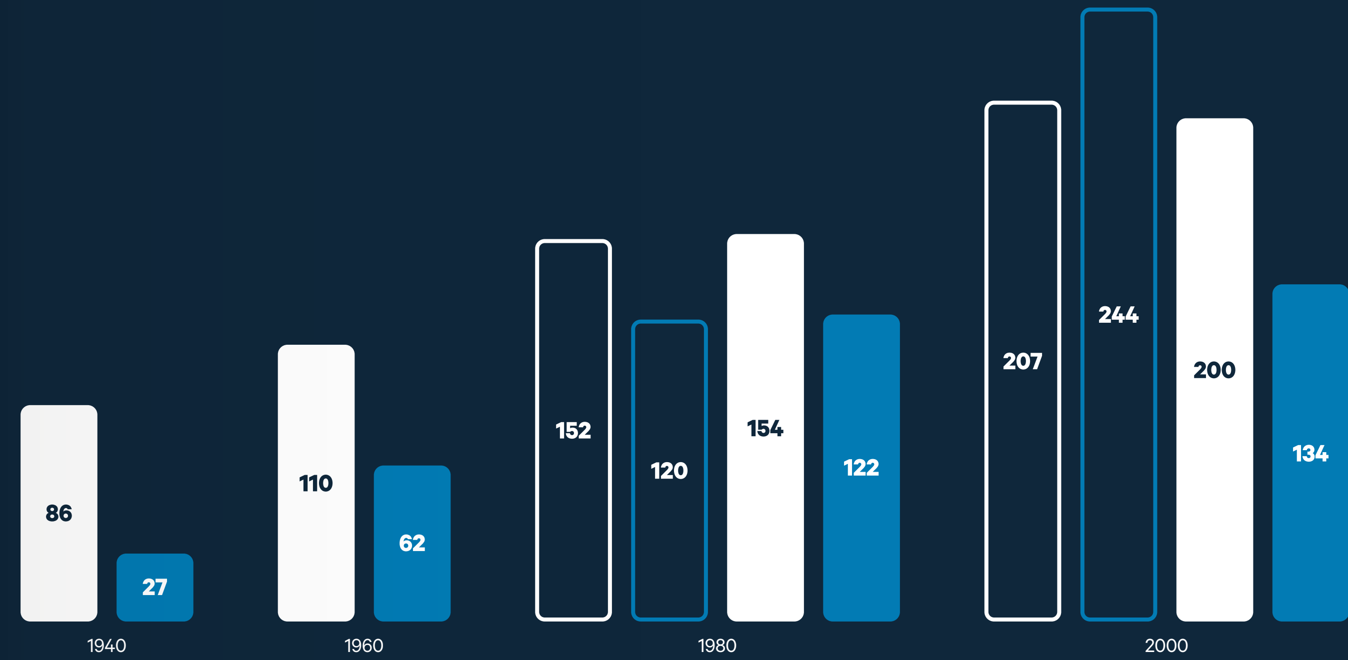


Growth in the Transportation Sector

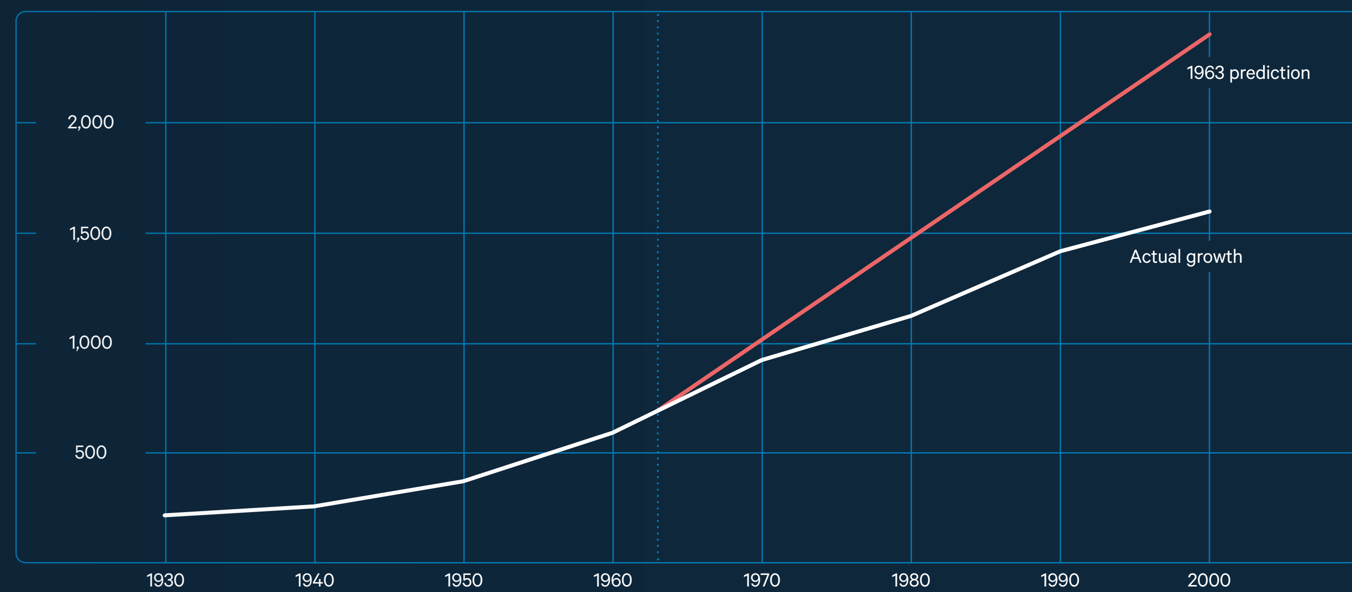
In their original article, Landsberg, Fischman, and Fisher estimated that the number of private vehicles would exceed the number of people aged 20 or more by the year 2000, if the observed 1930–1960 trends persisted. Even though personal vehicles did not eventually outnumber persons by the year 2000, a distinct trend in the predicted direction nonetheless was observed in the United States.

