Dynamic Markets for Dynamic Environments: The Case for Water Marketing

Terry L. Anderson

Abstract: Static models used in economics and ecology ignore dynamic processes at work in both human and natural systems. In the case of water management, whether for quantity or quality, static models fail to connect changing human demands on water systems with changing supplies due to short-run climate variations and long-run climate change. Water markets provide a way of connecting human demands to nature's supplies through prices, which signal values and scarcity. For water markets to make this connection, water rights must be well-defined, enforced, and tradeable. When they are, entrepreneurs are able to meet old and new demands on water ecosystems in novel ways, as examples in this essay illustrate.

TERRY L. ANDERSON is the William A. Dunn Distinguished Senior Fellow at PERC (the Property and Environment Research Center) and the John and Jean De Nault Senior Fellow at the Hoover Institution at Stanford University. His many publications include *Free Market Environmentalism for the Next Generation* (with Donald R. Leal, 2015), *Environmental Markets: A Property Rights Approach* (with Gary D. Libecap, 2014), and *Tapping Water Markets* (with Brandon Scarborough and Lawrence R. Watson, 2012).

Analyzing nature and economies as static systems gravitating toward equilibria distracts our attention from the dynamic forces in both. Focusing, instead, on the dynamic processes at work in the environment and in markets provides a link between the two by emphasizing that 1) environmental problems result from a lack of clear property rights; 2) property rights problems are entrepreneurial opportunities; and 3) entrepreneurs respond to and create market signals, which incorporate environmental conditions.

Economics, in general, and environmental economics, in particular, are saddled with static models. Although economic models of market equilibrium provide useful predictions of tendencies toward equilibrium, they do not tell us much about the process of getting there. Natural resource economic models, meanwhile, emphasize the static notion that private costs are often less than social costs. This allows private actors to ignore some costs of their actions and thereby engage in practices that are not beneficial to society: too much fishing of a stock of fish, too many emissions into the air, and too much diversion of

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water from rivers, for example. The implication, therefore, is that to achieve socially optimal resource use, private action must be curtailed by collective action. This static conclusion fails to recognize that any such divergences result from property rights that are not well-defined and enforced[1] and that property rights are continually evolving.[2]

Just as equilibrium models oversimplify markets and ignore the important dynamic forces of entrepreneurship, environmental models have oversimplified ecological systems and ignored the importance of dynamic organisms. They build on a perspective of natural balance, rather than on ecosystems that are continually confronting and generating new constraints and adjusting to them. In the words of ecologist Daniel Botkin, "We have tended to view nature as a digital camera's [*kodachrome*, as he called it] still life, much like a tourist-guide illustration of La Salute; but nature with and without people is and always has been a moving-picture show, much like the continually changing and complex patterns of the water in the Venetian lagoon."[3] Botkin asks, "How real is the concept of a balance of Nature? What is the connection between people and nature? What are our roles in and obligations to nature?"[4]

As with ecologists, economists must ask: how real are market equilibria? Given that markets are never in equilibrium, we need to focus on dynamic processes in both nature and markets and on the links between human action and nature. Those links are determined by property rights – the rules of the game – that determine who has the right to decide how resources are used and to derive value therefrom. If, at a point in time, property rights are clearly defined and enforced, then the roles and obligations of human beings to one another as users of nature would be clear according to the human values and natural conditions at that time.

As values and environmental conditions change, however, dynamic forces come into play and property rights must evolve: the property rights that had clearly defined roles and responsibilities before the change in conditions may no longer be adequate.[5] Once abundant resources become scarce, individuals with different values will compete for uses, necessitating allocation among competing interests. Effective environmental entrepreneurship, therefore, is akin to Darwinian evolution in economies. It is, as popular science writer Matt Ridley put it, "spontaneously self-ordered through the actions of individuals, rather than ordained by a monarch or a parliament."[6]

Provided property rights are transferable, markets can accommodate changing values and changing environments, but not without entrepreneurs who observe changing values, recognize opportunities, and respond to new demand and supply conditions. The challenge for the entrepreneur is to discover the values of goods, services, and the inputs that go into their production and to capture those values through market exchanges of ownership claims to labor, capital, and natural resources.

