OPEN-ACCESS LOSSES AND DELAY IN THE ASSIGNMENT OF PROPERTY RIGHTS

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Even though formal property rights are the theoretically optimal response to open access problems involving natural and environmental resources, they typically are adopted only after considerable waste has taken place. Instead, the usual response in local, national, and international settings is first to rely on uniform rules and standards as a means of constraining behavior. While providing some relief, uniform rules do not close the externality, and excessive exploitation along unregulated margins continues. As external costs and resource values rise, there finally is a resort to property rights of some type. However, the need for transfers and other concessions addressing distributional concerns affects the ability of rights arrangements to mitigate open-access losses. This Article outlines the reasons this pattern exists and presents three empirical examples—overfishing, over extraction of oil and gas, and excessive air pollution—to illustrate the main points.

> *[T]ypically, ITQs have been put in place after a fishery has reached a crisis and other regulations have proven inadequate. Even then the disputes over initial allocations and other design features of the proposed system have gone on for years. In the meantime the situation has gotten worse. This has happened in the United States, in Iceland, and in Chile.*[1]
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> *The contrasts between unit operation in southwest Asia and "unregulated" operation in the United States are unfavorable to the wasteful system followed in developing American fields . . . . It is*

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1. RÖGNVALDUR HANNESSON, THE PRIVATIZATION OF THE OCEANS 171–72 (2004).

> *difficult to understand why in the United states, even admitting all obstacles of law and tradition, not more than a dozen pools are 100 percent unitized (out of some 3,000) and only 185 have even partial unitization.*[2]
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> *Turning to institutional considerations, the very structure of pollution problems promised something less than rapid resolution; there were strong incentives to pollute and weak ones at best to achieve control. Policy, of course, aggravated these unhappy facts. By its inertia, its allocation of the burden of uncertainty, its early reliance on volunteerism, its approach of technological feasibility, it invited delay in many ways.*[3]

INTRODUCTION

Despite their attractions as effective reducers of open-access losses involving natural and environmental resources, formal property rights typically come late, after considerable waste has occurred. The government's first official response, when it comes, instead tends to be prescriptive regulation that calls for uniform rules and standards as a means of constraining behavior. Only later, when these regulations have proven ineffective to prevent further external costs and when resource values have risen is there a resort to property rights of some type.[4] This Article outlines the theoretical reasons for why this pattern occurs and presents three empirical examples, including overfishing, over extraction from oil and gas reservoirs, and too much air pollution to illustrate the main points. This Article does not advocate the assignment of property rights as the only institutional response to the wastes of over access, but rather it describes delay as a common feature of that assignment.

The key argument against property rights as a per se response is that early, *formal* property rights, such as those described below for fisheries, oil and gas, and air emissions, involve high resource and political costs relative to their expected gains. Property rights have formidable information and input requirements in allocation, measurement, bounding, and enforcement, and they exert substantial distributive effects when there is too much uncertainty as to the

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2. JOE S. BAIN, THE ECONOMICS OF THE PACIFIC COAST PETROLEUM INDUSTRY, PART III, at 29 n.13 (1947).

3. JAMES E. KRIER & EDMUND URSIN, POLLUTION AND POLICY: A CASE ESSAY ON CALIFORNIA AND FEDERAL EXPERIENCE WITH MOTOR VEHICLE AIR POLLUTION 1940–1975, at 296 (1977).

4. There are exceptions when the resource is of very high value, information costs regarding the problem are low, and rights can be relatively easily assigned. Consider gold and silver and other hard rock minerals. For discussion see Gary D. Libecap, *The Assignment of Property Rights on the Western Frontier: Lessons for Contemporary Environmental and Resource Policy*, 67 J. ECON. HIST. 257, 266–271 (2007). When these conditions are not met, however, the general processes of delay and inertia are characteristic. Throughout this discussion I am referring to formal regulation and property rights rather than informal norms and customs that can be adopted under certain circumstances to address common pool resources ("CPR"). *See generally* ELINOR OSTROM, GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION chs. 3–5 (1990) (discussing local responses to open-access losses).

impact on key constituencies. These resource and political costs hamper the assignment of property rights to address open access. To illustrate, Scott Gordon wrote his classic article on waste in open-access fisheries in 1954.[5] It was not until 32 years later that New Zealand, among the world's foremost fishing nations, adopted one of the first property rights systems in its fisheries in 1986.[6] In this context, delay implies an optimal time for shifting regimes, from open access to uniform regulation to property rights. During this period of transition, asset rents dissipate, but enduring these losses does not imply inefficiency considering the resource costs of developing the institutional response (e.g., regulation or property rights). As outlined below, in addition to focusing on rent dissipation to determine the optimal timing of response, I have included the transaction costs of collective action within groups, within the political arena, and across countries.[7]

When the value of the resource or the cost of the externality is relatively low, prescriptive regulation to limit exploitation through uniform restrictions can be cost effective and politically acceptable. Information demands are limited to the setting and administering of general rules and standards; it does not involve obvious redistribution; and reliance upon standardized regulations reduces uncertainty regarding the impact on constituencies. The various parties involved can generally predict how they might be affected and their current political and wealth standings are unlikely to be importantly altered. At the same time, however, these policies incompletely address the externality (competitive draw down of oil reservoirs), leaving many margins for rent dissipation unconstrained.

Over time as the externality becomes more serious, information is generated about the benefits and costs of property rights in confronting it; information asymmetries are reduced; and overall uncertainty is diminished. At that point, more parties see that they will be made better off, and it becomes more economically rational and politically feasible to adopt property rights.

Property rights are relevant because they address the externality directly and link individual incentives with social objectives for resource use. But they are typically adopted only when their costs are offset by the aggregate rents that are saved from overexploitation. Because these transaction costs can be quite considerable, the value of the resource and the nature of uncertainty determine the optimal time for introducing formal property rights. Crises that suddenly and sharply raise benefits and lower uncertainty accelerate this process.[8] Crises are

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5. H. Scott Gordon, *The Economic Theory of a Common-property Resource: The Fishery*, 62 J. POL. ECON. 124 (1954).

6. Richard G. Newell, James N. Sanchirico & Suzi Kerr, *Fishing Quota Markets*, 49 J. ENVTL. ECON. & MGMT. 437, 441 (2005).

7. Even greater complications of devising property institutions in response to open access in the third world arise when there are contested institutional interactions among laws, norms, and agreements. Daniel Fitzpatrick, *Evolution and Chaos in Property Rights Systems: The Third World Tragedy of Contested Access*, 115 YALE L.J. 996, 1002–03 (2006).

8. *See* KRIER & URSIN, *supra* note 3, at 263–64; James E. Krier, *The End of the World News*, 27 LOY. L.A. L. REV. 851, 852–58 (1994); Tom Tietenberg, *Tradable Permits in Principle and Practice*, *in* MOVING TO MARKETS IN ENVIRONMENTAL REGULATION: LESSONS FROM TWENTY YEARS OF EXPERIENCE 63–94 (Jody Freeman & Charles D. Kolstad

events or spikes that dramatically raise the wastes associated with open access and at the same time lower the transaction costs of collective action by providing new information about the benefits of institutional change to combat the problem.

I. THE PROBLEM OF OPEN ACCESS

Too much air pollution, overfishing and depletion of stocks, too rapid withdrawal from subsurface oil and gas reservoirs or water from aquifers all exemplify "The Tragedy of the Commons."[9] The tragedy occurs because of a lack of clear property rights (informal or formal, group or individual) to the resource, and open access prevails. As a result, individuals do not bear the full costs of their actions, thereby creating excess and waste. Aggregate short-term production or use levels are too high and investment is too low. Parties inflict harm on one another with costly technological and pecuniary externalities. In anticipation of these spillovers, there can be a competitive rush to exploit the resource. Because exchange is not possible within large groups in the absence of property rights, the parties cannot bargain with one another to constrain behavior to limit wasteful competition or to re-allocate the resource to higher-valued uses currently or across time.[10] There are no price signals to reveal opportunity costs and free riding is rampant. Valuable labor and capital inputs are diverted from productive use to predation and defense.[11] Conflict and violence may follow. This point is illustrated by John Umbeck's examination of western mining camps in the nineteenth century where initially there were no formal or informal mineral rights.[12]

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eds., 2007) (pointing to a belated trend in resort to property rights with 9 applications in air pollution control, 75 in fisheries, 3 in managing water resources, 5 in controlling water pollution, and 5 in land use control).

9. Garrett Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243 (1968), *available at* http://www.sciencemag.org/cgi/content/full/162/3859/1243. Hardin was not the first to outline the logic and losses in the tragedy of the commons. More than a decade before his article, H. Scott Gordon clearly described a similar process. H. Scott Gordon, *The Economic Theory of a Common-property Resource: The Fishery*, 62 J. POL. ECON. 124, 124 (1954) (analyzing common ownership and resource exploitation in the fishing industry). Gordon's analysis was extended by Steven N. S. Cheung and Anthony Scott, among others. Steven Cheung, *The Structure of a Contract and the Theory of a Non-Exclusive Resource*, 13 J.L. & ECON. 49, 52–54 (1970); Anthony Scott, *The Fishery: The Objectives of Sole Ownership*, 63 J. POL. ECON. 116, 116–17 (1955).

10. Bargaining of the kind discussed by Ronald Coase is not possible. *See* Ronald Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1, 1–2 (1960) (discussing allocation of the costs of harmful effects between a property owner and those affected).

11. For a classic study in the early California gold rush, see John Umbeck, *Might Makes Right: A Theory of the Formation and Initial Distribution of Property Rights*, 19 ECON. INQUIRY 38, 40–43 (1981) (analyzing land allocation through the use or threat of violence). For a more nuanced view on the problem, see Karen Clay & Gavin Wright, *Order without Law? Property Rights During the California Gold Rush*, 42 EXPLORATIONS IN ECON. HIST. 155, 157 (2005) (arguing that mining districts were means of managing access to an open-access, non-renewable resource); Richard O. Zerbe Jr. & C. Leigh Anderson, *Culture and Fairness in the Development of Institutions in the California Gold Fields*, 61 J. ECON. HIST. 114, 115 (2001) (arguing that the social institutions created by California gold miners in the early years of the gold rush limited violence).

12. Umbeck, *supra* note 11, at 49–51.

These wastes can be large, and the social savings from avoiding them provide the incentives for collective action to secure more official group or government regulation of access and resource use or to assign property rights for private restrictions on behavior. In the following Part, I present a framework to describe the collective action problem in bargaining within groups and across groups to address the tragedy of the commons.

