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# The tragedy of the commons: property rights and markets as solutions to resource and environmental problems

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In one way or another, all environmental and natural resource problems associated with overexploitation or under provision of public goods, arise from incompletely defined and enforced property rights. As a result private decision makers do not consider or internalize social benefits and costs in their production or investment actions. The gap between private and social net returns results in externalities – harmful effects on third parties: overfishing, excessive air pollution, unwarranted extraction or diversion of ground or surface water, extreme depletion of oil and gas reservoirs. These situations are all examples of the 'The Tragedy of the Commons'. In this paper, I consider options for mitigating the losses of open access: common or group property regimes, government tax and regulation policy, more formal private property rights. I briefly summarize the problems and advantages of each option and describe why there has been move toward rights-based instruments in recent years: ITQ (individual transferable quotas), tradable emission permits, and private water rights. Introductions to the papers in the special issue follow.

**Key words:** Fisheries, efficiency, environmental & ecological economics, development economics, economic growth, bioeconomic models.

In one way or another, all environmental and natural resource problems associated with overexploitation or under provision of public goods, arise from incompletely defined and enforced property rights, whether they be informal or formal, group or individual. Under these circumstances, private decision makers do not consider or internalise social benefits and costs in their production or investment actions.[1] The gap between private and social net returns results in externalities – harmful effects on third parties. These include overfishing that depletes the aggregate stock, excessive air pollution that reduces overall air quality, unwarranted extraction or diversion of ground or surface water that diminishes supplies, extreme depletion of oil

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[1] Ronald Coase, 1960, 'The Problem of Social Cost,' *Journal of Law and Economics* 3: 1–44; Carl Dahlman, 1979, 'The Problem of Externality,' *Journal of Law and Economics* 22: 141–62.


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and gas reservoirs that lowers overall production and raises costs, as well as too little private investment in natural amenities and biodiversity.[2]

These situations are all examples of the 'The Tragedy of the Commons.'[3] The tragedy occurs through aggregate short-term production or use levels that are too high and long-term investment in the stock that is too low. Competitors for resource rents inflict costly technological and pecuniary externalities on one another. Anticipation of these spillovers generates a damaging rush to exploit the resource. Compounding the tragedy, in the absence of recognised property rights exchange is not possible. The parties involved cannot bargain with one another in the manner described by Coase (1960) to constrain behaviour to limit dissipation and to re-allocate the resource to higher-valued uses currently or across time. Free riding is rampant. As a result, there can be no price signals to reveal opportunity costs, underwriting wasteful use decisions that are made in ignorance of such information. Finally, the tragedy is accentuated by the diversion of valuable labour and capital inputs from productive use to predation and defence. Damaging conflict and violence may follow.[4]

The wastes associated with the common pool resources can be large, and the social savings from avoiding them provide the incentives for collective action (i) to develop informal property rights (individual or group) or if these are not feasible, (ii) to secure more official government regulation of access and resource use or (iii) to assign formal property rights for private restrictions on behaviour.[5]

Considering each of these options in turn, the first, group solutions or common property, can be effective if the parties involved are relatively homogeneous in costs, discount rates and production objectives, and if their numbers are comparatively small.[6] Under these conditions, cooperative internal

[2] The problem of open access in fisheries is discussed by H. Scott Gordon, 1954, 'The Economic Theory of a Common-property Resource: The Fishery,' *Journal of Political Economy* 62: 124–42; Anthony Scott, 1955, 'The Fishery: The Objectives of Sole Ownership,' *Journal of Political Economy* 63: 116–24. Oil and Gas problems are addressed by Gary D. Libecap and Steven N. Wiggins, 1984, 'Contractual Responses to the Common Pool: Prorationing of Crude Oil Production,' *American Economic Review* 74: 87–98. Land use problems are described by Lee J. Alston, Gary D. Libecap, and Robert Schneider, 1996. 'The Determinants and Impact of Property Rights on the Frontier: Land Titles on the Brazilian Frontier,' *Journal of Law, Economics, and Organisation* 12(1): 25–61. Ground water problems are described by Robert Glennon, 2002, *Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters*, Washington D.C.: Island Press.

[3] Garrett Hardin, 1968, 'The Tragedy of the Commons,' *Science* 162: 1243–48.