When an entrepreneur successfully responds to disequilibrium conditions created by changing human values or by changing ecosystems, he or she is attempting to resolve what Daniel Botkin calls "discordant harmonies."[7] Just as ecological disturbances create discordance in the environment to which species respond by filling niches and evolving, economic disturbances create market discordance to which entrepreneurs respond. If they are successful, they create harmony from dissonance.

Consider more generally how environmental entrepreneurs interface with water resources. With water covering 70 percent of the blue planet's surface, it might appear that water is not scarce enough to attract

entrepreneurial attention. Of course, it is scarce because most of it is either in the wrong place or the wrong form. Water is not where the people want to use it; its supply is variable relative to human demands; it is of the wrong quality (whether too saline or too contaminated) to satisfy human demands; or it is unattractive for some combination of these reasons.

This begs the question, why is water different from many other resources? Again, the answer is property rights. Water problems arise when there are competing demands for scarce water, for which property rights are not clear.

The dewatering of rivers in arid parts of the American West offers a classic example.[8] Diversion rights to water in Oregon and California's Klamath River were sufficiently well-defined to allocate the scarce resource among competing uses, even if it meant leaving the river dry. However, because it was so costly to transfer water from diversion to instream uses, it was neither economical nor possible to divert the river to meet the environmental demands for instream flows to support spawning salmon and steelhead, leading to further conflicts about resource allocation. Entrepreneurial responses to competing demands for water use, whether from increased demands or reduced supplies, require reallocating water within the existing institutions or altering those institutions to accommodate new constraints and new allocations.

Water markets offer an increasingly important tool in institutional debates about reallocation and resource use. This paper first explains the importance of markets in providing an interface between dynamic human demands for water resources and dynamic environmental conditions for their supply. It then focuses on examples of the role that entrepreneurs play in dynamic environments and dynamic markets.

Economists have traditionally analyzed markets using comparative statics, comparing one equilibrium with another and specifying the conditions required for the equilibrium to hold. The standard blackboard assumptions of perfect information, costless market transactions, and perfect competition focus attention on points of equilibrium in which the forces of supply and demand are perfectly balanced.

Philosopher Mark Sagoff has confronted economists who view markets and ecosystems as equilibrium systems that can be objectively valued for their contributions to human welfare: "Ecological knowledge, like any kind of empirical knowledge that is relevant to economic activity, is too spread out among people and too sensitive to the moment to be captured by any one individual or by any group – even scientists given sufficient resources." Remarking on recent attempts by economists and scientific experts to assign values to ecosystem services from the top down, Sagoff concluded that the "'ecosystem services' project is bound to fail in its attempt to substitute an *in natura* calculus of value for the artifice of market price."[9] Instead of seeking to valuate ecosystems, markets aggregate disparate knowledge through entrepreneurial action.

Viewing markets as if they exist in equilibrium distracts us from the market processes, entrepreneurial activities, and institutional evolution that tend to move markets in the direction of equilibrium. Just as nature is never in equilibrium, neither are markets. Certainly equilibrium concepts are useful for developing hypotheses and gaining insights into basic market responses to changing conditions, but they obscure the moving picture show of the market process.

Dynamic processes, found in both ecosystems and markets, call for a better understanding of the connection between ecology and economics. In the words of

environmental writer Emma Marris, ecosystems are "fundamentally stable entities afflicted by changes from without and within about as much as a ballet is a fundamentally static object afflicted with motion."[10] Marris's description could just as easily apply to markets that, although often viewed as if they exist in balance, are fundamentally driven by a barrage of changes from within and without.

Much like the interaction of organisms in nature, the market process emphasizes the interaction of individuals based on factors that are time- and place-specific. Just as individual species fill niches in ecosystems, entrepreneurs find market niches and specialize in production and marketing to fill those niches. Successful entrepreneurship requires the entrepreneur to use local knowledge and resources more efficiently than is the current practice. As a result, inefficient resource use in markets and in ecosystems is crowded out in an evolutionary process where sustainability requires profitability for survival.

In this sense, human action is ordered spontaneously through market processes just as animal and plant speciation is ordered through evolutionary processes. Information on which niches are opened and how they should be filled cannot be acquired or ordained from the top down; it requires responses to what economist and Nobel laureate Friedrich Hayek described as "rapid adaptation to changes in the particular circumstances of time and place."[11]

The ability of market institutions to resolve conflicting human demands on the environment relies on entrepreneurs who reallocate inputs and outputs guided by market prices and property rights. With clear and transferable property rights, owners of resources will have to compare the value they place on resources with offers made by others. These competing values are embedded in prices, which provide condensed information about individual preference, resource scarcity, and technology, among other inputs.