II. ANALYTICAL FRAMEWORK

A. Bargaining within groups

In collective action negotiations, each party determines whether or not to participate by comparing their current welfare situation with the outcome forecast through group efforts. If individual expected net gains are positive, the parties will choose to take action with the group. These net gains are a function of the predicted aggregate benefits and costs of eliminating the externality and their proposed distribution among group members. The greater the uncertainty associated with cost and benefit calculations, the lower the anticipated returns. The benefits of group efforts also depend upon monitoring and enforcement. If monitoring and enforcement costs are so high that free riding is prevalent, then the advantages of collective action decrease. Indeed, as in cartels, widespread defection or failure to comply among members can lead to an unraveling of any arrangement to mitigate the losses of open access.[13]

Collective action is promoted if: (1) the number of parties is small; (2) they are similar in the expected net gains of agreement; (3) there is little uncertainty regarding the size and distribution of costs and benefits (information, measurement, bounding, and compliance costs are small); and (4) the aggregate gains of taking action are large relative to the costs. These conditions characterize successful efforts among relatively homogeneous, small groups.[14]

Important deviations from these criteria, however, hinder group efforts. If aggregate net gains are limited—the common resource is of low value and/or the transaction costs of addressing the problem are high—there are few incentives for action until values increase or costs fall. As group size grows, bargaining and compliance costs rise. If the aggregate benefit is a public good (high bounding costs) whereas the costs of taking action are private, free riding and defection are encouraged.

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13. *See* Bjarke Fog, *How Are Cartel Prices Determined?*, 5 J. INDUS. ECON. 16, 19–21 (1956); George A. Hay & Daniel Kelley, *An Empirical Survey of Price Fixing Conspiracies*, 17 J.L. & ECON. 13, 13–14 (1974) (analyzing collusion in price-fixing cases).

14. Elinor Ostrom, *Self Governance of Common-Pool Resources*, *in* 3 THE NEW PALGRAVE DICTIONARY OF ECONOMICS AND THE LAW, at 424–32 (Peter Newman ed., 1998). The conditions necessary for self-governance of common pool resources include: (1) clearly defined boundaries; (2) distribution of benefits roughly proportionate to costs and appropriation rules consistent with local conditions; (3) participation of affected individuals; (4) monitors accountable to appropriators; (5) graduated sanctions; (6) appropriator access to low cost, local arenas for resolution of conflicts; (7) a right to organize, unchallenged by governmental authorities; and (8) nested enterprises for appropriation, provision, monitoring, enforcement, conflict resolution, and governance. *Id.*

High information costs lead to uncertainty in calculating aggregate net gains and their distribution, and hence, in estimating how individuals will fare through group action. If the uncertainty is uniformly distributed across members, agreement on measures to be taken can still be reached. But asymmetric information and related differences in publicly-available and privately-held information about costs or benefits result in divergent views of the overall advantages of addressing the externality and sharing the resulting net returns.

Collective action, which was not possible early, can become more practical after delay, as transaction costs fall. New information emerges regarding the severity of the problem, reducing uncertainty and measurement costs and eliminating information asymmetries; the resource becomes more valuable—perhaps due to greater depletion, raising the benefits of action; new technology or techniques are developed to lower the costs of closing the externality; and the number of parties declines as the private returns to exploitation fall. At this point, distributional concerns become subordinate to the overall need to respond to open access, and successful group efforts become more likely.

B. State action: political bargaining across constituencies

If the open-access problem is larger, spreading across multiple groups or constituencies, then its resolution requires broader government involvement and the efforts of politicians. When there are numerous constituencies affected differently by the problem and the costs of its resolution, politicians must balance constituent interests to maximize political support for taking action.[15] In so doing, politicians face the same problems encountered in the group negotiations outlined above.

When constituencies are heterogeneous in the net gains of collective action, politicians must devise side payments from high gainers to those who expect to do less well in order to build a political consensus. Because politicians seek transfers that minimize political opposition and risk, this tactic can also cause controversy among general taxpayers if the transfers seem to be too obvious and unfairly rewarding particular groups. Camouflaging transfers, linking them to popular public goods, and tying them to broad distributional norms can, however, reduce the political costs of transfers. Their design, however, may lower the overall effectiveness of the government regulation of the externality. Uncertainty in predicting aggregate costs and benefits and their distribution across constituencies complicates the crafting of side payments by encouraging disputes over the size, nature, and direction of compensation. These disputes increase political risk and reduce the expected politicians' benefits from deal making to address the externality.

As a result, politicians select policies that lower uncertainty and raise expected net gains for key constituents. These policies include postponing any action; encouraging research in information about the externality; promoting new

15. Gary S. Becker, *A Theory of Competition Among Pressure Groups for Political Influence*, 98 Q.J. ECON. 371, 394–96 (1983); Sam Peltzman, *Toward a More General Theory of Regulation*, 19 J.L. & ECON. 211, 212–14 (1976).

technology that lowers costs; investing in resource stock enhancement, including restricting access by non citizens or other politically-weak groups; and adopting standardized regulations that reduce the externality while appearing to remain neutral and not changing the existing distribution of wealth and political power.

The assignment of property rights to address open access entails more hazards to politicians, who resort to property rights only if general regulation fails to adequately remedy the problem and if the benefits of a rights system are clear enough to reward politicians and to offset political reaction. They entail the most direct and transparent assignment of benefits and costs, as well as require more costly allocation, bounding, and enforcement policies.[16] Any property right that has meaning involves exclusion, which potentially raises distributional conflicts. Further, the resource may rebound if open access losses are reduced and become more valuable so that ownership brings new wealth, status, and political influence. This shift results in changes to existing social and political positions and incites controversy, which can be costly to politicians. Finally, constituencies that benefited from the previous regulatory arrangement are likely to be disadvantaged by the new rights system. As we can see, inefficiencies generate their own constituencies for keeping things the same.[17]

To build political support, politicians mold the assignment of property rights in a manner that achieves other distributional objectives or meets the demands of those who claim to be harmed. These adjustments also weaken the ability of the rights regime to reduce the losses of open access.

The arguments outlined here regarding the government response to open access are similar to those described by Krier and Ursin.[18] They listed six themes associated with government environmental policies: (1) Politicians (and agency officials) adopt regulations that take the path of least resistance; the policies are reactive, rather than precautionary in order to garner political support for regulation and to minimize the political risk of adopting inappropriate or extremely costly policies. (2) Politicians place the burden of uncertainty on those parties seeking policy change. Because new regulations potentially impose vague costs on other constituencies, politicians insure that proposed standards and other controls are based on reliable data through additional research. (3) Political action follows crises that clarify the benefits of new policies through the generation of additional information and a broader sense of immediacy among citizens. (4) Politicians rely on technological solutions, rather than more fundamental programs to change citizen behavior, which can be controversial with costs spread unevenly. Because technology mandates can be applied uniformly, they appear to maintain existing

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16. As Thomas Merrill noted, the nature of the *ex ante* allocation rule affects the costs of assigning property rights. For example, assignment of rights where possible by accession (tying rights to the ownership of related resources) could be less costly than reliance upon first possession where documenting past use is required and where there is the potential for dissipation due to a race to document previous use. For discussion of the costs of first possession, see generally David D. Haddock, *First Possession Versus Optimal Timing: Limiting the Dissipation of Economic Value*, 64 WASH. U. L.Q. 775 (1986).

17. HANNESSON, *supra* note 1, at 173.

18. KRIER & URSIN, *supra* note 3, at 11–13, 252–304.

distributions of wealth and political support and avoid divisive distributional issues, especially in the design of transfer payment schemes. (5) Politicians take action only after research and learning reveal what is most likely to work, lowering uncertainty and the costs imposed on constituents. (6) There is a lag or a seemingly "unwarranted delay in government resolution of a social problem."

C. Bargaining across countries

When environmental and natural resource externality problems cross political boundaries, as in the case of green house gas ("GHG") emissions and wild ocean fisheries, the bargaining to address them occurs among politicians as representatives of various national constituencies. The same information and uncertainty problems and public choice considerations described above apply in these negotiations. In fact, they are often more severe because of greater information problems, more heterogeneity, and higher monitoring and enforcement costs among the jurisdictions affected.[19]

In international negotiations toward resolution of an open-access resource problem, the expected benefit a country derives is the sum of both the net gains resulting from international actions plus any transfer payments that it receives (or provides). No national politician will seek the support of his or her constituents unless the country's expected net benefits exceed the cost of no agreement.

If the underlying constituencies in a country are very heterogeneous with respect to support for international efforts, then the politician representing them has to balance international demands with differential constituent costs and benefits to maximize internal political support. As noted above, this requirement poses a formidable public-choice problem, and it is more complicated the greater the uncertainty about the net benefits of international efforts. The benefit that any internal group derives from a particular international effort, of course, depends on its outcome. Incomplete and imprecise information about the effects of international actions, the costs involved, and compliance generate uncertainty about the potential results of collective action.

If uncertainty is widespread across countries, international efforts are unlikely. If countries vary in their expected returns, however, there is an opportunity to devise transfers to gain support. As in national negotiations, devising transfers is complex because of differing views on the appropriateness, size, form, direction, and timing of side payments. Additionally, there are greater problems of enforcing compliance by sovereign member states. Compliance problems are illustrated in the examples described below.

For these reasons, just as in the national political arena, politicians have incentives to delay action in the international arena until the open-access problem becomes serious enough to generate the information needed to make the distribution of the benefits and costs across countries and across constituencies

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19. For discussion of the transactions costs of cross-country bargaining, see JAMES K. SEBENIUS, NEGOTIATING THE LAW OF THE SEA 1–2, 49–73, 113–144 (1984) and Beth V. Yarborough & Robert M. Yarborough, *International Contracting and Territorial Control: The Boundary Question*, 150 J. INST. & THEOR. ECON. 239 (1994).

within them clearer. At that time, politicians are better able to mobilize political support for international action that entails both costly production adjustments as well as paying (or receiving) internal and external transfers to garner collective efforts.

All told, in group, national, and international actions to reduce the losses of open access, the incentives seem clear. The parties involved are more likely to reach agreement when uncertainty is reduced, when differences in expected costs and benefits across constituencies are narrowed, and when the aggregate benefits of collective efforts (reduced resource rent dissipation from open-access externalities) exceed the transaction costs involved. These points suggest that there will be widely differing views regarding the extent of early open-access problems and the importance of confronting them. These conditions encourage group members and politicians to wait. When action is taken, it will involve general rules, regulations, and standards that involve the fewest costs and information demands and raise the least allocation concerns.[20] These acts will be insufficient so that the problem will intensify. Only then, will formal property rights be implemented, and their success in attacking the externality will depend upon how distribution demands were overcome in their design and allocation. We now turn to three examples to illustrate the arguments of this Part.

