

# GRASPING FOR THE HEAVENS: 3-D PROPERTY RIGHTS AND THE GLOBAL COMMONS

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## I. INTRODUCTION

With the attention of policymakers worldwide focused on environmental problems that transcend national borders and reach even to the heavens' heights, an examination of property rights solutions to global problems is appropriate. The institution of private property is an effective way of dealing with many environmental problems.<sup>1</sup> However, before the efficacy of property rights solutions to global environmental problems can be addressed, the prospects for the emergence of property rights in the global commons must be analyzed. Predictions about the effectiveness of a property rights regime for the global commons are of little relevance, if such a regime cannot arise or is unlikely to arise at the global level. Thus, this article is about institutions and how they evolve—specifically, how the institution of private property emerges and evolves and whether or not the institution might emerge at the global level. This inquiry does not concern property rights in their broadest sense; some kind of rights will surely develop in the global commons.<sup>2</sup> Rather, this article addresses the more interesting question regarding the extent to which a

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1. See TERRY L. ANDERSON & DONALD R. LEAL, *FREE MARKET ENVIRONMENTALISM* (1991); ELIZABETH BRUBAKER, *PROPERTY RIGHTS IN THE DEFENCE OF NATURE* (1995); DENNIS J. COYLE, *PROPERTY RIGHTS AND THE CONSTITUTION* (1993); J.H. DALES, *POLLUTION, PROPERTY AND PRICES* (1968); JAMES V. DELONG, *PROPERTY MATTERS: HOW PROPERTY RIGHTS ARE UNDER ASSAULT—AND WHY YOU SHOULD CARE* (1997); WHO OWNS THE ENVIRONMENT? (Peter J. Hill & Roger E. Meinert eds., 1998).

2. The development of property rights in the global commons involves two issues: the emergence of a property rights regime and the choice of the property rights regime. The first issue concerns avoiding the so-called tragedy of the commons, where free access to the commons leads to its overuse and ruination. See Garrett Hardin, *The Tragedy of the Commons*, 162 *SCI.* 1243, 1244 (1968). History teaches that some form of control will emerge that will reduce the scope and severity of possible tragedies. See Harold Demsetz, *Toward a Theory of Property Rights*, 57 *AM. ECON. REV.* 347, 350 (1967) (theorizing that property arrangements in all societies emerge and evolve in response to changes in technology, relative prices, and other economic conditions); see generally DOUGLASS C. NORTH, *STRUCTURE AND CHANGE IN ECONOMIC HISTORY* (1981) (describing the emergence and evolution of institutions throughout history); Robert C. Ellickson, *Property in Land*, 102 *YALE L.J.* 1315 (1993) (describing the development and evolution of various land regimes in a variety of settings throughout history). The rationing mechanism that limits overuse of the commons, however, is often simple command-and-control, which implies property rights. See Daniel H. Cole, *Clearing the Air: Four Propositions about Property Rights and Environmental Protection*, 10 *DUKE ENVTL. L. & POL'Y F.* 103, 111 (1999) ("What distinguishes transferable pollution 'rights' schemes from command-and-control regulations is not that the former are property-based and the latter are not. Command-and-control involves the (often implicit) assertion of public/state-property rights on environmental goods. The difference lies in the type and extent of property rights imposed."). The second issue stems from the choice of the property rights regime. See Bruce Yandle, *The Commons: Tragedy or Triumph*, *THE FREEMAN*, Apr. 1999, at 30, 32-34 (providing examples and explaining how the choice of property rights regime either can avoid or hasten the tragedy of the commons).

future people will develop property institutions that support a liberal order, one that accommodates efficiency-improving market incentives and yields wealth-enhancing gains from voluntary trade. In other words, this article addresses the prospects for the emergence of 3-D property rights, private rights that can be *defined*, *defended*, and *divested* or transferred.<sup>3</sup>

An analysis of the likelihood that 3-D property rights will emerge in the global commons of the earth's atmosphere is informed by the emergence of 3-D environmental rights a little closer to home.<sup>4</sup> This article uses lessons from human experience with resources on earth to forecast institutional change in the heavens. Informed by earthly experience, this article seeks to answer the following two questions: (1) *can* 3-D property rights emerge for heavenly assets, or the global atmosphere, and (2) *how* will such property rights emerge?

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3. The author expresses appreciation to Richard Stroup, PERC Senior Associate and Professor of Economics at Montana State University, for first suggesting the term "3-D rights" to him. While not specifically adopting the phrase "3-D rights," Anderson and Leal provide a good explanation of 3-D property rights.

The key, therefore, to effective markets in general and free market environmentalism in particular is the establishment of well-specified and transferable property rights. When a conservation group purchases a conservation easement on a parcel of land, the exchange requires that property rights be well defined, enforced, and transferable. The physical attributes of the resources must be specified in a clear and concise manner; they must be measurable. For example, the rectangular survey system allows us to define ownership rights over land and clarifies disputes over ownership. The system may also help us define ownership to the airspace over land, but more questions arise here because of the fluidity of air and the infinite vertical third dimension above ground. If property rights to resources cannot be *defined*, then they obviously cannot be exchanged for other property rights.

Property rights must also be *defendable*. A rectangular survey may define surface rights to land, but conflicts are inevitable if there is no way to defend the boundaries and prevent other incompatible uses. Barbed wire provided an inexpensive way to defend property rights on the western frontier; locks and chains do the same for parked bicycles. But enforcing one's rights to peace and quiet by "fencing out" sound waves may be more difficult, as will keeping other people's hazardous wastes out of a groundwater supply. Whenever the use of property cannot be monitored or enforced, conflicts are inevitable and trades are impossible.

Finally, property rights must be *transferable*. In contrast to the costs of measuring and monitoring resource uses, which are mainly determined by the physical nature of the property and technology, the ability to exchange is determined largely by the legal environment. Although well-defined and enforced rights allow the owner to enjoy the benefits of using his property, legal restrictions on the sale of that property preclude the potential for gains from trade. Suppose that a group of fishermen values water for fish habitat more highly than farmers value the same water for irrigation. If fishermen are prohibited from renting or purchasing the water from farmers, then gains from trade will not be realized and potential wealth will not be created.

ANDERSON & LEAL, *supra* note 1, at 20-21 (emphasis added).

4. For something of a pessimistic status report on the extent to which market forces and property rights are seen as components of U.S. environmental policy, see *BREAKING THE ENVIRONMENTAL POLICY GRIDLOCK* (Terry L. Anderson ed., 1997).

Part II examines environmental property rights in the abstract and considers the prospects for expanded trade in such rights. This part analyzes whether 3-D property rights for heavenly assets, such as air quality, have existed in the past. Part II then describes the degree to which 3-D property rights currently exist, finding that most 'property rights' markets today trade in regulatory property rather than private property. Finally, this part explains why political markets often intervene and stifle the emergence of private 3-D rights. Markets in 3-D property rights are often destroyed by the passage of statutes and regulations. However, while politics often usurps the common law creation of 3-D rights, there are reasons that the existence of 3-D property rights in the global commons may be more likely.

Part III describes the process by which the institution of property rights emerges and examines specifically how a property rights regime might emerge for the global atmosphere. Part III begins by describing a simple pattern of property rights development and discusses the evolution of 3-D property rights in the context of environmental resources. Then, this part examines attempts to protect the ozone layer and limit greenhouse gas emissions in an effort to identify the extent to which property rights are evolving in the global commons.

Part IV analogizes to notions of hunter/gatherers and food producers to draw some final conclusions about property rights evolution. This part uses these notions to explain why the global commons will likely remain a commons for a long time but will eventually yield to a regime of public and then private property rights.

## II. RECOGNIZING 3-D ENVIRONMENTAL RIGHTS WHEN WE SEE THEM

With regard to the recognition of 3-D property rights, there are several questions to consider. First, have 3-D property rights existed in the past for specific elements of air or water quality and other environmental resources? If so, do 3-D property rights exist now in 2000? If 3-D rights are possible, what explains their absence in certain contexts and their emergence in others? Examining whether or not 3-D property rights for resources, such as air quality, exist and under what circumstances they exist informs predictions for whether such rights might emerge in the global commons.

A. *Air and Sunlight: Can 3-D Property Rights Exist for Heavenly Resources?*

So, have 3-D property rights ever existed for heavenly assets, such as air quality? Those who attempt to stay abreast of evolving environmental law and policy will likely respond to this question by talking about developments in the latter half of the twentieth century.<sup>5</sup> For example, such persons might mention tradable permits for sulfur dioxide emissions, bring up EPA's bubble and offset policies, or discuss the possible market for carbon dioxide emission permits associated with the Kyoto Protocol.<sup>6</sup> They will likely suggest that tradable rights to use the environment are a very modern concept, rights that have only recently evolved. However, tradable rights have an earlier ancestry, as evidenced by the nineteenth century writings of John Stuart Mill.<sup>7</sup>

In 1848, John Stuart Mill had this to say about property rights to air quality:

Air, for example, though the most absolute of necessities, bears no price in the market, because it can be obtained gratuitously: to accumulate a stock of it would yield no profit or advantage to any one; and the laws of its production and distribution are the subject of a very different study from Political Economy . . . . If it became customary to sojourn long in places where the air does not naturally penetrate, as in diving-bells sunk in the sea, a supply of air artificially furnished would, like water conveyed into houses, bear a price: and if from any revolution in nature the atmosphere became too scanty for the [sic] consumption, or could be monopolized, air might acquire a very high marketable value.<sup>8</sup>

Although Mill saw very limited prospects for markets in air quality, he predicted that such markets *could* indeed emerge.