[4] John Umbeck, 1981, 'Might Makes Right: A Theory of the Formation and Initial Distribution of Property Rights,' *Economic Inquiry* 19: 38–59; Gary D. Libecap, 1978, 'Economic Variables and the Development of the Law: The Case of Western Mineral Rights,' *Journal of Economic History*, 38: 338–62.

[5] This progression is described by Gary D. Libecap, 2008, 'Open-Access Losses and Delay in the Assignment of Property Rights,' *Arizona Law Review*.

[6] For discussion of informal or common property solutions, see Elinor Ostrom, 1990, *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge: Cambridge University Press and Jean-Marie Baland and Jean-Philippe Platteau, 1996, *Halting Degradation of Natural Resources: Is There a Role for Rural Communities*, Oxford: Clarendon Press.

rules can be agreed upon and put into place to manage the resource or to provide group goods.

Exogenous factors, such as price increases or new production technologies, however, can make common property less effective. The incentives for defection among the existing group members rise, and new, more heterogeneous entrants are attracted, who are not part of the original compact, and hence have less incentive to adhere to its constraints. These conditions lead localised arrangements to collapse, especially if they do not receive recognition and enforcement from the state, which they may not if group members are not as politically influential as are the new entrants.[7]

The second option, government regulation, involves constraints on inputs or outputs to bring production in line with more optimal levels and/or tax schemes to bring private and social use costs into closer alignment.[8] Although central (command and control) regulation and taxes can eliminate externalities and hence, the 'Tragedy of the Commons,' the empirical history in many cases has not been particularly satisfying.

Effective regulation and taxes require that politicians and regulators have information not only about social costs and optimal levels of production, but also about the (often varying) private production and compliance costs of individual users. This is a requirement that few regulators can meet. As a result, government regulation typically relies upon uniform standards, including standardised controls on access, fixed tax levels, and similar constraints on timing of use and/or limits on technology or production capital. Uniformity reduces information demands and makes regulation appear to be equitable, making it more politically attractive.

Uniform regulations and taxes, however, do not reflect differences in production or compliance costs. Accordingly, centralised rules are unlikely to align with the incentives of actual users of the resource. Rather, the motives of the regulated or taxed parties are for evasion, raising enforcement costs. Under regulation and tax policies, users, by definition, are not 'owners' and hence, typically do not capture the increased social returns from protecting or investing in the stock through conservation.[9] As such, they rationally maximise private returns through cheating. The setting becomes one of agents against the state, and the resource suffers.

[7] The collapse of cartels illustrates this point, see Bjark Fog, 1956, 'How Are Cartel Prices Determined?' *Journal of Industrial Economics* 3(1): 16–23 and George A. Hay and Daniel Kelly, 1974, 'An Empirical Survey of Price-Fixing Conspiracies,' *Journal of Law and Economics*, 17(1): 13–39.

[8] The classic discussion is Arthur C. Pigou, 1920. *The Economics of Welfare*. London: Macmillan and Co.

[9] For discussion of the impact on incentives in fisheries, see Ronald N. Johnson, 1995, 'Implications of Taxing Quota Value in an Individual. Transferable Quota Fishery,' *Marine Resource Economics*, 10(4): 327–340.

Finally, and critically, the decisions by all parties, regulators in implementing policies, and actual users in harvesting, extracting and emitting, take place in the absence of information about the value of alternative resource uses (opportunity costs) that market trades otherwise would generate. This condition results in wasteful misallocation.

Overall, government regulation and tax policies suffer from a variety of well-known problems including high cost, inflexibility, ineffectiveness and industry capture. Generally, no party involved – actual users, regulators, politicians – is a residual claimant to the social gains from more optimal resource management and use.[10] Accordingly, extraction, production, investment and allocation decisions are based on other factors that are apt not to be consistent with maximising the economic value of the resource or of conserving it. Often, the amounts at stake in implementing regulatory and tax policies are large, encouraging costly rent seeking as parties attempt to mould government actions in their behalf.[11]

This is not to say that regulation and tax policy have no place in the menu of responses to open-access problems. In many cases, there may be no feasible alternative due to the high resource costs of defining and enforcing rights-based arrangements or to the high political costs of 'privatizing' assets that many believe are inherently social. Nevertheless, the resort to government action following standard prescriptions ignores many real costs. In the case of fisheries and air pollution regulation, as described below, centralised regulation often has proved very costly with limited effectiveness.