III. APPLICATION: DELAY IN THE ASSIGNMENT OF PROPERTY RIGHTS

A. Fisheries

Wild ocean fisheries constitute a classic open-access resource. With virtually unlimited entry and growing harvest pressures, the result has been depleted stocks, falling catch-per-unit-of-effort, declining incomes, and over capitalization. These conditions follow from the high and growing value of fish as a source of protein, the fugitive nature of most species, the great migratory distances involved, overlapping or absent political jurisdictions, the absence of property rights, and large numbers of heterogeneous, competing fishers.[21]

The implications of open access have been understood for a very long time—certainly by fishers themselves and by pioneering students of the problem, such as Scott Gordon, Anthony Scott, and Vernon Smith.[22] Nevertheless, in 2000, Quinton Grafton, Dale Squires, and Kevin Fox described the continuing dramatic

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20. For instance, consider the very general, non-binding emissions targets adopted by Pacific Rim nations due to a lack of urgency on the issue of climate change. *See* Tim Johnston, *Pacific Rim Nations Adopt Nonbinding Emissions Targets*, N.Y. TIMES, Sept. 10, 2007, at A12.

21. *See* Ronald N. Johnson & Gary D. Libecap, *Contracting Problems and Regulation: The Case of the Fishery*, 72 AM. ECON. REV. 1005 (1982) (discussing the bargaining problem with heterogeneous fishers); EVOLVING PROPERTY RIGHTS IN MARINE FISHERIES 4–19 (Donald R. Leal ed., 2005) (discussing generally the emergence of various regulatory/property regimes); Tietenberg, *supra* note 8, at 73–75 (same); HANNESSON, *supra* note 1 (same).

22. *See* Gordon, *supra* note 9, at 174; Scott, *supra* note 9, at 116–17; Vernon L. Smith, *On Models of Commercial Fishing*, 77 J. POL. ECON. 181, 189–91 (1969).

wastes of over fishing and inappropriate regulation in the Pacific Northwest halibut fishery; in 2003, Ransom Myers and Boris Worm warned that the world's major predatory fish populations were in a state of serious depletion; and in 2006, Jennifer Devine, Krista Baker, and Richard Haedrich provided a similar dire assessment for other deep-sea fisheries.[23]

The first government reaction to open access involved implementation of uniform restrictions on access and fishing effort, which minimize information requirements and avoid significant deliberate changes in *status quo* economic and political rankings among the parties involved. Uniform regulations, however, are unlikely to be fully effective because they do not align the incentives of the parties with the objectives of reduced harvest and conservation of the stock. Accordingly, if the fishery is sufficiently valuable, at some point there has been a turn to property rights of some type. But these have come late, only after the stock has collapsed and declining returns have made existing practices untenable. Even then, conflict over the nature of the rights to be granted and their allocation has slowed adoption of a rights regime, constrained the privileges assigned, and limited the overall benefits obtained.

To illustrate these points, Rögnvaldur Hannesson, Ragnar Arnason, and Ross Shotton, among others, outline a common process of open-access losses, delayed regulation, and finally, a limited adoption of individual transferable quotas ("ITQs") or individual vessel quotas ("IVQs").[24] Further, Ronald Johnson and Gary Libecap describe the contracting problem among fishers, who differ in skill and returns under both open access and regulation. These heterogeneities determine the kinds of regulations that can be agreed to and limit their timely adoption.[25]

For migratory offshore fisheries, the closing of the commons required the existence of political jurisdictions and/or international agreements on fishing restrictions.[26] This movement began with the establishment of 200-mile exclusive

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23. Jennifer A. Devine, Krista D. Baker, & Richard L. Haedrich, *Fisheries: Deep-Sea Fishes Qualify as Endangered*, 439 NATURE 29 (2006); R. Quentin Grafton, Dale Squires & Kevin J. Fox, *Private Property and Economic Efficiency: A Study of a Common-Pool Resource*, 43 J.L. & ECON. 679 (2000); Ransom A. Myers & Boris Worm, *Rapid Worldwide Depletion of Predatory Fish Communities*, 423 NATURE 280 (2003).

24. ITQ's are the most widely applied form of property right in fisheries. HANNESSON, *supra* note 1, at 56; *see also* RAGNAR ARNASON, CEMARE REPORT 58: A REVIEW OF INTERNATIONAL EXPERIENCES WITH ITQS (2002) (annex to AARON HATCHER ET AL., FUTURE OPTIONS FOR UK FISH QUOTA MANAGEMENT, REPORT TO THE DEPARTMENT FOR THE ENVIRONMENT, FOOD AND RURAL AFFAIRS (2002)), *available at* http://statistics.defra.gov.uk/esg/reports/fishquota/revitqs.pdf; Ross Shotton, *Current Property Rights Systems in Fisheries Management*, *in* FAO FISHERIES TECHNICAL PAPER 404/1 USE OF PROPERTY RIGHTS IN FISHERIES MANAGEMENT 45–50 (Ross Shotton ed., 2000), *available at* ftp://ftp.fao.org/docrep/fao/009/x7579e/x7579e00.pdf.

25. Johnson & Libecap, *supra* note 21, at 1006.

26. Inshore, less mobile fisheries provide more opportunities for addressing the losses of open access. *See* BONNIE J. MCCAY, OYSTER WARS AND THE PUBLIC TRUST: PROPERTY, LAW, AND ECOLOGY IN NEW JERSEY HISTORY xxv–xxviii, 7–11, 163–77 (1998) (examining open access relative to other shellfish); James M. Acheson, *The Lobster Fiefs: Economic and Ecological Effects of Territoriality in the Maine Lobster Industry*, 3 HUM.

economic zones ("EEZs") by coastal states, but it did not occur until the 1970s following the Law of the Sea negotiations.[27] For instance, Iceland staked its claims in 1975; the U.S. Congress did so in 1976, followed by Presidential Proclamation in 1983; and Canada acted in 1977.[28] These national ocean claims, however, were not made part of international law until 1994.[29] Although arbitrarily determined, the 200-mile zones encompassed most of the world's fisheries. A few, highly-migratory species (such as tuna), however, travel beyond these zones and hence, were unaffected by this important institutional change.[30] Efforts in 1993 to extend EEZs to more effectively address over-harvest in the open seas under the United Nations Conference on Straddling Stocks and Highly Migratory Fish Stocks failed due to disputes among coastal states over the size of allotments.[31] An international agreement was reached in 1995, but it did not extend the exclusive zones; rather it avoided the issue by vesting management in regional fisheries' organizations that lacked any real enforcement power.[32]

The 200-mile limit, however, made regulation possible within it, and by the 1970s important, valuable fisheries were already seriously overexploited. Among these were the British Columbia salmon fishery, the North East Atlantic, Icelandic, the North Sea Herring fisheries, and the Norwegian cod fishery.[33] In response to these conditions, ITQs were suggested by fishery economist Francis Christy in 1973 as a means of raising fishing incomes and of motivating fishers to conserve stocks.[34]

The response to overharvest, however, was not the assignment of property rights, but rather the adoption of generalized season, vessel, and equipment controls. With diverse interests, ranging from inshore and offshore fishers, large and small boat owners, fishers from different locales, sports and commercial fishers, processors, equipment sellers, labor groups, and regulatory officials, there could be agreement only on standardized rules and not on the more difficult task of assigning and monitoring individual property rights.[35] Indeed, fishers and

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ECOLOGY 183 (1975) (examining lobster fisheries in Maine); Fikret Berkes, *Local-Level Management and the Commons Problem: A Comparative Study of Turkish Coastal Fisheries*, 10 MARINE POL'Y 215 (1986) (analyzing open access losses for in-shore fisheries).

27. HANNESSON, *supra* note 1, at 36–39, 51–53, 72.

28. *Id.* at 38, 107, 116.

29. *Id.* at 38.

30. James N. Sanchirico & James E. Wilen, *Global Marine Fisheries Resources: Status and Prospects* 3 (Resources for the Future, Issue Brief No. 02-07, 2002).

31. HANNESSON, *supra* note 1, at 41.

32. *Id.* at 41–42. On August 4, 1995, the United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks outlined an agreement on this migratory species. *See* Div. for Ocean Affairs and Law of the Sea, United Nations, Documents of the Conference, http://www.un.org/Depts/los/fish_stocks_conference/fish_stocks_conference.htm (last visited Apr. 16, 2008).

33. *Id.* at 69–71, 103, 116–17.

34. *Id.* at 71.

35. *Id.* Hannesson stated:

> More typically, ITQs have been put in place after a fishery has reached a crisis and other regulations have proven inadequate. Even then the

government officials had incentives to adopt visible, yield-enhancing restrictions that seemed to benefit all parties as a public good and to avoid policies that would more directly and transparently allocate fishing rents to specific individuals or groups. In this process, fishers were uncertain how they might fare in a property rights allocation, relative to their expected returns under more certain uniform rules.[36]

Unfortunately, while attractive for technological and distributive reasons, these regulations did not successfully address open access. Non-citizens were excluded or given only very narrow access privileges, and this action alone provided short-term gains to the countries that implemented controls.[37] But nationals were allowed to expand their fleets to fill the void, and they did so. Domestic fleets were subject to season constraints and equipment controls, such as vessel licenses to limit the total number in the fishery and minimum net sizes to release adolescent fish.[38]

Nevertheless, boat capitalization increased, stocks plummeted, and fishing seasons were shortened drastically. For example, in the British Columbia halibut fishery, when regulation began in 1980, total capacity was 435 vessels, and new entry to meet that target was rapid, with the number of vessels rising by 31% within 9 years.[39] Increased fishing pressure, however, brought a fall in the stock, and regulators gradually reduced the season from 65 days to 6 days by 1990.[40] The shortened season led to further investment by fishers in larger and more powerful vessels and to a competitive fishing derby to harvest as many fish as possible in the limited time available. Harvests had to be processed and frozen, and more valuable fresh halibut were not available for market after the season closed. In response to these conditions, IVQs were adopted in 1991.[41] The new rules caused the number of vessels to fall as quotas were purchased and consolidated, and the season was expanded to 245 days by 1993 as stocks rebounded. With longer seasons, fresh halibut again could be offered for most of the year.[42]

Similar problems with uniform regulation occurred in other fisheries. For example, in the 1970s the Alaska halibut and sablefish season lasted over 100 days annually, but by 1995 (just before adoption of the ITQs) it dropped to 2–3 days.[43] Additionally, the Canadian sablefish season shrank from 245 days in 1981 to 14

> disputes over initial allocations and other design features of the proposed system have gone on for years. In the meantime, the situation has gotten worse. This has happened in the United States, in Iceland, and in Chile.