Mill, however, did not recognize that alienable environmental rights and markets in those rights did exist at the time he was writing and, in fact, had existed for centuries. During Mill's time, English common law granted 3-D property rights to owners and occupiers of

5. See generally Bruce Yandle, *Environmental Regulation: Lessons from the Past and Future Prospects*, in BREAKING THE ENVIRONMENTAL POLICY GRIDLOCK, *supra* note 4, at 140 [hereinafter Yandle, *Environmental Regulation*].

6. See, e.g., TOM TIETENBERG, ENVIRONMENTAL AND NATURAL RESOURCE ECONOMICS 364-75 (4th ed. 1996) [hereinafter TIETENBERG, NATURAL RESOURCE ECONOMICS]; TOM TIETENBERG, ENVIRONMENTAL ECONOMICS AND POLICY 254-65 (2d ed. 1998) [hereinafter TIETENBERG, ENVIRONMENTAL ECONOMICS].

7. See JOHN S. MILL, PRINCIPLES OF POLITICAL ECONOMY (London, Longmans, Green & Co. 1880) (1848).

8. *Id.* at 4.

land downwind or downstream from a polluter.<sup>9</sup> A landowner had a cause of action against an upstream or upwind polluter and could enforce his rights by way of an injunction or the provision of damages or both.<sup>10</sup> Therefore, the common law encouraged a market process in which rightholders and those desiring to consume environmental quality could bargain.<sup>11</sup> If persons wanted to consume environmental quality (pollute), they could enter into a contract with landowners, purchasing landowners' rights to sue for damages or injunctive relief regarding the polluting activity.<sup>12</sup> In this process of contracting around the common law rule, specific rights to air and water quality were defined and transferred from downstream property holders to polluters; common law courts enforced these transferred rights.<sup>13</sup>

Of course, these same environmental rights enforced at common law conceptually migrated to the United States with English Law. For years there were no highly articulated auction markets for emission privileges, such as the government-sponsored market for SO<sub>2</sub> emission allowances, but there *were* spontaneous markets for environmental rights. For example, as Davis reports, Wisconsin paper mills routinely purchased riparian rights and land along rivers affected by paper-making discharge in order to obtain what might be called environmental rights.<sup>14</sup> Furthermore, as early as 1891, land trusts engaged in the purchase of land and environmental easements.<sup>15</sup> Transactions such as these, involving the direct purchase of environmental rights, supplemented the purchase of land for the purpose of obtaining valuable environmental features.

In 1950, John R. Commons recognized that environmental rights were indeed part of the bundle of land rights protected at common law when he wrote:

Scarcity in economics is property in jurisprudence, and the rights and duties of property are the working rules of sovereignty in control of scarcity. Nobody would ask his government to protect him

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9. See BRUCE YANDLE, COMMON SENSE AND COMMON LAW FOR THE ENVIRONMENT: CREATING WEALTH IN HUMMINGBIRD ECONOMIES 91-93 (1997) [hereinafter YANDLE, COMMON SENSE AND COMMON LAW].

10. See *id.*

11. See *id.* at 92-93.

12. See *id.* at 93.

13. See Roger Meiners & Bruce Yandle, *Common Law and the Conceit of Modern Environmental Policy*, 7 GEO. MASON L. REV. 923, 946 (1999); Peter N. Davis, *Theories of Water Pollution Litigation*, 1971 WIS. L. REV. 738, 756-58.

14. See Davis, *supra* note 13, at 777-79.

15. See COUNCIL ON ENVIRONMENTAL QUALITY, ENVIRONMENTAL QUALITY: 15TH ANNUAL REPORT OF THE COUNCIL ON ENVIRONMENTAL QUALITY 374 (1984).

against others in getting exclusive ownership of what is as abundant as pure air in the United States of America. He asks protection in getting legal control of strategic land sites that are blessed with pure air. He has evidently, in times past, used physical force to push weaker people into the cold air of the arctic or the hot air of the tropics. When he learned to manufacture warm air in winter and cool air in the summer, he claimed and acquired private property in the patents, the instruments, tools, materials, and building which were scarce and needed in the process.

Pure air is the most valuable of all natural resources, but it has no scarcity value. Its value is its "use value." It is useful but abundant. Scarcity value adheres to property rights in what is scarce and expected to be scarce.<sup>16</sup>

Unlike Mill, Commons begins by explaining how rights to air quality actually emerge, indicating that transacting parties would first look to the sovereign to protect exclusive rights to clean air sites that then evolve in the market process. This evolution occurs when the scarcity value of environmental rights becomes large enough to offset transaction costs. At this point, distinct environmental rights would be traded separately from the land related to them. In this way, tradable site rights are early substitutes for tradable air rights. As Davis suggests, upstream dischargers could simply purchase potentially affected riparian sites and internalize the effects of their pollution.<sup>17</sup>

However, Commons' analysis is not entirely complete. For example, Commons recognizes that there is something peculiar about the relationship between air quantity and quality, but he is unable to identify it.<sup>18</sup> When the different concepts of quantity and quality are not recognized, a puzzle emerges: air seems to be simultaneously abundant *and* scarce. The confusion is eliminated when air *quality* is considered to be a separate stick in the property rights bundle that describes the characteristics of a particular site. However, if ambient air quality is to be maintained at a particular site, given current technology for enclosing particular land parcels, then the same air quality must obtain for other sites in the region of the one protected. So, air

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16. JOHN R. COMMONS, *THE ECONOMICS OF COLLECTIVE ACTION* 89 (Kenneth H. Parsons ed., Univ. of Wis. Press 1970) (1950).

17. See Davis, *supra* note 13, at 756-58, 777-80 (describing both contracting around the common law rule and purchases of land).

18. If pure air were truly abundant, as Commons initially implies, why would individuals seek to gain control of land solely on the basis of securing access to pure air? Commons seems to contradict himself on this point. See COMMONS, *supra* note 16.

quality is non-excludable;<sup>19</sup> it is a collective or public good. Therefore, effective maintenance of air quality requires a collective effort.

An interesting example of how a collective outcome for an environmental right can emerge for multiple locations is seen in the treatment of rights to sunlight in Japan.<sup>20</sup> The example shows how 3-D property rights can emerge for heavenly assets—in this case, sunlight. Due to population pressures, Japan underwent a construction boom in the 1960s, and tall buildings constructed close to residential homes obstructed light that previously came to those homes.<sup>21</sup> This high-rise construction caused an upsurge in disputes concerning access to sunlight falling upon property owners' premises.<sup>22</sup> These disputes were widespread, because access to sunlight was being curtailed in a country that already viewed solar access as quite valuable.<sup>23</sup>

Since the Japanese national government was slow to tackle the issue of sunlight obstruction, local governments, which dealt with sunshine disputes on a daily basis, adopted sunshine guidelines to protect residents' access to light.<sup>24</sup> These sunshine guidelines assigned light rights (or protection from shadows) to the owners of individual parcels of land.<sup>25</sup> The sunshine guidelines were not ordinances enacted by local assemblies and therefore were not legally binding in themselves.<sup>26</sup> However, local governments did “enforce” their own guidelines, when necessary, by taking actions such as delaying approval of proposed construction plans and threatening to deny developers connection to the water supply or sewage system.<sup>27</sup> Thus, although only the Civil Code and other national laws define property rights under the Japanese legal system, sunshine rights provided by local guidelines *were* property rights.<sup>28</sup>

These light rights were *defined*, because they specified minimum amounts of sunlight that a builder had to secure for neighboring

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19. See TIETENBERG, NATURAL RESOURCE ECONOMICS, *supra* note 6, at 51-52 (describing how public goods are non-excludable, which means that no one can be prevented from using them).

20. See Shohei Koike, Public Choice of Property Rights to Sunlight: A Study of Japanese Sunshine Rights (1984) (unpublished Ph.D. dissertation, Univ. of Or.) (on file with Univ. Microfilms Int'l, Ann Arbor, Mich.).

21. *See id.* at 49.

22. *See id.* at 48.

23. *See id.* at 54-55.

24. *See id.* at 68.

25. *See id.* at 74.

26. *See id.* at 72.

27. *See id.* at 72-73.

28. *See id.* at 74.

homes, measurable using several methods adopted by local municipalities.<sup>29</sup> Furthermore, sunshine rights gave *exclusive* rights to the use and enjoyment of sunshine and were *defensible*.<sup>30</sup> These rights could also be traded and were, thus, *divestible*.<sup>31</sup> Therefore, local Japanese sunshine rights *were* 3-D property rights.<sup>32</sup>

These 3-D light rights forced builders to initiate negotiations with residents if the developers wished to secure airspace in order to construct a building.<sup>33</sup> A person seeking to construct a building that would block residents' sunlight and, thus, violate the residents' light rights had to obtain unanimous consent from all affected property owners.<sup>34</sup> In effect, the Japanese rightholders held *de facto* rights to undisturbed sunlight.<sup>35</sup>

So, in the process of establishing guidelines for protecting solar access, Japanese municipalities created 3-D property rights for sunlight. Likewise, in the process of contracting around English common law nuisance rules, 3-D property rights were created for air and water. Therefore, it is possible for 3-D property rights to exist for heavenly assets or elements of the atmosphere; however, the extent to which such rights *actually* exist today must be analyzed in greater detail.

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29. *See id.* at 68-72.

30. *See id.* at 74.