More formal property rights serve as the third alternative to addressing the problems of the commons. Property rights can be a solution because they address the externality directly and link individual incentives with social objectives for environmental and natural resource use. Property rights allow for markets, and markets provide price signals on alternative uses, generating data on the costs and benefits of constraining emissions, fishing, and other forms of common-pool extraction and of providing environmental amenities and other potential public goods.[12]

Property rights, however, are costly to define and enforce due to the resources used in allocating and demarcating entitlements, policing compliance and in arbitrating disputes. Allocation may involve important political costs because of the impact of property rights assignments on the distribution of

[10] Bureaucratic incentives are examined by Ronald N. Johnson and Gary D. Libecap, 1994. *The Federal Civil Service and the Problem of Bureaucracy: The Economics and Politics of Institutional Change*, Chicago: University of Chicago Press. 156–71.

[11] Rent seeking occurs when an individual, organisation or firm seeks profits by manipulating the economic and/or legal environment rather than by trade and production of wealth. See Gordon Tullock, 1967, 'The Welfare Costs of Tariffs, Monopolies, and Theft,' *Western Economic Journal* (now *Economic Inquiry*) 5: 224–32 and Gordon Tullock, 1987, 'Rent seeking,' *The New Palgrave: A Dictionary of Economics*, London: Palgrave Macmillan, Vol. 4, 147–149.

[12] This fundamental role of markets is described by Harold Demsetz, 1967, 'Toward a Theory of Property Rights,' *American Economic Review: Papers and Proceedings* 57(2): 347–359.

wealth and political influence.[13] To be effective any rights institution requires exclusion, and exclusion creates winners and losers. Resource ownership involves the right to the stream of net revenues from production, investment and trade, and if the stock rebounds from open-access depletion, the wealth and associated distributional impacts can be large, affecting established social patterns and political influence. There may be costs from deteriorating social cohesion and the possible losses of other collective values.[14] These factors are difficult to evaluate because of the problem of disentangling true social public good objectives from rent seeking that is driven by competition for resource rents and political power. Even so, distributional pressures play an important role in the political economy of rights-based arrangements, mould the kinds of property rights granted, and affect their ability to address open access.[15]

To mitigate distributional reaction and to (possibly) direct revenues toward socially or politically desirable outcomes, auctions, rather than the free granting of property rights through grandfathering or first possession, are often advocated by economists, as argued, for example, by Burtraw and Evans in this volume.[16] At the same time, of course, auctions are costly to design and administer and also can be moulded by rent-seeking efforts by those who seek preferential ownership through them.[17]

Nevertheless, the key point is that the benefits of property rights definition and enforcement in mitigating open-access losses relative to the resource and political costs involved determine when rights-based regimes are the socially preferred solutions to the 'Tragedy of the Commons.' Such a regime is efficient when the expected benefits of adopting it offset the costs involved. Society gains in closing the externality; there is less over use; more investment and trade; and losers in the allocation of rights (those who benefited from open access) can potentially be compensated through political side payments (subsidies, tax rebates) from the wealth saved from open-access losses.

For these reasons, there is an accelerated trend toward assigning property rights of some type to resources in order to mitigate the losses of the

[13] This point is emphasised by Gary D. Libecap, 2008, 'Open-Access Losses and Delay in the Assignment of Property Rights,' *Arizona Law Review*.

[14] For discussion of collective values and goods, see Carol Rose, 1986, 'The Comedy of the Commons: Custom, Commerce, and Inherently Public Property,' *University of Chicago Law Review* 53(3): 711–81.

[15] Distributional concerns and their impact on ITQ design are described in Olivier Guyader and Olivier Thebaud, 2001, 'Distributional Issues in the Operation of Rights-Based Fisheries Management Systems,' *Marine Policy* 25: 103–112.

[16] Issues regarding auction and grandfathering are discussed by Gary D. Libecap, 2007, 'Assigning Property Rights in the Common Pool: Implications of the Prevalence of First-Possession Rules for ITQs in Fisheries,' *Marine Resource Economics* 22(4): 407–24. As noted above in the text, there is a similar debate regarding the taxation of fishery rents (Johnson, 1995).