Id. at 172.

36. *See* Johnson & Libecap, *supra* note 21, at 1008–10 (discussing Gulf Coast Shrimpers & Oystermens Ass'n v. United States, 236 F.2d 658 (1956)).

37. Sanchirico & Wilen, *supra* note 30, at 4.

38. HANNESSON, *supra* note 1, at 61–62.

39. Grafton, Squires & Fox, *supra* note 23, at 684. Vessel numbers grew from 333 to 435 over 9 years, an increase of 31%. *Id.*

40. *Id.* at 685, tbl.1.

41. *Id.* at 686; HANNESSON, *supra* note 1, at 111.

42. Grafton, Squires & Fox, *supra* note 23, at 685. See Table 1 for vessel numbers and fishing seasons.

43. HANNESSON, *supra* note 1, at 141.

days in 1989; the fishery was closed in 1995 and reopened with tighter restrictions in 1996.[44]

Although centralized regulation in fisheries generally has not been successful in protecting, let alone re-establishing stocks, ITQs and IVQs have been adopted only after crises as stocks have crumbled. This pattern is not only found in the halibut fisheries described above but also in the Canadian West Coast salmon fishery, the Newfoundland and Iceland cod fisheries, and others.[45]

Under ITQs and IVQs, regulators set the total annual allowable catch based on assembled biological information, anticipated environmental conditions, and expected harvest impacts. Each authorized fisher or vessel is granted a share in the annual catch based on the allocation rule, and the quotas generally can be traded, although with varying restrictions. The most common allocation rule is based on first-possession or historical catch.[46] Past investment in vessels and equipment also is often taken into account.[47] The advantage of ITQs is that they better align the harvest practices of fishers with practices that protect or enhance the stock. The value of their quotas, which often can be major sources of wealth, depends upon the long-term health of the stock.[48] Hence, there are incentives for self and group monitoring of compliance, and importantly, ITQs, as a property right, are the basis for further contracting among fishers to reduce fishing pressure.

These advantages depend upon the strength of the property right, which varies across countries. ITQs in the United States and Canada are clearly specified as being use privileges and not property rights, revocable without compensation.[49] By contrast, in Iceland, New Zealand, and Australia, ITQs are considered to be more secure property rights.[50] These differences in the nature of property rights follow from controversies over allocation and how some parties might fare under an unrestricted market system.

Distribution concerns have resulted in various constraints on ITQs, and they are most severe in countries where fishing is a tiny portion of the gross

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44. *Id.* at 107–08.

45. *Id.* at 88, 109, 119. For further discussion, see ARNASON, *supra* note 24 (Icelandic fisheries); Katrina Miriam Wyman, *Why Regulators Turn to Tradable Permits: A Canadian Case Study*, 52 U. TORONTO L.J. 419 (2002) (Canadian fisheries). For a discussion of timing of regulation and rights, see Shotton, *supra* note 24, at 45–50 and Anthony Scott, *Moving Through the Narrows: From Open Access to ITQs and Self-Government*, *in* FAO FISHERIES TECHNICAL PAPER 404/1, *supra* note 24, at 105–17.

46. HANNESSON, *supra* note 1, at 58.

47. For discussion of the prevalence of first possession rules in fisheries, see Gary D. Libecap, *Assigning Property Rights in the Common Pool. Implications of the Prevalence of First-Possession Rules for ITQs in Fisheries*, 22 MARINE RES. ECON. 407 (2008).

48. *See* ARNASON, *supra* note 24, at 32, fig. 5.4 (discussing the success of the quota system in Iceland and rising quota values).

49. *Id.* at 14–15, 54; HANNESSON, *supra* note 1, at 77.

50. HANNESSON, *supra* note 1, at 77–78, 90; ARNASON, *supra* note 24, at 3–11, 52–57.

national product, such as the United States.[51] In the United States, with its relatively few ITQ systems, there has been an effort to preserve the relative position of regions, communities, fleets, capital, and crew by limiting the assignment and trading of ITQs.[52] Some United States ITQs are reserved for community development and not granted to individuals. There also are formal limits on the size of individual quota holdings and their transferability. In the Alaska halibut fishery, for example, only transfers from larger to smaller vessel classes are permitted, and no individual is allowed to own more than 0.5% of the total quota.[53] Other controls over share concentration limit holdings and maintain a targeted number of vessels in the halibut fleet.[54] Further, in 1996 the Magnuson Act placed a four-year moratorium on the adoption of further ITQs in U.S. fisheries.[55] In sum, while excessive overharvest in wild ocean fisheries began to become noticeable in the 1950s, property rights solutions did not appear until the 1980s and thereafter and even then, their adoption has been slow and constrained as these examples reveal.[56]

B. Oil and gas extraction

As with wild ocean fisheries, oil and natural deposits that lie under private lands in the United States are open-access resources. These deposits are lodged in subsurface reservoirs under great pressure. When any part of the surrounding geologic formation is punctured by a well bore, a low-pressure area is created. Natural gas and oil migrate rapidly toward the opening. Migration potentially allows adjacent landowners to extract their neighbor's oil. Movement depends upon subsurface pressures, oil viscosity, and the porosity of the surrounding rock.

Because of the fugitive nature of subterranean oil and gas, *in situ* property rights are not assigned to surface land owners, as is done with fixed subsurface mineral resources, but instead are granted only upon extraction or capture, as with wild animals (minerals *ferae naturae*).[57] This ownership rule creates conditions for

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51. HANNESSON, *supra* note 1, at 124, 135, 167. Indeed, the United States has been characterized as a major fishing nation, but not a major ITQ nation. *See* ARNASON, *supra* note 24, at 52.

52. HANNESSON, *supra* note 1, at 135–37. As of 2002, there were only three ITQ systems in the United States as compared to over 40 in Canada. *See* ARNASON, *supra* note 24, at 12, 53 (summarizing quota systems in the United States).

53. ARNASON, *supra* note 24, at 54–55.

54. Rajesh Singh, Quinn Weninger & Matthew Doyle, *Fisheries Management with Stock Growth Uncertainty and Costly Capital Adjustment*, 52 J. ENVTL. ECON. & MGMT. 582, 594–95 (2006).

55. HANNESSON, *supra* note 1, at 151. For a summary of allocation issues in fisheries, see Libecap, *supra* note 47.

56. *See also* Sanchirico & Wilen, *supra* note 30, at 3, 7.

57. The problems of open access in oil production are discussed in Gary D. Libecap & James L. Smith, *The Economic Evolution of Petroleum Property Rights in the United States*, 31 J. LEGAL STUD. 589, 591–95 (2002). For additional discussion of the common-law rule of capture, unitization, and other regulations, see generally JACQUELINE LANG WEAVER, UNITIZATION OF OIL AND GAS FIELDS IN TEXAS: A STUDY OF LEGISLATIVE, ADMINISTRATIVE, AND JUDICIAL POLICIES 9–29, 201–60 (1985). The problems of first-

competitive withdrawal. Owners lease exploration and production rights to oil and gas firms, and these firms have incentives to drill and drain to increase their shares of oil field rents, even though these individual actions lead to aggregate open-access losses.

Rents dissipate as capital costs are driven up with the drilling of excessive numbers of wells (more than geologic conditions require or price and interest rate projections warrant) and with the construction of surface storage, where the oil can be held safely from drainage by other firms. Unfortunately, once in surface storage, oil is vulnerable to fire, evaporation, and spoiling. Rapid extraction also increases production costs as subsurface pressures are vented prematurely, forcing the early adoption of pumps and injection wells. Total oil recovery falls as pressures decline because oil becomes trapped in surrounding formations, retrievable only at very high extraction costs. Finally, rents dissipate as production patterns diverge from those that would maximize the value of output over time.

The problem of competitive withdrawal was recognized when oil was first discovered in the United States in 1859.[58] The nature and extent of the externalities involved, however, were not well enough understood to attempt coordinated strategies to constrain them.[59] By the early twentieth century, however, the economic value of oil became high enough to raise concern about waste. For example, in 1910, it was estimated that up to 11% of California's (a major producing state) annual oil output was lost due to fire while in surface storage.[60] In 1914, the director of the Bureau of Mines estimated that the costs of excessive wells equaled about a quarter of the value of total annual U.S. oil production.[61] Oil recovery was estimated at only 10-20% of the total resource in place, but in many cases, it would have been much less than this overall average.[62]

These losses stimulated scientific research on subsurface reservoir mechanics and on how production practices could affect over all recovery.[63] This knowledge provided a basis for negotiations among private parties to reduce the losses of open access. Buyouts of all but one party on a reservoir to create single ownership or unitization for cooperative production were the most complete solutions. Neither was widespread. As a result, as with fisheries, initial formal efforts to address open access turned to state regulation. This too, however, did not arrive until comparatively late, in the 1920s and 1930s.[64]

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possession rules assigning ownership to flows rather than to the resource stock are discussed in Dean Lueck, *The Rule of First Possession and the Design of the Law*, 38 J.L. & ECON. 393, 396–410 (1995).

58. Libecap & Smith, *supra* note 57, at 591–92.

59. *See id.*

60. *Id.* at 592.

61. For an estimate of the rental losses involved, see Gary D. Libecap & Steven N. Wiggins, *Contractual Responses to the Common Pool: Prorationing of Crude Oil Production*, 74 AM. ECON. REV. 87, 90–91 (1984).

62. Libecap & Smith, *supra* note 57, at 593 n.14.

63. *Id.* at 593.

64. *Id.* at 594.

State regulation focused on limiting well drilling and the extraction of oil and gas from them. The Texas Railroad Commission and other state regulatory agencies set monthly statewide production levels and allocated the total among regulated wells as quotas under a system termed prorationing.[65] These production rules applied uniformly to all oil fields, even though each field had a unique physical configuration and optimum production potential.

Regulation was controversial, especially among the very numerous small firms (independents) that had adapted to open access and produced more than their share of field deposits would warrant.[66] Large firms (majors) tended to advocate for state intervention because they bore more of the field-wide losses of competitive extraction.[67] To elicit the political support of small firm owners and oil-field equipment suppliers for regulation, they were granted preferential treatment. These privileges were a costly form of transfer payment, but were less transparent and more politically feasible than outright cash payments.[68]

For example, individual well quotas, or allowables, were based on acreage and depth, but the Commission gave more weight to depth, encouraging oil firms with limited leased acreage to drill deeper. Minimum spacing rules were adopted to limit overall drilling, but the Commission also routinely granted exemptions to small firms. Further, in Texas, the large numbers of very high-cost wells (stripper wells) were exempted from any production controls.[69] The costs of these uniform prorationing regulations and exemptions were criticized. By the early 1960s, energy economist M.A. Adelman estimated that these costs were substantial, probably exceeding $2 billion per year.[70] State regulation of well spacing and well production rates was able to reduce some of the losses of open access.