Persons aged 20+ (millions)
Actual growth
Predicted in 1963

Vehicles (millions of registered vehicles)
Actual growth
Predicted in 1963



Vehicle Miles Traveled
(billions of miles, all registered vehicles)



Policies, like actions, tend to come in bits and pieces, never thoroughly consistent in their direction. The real task is to make them more consistent, to fit them more to a well-conceived pattern.

Hans H. Landsberg *was a senior fellow (1960–1983) and senior fellow emeritus (1984–2001) at Resources for the Future. He passed away in 2001.* **Leonard L. Fischman** *was a consulting economist and fellow (1973–1979) at Resources for the Future. He passed away in 2015.* **Joseph L. Fisher** *was a founding member of the research staff and president (1960–1973) at Resources for the Future; he also served in the US House of Representatives (D-VA) in 1975–1981. He passed away in 1992.*

The original text of this article, printed in a 1963 issue of Resources, *is reproduced from the book* Resources in America's Future: Patterns of Requirements and Availabilities, 1960–2000. *The book was published for Resources for the Future by the Johns Hopkins Press in April 1963. As first stated in the magazine: "The study inquires into the adequacy of available natural resources to support continued economic growth and rising levels of living in the United States for the balance of the century ... The text of the original has been followed closely, either by paraphrase or direct quotation."*

not meant that, through history, resources have in any general sense become increasingly scarce in this country. The degree of economic scarcity varies not only with the intensity of demand for resource products but also with the technology of exploiting them or developing substitutes.

"The early frontier farmer, hemmed in by forests and trying to work a field full of stones with a crude plow, was probably not impressed by a superabundance of cropland … The limits of economic scarcity have been pushed back in step with the growth in demand—and sometimes even faster."

The limiting factor usually is not the physical volume of any substance within the confines of the earth, but the cost of obtaining the desired materials and making them useful.

For each of the major groupings of resources, the generally favorable outlook is contingent on steady improvements in technology and keeping political and economic arrangements abreast of developments.

If crop and livestock yields do not keep rising, the projections of ample supplies of food and fiber will not be realized. Even when one assumes the development of faster-growing hybrid trees and better forestry practices in general, shortages of domestic timber might be a brake on economic growth without larger imports and some substitution of light metals and plastics for wood. Space needs of growing cities and highway systems and the very large expected increases in demand for outdoor recreation could cause a shortage in the total land supply, unless effective programs of more intensive use or of multiple use are developed.

In many instances, adequate supplies of fuels and of the nonfuel minerals appear to depend on better methods of discovery and extraction, or larger imports, or both. For some metals, even world supplies may become inadequate by the end of the century, so that substitution of more plentiful materials—either natural or synthetic—may have to provide the escape hatch from scarcity. For the next few decades, adequacy of usable fresh water depends more on better social machinery for devising and administering broad river basin programs than on gains in technology, though both will help.

Even though recent trends are in the right direction, the required degree of technological and institutional advance cannot be expected to come about automatically. The general conclusions that point to the potential adequacy of supply are projections of what can happen with appropriate public and private action, rather than predictions. The detailed findings that indicate possible scarcity for certain resource products are not predictions, either; they simply point to a need for especially vigorous action.

The need for continued technological advance calls for large, varied, and effective programs of research and development in science, engineering, economics, and management, backed up by a strong system of education at all levels. All this, in turn, will require discriminating but large-scale investment. Maintenance of a reasonably free flow of world trade raises questions of tariffs and other import controls and of overseas investment: How can the advantages of low-cost materials from abroad be reconciled with national security, the position of affected regions and industries in this country, and the interests of friendly nations? Needs for flexibility and innovations of public policy will be especially great in management of land and water resources—how, for instance, to take the social, economic, and legal steps that will facilitate a shift from low-value use of water in irrigation to higher-value municipal and industrial uses; or how to make sure that planning for both urban growth and larger timber output allows for recreation space and sheer natural beauty.

"We do not envision any single, monolithic Resource Policy, through the application of which all resource problems will be solved … Policies, like actions, tend to come in bits and pieces, never thoroughly consistent in their direction. The real task is to make them more consistent, to fit them more to a well-conceived pattern. Clearly established general objectives and well-designed processes of policy debate and formulation, plus systematic review and evaluation, offer the best guarantee of policy improvements." ■

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