In her recommendations, Emma Marris has summarized the modern challenges facing environmentalists: "Give up romantic notions of a stable Eden, be honest about goals and costs, keep land from mindless development, and try just about everything."[12] This is what entrepreneurs do. In some cases, their decisions will be wrong. However, just as poor adaptations in nature are eliminated, albeit slowly, via evolutionary processes, bad decisions in markets are purged by economic losses.

In summary, the effectiveness of market processes and entrepreneurship in adapting to changes in nature depends on well-defined, enforced, and transferable property rights to environmental resources. If those rights exist, costs and benefits will be internalized by owners. If they do not, entrepreneurs are incentivized to establish property rights in order to capture the benefits of ownership. The evolution of property rights may come from the bottom up or from political processes that distribute rights.[13] In either case, there is no more guarantee that property rights will be complete than there is that governmental control allocation of environmental assets will respond to dynamic ecosystem changes.

Water markets provide a way of adapting to a dynamic world of changing human demands for water and the changing supplies of it. Doing so via water markets requires that water rights be well-defined, enforced, and transferable. Not surprisingly, water rights vary considerably depending on human demands relative to natural supplies. The Eastern United States relies mainly on the common law of riparian rights, which gives riparian landowners an equal right to an undiminished quantity and quality of water. This system was appropriate given the relative abundance of water in the East and the uses to

which water was put: namely, power generation and human consumption, rather than diversion for irrigation.[14] Because prior appropriation rights are more clearly specified, they are more amenable to exchange.[15] This system evolved in response to "institutional entrepreneurs" who found water law from the East inadequate for purposes requiring diversion.[16]

The importance of property rights evolution is seen in the recent allowance of diversion rights to be converted to instream flow rights. The prior appropriation system was based on the "use it or lose it" principle, which required diversion or was considered abandoned, and therefore could be claimed by others. Given the increased value placed on instream flows for water quality, recreation, and environmental amenities, entrepreneurs have brought pressure to change the laws so that every Western state today recognizes instream flows as a beneficial use of water.

Obstructing water entrepreneurs are a variety of political impediments that raise transaction costs for exchange. The battle over water flowing through California's Central Valley into the San Francisco Bay is the quintessential example.[17] The rights to Central Valley water are largely held by agricultural users or are allocated through contracts between agricultural users and the state or federal government. Environmental demands based on the need for water to ensure survival of the delta smelt or migrating salmon have been articulated through political processes, especially the Endangered Species Act. Because it is almost impossible to shift agricultural water to environmental uses through market transactions, the only alternative for environmentalists is politics in which the stakes are high and the battles fierce. Indeed, given the slowness with which bureaucracies move, there is good reason to expect that they may be less dynamic than market entrepreneurs.[18]

Water markets provide an alternative to political allocation that allows flexibility in light of dynamic environmental constraints and human demands. The following are examples of water markets at work and reflect how entrepreneurs respond to disequilibria.

Tradable water rights allow conservation organizations and agriculturalists to negotiate mutually beneficial agreements to share the water. For example, in 2005, Montana Water Trust (now the Clark Fork Coalition) entered into a ten-year lease agreement with irrigators to reduce diversions along Tin Cup Creek in Western Montana. The upper portion of Tin Cup lies within the Selway-Bitterroot Wilderness and provides critical native fish habitat, fostering westslope cutthroat trout and bull trout. The lower portion, however, was heavily appropriated for irrigation use and diversions that depleted stream flows to levels insufficient for fish. With the lease agreements in place and consequent reductions in diversions, instream flow levels were restored, reconnecting migration routes between Upper Tin Cup Creek and the Bitterroot River downstream. In Idaho, the trout and salmon conservation organization Trout Unlimited collaborated with the city of Pocatello to acquire senior water rights upstream from irrigators. The added flows help Trout Unlimited meet its goal of restoring flows for Yellowstone cutthroat trout while the additional water instream improves water quality and reduces the city's need to pump scarce groundwater.[19]