Nevertheless, dissatisfaction with state regulation led larger oil and natural gas firms to consider either private collective action through buyouts or unitization of fields. The latter was the preferred solution for many firms because it maintained their lease ownership in the field at a time of considerable uncertainty about long-term lease values that prevented agreement on sales prices. But lease valuation problems also hindered unit agreements.[71]

Unitization production rights are delegated through negotiation to a single firm—the unit operator—with net revenues apportioned among all parties on the

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65. Libecap & Wiggins, *supra* note 61, at 90.

66. *Id.* at 91.

67. *Id.*

68. Libecap & Smith, *supra* note 57, at 595.

69. Libecap & Wiggins, *supra* note 61, at 95–96.

70. M.A. Adelman, *Efficiency of Resource Use in Crude Petroleum*, 31 S. ECON. J. 101, 105 (1964).

71. Steven N. Wiggins & Gary D. Libecap, *Oil Field Unitization: Contractual Failure in the Presence of Imperfect Information*, 75 AM. ECON. REV. 368, 368 (1985). For discussion of unitization, see Gary D. Libecap, *Unitization*, *in* 3 THE NEW PALGRAVE DICTIONARY OF ECONOMICS AND THE LAW, *supra* note 14, at 641–44; Gary D. Libecap & James L. Smith, *The Self-Enforcing Provisions of Oil and Gas Unit Operating Agreements: Theory and Evidence*, 15 J.L. ECON. & ORG. 526 (1999); James L. Smith, *The Common Pool, Bargaining, and the Rule of Capture*, 25 ECON. INQUIRY 631 (1987).

field, including those that would otherwise be producing. As the only producer on the field and a residual profit claimant, the unit operator has incentive to maximize field rents. Accordingly, unitization results in important economic gains: a time stream of output that more closely approximates the rent-maximizing pattern, increased oil recovery, and reduced wells and other capital costs.

Unit agreements, especially during primary production, when natural subsurface pressures could force oil to the surface, were very difficult to complete. Unitization during secondary recovery was easier because of existing coordination among producers for injecting water, gas, or other fluids to push oil out of the ground. Accordingly, secondary recovery and unit agreements could be written jointly, but the losses of competitive production during primary recovery remained unconstrained because of a lack of agreement.

The key issue of contention in these collective efforts is how shares of the net proceeds of unit production should be allocated.[72] These shares are property rights to the unit rents and are based on estimated pre-unit lease values. Contingent updates are not possible because once the unit is formed individual leases lose their meaning and reservoir production dynamics change.[73] The bargaining problem arises due to disagreement on lease values.

Lease values are based on current and cumulative oil and gas production, the estimated size of the deposit below them, predicted oil migration and viscosity, the porosity of the surrounding medium, and other environmental factors. Assessing these factors and calculating lease value involves subjective guesswork, as is common in valuation, and the process is contentious. Firms have private information that may be difficult to credibly convey to other parties. Public information, such as past production and surface acreage, can be poor indicators of lease value. The problems are greatest for small, strategically-located leases with the most production potential, longest expected life, and hence, greatest long-term uncertainty. As fields age and primary production wanes, many leases become unproductive and others have short futures unless secondary injection begins. Accordingly, at those times, private and public information about lease characteristics converge and unit agreement is more feasible.

As a result of conflicts over allocation, unit agreements can take a very long time to negotiate, or they break down and result in incomplete units that cover only part of a field. In their detailed analysis of seven units in Texas and New Mexico, Steven Wiggins and Gary Libecap found that negotiations often required four to nine years to complete.[74] Moreover, in five of the seven cases, the acreage in the final unit was less than that involved in the early negotiations. With incomplete units, part of the reservoir remained open access or was organized into

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72. *See* GARY D. LIBECAP, CONTRACTING FOR PROPERTY RIGHTS 93–114 (1989); *see also* Libecap & Smith, *supra* note 71, at 532–34 (describing the nature of a complete unit contract); Wiggins & Libecap, *supra* note 71, at 369–71 (examining the bargaining problem underlying unit formation).

73. Updates are possible during certain pre-agreed-to events such as the shift from primary to secondary recovery. *See* Libecap & Smith, *supra* note 57, at 595–97.

74. LIBECAP, *supra* note 71, at 103.

competitive subunits with significant losses as the subunits vied for the oil and gas.[75]

The problems of negotiation are more difficult for reservoirs that involve mixtures of oil and natural gas. Differences in price volatility for the two substances make it difficult to agree upon conversion factors. Such reservoirs are frequent because 63% of the largest U.S. oil fields contained significant volumes of natural gas along with oil.[76] Oil lease owners prefer to re-inject gas into the formation to expel the oil, whereas gas lease owners prefer to sell their gas and leave the oil be.

The huge Prudhoe Bay field is a case in point.[77] It was discovered in 1968, and unit negotiations took over eight years. Even then, the field was not effectively unitized, but rather was partitioned into two competing units or participating areas, one for oil, led by British Petroleum ("BP") and one for gas, led by Atlantic Richfield ("ARCO"). Conflicts between the firms continued because of their differential production incentives. The original unit agreement was significantly amended on at least seven occasions during the 1980s and 1990s as the companies settled disputes on a piecemeal basis. By 1988, Prudhoe Bay production began to decline, not because of physical depletion of the underlying oil deposit but because of disagreement about which parties would pay for the facilities required to handle the rising volume of gas that was produced along with oil as the field matured. Finally in 1999, BP purchased ARCO and effectively unitized the field, 31 years after discovery.[78]

To promote unitization and thereby reduce the losses of competitive extraction, states have intervened with compulsory or forced unitization statutes.[79] These statutes relaxed the unanimity voting rule on share allocations. In Oklahoma, compulsory unitization legislation was enacted in 1945. It stated that once 85% of the leases approved unitization, the remainder could be forced to join.[80] Small firms resisted the new law, challenged it in court, and attempted repeal in 1947. By 1951, however, opposition to compulsory unitization in Oklahoma was largely spent, and the original law was amended with little controversy to lower the required majority from 85 to 63%.[81]

In Texas, however, small firms resisted the loss of the regulatory advantages afforded them through the state's prorationing regulation, and because of their large number and political influence, Texas never adopted a compulsory unitization law.[82] Between the late 1940s and the 1960s, all other oil-producing

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75. Wiggins & Libecap, *supra* note 71, at 377–83.

76. Libecap & Smith, *supra* note 57, at 597.

77. For discussion of Prudhoe Bay, see Libecap & Smith, *supra* note 71, at 543–45.

78. Libecap & Smith, *supra* note 57, at 605–06.

79. *See id.* at 596, 606.

80. Unitization Act, 1945 Okla. Sess. Laws 162.

81. Act effective May 26, 1951, 1951 Okla. Sess. Laws 138.

82. Gary D. Libecap & Steven N. Wiggins, *The Influence of Private Contractual Failure on Regulation: The Case of Oil Field Unitization*, 93 J. POL. ECON. 690, 706–12 (1985).

states adopted some form of forced unitization law to facilitate unit formation.[83] Not surprisingly, Texas has had a lower share of production from fully-unitized fields than does other states. It also has had more high-cost producers than other states. For instance, as late as 1975 only 38% of Oklahoma production and 20% of Texas production came from complete, field-wide units.[84]

Accordingly, the pattern of responding to open access in oil and gas reservoirs is similar to that which occurred in fisheries. This pattern involves: tolerance of open access until the costs became large compared to expected benefits of minimally addressing it; adoption of uniform production rules, molded by political factors; and finally, resort to property rights, in this case through buyout or field unitization. Uncertainty in estimates of how the parties would fare under new regulations or property rights regimes, relative to the *status quo*, delayed action. Even then, the extent and form of the side payments necessary to meet distributional and political demands limited the effectiveness of the regulations and unitization (rights) arrangements that were possible.

C. Air pollution

Excessive air pollution equally involves an open-access problem. Emissions arise from manufacturing plants, utilities, vehicle exhaust, as well as myriad other sources that are part of a modern economy. The opportunity to dispose of wastes in the air has been viewed as an entitlement, a form of property right.[85] At the same time, there are no property rights to the atmosphere, which is fugitive and virtually impossible to bound. All of this provides the potential for too many emissions. If the emitted particles are relatively large or they interact with local sunlight and geographical factors, as with urban smog, air pollution has localized effects. Where the emissions travel larger distances, as with SO_2, the external effects are more broadly cast; if they migrate to the upper atmosphere, global externalities result, as with chlorofluorocarbons ("CFCs") and CO_2.[86]

So long as releases are limited and the airborne stock is small relative to the atmosphere affected, there is little adverse impact. As emissions grow and the stock of pollutants increases, however, air pollution becomes a more serious problem. As concerns about air pollution have risen, the regulatory response has been slow and the adoption of property rights to mitigate the problem, when it has occurred, generally has come even later. Indeed, the notion of tradable emission permits to address air pollution was put forward by Thomas Crocker in 1966 and by J.H. Dales in 1968, but adoption of such permits took another 30 years.[87]

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83. *Id.* at 701.

84. *Id.* at 702.

85. For discussion of the property-rights aspects of emissions and regulatory response, see Jason Scott Johnston, *Tradable Pollution Permits and the Regulatory Game*, *in* MOVING TO MARKETS IN ENVIRONMENTAL REGULATION, *supra* note 8, at 353–85.

86. For discussion of regional and global air pollution problems, see TOM TIETENBERG, ENVIRONMENTAL AND NATURAL RESOURCE ECONOMICS 395–402 (7th ed. 2005).

87. J.H. DALES, POLLUTION, PROPERTY & PRICES 77, 81–97 (1968) (proposing such permits to address water pollution, but acknowledging their applicability to air

1. Local air pollution—urban smog

Consider the problem of urban smog. James Krier and Edmund Ursin (1977), and James Krier (1994) describe the sluggish pace of government response to air pollution in Southern California, the part of the country that perhaps most exemplifies the problem of dirty air. Although there was a growing persistence of smog in the Los Angeles Basin by the early 1940s, it took approximately 35 years before legislators enacted regulations to directly attack the major source of the problem—auto exhaust.[88] Early state and local regulations completely ignored vehicle emissions.[89] In 1950, research revealed that a photochemical reaction converted pollutants from refineries and motor vehicles into smog, yet the focus of government action was on further research on air quality standards and the extent and nature of vehicle pollution rather than on developing emission controls.[90] All the while, as further research confirmed the link between exhaust and smog, the problem intensified.[91]

Although the California Pure Air Act of 1968 authorized air pollution control districts, their authority was limited.[92] The primary regulatory response included technological adjustments to reduce emissions as a condition for licensing new vehicles and some used cars, and the establishment of uniform emissions standards for stationary sources, rather than behavioral changes, such as restrictions on driving.[93] Most mobile pollution sources remained relatively unregulated by the state.