31. *See id.*

32. *See id.* While Japanese sunshine guidelines and, thus, the property rights in sunlight that they created were not recognized by formal Japanese law, residents had *de facto* 3-D property rights in sunlight. Economists often recognize such *de facto* property rights that, while not recognized by formal law, are recognized in fact. *See* RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 53 (5th ed. 1998). Posner uses broadcast frequencies as an example of such *de facto* property rights. *See id.* at 51-53. While Congress expressly provided that licensees had no property rights in the broadcast frequencies that they were assigned by the Federal Communications Commission (FCC), there are property rights in these frequencies in economic terms. *See id.* at 52. Broadcast licenses are *defined* and granted by the FCC. *See id.* at 51. Once obtained, rights to use a certain broadcast frequency are *divestible* or transferable as an incident to the physical assets of a radio or television station (much like Commons' idea about air quality being traded as an incident to land). *See id.* at 52. Furthermore, interference with a licensee's use of his frequency will be enjoined; so, the right to use the broadcast frequency is *exclusive* and *defensible*. *See id.* Thus, there can be *de facto* 3-D property rights in an economic sense without formal legal status. *See id.* at 51, 53.

33. *See* Koike, *supra* note 20, at 74.

34. *See id.* at 68, 74.

35. *See id.* at 74; *see also* POSNER, *supra* note 32, at 51, 53.

### B. *What Do We Really Have Here, Private Property or Regulatory Property?*

Like Mill, those today who call for market solutions to environmental problems seem to be looking for something more or less than common law institutions.<sup>36</sup> For example, promoters of the modern market celebrate “permit markets”<sup>37</sup> where *regulatory* property is traded.<sup>38</sup> However, these same promoters of permit markets seldom exhibit excitement for common law *private* property rights or the ability of individuals to quietly contract due to the presence of evolved 3-D rights.<sup>39</sup> These more highly evolved and decentralized private law transactions are rarely recognized by today’s promoters of market solutions to environmental problems.<sup>40</sup> So, to what extent do 3-D property rights really exist for air quality or other environmental resources today?

The implicit forecasts contained in the comments of Mill and Commons have come true. Though embryonic, crude, and largely government-managed, markets for some specific components of air quality *do* exist today.<sup>41</sup> But, in what assets do these markets actually

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36. See BRUCE YANDLE, COMMON SENSE AND COMMON LAW, *supra* note 9, at 144-46, 160-62. That is, some special interest groups want centralized command-and-control and an end to common law; they want something less than common law. Others seek a stronger common law with special courts; they want something more than common law. See, e.g., MICHAEL S. GREVE, THE DEMISE OF ENVIRONMENTALISM IN AMERICAN LAW 115 (1996):

By *common law* I do not mean the *historical* common law as it existed at the time of Blackstone or at the end of the nineteenth century. Rather, I have in mind the basic logic of a legal system whose principal purpose lies in protecting private orderings. Such a system guarantees robust individual rights to exclude others (property); provides avenues for voluntary exchanges (contracts); and protects against aggression by outsiders (torts). Its fundamental maxim is “keep off.”

37. See, e.g., Robert W. Hahn, *Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor’s Orders*, 3 J. ECON. PERSP. 95, 95-97 (1989) (arguing that “both normative and positive theorizing could greatly benefit from a careful examination of the results of recent innovative approaches to environmental management”—marketable permits and emission charges); Robert W. Hahn & Roger G. Noll, *Environmental Markets in the Year 2000*, 3 J. RISK & UNCERTAINTY 351, 352-56, 365-66 (1990) (hailing marketable emission permits as the key to avoiding the ills of command-and-control regulation and maintaining optimism about marketable permits, despite the fact that “emissions-permits markets that resemble the economist’s textbook definition will be the exception rather than the rule”).

38. Jonathan Baert Wiener has properly referred to the assets traded in modern permit markets as “regulatory property.” Jonathan Baert Wiener, *Global Environmental Regulation: Instrument Choice in Legal Context*, 108 YALE L.J. 677, 800 (1999) [hereinafter Wiener, *Instrument Choice in Legal Context*].

39. See e.g., Hahn & Noll, *supra* note 37.

40. See Meiners & Yandle, *supra* note 13, at 956-57.

41. See TIETENBERG, NATURAL RESOURCE ECONOMICS, *supra* note 6, at 364-75; TIETENBERG, ENVIRONMENTAL ECONOMICS, *supra* note 6, at 254-60.

trade? Electricity generators routinely purchase allowances<sup>42</sup> that enable them to emit one ton of sulfur dioxide annually. Expanding industrial facilities also routinely purchase offsetting pollution reductions from firms in the same region.<sup>43</sup> Dischargers of nitrogen and phosphorous in some locations pay for the right to emit these nutrients.<sup>44</sup> Further, as Commons' analysis suggests, real estate markets routinely assign differential values to land as determined by local environmental quality.

But while this might sound good for property rights enthusiasts, most of these crude markets are themselves components of a command-and-control regime that emerged in the United States in the 1970s for managing scarce and valuable environmental assets.<sup>45</sup> This new *regulatory* property did not evolve spontaneously through the free interaction of individual agents. In fact, in some cases, the rights may have little or nothing to do with human and environmental well-being.<sup>46</sup> That is, the rights may simply represent contrived scarcity.

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42. However, these allowances are carefully defined by statute as *not* being property rights. See James L. Johnston, *A Market Without Rights: Sulfur Dioxide Emissions Trading*, REG., Fall 1991, at 24, 25 (discussing the non-property status of allowances traded under Title IV of the 1990 Clean Air Act amendments); James L. Johnston, *Pollution Trading in La La Land*, REG., Summer 1994, at 44, 48 (describing how Los Angeles' RECLAIM program explicitly denies property-right status to the credits traded under that program by stating that RECLAIM trading credits do "not constitute a security or other form of property"); 42 U.S.C. § 765b(f) (1996); Cole, *supra* note 2, at 113 (quoting § 403(f) of the 1990 Clean Air Act amendments); South Coast Air Quality Management District, *Rule 2007. Trading Requirements* (last modified July 7, 1999) <<http://www.aqmd.gov/rules/html/r2007.html>> (containing the language of Rule 2007(b)(3) under Regulation XX defining the RECLAIM program). Since 1994 some 100 million one-ton allowances have been traded, with the most recent trades fetching between \$150 and \$200 per allowance. See U.S. Env'tl. Protection Agency, *Emissions Trading and Market Trends* (last modified Jan. 13, 2000) <<http://www.epa.gov/acidrain/ats/trends.html>>.

43. See Robert W. Hahn & Gordon L. Hester, *Marketable Permits: Lessons from Theory and Practice*, 16 ECOLOGY L.Q. 361, 368-69, 371-72 (1989).

44. See Bruce Yandle, *Community Markets to Control Agricultural Nonpoint Source Pollution*, in TAKING THE ENVIRONMENT SERIOUSLY 185, 197 (Roger E. Meiners & Bruce Yandle eds., 1993) [hereinafter Yandle, *Community Markets*].

45. See, e.g., TIETENBERG, NATURAL RESOURCE ECONOMICS, *supra* note 6, at 354-58; YANDLE, COMMON SENSE AND COMMON LAW, *supra* note 9, at 143-45; BRUCE YANDLE, THE POLITICAL LIMITS OF ENVIRONMENTAL REGULATION: TRACKING THE UNICORN 2-4 (1989) [hereinafter YANDLE, TRACKING THE UNICORN]; Bruce Yandle, *Escaping Environmental Feudalism*, 15 HARV. J.L. & PUB. POL'Y 517, 536-37 (1992).

46. Federal air and water pollution statutes apply a uniform technology-based command-and-control regulation as the instrument for controlling emissions. It is well recognized that control of inputs does not necessarily translate into control of outcomes. One can easily see that an expansion of approved polluters along a particular river, with each satisfying command-and-control regulation, can yield more total pollution. For a discussion of this reasoning, see generally ROBERT W. CRANDALL, CONTROLLING INDUSTRIAL POLLUTION (1983); PAUL B.

Furthermore, although real estate markets routinely assist in the allocation of differing environmental conditions, a mammoth and growing system of land-use control stands ready nationwide to deal with such ill-specified problems and noble objectives as urban sprawl, sustainability, and pollution prevention.<sup>47</sup> All this leads to one conclusion: most of the markets that exist today do *not* trade in 3-D private property, rather they trade in regulatory property.

In fact, given that so many of the property markets today actually trade in regulatory property, it is difficult to determine with any degree of accuracy the extent to which private property rights approaches to environmental problems are expanding or, indeed, contracting. So, given this experience, only the most optimistic supporter of markets, property rights, and the common law would argue that 3-D property rights would somehow evolve for *all* environmental resources. A more sober judge, looking at specific situations, will recognize *competing* property rights institutions and perhaps see the merit in John R. Commons' assessment regarding the competition— at the end of the day, only sovereignty transfers ownership; so, the sovereign will have its way.<sup>48</sup> In this way, when called upon to settle ownership controversies involving environmental use, the sovereign will take command of the problem.<sup>49</sup>

Indeed, in the two examples of 3-D property rights for heavenly assets discussed above,<sup>50</sup> air and sunlight, the sovereign did take command of the problem. In the United States, the highly evolved

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DOWNING, ENVIRONMENTAL ECONOMICS AND POLICY (1984); TIETENBERG, NATURAL RESOURCE ECONOMICS, *supra* note 6.