Just as markets are dealing with water scarcity issues, markets can also work to address water quality concerns and the associated economic costs.[20] Though the Clean Water Act does not specifically authorize markets in water quality credits, the act's directive to states to establish plans to control point and nonpoint source

pollution ultimately leads to the creation of credit markets.[21] States have been drawn to incentive-based market schemes for controlling pollutant sources because they introduce flexibility in how effluent targets are met, which reduces costs to regulated dischargers while encouraging reductions in pollutant levels. The number of water quality trading programs in the United States has grown considerably since the emergence of the first generation in the 1980s.[22] The Environmental Protection Agency (EPA) identifies forty-eight domestic trading programs in twenty-five states. Such programs are helping states meet water quality standards more efficiently and at reduced costs to regulated industries.

For instance, in the Long Island Sound of New York and Connecticut, runoff and excessive discharges from sewage treatment plants into area streams were threatening local fish and shellfish populations. A coordinated effort between the EPA, the Connecticut Department of Environmental Protection, the New York State Department of Environmental Conservation, and private organizations and landowners developed a watershed-based nutrient reduction plan. Through negotiation among the various interests, the plan established a statewide cap on the total amount of nitrogen that may enter the watershed, and also allocated individual discharge targets to seventy-nine municipal waste treatment plants in the area. If it is too expensive for one plant to meet its target level, it can buy credits from other dischargers that have reduced their pollution levels below their respective targets or permitted levels. Discharge sources with lower control costs have the incentive to reduce pollution amounts, thereby creating tradable pollution credits. Higher-cost dischargers can buy credits and clean up less. Either way, the net amount of discharge does not exceed the total allowed amount.

However, water quality markets still rely on governmental control to establish target levels of pollution. Such a strategy "presumes regulators are correct in their knowledge about how much pollution is 'right.'"[23] But no matter how well-intentioned or informed agency officials may be, it is impossible for them to determine the optimal limit on pollution in every case. Agencies are subject to political pressures and, in promulgating regulations, they set uniform standards that are applied over an overly broad range of pollution contexts. In a true market approach to water quality, the residual claimants determine the acceptable amount of pollution or level of water quality and, through negotiation, the contract for achieving the target level.

Most water quality trading programs are driven by top-down regulations, but some arise through bottom-up collective action. For example, Wichita, Kansas, is paying upstream farmers in the Cheney Lake Watershed to reduce nutrient runoff tied to agricultural production.[24] In the early 1990s, algal blooms and increased sedimentation in Cheney Lake alerted area residents, farmers, and the City of Wichita – which relies on the lake for drinking water – that water quality was no longer something that could be taken for granted. In a region dominated by agricultural users, the source of the pollution was clear, and the offending farmers themselves decided something had to change.

Like many nations, Australia is facing increasingly scarce water resources, a product of supply shocks and increasing competition among consumptive and environmental water demanders.[25] The development of Australian water markets first required institutional changes to provide opportunities for formal markets and a means of balancing water supplies and demands. Early reforms in the 1980s, which created temporary trading opportunities, were fol-

lowed by broader reforms in 1994, when the Council of Australian Governments (COAG) endorsed the Strategic Framework on Water Reform, laying the foundation for a nationwide transition to formal water markets. Central to the reforms were provisions for defining water entitlements, severing water claims from land, and incorporating environmental flows into water management plans. State and territorial governments were tasked with redefining entitlements in terms of ownership, volume, reliability, transferability, and, if appropriate, quality, while also developing plans to manage water for instream applications.[26] The reforms in the 1990s resulted in "considerable progress toward more efficient and sustainable water management."[27]

If water problems are caused by either the fact that water is not where the people want to use it, that its supply is variable relative to human demands, that it is of the wrong quality to satisfy human demands, or some combination of the three, they will be exacerbated by climate variability. In the context of water, climate change is best thought of in terms of what it means for variations in water supplies and demands. In his book *Windfall: The Booming Business of Global Warming*, McKenzie Funk explains that market responses to climate variation are "tribal, primal, profit-driven, short-term, and not at all idealistic."[28] Seen this way, water markets provide an alternative way of dealing with increased climate variance.