[17] The costs of auctions are illustrated in the design of United States auctions for the spectrum. See John McMillan, 1994, 'Selling Spectrum Rights.' *Journal of Economic Perspectives*, 8(3): 145–62.

common pool. A recent survey found that tradable use permits were used in 9 applications in air pollution control, 75 in fisheries, 3 in water and 5 in land use control.[18] These institutional innovations have taken place as the resources at issue have become more valuable, as they have faced growing common-pool wastes, and as dissatisfaction has increased with existing centralised regulation.[19]

There are multiple advantages of property rights arrangements including flexibility, cost-savings, information generation, migration to high-valued uses and better alignment of incentives for conservation or investment in the resource. The more complete are property rights, the more the private and social net benefits of resource use are meshed, eliminating externalities and the losses of the common pool. Furthermore, when agents are owners of some part of the greater rents from reducing the externality, they have greater incentives to comply, to police one another, and potentially, invest in the stock.[20]

To illustrate trends in rights based management, tradable harvest rights, often referred to individual transferable quotas (ITQs) have been widely implemented in fisheries in order to alleviate the losses of open access.[21] ITQs involve the setting of annual total allowable catch (TAC) in a fishery and the distribution of limited, tradable shares of the TAC to fishers and other stakeholders. As such, ITQs are a use right or the right to fish, rather than the right to the stock, but they fundamentally change incentives for fishing and for private investment in the stock (through avoiding harvest of juvenile fish, limiting pollution and other damage to habitat). The value of the ITQ depends upon the condition and value of the stock, and as owners of rights to it, fishers are motivated to conserve it a manner not found under open access. ITQs may be cost effective, relative to ownership of the stock or part of the ocean, when migratory species are involved, when associated measurement and enforcement costs are large, and when political opposition to sole ownership is intense.

Arnason shows that appropriately designed ITQs are capable of maximising economic rents from a previously open-access fishery.[22] Additionally, there is growing empirical evidence of the advantages of ITQ-managed fisheries

[18] Tom Tietenberg, 2007, 'Tradable Permits in Principle and Practice,' in Jody Freeman and Charles D. Kolstad, eds, *Moving to Markets in Environmental Regulation: Lessons from Twenty Years of Experience*, New York: Oxford University Press, 63–94, 69.

[19] Robert N. Stavins, 1998, 'Economic Incentives for Environmental Regulation,' *The New Palgrave Dictionary of Economics and the Law, MacMillan, London*, Peter Newman Ed., Vol. 2: 6–13.

[20] There may be differential incentives depending on whether the resource is renewable and boundable, as with fisheries, or is not boundable and generally, not renewable, such as with the atmosphere.

[21] The progression toward ITQs is discussed in Rögnvaldur Hannesson, 2004, The Privatisation of the Oceans, Cambridge, MIT Press.

[22] Ragnar Arnason, 1990, 'Minimum Information Management in Fisheries,' *Canadian Journal of Economics* 23: 630–53.

around the world.[23] Recently, Arnason (2005) reports that over 10 major fishing nations use ITQs as the main or a major component of their fisheries management system and between 10 and 15 per cent of the global ocean catch is taken under ITQs.[24] Other forms of fishery rights also exist, including territorial use rights to fish (TURFs) and community rights (common property).

Similar approaches have been adopted to control air pollution emissions, such as tradable $SO_2$ emission quotas used in the United States, as well as the cap-and-trade system adopted by the European Union for $CO_2$ regulation. In these situations, as with fisheries, a limit on total releases is set, and shares of the total are allocated to firms. They can be traded, and in some cases, banked. Cap-and-trade arrangements are attractive because they lower the cost of meeting emission targets and align the incentives of parties toward investment in technologies that lower releases into the atmosphere. The regulated parties decide how, where and when to reduce pollution. Through permit trades, the marginal costs of abatement are equalised across firms. Those with relatively high marginal costs for pollution control purchase permits from those with lower marginal abatement costs within the overall emissions cap. The scarcity of emissions allowances determines the market price. Once the cap is set, permit trading requires little information of the regulator regarding firm compliance costs.