47. See Robert H. Nelson, *Federal Zoning: The New Era in Environmental Policy*, in LAND RIGHTS: THE 1990S' PROPERTY RIGHTS REBELLION 295, 296-99 (Burce Yandle ed., 1995).

48. See COMMONS, *supra* note 16, at 84:

The many technicalities of law required to define ownership may be summarized, for economic purposes, as transfers of legal control by sovereignty, distinguished from transfers of physical control by labor. The early English economists, habituated to the Revolution of 1689, took for granted that the transfers of ownership were made by individuals, like the exchange of commodities, and, therefore, that sovereignty could be eliminated from economic theory. But recent revolutions do not permit us to take the economic behavior of sovereignty for granted, and both the law books and observations reveal that only sovereignty transfers ownership.

49. See *id.* Robert Nelson argues that this transformation of private property to public property rights is in fact the way modern property rights evolve. The benefits that flow from regulation are seen as being no different than the stream of benefits that comes from any other form of property. See Robert H. Nelson, *Private Rights to Government Actions: How Modern Property Rights Evolve*, 1986 U. ILL. L. REV. 361, 364; ROBERT H. NELSON, PUBLIC LANDS AND PRIVATE RIGHTS: THE FAILURE OF SCIENTIFIC MANAGEMENT 335-37 (1995) [hereinafter NELSON, PUBLIC LANDS & PRIVATE RIGHTS].

50. See discussion *supra* Part II.A.

but largely invisible common law markets for air and water were sharply constrained or eliminated by federal statutory law in the late 1960s and early 1970s.<sup>51</sup> Federal statutory law transformed *private* property rights into *regulatory* property rights.<sup>52</sup>

Likewise, Japanese sunshine rights met the same fate as U.S. common law property rights—the national government intervened and turned private property rights into regulatory property rights. Since Japanese sunshine rights required developers to gain unanimous support of affected residents, the process of obtaining light rights from landowners was costly and slow, requiring developers to bear high transaction costs.<sup>53</sup> With each affected landowner holding veto power, landowners raced to be last in the negotiating process in order to increase their bargaining power with developers.<sup>54</sup> This phenomenon is known as the holdout problem.

Chaffing at the prospects of dealing with holdouts who theoretically could obtain all the rents associated with a planned high-rise building, Japanese developers turned to the national government and obtained statutes and regulations, abrogating local sunshine guidelines.<sup>55</sup> The national government adopted a statute whereby the government regulates the “emission” of shadows extending beyond a building site rather than requires a builder to secure a certain amount of sunshine for adjacent homes.<sup>56</sup> In this way, the Japanese government decided to regulate building construction through a shadow “emission” standard rather than to assign property rights to sunlight

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51. The alteration of environmental property rights brought about by the 1972 Federal Water Pollution Control Act illustrates the point. See Todd J. Zywicki, *Environmental Externalities and Political Externalities: The Political Economy of Environmental Regulation and Reform*, 73 TUL. L. REV. 845, 907 (1999) (“[T]he government could still prosecute a paper mill for violating the Clean Water Act, even if all those actually affected by the use voluntarily bargained to allow the use. The violation of the statute is itself a harm punishable by the government . . .”).

52. Wiener sees these evolving rights as part of a “meta-market response to the incompleteness of status quo markets.” Wiener, *Instrument Choice in Legal Context*, *supra* note 38, at 800. While this is a logical public interest or efficiency explanation for regulatory property, there is also a special interest explanation. See discussion *infra* Part II.C.

53. See Koike, *supra* note 20, at 72.

54. See *id.* (“Builders and developers claimed that some residents stubbornly refused to negotiate or that they demanded huge compensation even when a proposed building would shade an attic or a small portion of a garden or fence. Prolonged negotiations delayed commencement of construction and often led to the cancellation of construction plans.”).

55. See *id.* at 85-86. The degree to which a holdout could obtain such monopoly power relates to the skill of the bargaining parties and the availability of competing locations for a high-rise building. The problem is similar to that confronted in obtaining the right-of-way for a highway. See Bruce Yandle, *Externalities and Highway Location*, 24 TRAFFIC Q. 583, 586-90 (1970).

56. See Koike, *supra* note 20, at 81.

for homeowners.<sup>57</sup> Private property rights to sunlight were converted to regulatory property rights.<sup>58</sup> Special interests, the developers, were able to effect this change, overriding private law markets and institutions, by using political power to provoke the national sovereign to act.

### C. *The Rule of Politics and the Rule of Law*

Why, at some point, does the rule of politics tend to enter and override the rule of private law and markets in the development of new environmental property rights? A partial answer to the question requires a public choice interpretation of political decision-making.<sup>59</sup> The process of defining property rights defines wealth and its distribution in society. Thus, any process that redefines property rights redistributes wealth. The slow and continuous common law process may disrupt property rights at the margin (for the controversy before the court) but cannot disrupt a property rights system entirely.<sup>60</sup> In contrast, the statutory law process can redefine the status of all existing rightholders while simultaneously setting new rules for all future transactions.

In the case of Japanese sunlight, resort to regulation and the law of politics implied that rights were transferred from a large number of highly diverse individual landowners to politicians,<sup>61</sup> who were responding to a much smaller number of better-organized developers and related interest groups. These special interest groups had to persuade the politicians to decide in their favor. Although persuading the politicians may not have been very difficult, the parties involved were operating behind a veil of uncertainty. Developers knew that they were developers; however, they did not know where and when

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57. *See id.* at 82-83.

58. *See id.* at 83:

Unlike the municipal government's sunshine guidelines, the [national statute] neither requires the builder to obtain consent from residents nor allows the parties to engage in voluntary trade. The national government insisted that the 1976 revision did not incorporate the notion of [sunshine rights], but instead set a shadow 'emission' standard thereby regulating building construction.

59. *See* YANDLE, COMMON SENSE AND COMMON LAW, *supra* note 9, at 63-85.

60. *See* Meiners & Yandle, *supra* note 13, at 946-48; POSNER, *supra* note 32, at 570 ("Ordinarily, the only way a common law court can redistribute wealth is by means of (in effect) an excise tax on the activity involved in the suit. It is not easy to redistribute wealth by this means.").

61. Of course, a formal transfer of rights does not take place when politicians decide to regulate. But an informal or implied transfer takes place any time that politicians revise a statement that redefines wealth.

they might be developing land in the future. In a similar way, residential holders of sunlight rights did not know when they might wish to sell their land for development purposes. Establishing codes or regulations may have reduced transaction costs for all parties,<sup>62</sup> including owners of individual sites who wished to develop their land, but these regulations have costs of their own. Generally, there are differential effects in such actions. In fact, it is highly likely that some individual site owners lost wealth, because landowners no longer held the power to veto the construction of tall buildings.

From the politician/broker's standpoint, the opportunity to extract political payments is large when newly formed or revised property rights are redefining wealth.<sup>63</sup> However, in order to extract these rewards, the gains must be appropriable by a pre-identified special interest group. That is, the politician/broker, as well as the potential recipient of wealth redistribution, must know who will receive the politically formed wealth. With constitutional dominance over customary and common law, authors of statutes can suppress the informal property rights process and replace it with statutory law and political control. In instances where it is costly to construct political markets, where the expected gains are not appropriable and the beneficiaries not well recognized, or where political gains are exhausted, the sovereign, by benign neglect, may actually encourage 3-D property rights and unfettered markets.

What about the global commons? As humans encourage rules for managing the global commons, is there any reason to think that property rights institutions for the global commons will vary from the command-and-control/regulatory property model that predominates today? The answer is yes. Because of the high cost of constructing political markets and the absence of tangible political gains, politicians and the interest groups they serve may be so constrained that 3-D rights will emerge in the global commons. Because there is no

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62. For a discussion of why parties may desire regulation and the lessons that Public Choice offers, see Bruce Yandle, *Public Choice at the Intersection of Environmental Law and Economics*, 8 EUR. J.L. & ECON. 5 (1999); YANDLE, COMMON SENSE AND COMMON LAW, *supra* note 9, at 63-82.

63. The reference here, of course, is to rent-seeking and rent-extracting behavior. For more on rent seeking, see Anne O. Krueger, *The Political Economy of the Rent-Seeking Society*, in TOWARD A THEORY OF THE RENT-SEEKING SOCIETY 51, 51-70 (James M. Buchanan et al. eds., 1980); FRED S. MCCHESENEY, MONEY FOR NOTHING: POLITICIANS, RENT EXTRACTION, AND POLITICAL EXTORTION 20-42 (1997). See generally Zywicki, *supra* note 51; GORDON TULLOCK, RENT SEEKING (Locke Inst., Shaftesbury Papers 2, Charles K. Rowley ed., 1993).

world constitutional order, the cost of constructing political markets at the international level is extraordinarily high.<sup>64</sup>

### III. THE EVOLUTION OF 3-D PROPERTY RIGHTS

It has been shown that 3-D property rights can emerge for heavenly assets, such as air quality.<sup>65</sup> Furthermore, because of the high transaction costs associated with constructing international political markets, it is possible that 3-D property rights will emerge for the global commons. It remains, however, to explain *how* this institution will emerge. To describe this process, a simple, stylized model of property rights development is explained. Then, current examples of property rights at the global level are examined. Finally, the pieces are brought together to begin to paint a picture of how property rights will emerge in the global commons.