John Dickerson, CEO of Summit Global Management, is harnessing water markets in response to climate variation by investing in what he calls "wet water" – in contrast to water infrastructure – through the purchase of water rights in America's Colorado River basin and in Australia's Murray-Darling basin. As noted above, both sites have reasonably well-defined, enforced, and tradeable water rights to facilitate water marketing. According to Dickerson, "The real future is going to be the direct assets – not through the medium of a utility, not through the medium of a pump company – but the direct, physical water assets."[29] Or as Funk puts it, "Carbon emissions are invisible, temperatures are an abstraction. But melting ice, empty reservoirs, lapping waves, and torrential rainstorms are physical, tangible – the face of climate change. Water is what makes it all real."[30]

Dickerson had trouble raising money for his fund until the publication of Al Gore's *Inconvenient Truth* kick-started the market.[31] Fifteen water mutual funds started in 2007, more than doubling the preexisting number. Funk reports that "[i]n two years, the amount of money under management ballooned tenfold to $13 billion. Credit Suisse, UBS, and Goldman Sachs hired dedicated water analysts."[32]

To help markets along, governments need to follow the lead of Western U.S. states and Australia by making water rights more secure and by encouraging trading. As Dickerson has put it, governments can "allow water to be priced at what it's worth, then create a mechanism by which the rice farmer can sell his water to the wine producer."[33] By buying low and selling high in the American West's Colorado River basin and in Australia's Murray-Darling basin, Dickerson and other speculators are reducing water waste, improving water use efficiency, and hedging against fluctuations in water supply caused by climate variation.

The proposal to create a Colorado River water bank illustrates another way in which markets can adapt to climate variation.[34] In Colorado, agricultural users on the west slope of the Rocky Mountains have more senior water rights than municipal users on the west slope, who divert water eastward across the continental divide. As long

as there is sufficient water to meet both senior and junior water rights holders, there is no problem; but when droughts limit supplies, the east-slope municipalities are the first to go dry.

To make matters worse, drought in the upper reaches of the Colorado River is not the only event that drives scarcity: demands from states at the lower end of the river – Nevada, Arizona, and California – who have claims to a share of the river's flow through the Colorado River Compact, can further jeopardize water supplies for east-slope communities. Under that 1922 compact, states in the upper basin (Colorado, New Mexico, Utah, and Wyoming) are required to deliver 7.5 million acre-feet of water per year on a ten-year rolling average to the lower basin states (Arizona, California, and Nevada). If the ten-year rolling average falls below 7.5 million acre-feet, the lower basin states force a "compact curtailment" on the upper basin states. In this case, upper basin junior water rights holders, including many east-slope municipalities, would be the first to be cut off.

Assuming that the marginal value of water to east-slope municipalities is greater than it is to west-slope irrigators, a water bank could significantly improve water use efficiency. The proposed bank would allow west-slope irrigators with senior rights to deposit their rights in a central recording system from which east-slope municipalities with junior rights could purchase a call on the deposited rights. If a compact curtailment occurred, the bank would require lower value irrigation users to meet the call by reducing their diversions, thereby allowing higher-value municipal users to continue their consumption. In a world of greater climate variation, water banking of this sort offers efficiency gains without political battles to determine who gets how much water.

Finally, consider how climate variation can affect conservation efforts: in this case, habitat for migratory shorebirds on their annual journey from South America and Mexico to the Arctic. This journey takes many of the birds through California's Central Valley, where water engineers have harnessed the natural systems to provide water for agricultural, municipal, and industrial uses. In the process, 95 percent of the original wetlands have disappeared.[35]

BirdReturns, an innovative market transaction between bird lovers and farmers, is working to restore wetlands to the region, thereby welcoming birds back. The transaction begins with bird watchers who use a smartphone app called eBird to record shorebird sightings, which are then used by the Cornell University Ornithology Lab in New York to map where water is needed. The Nature Conservancy then uses private donations to pay farmers to flood the fields – which otherwise would have been drained – most directly in the migratory bird flight path. Given that the birds are only there for a short time, the Nature Conservancy does not have to purchase the water outright; it only needs to "rent" it when the birds are in residence. The Nature Conservancy uses a reverse auction in which farmers submit bids and the lowest bidder willing to provide water wins. Through this competition, the Nature Conservancy keeps down the costs of achieving its goal.