Consider the experience with the $SO_2$ or acid rain programme. In 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 in the United States and in Canada. The 1970 and 1977 Clean Air Act Amendments set national maximum concentrations of $SO_2$, and the states were charged with meeting those standards.[25] 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-sulphur coal, and setting new source performance standards applying to new plants.[26]

Subsequent dissatisfaction with the costs of these regulations led to the adoption of limited trading programmes, including: (i) bubbles, allowing

[23] Ross Shotton, ed, 2000, 'Use of Property Rights in Fisheries Management,' *FAO Fisheries Technical Paper* 401/1 and 401/2. Rome: Food and Agriculture Organisation of the United Nations; R. Quentin Grafton, Dale Squires, and Kevin J. Fox. 2000, 'Private Property and Economic Efficiency: A Study of a Common-Pool Resource,' *Journal of Law and Economics* 43: 679–713; and James N. Sanchirico and James E. Wilen, 2002, 'Global Marine Fisheries Resources: Status and Prospects,' *RFF Issue Brief 02-17*, Washington D.C.: Resources for the Future.

[24] Ragnar Arnason, 2005, 'Property rights in Fisheries: Iceland's Experience with ITQs,' *Reviews in Fish Biology and Fisheries* 15(3): 243–64.

[25] Clean Air Amendments of 1970, Pub. L. No. 91–604, 84 Stat. 1676 (1970); Clean Air Act Amendments of 1977, Pub. L. No. 95–95, 91 Stat. 685 (1977); Paul L. Joskow and Richard Schmalensee, 1998, 'The Political Economy of Market-Based Environmental Policy: The U.S. Acid Rain Program,' *Journal of Law and Economics*, 41(1): 37–83.

[26] Donald N. Dewees, 1998, 'Tradable Pollution Permits,' Peter Newman ed, *The New Palgrave Dictionary of Economics and the Law*, London: MacMillan, Vol. 3, 596–601.

exchanges among different sources in a single plant; (ii) netting, allowing plant expansion if overall pollution did not increase; (iii) banking, allowing firms to carry forward unused credits; and (iv) offsets, allowing new plants to be brought on line if existing ones reduced pollution.[27] Under these regulations, total emissions of $S0_2$ peaked in the 1970s and then declined through the 1980s.[28] But pollution abatement costs rose as stricter standards were adopted. By 1990, U.S. pollution control costs reached $125 billion annually, a nearly 300 per cent increase in real terms from 1972 levels.[29]

There was growing resistance to further restrictions to meet new, lower $SO_2$ emission targets. Existing uniform rules generally did not recognise that the costs of controlling emissions varied across and within firms.[30] In response, Title IV of the 1990 Clean Air Act Amendments authorised electric utilities to trade allowances to emit $SO_2$ while reducing total allowed emissions by approximately 50 per cent. This legislation represented the first large-scale, long-term U.S. environmental programme to rely on tradable emission permits.[31]

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. 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 gasses. 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.[32]

Rights-based solutions to open access, however, are not simple. The design, extent, allocation and enforcement of property rights are complex and costly processes, and the results vary according the empirical setting at hand. Research is critical for understanding when, how and for whom rights should be defined in order to determine when they may be effective options for addressing open access.

The papers in this volume examine a variety of issues regarding the intricacies involved in developing property regimes to address environmental

[27] These limited trades are estimated to have resulted in savings of $1–$12 billion in pollution control costs. See Dewees (1998, p. 600).

[28] Joskow and Schmalensee (1998, p. 45).

[29] Robert N. Stavins, 2007, 'Market-Based Environmental Policies: What Can We Learn from U.S. Experience (and Related Research)?' in Jody Freeman and Charles D. Kolstad, eds, *Moving to Markets in Environmental Regulation: Lessons from Twenty Years of Experience*, New York: Oxford University Press, 19–47, 34.

[30] Jody Freeman and Charles D. Kolstad, 2007, 'Prescriptive Environmental Regulations vs. Market-Based Incentives,' in Jody Freeman and Charles D. Kolstad, eds, *Moving to Markets in Environmental Regulation: Lessons from Twenty Years of Experience*, New York: Oxford University Press, 3–16, 5.

[31] Joskow and Schmalensee, (1998, p. 38); 1990 CAAA, Public Law 101-549; Stavins (2007, p. 23).

[32] Tietenberg (2007, p. 71), Stavins (2007, p. 23).

and resource problems. Two papers address issues in fisheries; three apply to water; and one addresses broader issues of land use and economic development as revealed on Native American reservations and reserves in the United States and Canada.