#### A. *A Simple Model of Property Rights Evolution*

##### 1. Laying Some Background

When analyzing property rights evolution, it is helpful to think about the process in a highly stylized fashion. Doing so suggests there are distinct stations that characterize the transition from common access to fee simple property rights when the property rights evolution process occurs for one community of people living under one constitution. These stations of development are the following:

1. The Commons,
2. Common Property,
3. Public Property, and either
4. Regulatory Property or
5. Private Property.

Starting with the commons, the story of how property rights evolve for particular resources begins when the commons becomes crowded and resources become scarce.<sup>66</sup> For rights evolution to un-

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64. See Douglass C. North, *Dealing with a Non-Ergodic World: Institutional Economics, Property Rights, and the Global Environment*, 10 DUKE ENVTL. L. & POL'Y F. 1, 5 (1999).

65. See discussion *supra* Part I.A.

66. See YANDLE, COMMON SENSE AND COMMON LAW, *supra* note 9, at 2-3; NELSON, PUBLIC LANDS & PRIVATE RIGHTS, *supra* note 49, at 346. For key contributions to property rights theory, see JOHN R. UMBECK, A THEORY OF PROPERTY RIGHTS (1981); Armen A. Alchian & Harold Demsetz, *The Property Rights Paradigm*, 33 J. ECON. HIST. 16 (1973); Terry L. Anderson & P.J. Hill, *The Evolution of Property Rights: A Study of the American West*, 18 J.L. & ECON. 163 (1975); Guido Calabresi & A. Douglas Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 HARV. L. REV. 1089 (1972); Steven N.S.

fold at this point of meaningful scarcity, interested parties first must be able to identify, measure, and monitor in acceptable ways the resource or resource characteristic that matters to them. Then, the benefits of doing so must be worth the cost of making the identification. Taking this step yields the first “D” in 3-D property rights. That is, rights to the resource or resource characteristic—the thing that matters to people—are technically *definable*. For example, if the thickness of the ozone layer matters to some meaningful number of people who embrace a single constitutional government and if its dimensions can be measured, monitored, and recorded, then it is technically possible for those people to define property rights in the ozone layer.

The next step in the evolutionary process, common property, arrives when leadership emerges from various struggling groups and encloses parts of the commons, by rule or by fence, for a particular group’s exclusive, but undivided, use. In that way, a system of feudal property emerges. If the enclosure can be monitored and made economically secure, the second “D” in 3-D property rights emerges. That is, the newly defined common property rights are *defendable*; undesirable visitors can be excluded. This assumes, of course, that the rights in question are worth defending. Again, using the ozone layer as an example, an organized community of people might agree to constrain actions that weaken or damage the collective ozone layer.<sup>67</sup> If cooperation is somehow induced, then common property rights and duties will have emerged.

At this point in the process, an institutional choice is implied, and different rights may emerge. There is a pending choice among property regimes. Economies of scale in defining and defending exclusive rights to a resource can lead to either the invention of a new government function or government takeover of the property rights function.<sup>68</sup> Therefore, at this stage in the evolutionary process, the Com-

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Cheung, *The Fable of the Bees: An Economic Investigation*, 16 J.L. & ECON. 11 (1973); Demsetz, *supra* note 2; James E. Krier, *The Pollution Problem and Legal Institutions: A Conceptual Overview*, 18 UCLA L. REV. 429 (1971).

67. The development of new property institutions that relate to aspects of the global commons may be seen in efforts to regulate chlorofluorocarbons (CFCs). *See generally* FOREST REINHARDT, DU PONT FREON PRODUCTS DIVISION (A) (Harvard Business School Case No. 9-389-111, 1989). The challenge here is how to protect a stock of stratospheric ozone that offers protection from exposure to ultraviolet rays that cause skin cancer and damage to crops and fisheries.

68. *See generally* John Umbeck, *Might Makes Right: A Theory of the Foundation and Initial Distribution of Property Rights*, 19 ECON. INQUIRY 38 (1981) (employing the theory of competition to explain the formation and distribution of property rights).

mon Property rights that have emerged can become: (1) Public Property, with government agents managing the resource in question; (2) Regulatory Property, with government agents allocating and managing inalienable rights; or (3) Private Property, with private parties allocating, managing, and transferring rights in the benign light of government. If private rights emerge and become alienable by strictly private agreement, then the last of the 3-D characteristics has evolved. The rights are *divestible* or transferable.

## 2. What Explains the Choice at the Property Rights Fork?

Saying that institutional choices are implied when either public or private property rights might emerge is not to say that the choices are made in some explicit and institutionally defined manner. Instead of trying to picture a New England town meeting that arrives at a consensus regarding an institutional structure, it is better to visualize a social/political tug-of-war where under certain circumstances property rights emerge in one way or another. With a host of political/economic/legal variables specified, only the bravest social scientists would attempt to forecast the details and specific timing of property rights outcomes. Unfortunately, the model for making such forecasts is not well specified. Therefore, it may be useful to speculate.

Private 3-D rights can emerge in either of two ways. First, 3-D rights can evolve directly from the commons and common property without meaningful collective action.<sup>69</sup> The public choice analysis applied to Japanese sunlight rights suggests that quiet evolution of rights will occur where there are no well-identified and organized special interest groups who might seek to resolve their property rights concern by political means.<sup>70</sup> Put differently, when rights are defined collectively, there are no easily identifiable interest groups that assign a high likelihood of receiving appropriable wealth. Neither the politician nor the rights recipients have much at stake in the process. In this case, the public sector does not play a role in getting the rights process started.

Alternately, private rights may evolve from regulatory property in a two-step process: (1) special interest benefits are sufficient to generate regulatory property; and (2) these special interest benefits

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69. See generally BRUCE L. BENSON, *THE ENTERPRISE OF LAW: JUSTICE WITHOUT THE STATE* (1994); ROBERT C. ELLICKSON, *ORDER WITHOUT LAW: HOW NEIGHBORS SETTLE DISPUTES* (1991).

70. See Koike, *supra* note 20; discussion *supra* Part II.C.

become obsolete in the eyes of the interest groups that supported their political creation, or competing interest groups emerge who seek 3-D rights. In this two-step process, government first sets initial boundary conditions, specifies rules that define a domain for trade or allocation, allocates allowances, and manages elements of the trading process. Then, because the regulated property ceases to be valuable or competing interest groups express an overriding demand for 3-D rights, or because government cannot stop the evolutionary process, the regulatory property rights become 3-D private property rights.<sup>71</sup>

### 3. Historical Notes on Property Rights Evolution

Demsetz<sup>72</sup>, Libecap<sup>73</sup>, Ostrom,<sup>74</sup> Anderson and Leal,<sup>75</sup> Anderson and Hill,<sup>76</sup> and others provide stories of property rights evolution that help one to focus on the economic and social forces that lead this evolutionary process. Put in the simplest possible terms, the steps that lead from one property rights station to the next will be taken when the benefits of doing so are greater than the costs.<sup>77</sup> As Anderson and Leal point out, capturing horses from the wild and training them to carry cowboys along property lines may be economic in a world without barbed wire.<sup>78</sup> But the invention of barbed wire can lead to the release of horses to the wild. In a story of benefits and costs, the common-access resource—horses in the wild—is converted

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71. There is obviously friction in the process just described. For example, grazing rights defined by the federal government allow owners of adjacent private land to graze animals on federal land. See Terry L. Anderson & Donald R. Leal, *Rekindling the Privatization Fires: Political Lands Revisited*, in *BREAKING THE ENVIRONMENTAL POLICY GRIDLOCK*, *supra* note 4, at 53, 76-77. The rights are not officially private property but they can be transferred when the related land is bought and sold. See *id.* Environmental groups now seek to purchase and retire grazing rights in the hope of reducing damage by cattle to riparian land. Ranchers who seek to maintain the status of their regulatory property rights oppose the interests of the environmentalists. See *id.* at 77-78; William J. Carney, *From Stakeholders to Stockholders: A View from the Organizational Theory*, in *WHO OWNS THE ENVIRONMENT?*, *supra* note 1, at 187, 187-88. The general problem here is referred to as the transitional gains trap. See Gordon Tullock, *The Transitional Gains Trap*, 6 *BELL J. ECON.* 671 (1975); TULLOCK, *supra* note 63, at 66-69.

72. See Demsetz, *supra* note 2.

73. See GARY D. LIBECAP, *CONTRACTING FOR PROPERTY RIGHTS* (1989).

74. See ELINOR OSTROM, *GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION* (1990).

75. See ANDERSON & LEAL, *supra* note 1.

76. See Terry L. Anderson & P.J. Hill, *From Free Grass to Fences Transforming the Commons of the American West*, in *MANAGING THE COMMONS* 119 (John A. Baden & Douglas S. Noonan eds., 2d ed. 1998).

77. See Demsetz, *supra* note 2, at 350 (“[P]roperty rights develop to internalize externalities when the gains of internalization become larger than the cost of internalization.”)

78. See ANDERSON & LEAL, *supra* note 1, at 31.

to private property when it is economic to do so and then released to become a common-access resource again when it no longer pays to keep horses.<sup>79</sup> In their current state, the progeny of these released horses are common property in some settings, meaning that members of a defined community have rights of capture that may be exercised with group permission, and public property managed by the United States government in other settings.