The Federal Clean Air Act of 1963 set the stage for greater involvement by the federal government in regulating air pollution, including federal auto emissions standards that followed from the Motor Vehicle Control Act of 1965.[94] The Federal Air Quality Act of 1967 required states to set air quality standards consistent with the Clean Air Act. California's Pure Air Act of 1968 set higher emissions standards and created the Air Resources Board with regulatory jurisdiction over mobile and stationary sources.[95] The Federal Clean Air Act Amendments of 1970 established uniform air quality standards across the country and identified non-attainment areas where more restrictive controls were to be implemented.[96] Market-based pricing approaches such as emissions taxes were not adopted.[97] Although pollution levels decreased in some areas, states consistently

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pollution); Thomas D. Crocker, *The Structuring of Atmospheric Pollution Control Systems*, *in* THE ECONOMICS OF AIR POLLUTION 61–68 (Harold Wolozin ed., 1966).

88. KRIER & URSIN, *supra* note 3, at 2; Krier, *supra* note 8, at 852–54.
89. KRIER & URSIN, *supra* note 3, at 6.
90. *Id.* at 8.
91. *Id.* at 78–86, 91, 112–14, 252–57.
92. *Id.* at 252–58, 263–65.
93. *Id.* at 8, 277–79.
94. *Id.* at 172–76.
95. *Id.* at 9–10.
96. *Id.* at 2–3.
97. Donald N. Dewees, *Tradable Pollution Permits*, *in* THE NEW PALGRAVE DICTIONARY OF ECONOMICS AND THE LAW, *supra* note 71, at 597. Emission taxes then and now have been viewed both as being too costly to administer relative to uniform standards and politically unacceptable, particularly by the interests that would be most affected. For

failed to meet targeted standards between 1970 and 1990, and in many areas, air quality actually worsened.[98]

Finally, in 1994, some 50 years after the first concerns about smog emerged, California implemented a property rights approach to reduce NO_X and SO_2, the major sources of smog, in the Los Angeles Basin with the Regional Clean Air Incentives Market ("RECLAIM").[99] Los Angeles was the only area in the country to fall into extreme non-attainment of ozone level targets, despite previous regulatory efforts. Unfortunately, RECLAIM applied only to certain stationary facilities—utilities, refineries, and manufacturing plants, and not motor vehicles.[100]

These facilities were granted emissions quotas, based on historical releases and annual reduction rates. The South Coast Air Quality Management District ("SCAQMD") set total annual allowable releases, with each facility's quota a share of the aggregate. The quotas were a property right to emit pollutants, and they could be traded to encourage those organizations that could reduce pollution at lower cost to do so while selling the residual to sources with higher abatement costs.[101]

2. National air pollution—acid rain

There is a similar pattern of delay, reliance upon technology and uniform standards, and ultimately on property rights in national efforts to lower SO_2 pollution. In the 1960s, there was growing awareness of the damage caused to lakes and forests from acid rain downwind from power plants that released SO_2 into the atmosphere. The 1970 and 1977 Clean Air Act Amendments set national maximum concentrations of SO_2, and the states were charged with meeting those standards.[102]

To reduce emissions, the laws employed technology-based regulations. These included specifying the equipment to be used, such as types of scrubbers, even if the utility used low-sulfur coal, and setting new source performance

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discussion, see *id.* at 600; KRIER & URSIN, *supra* note 3, at 304; Johnston, *supra* note 85, at 357.

98. KRIER & URSIN, *supra* note 3, at 258, 296–307; Johnston, *supra* note 85, at 358.

99. The Regional Clean Air Incentives Market ("RECLAIM") program, adopted by the South Coast Air Quality Management District ("SCAQMD") in October 1993, set an emissions cap and declining balance for many of the largest facilities emitting nitrogen oxides (NO_X) and sulfur oxides (SO_X) in the South Coast Air Basin. For further discussion, see Clean Air Mkts. Div., EPA, An Overview of the Regional Clean Air Incentives Market (RECLAIM) (Aug. 14, 2006), http://www.epa.gov/airmarkt/resource/docs/reclaimoverview.pdf.

100. Dewees, *supra* note 97, at 600.

101. TIETENBERG, *supra* note 86, at 387–88; A. Denny Ellerman, *Are Cap and Trade Programs More Environmentally Effective than Conventional Regulation?*, *in* MOVING TO MARKETS IN ENVIRONMENTAL REGULATION, *supra* note 8, at 48–62.

102. Clean Air Amendments of 1970, Pub. L. No. 91-604, 84 Stat. 1676; Clean Air Act Amendments of 1977, Pub. L. No. 95-95, 91 Stat. 685; Paul L. Joskow & Richard Schmalensee, *The Political Economy of Market-Based Environmental Policy: The U.S. Acid Rain Program*, 41 J.L. & ECON. 37, 43–45 (1998).

standards applying to new plants.[103] Older plants were not regulated so that controls moved at the pace of the slowest or least able source to comply.[104] These rules benefited high-sulfur coal producers, mining unions, and Midwestern and Northeastern utilities with older facilities that burned high-sulfur coal. The losers were utilities with new equipment and that used low-sulfur coal, as well as coal producers in the West, a major source of low-sulfur coal.

Subsequent dissatisfaction with the costs of these regulations led to the adoption of limited trading programs, including: (1) bubbles, allowing exchanges among different sources in a single plant; (2) netting, allowing plant expansion if overall pollution did not increase; (3) banking, allowing firms to carry forward unused credits; and (4) offsets, allowing new plants to be brought on line if existing ones reduced pollution.[105] Despite the costs, total emissions of SO_2 peaked in the 1970s and then declined through the 1980s.[106]

Nevertheless, acid rain continued to be a problem, and even more significant reductions in SO_2 releases were necessary, particularly new reductions aimed at controlling emissions from the dirtiest units.[107] The political and economic costs, however, were viewed as prohibitive unless policies were changed to allow for more cost-based approaches.

During the previous 20 years, pollution abatement costs continually increased as stricter standards were adopted. By 1990, U.S. pollution control costs reached $125 billion annually, nearly a 300% increase in real terms from 1972 levels.[108] Existing uniform rules generally did not recognize that the costs of controlling emissions varied across and within firms. Because traditional regulation gave advantages to old plants and technology, few incentives existed for those organizations to develop new technologies to reduce emissions at lower cost. Newer units were forced to adopt the technology specified by the regulator, rather than that which might have been more cost effective.[109] Further, central regulation and its reliance on uniform standards could be used politically to disadvantage certain firms and regions (those that used and produced low-sulfur coal) at the

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103. Dewees, *supra* note 97, at 597–98; Joskow & Schmalensee, *supra* note 102, at 43–44.

104. For discussion of the early acid rain program, see TIETENBERG, *supra* note 86, at 396–400.

105. These limited trades are estimated to have resulted in savings of $1–$12 billion in pollution control costs. *See* Dewees, *supra* note 97, at 600.

106. Joskow & Schmalensee, *supra* note 102, at 45.

107. *Id.* at 46–50; Nathaniel O. Keohane, *Cost Savings from Allowance Trading in the 1990 Clean Air Act: Estimates from a Choice Based Model*, *in* MOVING TO MARKETS IN ENVIRONMENTAL REGULATION, *supra* note 8, at 198.

108. Robert N. Stavins, *Market-Based Environmental Policies: What Can We Learn from U.S. Experience (and Related Research)?*, *in* MOVING TO MARKETS IN ENVIRONMENTAL REGULATION, *supra* note 8, at 34.

109. Jody Freeman & Charles D. Kolstad, *Prescriptive Environmental Regulations versus Market-Based Incentives*, *in* MOVING TO MARKETS IN ENVIRONMENTAL REGULATION, *supra* note 8, at 5.

behest of entrenched interests (those that used and produced high-sulfur coal) with little environmental benefit.[110]

In response, Title IV of the 1990 Clean Air Act Amendments finally authorized electric utilities to trade allowances to emit SO_2 while reducing total allowed emissions by approximately 50%. This legislation represented the first large-scale, long-term U.S. environmental program to rely on tradable emission permits.[111] The objective was to reduce SO_2 and NO_X emissions by 10 million and 2 million tons respectively from their 1980 levels. The flexibility underlying the tradable emission permit system overcame political opposition to the ambitious air pollution reduction objectives.[112]

Under the permit system, an annual targeted level of emissions was set and prorated across permit holders, who were allowed to discharge a specified amount of the gases. Emission permits were allocated to utilities through first-possession rules, based on past electricity production, heat generation, fuel use or emissions, free of charge, and hence grandfathered in existing utilities. Utilities in certain states such as Illinois, Indiana, and Ohio were allocated an additional 200,000 allowances annually during the first phase of regulation.[113] Those states had important coal interests and all had ranking members or chairs of key congressional subcommittees.[114]

These preferential quotas, as with those granted in oil and gas prorationing, were adopted, in part, to make the new property rights program politically viable for incumbent firms, and to encourage investment in new and renewable energy technology by newer utilities that had more limited quotas.

As in the RECLAIM program, the permits constituted a tradable property right to discharge a specified amount of SO_2 and NO_X. Rather than equating pollution levels across firms as in past regulation, by trading these instruments, marginal abatement costs could be equalized across firms. Those firms that could reduce emissions at lower cost could do so and sell the residual emission rights, apply them to offset excess emissions in other parts of their operations, or bank them. An active market in emission permits developed. Adoption of tradable emission permits has been viewed as a successful means of lowering overall air pollution with a cost savings of over $1 billion relative to what might have been possible under previous regulation.[115] But as with similarly successful ITQs in

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110. *See generally* B. Peter Pashigian, *Environmental Regulation: Whose Self-Interests are Being Protected?*, 23 ECON. INQUIRY 551, 562–70 (1985).

111. Joskow & Schmalensee, *supra* note 102, at 38; Stavins, *supra* note 108, at 23; *see* Clean Air Act Amendments of 1990, Pub. L. No. 101-549, 104 Stat. 2399.