In '*Conflicting Uses of Marine Resources: Can ITQs Promote an Efficient Solution?*' Ragnar Arnason examines the allocation problem arising from conflicting demands for marine resource use by (i) commercial fishers, (ii) recreational fishers; and (iii) conservationists. Members in each of these categories value the stock of fish, but have different optimal stock levels. Harvest externalities by fishers are negative within and across the groups. Actions by conservationists, on the other hand, provide positive externalities to both fishers and other conservationists. Arnason shows that decentralised trading of ITQs is capable of an efficient allocation of resource use between the first two groups of fishers, but is not effective in addressing the conflicting interests of fishers and conservationists. This outcome has not been developed formally previously.

The key problem is that quota trades between individual fishers and conservationists result in positive externalities as the later encourage stock enhancement. Because of these externalities fishers, as quota sellers, ask too high a price, while conservationists offer too low. Accordingly, there are fewer trades and less conservation than would be socially optimal. Arnason argues that if fishers and conservationists can organise themselves into two groups (ignoring how this might come about), so that within them groups stock externalities are internalised, quota trades between the groups can lead to efficient stock levels. He asserts that under such a system, there would be no requirement for the regulatory authority to set the TAC. Trades between conservationists and fishing groups determine the effective TAC and the aggregate catch.

In the second fishery paper, *'Encumbering Harvest Rights to Protect Marine Environments: A Model of Marine Conservation Easements,'* by Robert Deacon and Dominic Parker, explore how the common practice of using conservation easements to encourage land conservation might be applied to the marine environment. Easements over land conserve open-space amenities, such as scenery and wildlife habitat, by limiting land use in exchange for compensation through payments from private parties (NGOs) or governments through tax reductions. In contrast to centralised land-use regulations, easements are incentive-based policies that can be customised to motivate voluntary conservation by landowners. Conservation easements can also have efficiency advantages over the outright purchase of land because the land remains with those who know best how to use it.

Although marine environments generally are not owned as is land, commercial fishers often are regulated in a manner that provides some type of use right or privilege which restricts entry by others. Because these regulations grant harvesters rights to use marine environments in specified ways, the possibility of encumbering these rights to achieve conservation goals creates

a potential role for marine easements. These arrangements can be used to reduce the incidental catch of commercial and non-commercial species and to reduce damage to the terrestrial environment from certain types of trawling.

To determine the feasibility of such easements, Deacon and Parker examine alternative fishery management regimes, including sole ownership, open access, limited entry and ITQs. They find that marine easements tend to be most effective when harvest rights are delineated most fully. Their analysis suggests ways that marine easements as part of a rights-based approach to fishery management can have flexibility and transactions cost advantages over other options for achieving marine conservation goals. They also propose ways in which the design of laws allowing marine easements should follow, or depart from, the design of laws authorising conservation easements on land.

Three strong conclusions in their paper are: (i) Effective marine easements must apply to the permit or right in the same way that terrestrial easements 'run with land' regardless of the regulatory regime (limited entry, ITQ, and sole ownership). (ii) Marine easements are most valuable if the NGO has the flexibility to amend and sell easements back to the fishermen who own the encumbered harvest rights. (iii) Greater delineation of harvest rights implies greater scope for marine easements to accomplish conservation goals efficiently.

Turning to the control of air pollution, Dallas Burtraw and David Evans, *'Tradable Rights to Emit Air Pollution,'* state that the use of cap-and-trade to regulate air pollution promises to achieve environmental goals at lower cost than traditional prescriptive regulatory approaches. As discussed above, cap-and-trade has been applied to various air pollutants including $SO_2$, $NO_x$ and other gasses in the United States, and $CO_2$ in the European Union. Cap-and-trade is likely to be a primary response world wide for controlling greenhouse gas emissions (GHG). Burtraw and Evans argue that the method used to allocate tradable emissions allowances will have significant influence on the distributional impact and efficiency of the programme.

A lot is at stake. In the United States, the allocation emissions allowances under a $CO_2$ programme would constitute the largest creation and distribution of new property rights in over a century. Depending on how the programme is designed, the value of permits for a $CO_2$ programme could be \$130–\$370 billion annually by 2015.