By way of contrast, consider environmental resources that have traveled part, but not all, of the way through the property rights stations. An example is water quality in nineteenth century Prussia. In the nineteenth century, heavy pollution in the Ruhr, Emscher, and Wupper rivers had serious human health consequences.<sup>80</sup> This led the Prussian government to define, allocate, and defend public property rights in water quality by creating water management organizations.<sup>81</sup> Today, the water management organizations act with owner-like concern as they build treatment plants, determine and collect fees, and manage parks and recreational areas.<sup>82</sup> To the extent possible, public sector managers charge prices and manage environmental assets as though they were private property.<sup>83</sup> Therefore, there is a system of 2-D, feudal property rights that provides incentives for cost-effective pollution control. But the next step—the formation of fully alienable private rights to consume specified units of water quality—has not taken place, nor is it likely to occur.<sup>84</sup> The prospect is not bright for further efficiency gains that could come when dischargers and environmentalists buy and sell rights in open markets. Indeed, the author was told on his last visit to the Ruhr headquarters in Essen, Germany that there would never be another river basin association like the 2-D systems in all of Germany.<sup>85</sup> As the author's host saw it, the politics of control would not allow it. Why? How does the theory of property rights evolution explain this?

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79. See *id.* at 32; Anderson & Hill, *supra* note 76, at 129.

80. See David W. Riggs & Bruce Yandle, *Environmental Quality, Biological Envelopes, and River Basin Markets for Water Quality*, in *WATER MARKETING—THE NEXT GENERATION* 147, 152-53 (Terry L. Anderson & Peter J. Hill eds., 1997).

81. See BLAIR T. BOWER ET AL., *INCENTIVES IN WATER QUALITY MANAGEMENT: FRANCE AND THE RUHR AREA* 228-30 (Resources for the Future Res. Paper R-24, 1981).

82. See Interview with Detlef R. Albrecht, Ruhrverband Director of Public Affairs, in Essen, Germany (Apr. 6, 1998).

83. See *id.*

84. See *id.*

85. See *id.*

Apparently, the water quality management system within the Ruhr, Wupper, and Emscher basins continues to produce or protect enough appropriable wealth for well-defined interest groups to maintain those systems. Those who might oppose the current 2-D systems cannot dislodge them. However, consider a hypothetical decision point where government may redefine the property rights regime. Even though the current 2-D systems cannot be dislodged, the competing system of public property and command-and-control regulation introduced later in other German river basins generates more appropriable wealth for important interest groups than would the Ruhr approach. Therefore, those who might seek to install a Ruhr-like system of 2-D rights on other rivers cannot overcome the resistance of those who seek command-and-control regulation. So, what are the interest groups that gain from command-and-control but lose from a system that relies on economic incentives?

Three important groups come to mind: environmental groups, major industrial firms, and government bureaucrats. First, the German Green party and well-organized environmental groups oppose the notion of private property rights for environmental management. Allocating environmental assets by bidding is anathema to these groups. They prefer the more costly command-and-control approach, which is to say they prefer public property rights.<sup>86</sup> Second, major industrial firms often prefer technology-based regulation and dealing with politicians and bureaucrats to prices, property rights, and markets. Prices and fees, which can fall and rise, are direct additions to operating costs for firms. Command-and-control regulation, however, can be used to raise competitors' costs.<sup>87</sup> Finally, government

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86. For a discussion of German environmental groups and German automobile manufacturers as a Baptist-bootlegger coalition, see DAVID VOGEL, *TRADING UP: CONSUMER AND ENVIRONMENTAL REGULATION IN A GLOBAL ECONOMY* 63-67 (1995). For an interesting historical comparison with conservation groups involved in the negotiations over cleaning up the Ohio River Basin in the 1930s, see EDWARD J. CLEARY, *THE ORSANCO STORY* 31 (1967) ("Conservation groups . . . espoused federal control as the *only* solution to the problem." (emphasis added)).

87. See Michael T. Maloney & Robert E. McCormick, *A Positive Theory of Environmental Quality Regulation*, 25 *J.L. & ECON.* 99, 105-06, 121-22 (1982) (describing how environmental quality regulation can raise rivals' costs and "redistribute wealth among competing firms in [an] industry"); Jonathan Baert Wiener, *On the Political Economy of Global Environmental Regulation*, 87 *GEO. L.J.* 749, 763-64 (1999) (noting that industries supported the increased environmental standards in the Clean Water Act because they were seeking "to supplant patchwork state regulation . . . with uniform federal regulation"); VOGEL, *supra* note 86, at 259-61 (describing how domestic firms may rely on environmental regulation to burden international rivals and stating that these "regulations may amount to little more than disguised forms of protec-

bureaucrats prefer technology-based standards to 3-D rights or even 2-D rights, because the management of technology-based standards does not require any monitoring of environmental use.<sup>88</sup> Generally speaking, the bureaucracy loses power as dimensions are added to property rights.

A somewhat similar story can be told about the Ohio River and ORSANCO, the river association that resulted from a 1948 multi-state compact for the purpose of restoring water quality to safe levels.<sup>89</sup> In fact, the Ohio and Ruhr share similar histories. Both were major industrial rivers.<sup>90</sup> Both were located in coal and steel territories, and both experienced serious degradation from the discharge of human waste.<sup>91</sup>

By the 1930s, the Ohio River received wastes from 19 million people and some of the largest industrial plants in the world.<sup>92</sup> Cincinnati, Ohio, located at the lower end of the Ohio River, bore the brunt not only of its own untreated municipal sewage but the pollution received from upstream.<sup>93</sup> Even as cities along the Ohio began installing filtration plants, increased pollution caused a multitude of hardships for the river's water quality, such as concentration of sewage-associated bacteria, poor tastes and odors due to decomposition of organic matter, and conditions of excessive hardness and acidity in the water contributing to scale formation in steam boilers and corrosion of pipes respectively.<sup>94</sup> Sporadic outbreaks of gastrointestinal disorders were also prevalent.<sup>95</sup>

The stimulus that solved the prisoners' dilemma for the Ohio River and provided the impetus to change the river's status as an

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tionism"); see generally E. Donald Elliott et al., *Toward a Theory of Statutory Evolution: The Federalization of Environmental Law*, 1 J.L. ECON. & ORG. 313 (1985).

88. For a discussion of why command-and-control regulation appeals to bureaucrats, see Yandle, *Community Markets*, *supra* note 44, at 194-95.

89. See CLEARY, *supra* note 86, at 6-7; M.T. Maloney & Bruce Yandle, *Building Markets for Tradable Pollution Rights*, in WATER RIGHTS: SCARCE RESOURCE ALLOCATION, BUREAUCRACY, AND THE ENVIRONMENT 283, 294-95 (Terry L. Anderson ed., 1983).

90. See CLEARY, *supra* note 86, at 127; BOWER ET AL., *supra* note 81, at 217.

91. See CLEARY, *supra* note 86, at 11, 19; BOWER ET AL., *supra* note 81, at 216-17.

92. See Maloney & Yandle, *supra* note 89, at 295.

93. See *id.* The pollution costs imposed on Cincinnati by upstream cities were aptly described by the remarks of the Chairman of the Cincinnati Chamber of Commerce in 1934: "[C]itizens of Cincinnati don't want to be reminded everytime [sic] asparagus is served for supper in Pittsburgh or some other upstream community." CLEARY, *supra* note 86, at 28.

94. See CLEARY, *supra* note 86, at 25.

95. See *id.*

open-access commons occurred in 1935.<sup>96</sup> In 1935, the effects of pollution on Pittsburgh and other upstream cities, that had routinely discharged untreated human waste into the river, were particularly serious.<sup>97</sup> The presence of acids in the uppermost stretches of the Ohio River caused major corrosion damage and retarded decomposition of upstream sewage, causing a high concentration of bacterial pollution.<sup>98</sup> In an interesting way, Cincinnati got revenge. However, even at Cincinnati, halfway down the river where natural purification should have improved the situation, the water quality had deteriorated to the point where every known technique of water purification could not maintain an adequate margin of safety for Cincinnati residents.<sup>99</sup>

So, in late 1935, the Cincinnati Chamber of Commerce took the lead in beginning negotiations that eventually led to the establishment of the ORSANCO regional compact.<sup>100</sup> With the compact in place, the Ohio River ceased being a commons and became subject to a system of public property rights, managed by a multi-state river basin association, ORSANCO. ORSANCO developed a system of continuous water quality monitoring, imposed cost-effective cleanup standards on dischargers in the basin, and generally managed the Ohio River with owner-like concern.<sup>101</sup> Water quality and public health improved.<sup>102</sup>

In 1972, however, the Federal Water Pollution Control Act ended ORSANCO's evolutionary process.<sup>103</sup> The public property rights held and managed by the regional association were nationalized and made federal public property. The 1972 statute also stripped away the 3-D common law rights of riparian landowners that had operated in interstate matters and weakened the fully developed common law rights that protected the environment within the 50 states.

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96. See CLEARY, *supra* note 86, at 25; Maloney & Yandle, *supra* note 89, at 295.

97. See CLEARY, *supra* note 86, at 26.

98. See *id.*

99. See *id.*

100. See *id.* at 28-29. States continued negotiating the regional compact throughout the late 1930s. See *id.* at 42-45. In 1938, Congress submitted the final document creating the ORSANCO compact to the states for ratification. See *id.* at 45. The process of negotiation was not complete, however, until 1948 when the last state, Virginia, approved the compact. See *id.* at 47.