The first season of the program ended in April 2014, with birders having reported sightings of all species of birds they hoped to attract to what they have called "pop up" wetlands: ten thousand flooded acres owned by forty farmers. Birders hope to increase the number of shorebirds stopping in California from one hundred seventy thousand to four hundred thousand in both the spring migration north and the fall migration south. Although it is too soon to assess the program's overall suc-

cess, its potential is summed up by Mark Reynolds, the Nature Conservancy scientist who heads the program: "Migratory birds are a daunting challenge. It's a hemispherical scale, and it's seasonal, and every species has a different life history. This program allows us to be strategic with scarce conservation dollars."[36]

Because the challenge is even more complicated in light of climate variation, innovative contracting of this sort offers great hope for conservation interests.

Dynamic market responses to changing relative prices have always been the best response to the dynamic world in which we live. Typically, we associate market prices as a way of connecting demanders and suppliers of material goods and services, but they are even more important as a mechanism for connecting human demands on our natural world with the dynamic forces of nature. Prices provide condensed information about human demands and, if property rights to inputs are clear and transferable, they provide similar information about the human value of resources in competing uses. When human values for nature's bounty change, entrepreneurs who recognize the change have an incentive to economize by reallocating resources to higher-valued uses. And when the dynamic forces of nature increase or decrease the supply of resources, prices will speak on nature's behalf.

Successful entrepreneurship recognizes when human demands and nature's supply are in discordance, and reallocates resources in ways that harmonize the two. Producing more with fewer resources, discovering new sources, and developing technologies that better use resources are all tools in the entrepreneur's kit.

In order for dynamic markets to respond to dynamic environments, the right institutions – namely, well-defined, enforced, and tradeable property rights – must be in place. Where these institutions exist, as in the American West and Australia, water markets are encouraging development of new supplies, water use efficiency, and technological innovation. Climate variation adds another element to the demand and supply mix to which dynamic markets *may* respond. Whether they *will* respond depends largely on the property rights institutions, which, all too often, are not conducive to market transactions. In such cases, the link between dynamic markets and dynamic ecology is broken. The question then is whether politics can be dynamic enough either to facilitate the creation of new property rights and reduce transaction costs or to respond to dynamic ecology. There are some bright signs in the emergence of water markets, but, as Mark Twain supposedly put it, "Whiskey is for drinkin' and water is for fightin,'" and legislatures and courts are often the barroom in which the fightin' occurs.

ENDNOTES

1 See Ronald H. Coase, "The Problem of Social Cost," *Journal of Law and Economics* 3 (October 1960): 1 – 44.

2 See Harold Demsetz, "Toward a Theory of Property Rights," *American Economic Review: Papers and Proceedings* 57 (2): 347 – 359; and Terry L. Anderson and Peter J. Hill, "The Evolution of Property Rights: A Study of the American West," *Journal of Law and Economics* 18 (1): 163 – 179.

3 Daniel B. Botkin, *The Moon in the Nautilus Shell: Discordant Harmonies Revisited* (Oxford: Oxford University Press, 2012), 3.

[4] Ibid., 18.

[5] This analysis may seem unduly anthropocentric because it presumes that property rights are held by humans over nature. Some legal scholars have argued that flora, fauna, and even inanimate objects have rights, but accepting this, those rights can only be expressed by humans making claims for things in nature. All rights that have any meaning in our world therefore boil down to human rights, even if those rights are expressing an intrinsic value of nature.

[6] Matt Ridley, "The Natural Order of Things," *The Spectator*, January 7, 2009, http://www.spectator.co.uk/features/3213246/the-natural-order-of-things/ (accessed March 31, 2014).

[7] Daniel B. Botkin, *Discordant Harmonies: A New Ecology for the Twenty-First Century* (New York: Oxford University Press, 1990).

[8] See Charles J. Vörösmarty, Michel Meybeck, and Christopher L. Pastore, "Impair-then-Repair: A Brief History & Global-Scale Hypothesis Regarding Human-Water Interactions in the Anthropocene," *Dædalus* 144 (3) (2015): 94–109.

[9] Mark Sagoff, "The Quantification and Valuation of Ecosystem Services," *Ecological Economics* 70 (3): 497–502.

[10] Emma Marris, *Rambunctious Garden: Saving Nature in a Post-Wild World* (New York: Bloomsbury USA, 2011), 34.