The authors analyse role of auctions as compared to grandfathering or otherwise free distribution of allowances. The regulatory cap helps to set the value of the permits and accordingly, the opportunity cost of emissions. Depending on their compliance costs, firms (typically utilities) either can sell or must buy permits in order to operate. Internalising the cost of emissions through the purchase of the allowances makes resource allocation in the overall economy more efficient, but it imposes costs on firms and their consumers who have previously benefited from the externality. Because of the magnitudes involved, the effort will be politically unpopular. Nevertheless,

Burtraw and Evans show that a cap-and-trade programme would reduce emissions to target levels in a manner that minimises social cost, as compared to prescriptive regulation.

The authors turn to the question of allocation. They favour auction allocation and outline a variety of reasons why it could be preferable to free allocation via grandfathering or other arrangements. These benefits include (i) greater transparency; (ii) greater fairness; (iii) efficiencies from using the same allocation rules for incumbent emissions sources, new sources and sources that retire; (iv) greater alignment of price and true marginal cost of production, especially in the regulated electricity generation sector; (v) ability to use auction-generated funds to reduce pre-existing taxes, subsidise research and development of new technologies for addressing global warming, and to compensate parties who bear a disproportionate cost under the trading programme; and (vi) reduced rent seeking relative to free allocation of allowances.

This latter outcome is debatable, especially given the size of the revenues involved and observed behaviour by politicians in providing costly constituency earmarks and protecting large inefficient programmes, such as the U.S. and EU farm policies, funded by general tax revenues. Nevertheless, there still may be overall social gains from an auction allocation within an expanded incentive-based, cap-and-trade programme for achieving environmental goals.

The next three papers address water and use of water rights. In *'Double Trouble: The Importance of Accounting For and Defining Water Entitlements Consistent with Hydrological Realities,'* Michael Young and Jim McColl address pre-emptive diversions of water (interceptions) that disrupt existing water entitlements (shares of annual allocations) be over subscribing the available water.

Currently, the interceptions for system maintenance and environmental protection are not reflected in water entitlements, nor are those who make these interceptions required to engage in market trades to secure water. Pre-emptions of water include those involved in offsetting greater evaporation and requirements for instream flows as the climate becomes drier; in supporting plantation forestry for carbon offsets; in filling farm storage dams; in blocking salinity incursion into groundwater; and in increasing irrigation efficiency that reduces water released.

Unlike the seniority entitlement systems used in the western United States (see Donohew paper in this volume), most Australian water systems define pools that are shared in proportion to each party's volumetric entitlement. These sharing arrangements are fixed for 10–15 years. During times of shortage, each entitlement water allocation is reduced by the same uniform percentage. There can be trades of entitlements and annual allocations.

The authors use Australia's Murray Darling Basin to illustrate the problem of unregulated interception of water and describe options for incorporating these interceptions in a manner that maintains the integrity of the entitlement system. These include (i) offsets, whereby the water required for the interception

is estimated initially, and sufficient entitlements are then secured and retired. There is no further annual adjustment. The advantage of the offset approach is that it reduces the number of transactions required and may have less political opposition; (ii) a partial-accounting regime, whereby a defined minimum of entitlement shares is required to be held, and shortfalls between these and actual use is made up at a later date; and (iii) an annual-accounting regime, whereby all water users are required to hold enough entitlement shares through purchase of entitlements or annual allowances to cover their water use.

Young and McColl conclude that if the water rights regime is set up in a coordinated manner to reflect actual water supply (surface and ground) for all applications, then there can be market adjustments for entitlements or annual allocations among water uses in response to climatic shifts, changes in prices and changes in technology that do not compromise environmental objectives.

In '*Property Rights and the Public Trust Doctrine in Environmental Protection and Natural Resource Conservation*' Jedidiah Brewer and Gary Libecap examine the implications of the common law *public trust doctrine* for use in natural resource protection and conservation. The doctrine asserts that some resources are so inherently public in their nature that their permanent assignment to exclusive, private ownership is inappropriate. To insure group values are respected, the state through its administrative agencies has a duty to manage and reallocate the resource as values change. Existing private users have only usufruct rights that can be withdrawn without compensation whenever the state deems that they are inconsistent with the public trust. The focus of the public trust doctrine in this paper is on water, but the doctrine can apply to fisheries and other resources.