112. *See* Joskow & Schmalensee, *supra* note 102, at 41. Tennessee Valley Authority, *Annual Environmental Report: Pollution Prevention* (2000) (referring to the aims of the Clean Air Act Amendments to reduce SO_2 and NO_X emissions by targeted amounts), *available at* http://www.tva.gov/environment/reports/envreport00/pollprevent.htm; *see also* TIETENBERG, *supra* note 86, at 400–04 (summarizing the trading program).

113. A. DENNY ELLERMAN, MARKETS FOR CLEAN AIR 40–43 (2000); Joskow & Schmalensee, *supra* note 102, at 52.

114. Joskow & Schmalensee, *supra* note 102, at 52, 55.

115. Stavins, *supra* note 108, at 23; Tietenberg, *supra* note 8, at 71.

fisheries and unitization in oil and gas reservoirs, tradable emission permits were not adopted until existing regulation proved both to be too costly and too ineffective in mitigating the losses of open access. Moreover, by that time the benefits and costs of adopting property rights were sufficiently clear to allow side payments in the allocation property rights to address distributional demands.

3. International air pollution—chlorofluorocarbons and the ozone layer

In efforts to address global air pollution externalities, the problems of uncertainty in estimating the aggregate costs and benefits of regulation and their distribution across countries have been even more severe in hindering timely action. The very nature of global environmental externalities presents incentive problems. Abatement by any country benefits others as a public good, but if abatement is costly to a country's citizens, its politicians have incentive to invest less in reduction efforts than would be globally optimal and free ride on cutbacks taken elsewhere.

Consider first the most successful effort to address international air pollution: the Montreal Protocol of September 1987 on Substances that Deplete the Ozone Layer.[116] Concern about the buildup of CFCs in the upper atmosphere surfaced in 1974 when two studies hypothesized that chlorine released from the breakdown of CFCs had destructive effects on stratospheric ozone.[117] CFCs were inexpensive chemicals used since 1931 in refrigerants, solvents, propellants, and more recently in the production and cleaning of computer components and other electronics.[118] The United States accounted for 25 to 30 percent of the world production of CFCs between 1974 and 1986, and hence had a vital interest in any international agreement to regulate or eliminate their production.[119] Congressional hearings were conducted on the extent of ozone depletion and possible remedies, but no unilateral action was taken. In 1977, the EPA proposed to prohibit manufacture, processing, and interstate distribution of CFCs used as aerosol propellants.[120] The main advocates of the proposed rules were environmental organizations and certain groups of scientists.[121]

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116. Montreal Protocol on Substances that Deplete the Ozone Layer, Sept. 16, 1987, 26 I.L.M. 1541.

117. Mario J. Molina & F. Sherwood Rowland, *Stratospheric Sink for Chlorofluoromethanes: Chlorine Atomic Catalyzed Destruction of Ozone*, 249 NATURE 810, 810 (1974); Richard S. Stolarski & Ralph J. Cicerone, *Stratospheric Chlorine: A Possible Sink for Ozone*, 52 CAN. J. CHEM. 1610, 1610 (1974).

118. For discussion of the uses of CFCs, see Production and Use of Chlorofluorocarbons, http://www.ciesin.org/TG/OZ/prodcfcs.html (last visited Apr. 17, 2008).

119. *See* Orval E. Nagle, *Stratospheric Ozone: United States Regulation of Chlorofluorocarbons*, 16 B.C. ENVTL. AFF. L. REV., 531, 577 (1989).

120. For discussion of early regulatory efforts in the United States, see Edward Stevens Atkinson Jr., *Chlorofluorocarbons and Stratospheric Ozone: Regulatory Background* (pt. 2), 36 AM. STATISTICIAN 301, 301–02 (1982).

121. *See* RICHARD ELLIOT BENEDICT, OZONE DIPLOMACY: NEW DIRECTIONS IN SAFEGUARDING THE PLANET 29, 102 (1991) (discussing the role of environmental groups, scientists, and NGOs as treaty advocates).

In the 1970s, the imperative of taking unilateral action that could involve substantial economic costs in the United States did not compel key constituencies. The actual atmospheric mechanisms involved were incompletely understood, and the extent of ozone depletion and its consequences remained unclear.[122] Indeed, in 1983, under the Reagan Administration, the EPA advised Congress that no action should be taken until the relationship between CFCs and ozone depletion was more clearly determined.[123]

In March 1988, the NASA Ozone Trends Panel released additional scientific information suggesting that the ozone "holes" were larger than previously believed and that there were tighter links between ozone layer deterioration and CFC emissions.[124] This new information helped to shift the U.S. position on international collective action. It also changed because domestic political opposition to regulation had diminished. The chemical industry, with new technologies for CFC substitutes, no longer resisted domestic CFC controls, and it lobbied for international restrictions to phase out CFC production and trade.[125] A mandated switch to new CFC substitutes had potential to provide American firms with a competitive advantage relative to European producers of CFCs. Retrofitting by refrigeration and air-conditioning industries was costly, and U.S. CFC-substitute producers needed guarantees that their customers could not shift to alternative foreign sources of CFCs. An international agreement to regulate CFC trade would serve that purpose. Naturally, European firms were more skeptical of the need to restrict CFCs, and the support of European governments for regulatory action generally came later than the United States.[126] Even then, the United States and European representatives disagreed on timing and identification of the chemicals slated to be phased out.[127] The more serious opposition, however, came from representatives of undeveloped countries who saw restrictions on CFCs as being particularly costly.

The first international action was launched 11 years after the ozone "holes" were first detected.[128] The Vienna Convention for the Protection of the Ozone Layer was completed in 1985 and ratified by the United States one year

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122. *See id.* at 11–12.

123. A.L. Hollick & Richard N. Cooper, *Global Commons: Can They Be Managed?*, *in* THE ECONOMICS OF TRANSNATIONAL COMMONS 158 (Partha Dasgupta, Karl-Göran Mäler & Alessandro Vercelli eds., 1997); Nagle, *supra* note 119, at 543.

124. BENEDICT, *supra* note 121, at 110; R.T. WATSON, M.J. PRATHER & M.J. KURYLO, PRESENT STATE OF KNOWLEDGE OF THE UPPER ATMOSPHERE 1988: AN ASSEMENT REPORT (1988), *microformed on* NASA Microfiche No. N88-29233.

125. Irving M. Mintzer & Alan S. Miller, *The Ozone Layer: Its Protection Depends on International Cooperation*, 21 ENVTL. SCI. & TECH. 1167, 1168 (1987); Gary L. Scott, Geoffrey M. Reynolds & Anthony D. Lott, *Success and Failure Components of Global Environmental Cooperation: The Making of International Environmental Law*, 2 ILSA J. INT'L & COMP. L. 23, 54 (1995).

126. *See* BENEDICT, *supra* note 121, at 25–29 (explaining the differences in views regarding the necessity of CFC regulation in the United States and Europe). In this case, as opposed to global warming negotiations, the United States was the leading proponent, whereas Europe was more skeptical.

127. BENEDICT, *supra* note 121, at 144.

128. Stolarski & Cicerone, *supra* note 117 (the article was published in 1974).

later[129] As with early smog regulations in California, the convention offered no binding restrictions, but rather emphasized research. It established broad international objectives to protect human health and to promote study of the impact of CFCs on the ozone layer.[130] Disagreements, especially between representatives of developed and developing countries, blocked any actual CFC control measures.[131] For developing countries CFCs were a source of low-cost refrigerants, and the global externality resulted from a buildup of emissions from developed countries. Accordingly, representatives of developing countries, notably China and India, demanded side payments to as a condition for coordinated action to protect the ozone layer.[132]

In response, representatives from the United States, Canada, Japan, and Europe offered countries with low per capita consumption of CFC's various exemptions from international regulations. This concession helped to build agreement among developing countries for the 1987 Montreal Protocol (the "Protocol").[133] Under the Protocol, developed countries were to cut production and consumption of CFCs by 20% of their 1986 levels by 1993 and by 50% by 1998. CFC trade with countries not adopting the restrictions was to be stopped.[134] With the notion of common but differentiated responsibilities developing countries were allowed an extra 10-year delay to reach reduced production targets and were authorized to exceed their 1986 levels of production by up to 10% to satisfy "basic domestic needs."[135]

Even so, additional concessions had to be granted in order to get developing countries to ratify the protocol. A Second Meeting of the Parties to the Montreal Protocol was held in 1990 to devise additional side payments.[136] A Multilateral Fund was established to provide developing countries with financial assistance and CFC replacement technology was to be transferred if they agreed to the protocol.[137] The creation of a multilateral fund, however, raised new distributional concerns among donor and recipient countries. These issues included the size of individual contributions, the nature of penalties if donors defaulted on their assessments, the amount of money to be granted recipients, and their documentation requirements.[138] Not all of the disagreements could be resolved at

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129. Vienna Convention for the Protection of the Ozone Layer, Mar. 22, 1985, 26 I.L.M. 1516.

130. For discussion of the Vienna Convention's recommendations, see BENEDICT, *supra* note 121, at 44–47.

131. *See* BENEDICT, *supra* note 121, at 188, 232.

132. *See id.* at 72, 93–94, 99–101, 148–152 (showing the lack of enthusiasm among developing countries for the CFC controls discussed in the Vienna Convention).

133. *See id.* at 99–101, 123–124, 126–128.

134. *Id.* at 232.

135. The Montreal Protocol is provided in BENEDICT, *supra* note 121, app. at 230–41. Recognition of differential responsibilities is made in paragraphs 6, 7, and 9 of the preamble and Articles 5 and 10. Separate allowances for "basic domestic needs" is provided in Article 5. *Id.* at 235.

136. *See id.* at 152–158, 251–252.

137. *See id.* at 252; Bing Ling, *Developing Countries and Ozone Layer Protection: Issues, Principles, and Implications*, 6 TUL. ENVTL. L.J. 91, 97, 112–16 (1992).

138. BENEDICT, *supra* note 121, at 254–57, 294.

the second meeting. Only very general language exhorting the parties to take "every practicable step" to control CFC emissions merited consensus. The World Bank was to be the administrator, and $160 million was to be made available to developing countries for complying with the CFC accord. Further, the fund was to be increased by $80 million when India and China ratified the Montreal Protocol.[139]

It took 16 years to reach general international agreement on controlling the production and dissemination of CFCs. Regulation has been based on production bans and technological substitution. There also has been use of tradable emission permits for achieving compliance with the Montreal Protocol, and a tax on CFCs was introduced later to accelerate the phase out. CFC emissions have declined, and taxpayers in developed countries have born most of the costs of the regulations.[140] In the aggregate, these payments likely have been relatively small, given the benefits involved of protecting the ozone layer. Further, the chemical industry and environmental groups have been formidable constituencies within developed countries for the protocol.