101. See CLEARY, *supra* note 86, at 104-05, 106-08, 124-26, 197-210.

102. See CLEARY, *supra* note 86, at 221.

103. See Maloney & Yandle, *supra* note 89, at 301.

For interesting reasons, then, some private property rights and regional public property rights became national public property. Apparently, the amount of special interest wealth that could be generated at the level of the national government exceeded the wealth that had been formed around ORSANCO's activities. As has been discussed and documented elsewhere,<sup>104</sup> national politicians saw an opportunity to satisfy industry demand for uniform rules and industry desire to escape from common law, while simultaneously gaining the support and praise of environmental organizations that had much to gain by focusing attention at the level of the national government.<sup>105</sup>

A review of natural resource history can uncover elements of a rich process that seems to yield differing property rights institutions. Yes, certain rights to land, trees, and minerals that once were common-access resources can now be owned fee simple.<sup>106</sup> The examples provided and a vast set of other resources have 3-D property rights within the complex property rights bundle associated with a resource. At the same time, however, a growing set of restrictions on some natural resource property rights and the outright destruction or conversion of others can be observed.<sup>107</sup> So while some may feel comfortable with the notion that certain elements of the property rights evolution process are understood, researchers are not well equipped to predict accurately when and how 3-D private property rights to particular environmental resources will cross and re-cross the property threshold. The current understanding of the process is incomplete. With these notions in mind, it is time to consider the global commons.

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104. See YANDLE, TRACKING THE UNICORN, *supra* note 45.

105. See *id.* at 73-75.

106. See, e.g., Michael Markels, Jr., *Farming the Oceans: An Update*, REG., Spring 1998, at 9, 9-10 & n.2 (1998) (identifying a recent noteworthy enclosure of the high seas). Ocean Fishing, Inc., has negotiated a contract with the Republic of the Marshall Islands (RMI) to certain specific rights to 800,000 square miles of ocean. See *id.* at 10. The firm will fertilize the sea and harvest the fish. See *id.*

107. See, e.g., LAND RIGHTS: THE 1990S' PROPERTY RIGHTS REBELLION, *supra* note 47 (discussing various legal restrictions on property rights, from wetland regulation to endangered species regulation to federal zoning).

B. *Recent Experience with Property Rights in the Global Commons:  
The Montreal and Kyoto Protocols*

1. Phase One: Defining Property Rights to Heavenly Assets

The development of new property institutions relating to aspects of the global commons is best demonstrated by efforts to regulate chlorofluorocarbons (CFCs).<sup>108</sup> There, the challenge is how to protect the stock of stratospheric ozone, which offers protection from cancer-causing ultraviolet rays that can cause substantial damage to crops and fisheries.<sup>109</sup> At first glance, it appears that the lack of a constitutional framework and common social norms, just to mention two of many commonly identified obstacles, causes the global challenge to be far more daunting than efforts to solve national environmental problems. Yet, perhaps it is the very absence of a traditional political structure, thereby limiting the prospect of special interest rent seeking and political payoffs that will increase the pace of private property rights development.<sup>110</sup>

First, consider the ozone layer. Viewed simply, the ozone layer is a naturally provided roof that shelters and shields a protected population from externally imposed harm. Some members of the protected population engage in beneficial activities that weaken and damage the roof. The problem is that there is no landlord, no roof owner. The roof is a global commons. Thus, even when the cost of an ill-maintained roof is recognized, finding agreement to avoid roof-damaging activities and enforcing that agreement is costly. Because detection of those who violate the agreement is difficult, individuals find that there are attractive short-run gains to be obtained by engaging in roof-damaging activities.

However, if 3-D property rights were to emerge for the ozone layer, one could well imagine how a single owner might deal with trespassers who trampled the ozone. But such institutional infrastructure is almost totally absent with respect to the stratospheric ozone

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108. See generally REINHARDT, *supra* note 67.

109. See *id.* at 1.

110. The situation is similar to the legal environment faced by merchant adventurers in the Middle Ages when doing business across vast multi-national territories. See LEON E. TRAKMAN, *THE LAW MERCHANT: THE EVOLUTION OF COMMERCIAL LAW* 10-11 (1983). Lacking the reach of formal law, the merchants developed their own private law—the Law Merchant—and means for adjudicating controversies and punishing offenders. See *id.* at 7-22; BENSON, *supra* note 69, at 30-35. Trade sanctions were the principle means of punishing itinerant merchants. See BENSON, *supra* note 69, at 33 (“Merchant court decisions were backed by the threat of ostracism, a very effective boycott sanction.”). The same may hold true in the global commons.

layer. Therefore, quite possibly an agreement on major boundary conditions is the most that could be expected.

One example of how the global community has dealt with the destruction of the ozone layer is the Montreal Accord. The Montreal Accord, and subsequent U.S. regulation, phased down and then banned the production and sale of CFCs.<sup>111</sup> In this way, regulation focused on activities “under the roof” and implicitly made the CFC-sensitive part of the roof the common property of the United Nations. Thus, command-and-control ruled the day. But what about the interests of the major producers of CFCs? Would they prefer the Montreal phase-down to a cap-and-trade system that gives CFC users the option of purchasing easements or access rights?

As demonstrated by the CFC phase down, avoiding the tragedy of the commons inevitably means imposing restrictions on output.<sup>112</sup> In 1988, when the EPA announced the CFC restriction, the agency indicated that the phase-down would generate windfall profits of \$1.8 billion to \$7.2 billion by the end of the century for American producers of CFCs.<sup>113</sup> That said, it is important to note that the EPA estimates assumed that legitimate producers of CFCs and CFC substitutes would continue to hold the market.<sup>114</sup> Of course, that turned out not to be the case. In effect, the Montreal Protocol created an illegal market for CFCs, and this illegal market continues to flourish today. Still, the promise of phase-down profits must have comforted major CFC producers and provided powerful incentives for the world’s major CFC substitute producers to monitor government enforcement of the CFC phase-out. Like the merchant adventurers of old, these chemical companies sought to impose trade sanctions on marketers of contraband. Thus, such 2-D regulatory property rights crudely, but perhaps efficiently, addressed the problem. However, as monitoring capabilities improve and the opportunity for enclosure is enhanced, it is possible that other versions of 2-D regulatory rights will evolve.

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111. See Montreal Protocol on Substances that Deplete the Ozone Layer, Annex A, 26 I.L.M. 1550 (1987), reprinted in BASIC DOCUMENTS IN INTERNATIONAL LAW AND WORLD ORDER 840, 840-45 (Burns H. Weston et al. eds., 2d ed. 1990).

112. See James M. Buchanan & Gordon Tullock, *Polluters’ ‘Profit’ and Political Response: Direct Controls Versus Taxes*, 65 AM. ECON. REV. 139, 142 (1975) (describing how the attractiveness of regulation-induced profits leads the regulated to prefer command-and-control regulation to property rights and markets).

113. See Zywicki, *supra* note 51, at 871.

114. See *id.*

The 1997 Kyoto Agreement provides yet another example of the global effort to manage a specific dimension of the global commons.<sup>115</sup> In this case, carbon was assumed to be the culprit, and instead of eroding a heavenly roof, carbon emissions were determined to provide undesirable thickening of the roof that could effect the global climate.<sup>116</sup> The Kyoto Agreement and Montreal Protocol share many characteristics. However, the absolute right to emit carbon is far more vital to life in the developed world than the right to emit CFCs. Unlike the emission of CFCs, there are no known low-cost substitutes for carbon emissions. Nevertheless, although a total phase-out of carbon dioxide emissions would be impossible, there could be reductions in the amount of such emissions. The Kyoto Agreement seeks to achieve this aim by requiring developed nations to reduce carbon emissions to 1990 levels.<sup>117</sup> However, the undeveloped world is allowed to continue to emit with impunity.<sup>118</sup>

As with the Montreal Protocol then, Kyoto gives common property status to the atmosphere—the global carbon commons—with respect to developed nations, but the atmosphere remains a true global commons for the rest of the world, allowing non-developed nations to treat the atmosphere as an open-access carbon dump. Thus, the first “D” in 3-D property rights is in place for some, but not for others. The new property is managed by the United Nations, and self-imposed rationing becomes the political instrument for managing these new property rights.

An important question arises: aside from achieving the unlikely goal of reducing the probability of global climate change, what is the incentive, the payoff, that emerges from this new property?<sup>119</sup> As with

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115. Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 10, 1997, Conference of the Parties, 3d Sess., Agenda Item 5, U.N. Doc. FCCC/CP/1997/L.7/Add.1, reprinted in 37 I.L.M. 22 (1998) (not yet in force) (84 signatories and 22 Parties as of Jan. 20, 2000), available at <<http://www.unfccc.de/resource/docs/cop3/107a01.htm>>. See Peter G. Sparber & Peter E. O'Rourke, *Understanding the Kyoto Protocol, BRIEFLY . . . : PERSP. ON LEGIS., REG., & LITIG.* (Nat'l Legal Ctr. for the Pub. Interest, Washington, D.C.), Apr. 1998, at 7-8.

116. See Sparber & O'Rourke, *supra* note 115, at 2-7.

117. See *id.* at 7, 9.

118. See *id.* at 9-10.

119. The goal is unlikely to be achieved given the fact that the undeveloped world, producer of approximately 40 percent of current carbon dioxide emissions, is unconstrained and expanding emission-related production. See BRUCE YANDLE, *BOOTLEGGERS, BAPTISTS, AND GLOBAL WARMING 2* (Pol. Econ. Res. Ctr., PERC Pol'y Series PS-14, 1998) [hereinafter YANDLE, *BOOTLEGGERS*]; Bruce Yandle, *After Kyoto: A Global Scramble for Advantage*, 4 INDEP. REV. 19, 23 (1999) [hereinafter Yandle, *After Kyoto*].