A model of litigation and settlement among parties disputing existing natural resource use suggests that the public trust doctrine introduces more costs and is more time consuming than would be the case with alternative approaches, such as the purchase of private rights through market transactions. Because the doctrine allows for uncompensated redistribution, it is resisted by current resource users. The authors point out that by providing open standing to members of the public in challenging existing uses, public trust disputes encourage excessive demands, increasing the incidence of trial over settlement. This outcome is exacerbated if the plaintiffs derive utility from the 'cause' and provide litigation services at below-market rates, leading to greater investment in litigation. Furthermore, by weakening existing property rights, public trust rulings may reduce private incentives to invest in the conservation and wise use of the resource. Public investment may or may not offset lost private actions.

Brewer and Libecap speculate that the likely costs of the public trust doctrine appear to have limited its application beyond the level anticipated by proponents. They illustrate the implications of the model by presenting a case study of the Mono Lake controversy that led to the important 1983

California Supreme Court ruling in *National Audubon Society v. Superior Court* (685 P.2d 709), which placed private water rights subordinate to broader public use requirements and expanded the police power of the state in uncompensated reallocation of water as public values changed. The Mono controversy took over 20 years to resolve, large litigation expenses and all the while, the level of the lake continued to decline. Similar conflicts over water use are occurring elsewhere, and the authors conclude that reliance upon notions of the public trust may not be an efficient way to address competing claims.

In *'Property Rights and Western U.S. Water Markets'* Zachary Donohew examines the nature of water rights in the western United States and the institutional factors that affect water market development. He shows that the appropriative rights doctrine assigns water rights through the rule of first possession. The water can be separated from the land, and hence can be moved out of basin to meet urban and environmental demand. Because water is used sequentially and simultaneously, there can be third-party effects from water transfers that change the nature, timing and location of use. Accordingly, water trades are regulated and the regulations differ across the western states. Depending on the criteria for status of objectors, the range of allowable objections, and the scientific information required to be presented, regulatory approval times and costs can raise the transaction costs of trades.

Furthermore, water rights are seldom held solely by single owners. Most water is owned by irrigators and most new demands are for urban, environmental and recreational applications. Because water values are generally much higher at the margin for non-agricultural use, there are opportunities for trade. Yet, most water trades require also approval of irrigation district officials, as well as the Bureau of Reclamation (if the water is part of a federal water project) and state regulators. For all of these reasons, the transaction costs of trading can be high, and they in part explain the gaps between water prices for agricultural-to-agricultural trades and agricultural-to-urban trades. Only about 2 per cent of annual water used is traded. Donohew provides the most complete dataset available from 1987 to 2007 on the extent of water trading, the contractual forms used and the prices involved in the 12 western states.

The final paper addresses broader issues of property rights, incentives and economic development. In *'Economic Development Lessons from and for North American Indian Economies'* Terry Anderson and Dominic Parker review the empirical literature on economic development as it relates to indigenous people in the United States and Canada. They focus on how property rights institutions and judiciary systems affect the economic performance of reservation and reserve economies.

According to their survey, strong property rights to reservation and reserve land and other natural resources, whether communal or individual, are important determinants of productivity. Political and legal institutions that are perceived as stable and predictable to all parties improve economic

opportunities and performance. The research reviewed also shows that culture and acculturation are important in the development process. Anderson and Parker argue that although their emphasis is on North America, the findings are applicable to indigenous people in other parts of the world and shed light on growth questions that loom large for developing countries around the world.

The problem is an important one. Native peoples are among the poorest in both the United States and Canada, and those who live off reservations or reserves generally do better than those who live on them. Besides low income, natives also have higher infant mortality rates, lower life expectancy and greater incidence of single-parent families. There also is significant variation in the economic performance across reservations and the authors examine differences in land tenure and political and judicial institutions to explain those patterns.

In general, the literature reveals that where tenure is weak or non-existent, agricultural productivity lags significantly. Furthermore, the literature also reports that strong executive and legislative forms of government have a positive effect on reservation employment levels. Finally, variation in credible commitments to property rights through (U.S.) Public Law 280 is important in explaining differences in economic outcomes. The law required about a third of the 81 largest tribes to grant judicial jurisdiction to the states in which they resided resulted. The remaining two-thirds retained their judicial sovereignty. Anderson and Parker report that per-capita income on reservations under state jurisdiction grew about 30 per cent more than on reservations not subjected to such jurisdiction, all else equal. The latter reservations were characterised by unstable and unpredictable judicial conditions. These results mirror those from the broader economic development literature regarding the importance of sure property rights for economic growth.

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