Despite all of this action, the thickness of the South Pole ozone layer continues to decline during the peak ozone-depleting season, and there are calls for even stricter emissions controls. But the concessions made to developing countries to gain their participation pose barriers for further reductions. For instance, China, which has become a large producer of CFCs and related refrigerants, is likely to resist loss of a profitable new industry.[141]

4. International air pollution—global warming

International efforts to limit green house gas ("GHG") emissions, however, face even more difficult problems including delays, differential responses among countries to calls to address the externality, and no success in reducing overall emissions. It seems unlikely that any effective, coordinated response will take place until crises increase perceived benefits and mitigate international distributional concerns. The issues are quite similar to those that have arisen regarding CFC control.

Global warming has been a concern in many quarters at least since the 1990s and perhaps earlier.[142] It is clearly an open-access problem. With unrestricted access to the atmosphere, gases such as carbon dioxide (CO_2), Nitrous Oxide (N_2O), Chlorofluorocarbons (CFCs) and methane (CH_4) are released as by-products of human activities and other natural sources across countries. Regardless

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139. Ling, *supra* note 137, at 113.

140. For brief discussion of trading permits in CFCs for compliance with the Montreal Protocol, see Robert N. Stavins, *Economic Incentives for Environmental Regulation*, *in* 2 THE NEW PALGRAVE DICTIONARY OF ECONOMICS AND THE LAW, *supra* note 14, at 6, 9. For discussion of resistance to further reduction of CFCs in China, see John J. Fialka, *U.S. Plots New Climate Tactic: Speedier Chemicals Ban Sought by White House, but China May Resist*, WALL ST. J., Sept. 7, 2007, at A8 (addressing decline in ozone depleting gases).

141. *See* Fialka, *supra* note 140 (discussing China's likely resistance).

142. *See* Krier, *supra* note 8, at 857–59.

of their origin, the gases are spread around the globe with potential external effects. The gases retard the re-radiation of the sun's energy from the earth's surface back into space. Debate persists as to whether and how much the further accumulation of these gases will generate a damaging rise in global temperatures and what to do about it.[143]

There are many sources of uncertainty regarding the aggregate effects of global warming, their distribution among countries, and the costs of reducing GHG emissions. The magnitude of global warming and associated climate change remains generally undetermined, although there is more of a consensus on the issue than even a few years ago.[144] The scientific uncertainty comes in estimating the rate at which greenhouse gas concentrations will increase, the corresponding impact of rising GHG concentrations on temperatures, the patterns of climate change across the globe, and their impact on the regions affected. The research evidence on key aspects of these issues remains incomplete and inconclusive.[145] The resulting scientific uncertainty regarding global warming allows politicians to choose among conflicting evidence for justifying positions desired by critical constituencies with more certainty than actual understanding may merit.[146]

The necessary emission reductions in response to possible climate change and the associated economic costs involved are similarly unclear. The magnitude of the costs depends upon the amount of the reduction required for each country and its pace. There is the politically important issue of the global distribution of abatement costs, as the costs are the greatest for the countries that produce the most CO_2 and other green house gases. The United States and China are currently the largest producers of CO_2.[147] Within countries, abatement efforts will have differential impacts, with the transportation, manufacturing, and utility sectors incurring higher costs. There are many estimates of the costs of emissions controls in the United States, with the results depending on the assumptions made regarding timing, magnitude, and the instruments used.[148] Those countries and interests that

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143. Hollick & Cooper, *supra* note 123, at 159; John P. Weyant, *Costs of Reducing Global Carbon Emissions*, 7 J. ECON. PERSP. 27 (1993).

144. *See* Jeffrey Ball, *New Forecast for Climate Debate: Consensus on Emissions Cuts Takes Shape, but Debate Turns to Who Will Pay*, WALL ST. J., Sept. 4, 2007, at A2.

145. *See* MATTHEW PATERSON, GLOBAL WARMING AND GLOBAL POLITICS 9–15 (1996); Hollick & Cooper, *supra* note 123, at 159–63. For evidence of continuing uncertainty on projections, see *Gambling on Tomorrow*, ECONOMIST, Aug. 16, 2007, *available at* http://www.economist.com/science/displayStory.cfm?story_id=9645336&fsrc=nwlgafree.

146. PATERSON, *supra* note 145, at 14; *see also* Ronald N. Johnson & Gary D. Libecap, *Information Distortion and Competitive Remedies in Government Transfer Programs: The Case of Ethanol*, 2 ECON. GOVERNANCE 101, 103–04 (2001) (discussing the control of information in the political arena).

147. *See* Union of Concern Scientists, *Science of Global Warming: Each Country's Share of Global CO2 Emissions*, *available at* http://www.ucsusa.org/global_warming/science/each-countrys-share-of-co2-emissions.html.

148. Weyant, *supra* note 143, at 32; Hollick & Cooper, *supra* note 123, at 165; U.S. COMM. ON SCI., ENG'G & PUB. POLICY, POLICY IMPLICATIONS OF GREENHOUSE WARMING 47–63 (1991); Alan S. Manne & Richard G. Richels, *CO_2 Emission Limits: An Economic Costs Analysis for the USA*, 2 ENERGY J., 51 (1990).

anticipate bearing more of the costs of regulation understandably resist action until compensating arrangements are implemented, but agreement on them is subject to the same side-payment disputes noted above over who should pay and receive, the amounts involved and the forms and timing of compensation. These negotiations also are undermined by uncertainty regarding the magnitude and distribution of the costs and benefits of international efforts.

Additionally, as with the Montreal Protocol, there is no underlying enforcement mechanism within the Kyoto Protocol of 1997, which was the first formal international treaty to reduce GHG emissions.[149] Under the protocol monitoring depends on annual self reports by countries using comparable methodologies. Expert review teams are authorized with voluntary country visits. No consequences of noncompliance could be agreed upon, and the compliance provisions that are included apply only to Annex 1 or industrialized countries.[150] Absent effective enforcement, there are incentives for countries to defect whenever the political costs become too high.

Given the unclear and uneven distribution of the costs and benefits of international action and a general lack of immediacy in taking it, it is understandable that progress has been slow regarding global warming. As of December 2006, 169 countries had ratified the Protocol, but the United States and Australia had not, and China and India, as well as other developing countries which ratified it, are not required to take direct action.[151] Indeed, representatives of developing countries continue to demand that most restrictions be implemented in developed countries. The Kyoto Protocol expires in 2012, and GHG emissions continue to increase.[152]

To lower the costs of GHG abatement, the Kyoto Protocol incorporated tradable emissions permits based on their success in SO_2 regulation in the United States.[153] In response, the European Union, which ratified the protocol, created a multi-national GHG emissions trading scheme, the largest in the world. The Protocol capped emissions and allocated permits for virtually all stationary industrial and electricity-generating units in the E.U. A market developed with two trading periods, 2005–2007 and 2008–2012. The program is generally viewed as a

149. Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 11, 1997, *available at* http://unfccc.int/resource/docs/convkp/kpeng.html.

150. Compliance has remained a topic of international negotiations to strengthen enforcement since the initial Kyoto Protocol of 1997. *See* Chester Brown, *The Kyoto Protocol Enters Into Force* (2005), *available at* http://www.asil.org/insights/2005/03/insights050301.html.

151. *See Kyoto Protocol: Status of Ratification*, *available at* http://unfccc.int/files/essential_background/kyoto_protocol/application/pdf/kpstats.pdf. China also is likely to resist restrictions on its profitable CFC and HCFC industries. One by-product, HFC-23, is 11,700 times more powerful as a global warming gas than CO_2. *See* Fialka, *supra* note 140, at A8 (discussing China's production).

152. Energy Info. Admin., *Official Energy Statistics from the U.S. Gov't*, http://www.eia.doe.gov/environment.html.

153. Tietenberg, *supra* note 8, at 70.

success.[154] This is the unusual case where property rights were established relatively early in response to an open-access externality. One reason for this occurrence is general industry support due to lower information costs about the use of emission rights as compared to reliance upon uniform standards. Based on the lower costs and accomplishments of the United States' SO_2 trading program, relative to alternative centralized regulation, industry representatives may have preferred a cap-and-trade scheme over a more costly and uncertain multi-national regulatory arrangement. If so, this institutional response is consistent with the overall thesis of the paper.

IV. CONCLUDING REMARKS: DELAY IN RESPONSE TO OPEN ACCESS AND THE ADOPTION OF PROPERTY RIGHTS

Theory and research regarding collective action in addressing open-access resource problems indicates that success in controlling externalities comes when there is a consensus on the aggregate benefits to be gained, that the parties perceive positive net gains from agreement, and that they are homogeneous with respect to bargaining objectives and in the distribution of the costs and benefits to be incurred. Agreements reached under these conditions tend to be self-enforcing because it is in the interest of all parties to ensure success. Collective action may also achieve its objectives if the parties are heterogeneous with respect to the net gains from cooperation, if the spread is not too great and there are agreed-to bases for constructing side payments to compensate those parties that may bear more costs or receive fewer gains. The resulting arrangement must be secure enough so that the side payments are long term and predictable.

Uncertainty in predictions regarding aggregate benefits and costs of collective action and their distribution among constituencies complicates this process by raising transaction costs. Uncertainty makes it more difficult for parties to determine how they will fare with formal arrangements to mitigate open-access externalities. Accordingly, the incentives are for delay and for subsequent adoption of policies that involve the least cost and minimize distributive effects. Property rights which are the fundamental solution to open access, however, are more costly and they can result in a major redistribution of wealth and political influence. In this case, it is efficient to wait as we have seen in fisheries, common oil pools, and air pollution control. Accordingly, for individuals, as well as risk-adverse politicians and agency officials, property rights often are the solution of last resort, rather than the front line of attack on the tragedy of the commons.

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154. For discussion and evaluation of the European Union trading scheme, see Frank J. Convery & Luke Redmond, *Market and Price Developments in the European Union Emissions Trading Scheme*, 1 REV. ENVTL. ECON. & POL. 88 (2007); A. Denny A. Ellerman & Barbara K. Buchner, *The European Union Emissions Trading Scheme: Origins, Allocation, and Early Results*, 1 REV. ENVTL. ECON. & POL. 66 (2007); Joseph Kruger, Wallace E. Oates & William A. Pizer, *Decentralization in the EU Emissions Trading Scheme and Lessons for Global Policy*, 1 REV. ENVTL. ECON. & POL. 112 (2007). There are issues of allocation and the amount of allowances that have been provided. *See Emissions Trading: Lightly Carbonated*, ECONOMIST, Aug. 2, 2007, at 53–54.