CFC restrictions and the Montreal Protocol, output restrictions generate increased profits and change relative prices. Therefore, due to the Kyoto Protocol, cartelized cutbacks on carbon will raise the relative price of coal and reduce the relative price of natural gas and oil.<sup>120</sup> Huge profits and losses hang in the balance.<sup>121</sup> Coal is predicted to suffer the largest loss in market share, while natural gas becomes the fuel of choice.<sup>122</sup> Cleaner burning petroleum could also gain market share.<sup>123</sup> Apparently, the oil and gas interests will outperform the coal interests.<sup>124</sup> Although there is more to the story, there is clear evidence that the Kyoto output restriction will produce massive amounts of appropriable special interest wealth.

Unlike the emission of CFCs, world production and emissions of carbon dioxide will and must continue. This raises the prospect for the emergence of 3-D property rights. Although permit trading is the centerpiece of the Kyoto plan, with the necessary legal environment yet to be defined and the extent of the market for trade yet to be determined, the Kyoto Protocol provides only boundary conditions and prospects for a crude market.<sup>125</sup> It is very likely, though, that if a regulatory property market does emerge, the associated rents will eventually dissipate, and, eventually, 3-D property rights will emerge.

## 2. Phase Two: Measuring and Monitoring the New Property

The cost of measuring and monitoring the use of global common property is crucial to 3-D property rights evolution. For example, if certain dimensions of the ozone layer can be measured, but the cost of monitoring use of the layer is prohibitive, no more than 1-D property rights can be expected. Thus, common and/or regulatory property and command-and-control will be the dominant institutions. However, if monitoring costs fall, and the ozone layer is deemed valuable enough, the emergence of 2-D rights can be predicted. Consequently, the ozone layer can be defended against undesirable use. As monitoring costs fall further, holding constant the value of ozone layer use, alienability can emerge, giving rise to 3-D rights.

Science fiction writers help one to imagine an outer-space police force with carbon or CFC sensors properly tuned to identify earthly

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120. See YANDLE, *BOOTLEGGERS*, *supra* note 119, at 3, 10-18.

121. *See id.* at 13-18.

122. *See id.* at 3, 8-13, 18.

123. *See id.* at 3, 11, 18.

124. *See id.* at 3.

125. See Yandle, *After Kyoto*, *supra* note 119, at 24.

poachers who illegally invade, destroy, and disturb the ozone layer and climate stability. Perhaps a modern-day cowboy could peaceably ride the line, keeping out poachers, and could send the bill to those who exercise privately held rights to use global property. In either case, low-cost monitoring technology must form the necessary bridge that connects non-transferable common property to private property with 3-D rights. So what are the possibilities for the global as well as the earthly commons?

In a brief attempt to answer this question, the author asked some of his students to scan the remote sensing technology frontier and report their findings. Dendy Macaulay, a sophomore economics major at Clemson University, provided an interesting approach.<sup>126</sup> Consider first the emerging capabilities for identifying amounts and sources of emissions in rivers, streams, and the earth's atmosphere. Macaulay introduced the possibility of genetically engineered bacteria equipped with a bioluminescent gene.<sup>127</sup> The bacteria illuminate when they encounter particular pollutants in water; the degree of illumination varies directly with the pollution concentration.<sup>128</sup> In addition to identifying the presence of pollution, the bacteria can track the pollution to its source.<sup>129</sup>

Additionally, satellite remote sensing capabilities can now provide photographs and source-identifying data on oil slicks and other pollutants, including thermal pollution.<sup>130</sup> The combination of high-tech bacteria and satellites offer the prospect of reliable, low-cost monitoring of environmental use.<sup>131</sup> Indeed, were it not for statutory limitations, the combination could facilitate the resuscitation of common law and 3-D property rights on earth.

Despite these innovative approaches, 3-D property rights have not yet effectively emerged. In fact, many unique 3-D property systems have failed to replace current systems, even when those systems are much less effective. For example, the Stedman remote-sensing gun for reading automobile tailpipe emissions has been around for

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126. See Dendy Macaulay, *Technology and Emerging Environmental Markets* (Apr. 19, 1999) (unpublished ECON319 research paper, Clemson Univ.) (on file with author).

127. See Myrna E. Watanabe, *Environmental Biotechnology Meetings Bring Developers, Manufacturers, Users Together*, 30 ENVTL. SCI. & TECH. 244A, 244A (1996).

128. Cf. *id.* at 244A-45A.

129. See Macaulay, *supra* note 126, at 9.

130. See *id.* at 14.

131. Cf. Watanabe, *supra* note 127, at 245A; Yandle, *Environmental Regulation*, *supra* note 5, at 160.

years.<sup>132</sup> The device has been tested extensively and can accurately read and record emissions at the rate of 1,500 cars per hour in 65 mile per hour traffic.<sup>133</sup> However, no matter how cheering these facts may be, the EPA continues to cling to a mandatory system of inspections and maintenance for ozone-troubled cities.<sup>134</sup>

The Stedman system is a proven technology that can identify polluting vehicles and automatically send a summons or notice to the registered owner;<sup>135</sup> it is a system that allows holders of environmental rights to be protected from poachers. But the Stedman system has not been able to displace the higher cost, less effective, command-and-control inspection system that requires one hundred percent participation.<sup>136</sup> Thus, the bridge that leads from common property rights to public or even private property rights is present, but the gate is closed. It appears that it may be more difficult to foster the evolutionary process on earth than it is on the high seas or in space.

#### IV. HUNTERS, GATHERERS, AND THE GLOBAL COMMONS: SOME FINAL THOUGHTS

It is said, "A man's reach must exceed his grasp or what's a heaven for?"<sup>137</sup> The property rights institutions for earthly resources were not developed easily. Consequently, when it comes to the heavens or the high seas, mankind must continue to grasp.

Cultural anthropologists and other scholars sometimes divide human history into two periods that can be a useful distinction in the property rights context.<sup>138</sup> There is the time of the hunter-gatherer and then the food producer.<sup>139</sup> The hunter-gatherer period is dominated by nomadic people who engage in a particular chase, whether it be for animals, or fruit and berries.<sup>140</sup> The latter time period, or that

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132. See Rick Henserson, *A Better Way to Catch Polluting Cars*, CONSUMERS' RES. MAG., July 1992, at 18, 18.

133. See *id.*

134. See K.H. JONES & JONATHAN H. ADLER, TIME TO REOPEN THE CLEAN AIR ACT (Cato Inst., Pol'y Analysis Series No. 233, 1995), available at <<http://www.cato.org/pubs/pas/pa-233.html>>.

135. See Henserson, *supra* note 132, at 20.

136. See *id.* at 21 (stating that the EPA objects to the Stedman system because random testing will not check every vehicle).

137. Robert Browning, in BARTLETT'S FAMILIAR QUOTATIONS 466 (Justin Kaplan ed., 16th ed. 1992) (1855).

138. For a strongly recommended discussion of this topic, see JARED DIAMOND, GUNS, GERMS, AND STEEL: THE FATES OF HUMAN SOCIETIES (1997).

139. See *id.* at 86, 104-13, 354-56.

140. See *id.* at 86.

of the food producer, is characterized by more advanced people who have learned about animal husbandry and planting and harvesting and who settle down to form permanent communities.<sup>141</sup> From the point of view of property rights, the hunter-gatherer values common access or common property, because enclosures and exclusive rights pose problems for people and possessions moving across space. On the other hand, the food producers value private property rights, because enclosures and exclusive rights increase wealth.

This was the dichotomy that separated America's white Europeans from many, but certainly not all,<sup>142</sup> Indian tribes. As historian Stephen Ambrose put it, "All that was needed to put the Indian on the road to civilization was, in the words of Henry Knox, the Secretary of War in 1789, to give the Indian a love of exclusive property . . . . The Indians had a communal ideal and practice, while the whites had an individual ideal and practice."<sup>143</sup> As has been clearly evinced, the promoters of private property rights won in the struggle over western lands and territories. But that was just one struggle at one point in time, and it was not a total victory for property rights enthusiasts.

Although exclusive 3-D property rights evolved for large portions of western land, they were not developed for heavenly assets, such as air. Furthermore, while the progeny of some of the white Europeans and later settlers assumed their 'advanced' roles as food producers and permanent community builders, others continued to ply the high seas where common access continued to rule as the desired form of property rights. Eventually, the descendants of these people would orbit the earth and stake out the moon not with 3-D property rights but with the Indian-like notion of common access. In many ways, the advanced food producers are still much like the hunter-gatherers.

So, at any moment in time, there are multiple property rights margins that matter to a particular people, whether they are hunter-gathers, food producers, white Europeans, or Native American tribesmen. At the intensive margin, 3-D property rights evolve for certain resources because the benefits outweigh the costs. However,

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141. *See id.* at 104-13.

142. *See* Robert Higgs, *Legally Induced Technical Regress in the Washington Salmon Fishery*, 7 RES. ECON. HIST. 55, 58-60 (1982) (describing an aboriginal fishery that "rested on the enforcement of clearly understood property rights" and stating that "the Indians possessed a well-developed property system in the fishery").

143. STEPHEN E. AMBROSE, *CRAZY HORSE AND CUSTER* 31 (1975).

these same rights will be denied in another place because of their cost or, regardless of their efficiency, because of the politics of special interests. At the extensive margin, where exploration is still occurring and the cost of defining and defending a resource is unaffordable, the commons remains unsullied by the rule of law and markets. In between these margins, there are mixtures, hybrids, and evolving property rights. As costs fall and scarcity values increase, these margins continue to shift. Eventually, even resources that are currently understood to be part of the global commons will become subject to 3-D property rights.