[11] Friedrich A. Hayek, "The Use of Knowledge in Society," *American Economic Review* 35 (4): 519–530.

[12] Marris, *Rambunctious Garden*, 170.

[13] See Terry L. Anderson and Peter J. Hill, *The Not So Wild, Wild West: Property Rights on the Frontier* (Stanford, Calif.: Stanford University Press, 2004).

[14] Increasing urban demands that require water diversion and delivery to cities not located on streams have challenged the riparian system. See Terry L. Anderson, Brandon Scarborough, and Lawrence R. Watson, *Tapping Water Markets* (New York: RFF/Routledge, 2012), ch. 6.

[15] The priority system could also be based on an equal sharing or on a collective determination of the importance of various uses when supplies are not sufficient to meet all demands. The important element of water rights for market transactions is that they be clearly defined, enforced, and transferable.

[16] For further discussion of institutional entrepreneurship, see Anderson and Hill, *The Not So Wild, Wild West*, ch. 2.

[17] See Katharine L. Jacobs and Lester Snow, "Adaptation in the Water Sector: Science & Institutions," *Dædalus* 144 (3) (2015): 59–71.

[18] For a good discussion of political and bureaucratic processes, see Randy T. Simmons, *Beyond Politics: The Roots of Government Failure* (Oakland, Calif.: Independent Institute, 2011).

[19] Trout Unlimited, "Western Water Projects," http://www.tu.org/tu-programs/western-water. See also Clark Fork Coalition, "Bitterroot," http://clarkfork.org/our-work/where-we-work/bitterroot/.

[20] See Adena R. Rissman and Stephen R. Carpenter, "Progress on Nonpoint Pollution: Barriers & Opportunities," *Dædalus* 144 (3) (2015): 35–47.

[21] Esther Bartfeld, "Point-Nonpoint Source Trading: Looking Beyond Potential Cost Savings," *Environmental Law* 23 (1993): 43–106.

[22] In a worldwide survey, the World Resources Institute identified six trading programs outside the United States: four active programs (three in Australia and one in New Zealand) and two in development (one in Australia and one in New Zealand). See Mindy Selman, Suzie Greenhalgh, Evan Branosky, Cy Jones, and Jenny Guiling, "Water Quality Trading Programs: An International Overview," *WRI Issue Brief*, No.1 (March 2009).

23 Roger E. Meiners and Bruce Yandle, *Reforming the Clean Water Act* (Washington, D.C.: Manufacturers' Alliance for Productivity and Innovation, 1994), 91.

24 Reed Watson and Brandon Scarborough, "Cheney Lake Watershed: Farming Water Quality in Kansas," *PERC Case Study* (Bozeman, Mont.: The Property and Environment Research Center, 2010).

25 See Richard G. Luthy and David L. Sedlak, "Urban Water-Supply Reinvention," *Dædalus* 144 (3) (2015): 72–82.

26 Jeffery Bennett, *The Evolution of Markets for Water: Theory and Practice in Australia* (Cheltenham Glos, United Kingdom: Edward Elgar, 2005), 78.

27 Council of Australian Governments, Intergovernmental Agreement on a National Water Initiative, http://www.nwc.gov.au/nwi.

28 McKenzie Funk, *Windfall: The Booming Business of Global Warming* (New York: The Penguin Press, 2014), 8.

29 Ibid., 121.

30 Ibid., 118.

31 Al Gore, *An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do about It* (New York: Rodale Books, 2006).

32 Funk, *Windfall*, 118.

33 Quoted in ibid., 133.

34 For further discussion, see Reed Watson and Brandon Scarborough, "Colorado River Water Bank: Making Water Conservation Profitable," *PERC Case Study* (Bozeman, Mont.: The Property and Environment Research Center, 2010), perc.org/articles/colorado-river-water-bank-making-water-conservation-profitable.

35 For a complete discussion, see eBird, "Help TNC by eBirding in California's Central Valley," January 21, 2014, http://ebird.org/content/ebird/news/tnc_birdreturn/.

36 Quoted in Jim Robbins, "Paying Farmers to Welcome Birds," *The New York Times*, April 14, 2014, http://www.nytimes.com/2014/04/15/science/paying-farmers-to-welcome-birds.html?_r=0.