Environmental Harm and Dilemmas of Self-Interest: Does International Law Exhibit Collective Learning?

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I met a traveler from an antique land,
Who said: "Two vast and trunkless legs of stone
Stand in the desert. . . . Near them, on the sand,
Half sunk, a shattered visage lies, whose frown,
And wrinkled lip, and sneer of cold command,
Tell that its sculptor well those passions read
Which yet survive, stamped on these lifeless things,
The hand that mocked them, and the heart that fed:
And on the pedestal these words appear:
My name is Ozymandias, king of kings:
Look on my works, ye Mighty, and despair!
Nothing beside remains. Round the decay
of that colossal wreck, boundless and bare
The lone and level sands stretch far away."

—"Ozymandias," Percy Bysshe Shelley

I. INTRODUCTION

The Kyoto Protocol on climate change is one of the most ambitious attempts to address a global environmental issue to date.[1] As with many initiatives aimed at environmental protection, the Kyoto Protocol has been met with both criticism and inaction.[2] In an anarchic international system, where there is no authority above that of the sovereign state, the issue of adherence to agreements is especially problematic.[3] Without binding authority, enforcement must arise indirectly from the collective itself, making compliance, rather than content, the reflection of international norms. Unlike domestic laws that depend upon the authority of the issuing state for legitimacy, the legitimacy of international law is not created, but found in patterns of behavior. International law gains legitimacy when member states join in a united consensus, where before there was only autonomy and separation.

When considering the relative success of some international regimes in comparison with others, it becomes apparent that a lack of

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1. Protocol to the United Nations Framework Convention on Climate Change, 3d Sess., Dec. 11, 1997, 37 I.L.M. 32 (1998), *available at* http://unfccc.int/resource/docs/cpmvkp/kpeng.html [hereinafter Kyoto Protocol]. Article 3 of the Kyoto Protocol stated its aim of reducing the overall emissions of carbon dioxide and other greenhouse gases by at least five percent of the 1990 levels during the treaty's commitment period. See Annex A of the Kyoto Protocol for a list of the other greenhouse gases.

2. *See generally* SCOTT BARRETT, ENVIRONMENT AND STATECRAFT: THE ART OF ENVIRONMENTAL TREATY MAKING 360 (2003) (noting that Kyoto is criticized because the monitoring of the agreement is imperfect, its mechanisms are too complicated, its implementation too costly, and the agreement fails to solve the enforcement problem).

3. *See id.* at xi ("Under the rules of international law, states can act pretty much how they like, and there is no World Government.").

authority in the international system is not necessarily fatal to altering behavior. That one regime succeeds while another fails indicates that it is the subject and not the system that is determinative. If the success of international law is subject-based, then the social perception of value underlies every regime. For instance, the phenomenal success of economic regimes, such as the World Trade Organization (WTO), rests in large part upon the importance of their subject matter to the concerns of decisionmakers.[4] In this sense, it is not the rules themselves that require examination, but the social perception of the game that is played.

International environmental law presents a unique opportunity to objectively scrutinize a system against the principles that it purports to hold. In the past, criticism of economic structures has largely been centered on normative disagreement with the human consequences resulting from competition. This Article assumes self-interested competition is a given and questions the rationality of the system upon its own terms. Instead of challenging the system in place, this Article questions whether the market provides the rational results so often claimed.

The correlation between environmental degradation and individual well-being allows the environment to serve as a measurable connection between economic practice and social goals. The environment provides a scientifically observable screen upon which individual economic strategies contrast with collective benefit. My ultimate purpose is to construct a model for discerning paradigmatic breakdown and its systemic consequences. The question is, in what situations do dilemmas of rationality lead to contradictions in the basic aims of a system? The significance for international law lies in the possibility of constructing a logical system with which to view the effect of new knowledge upon preexisting assumptions and patterns of behavior.

Part II of this Article discusses how new knowledge can redefine an apparently stable system. The problems posed by climate change are reflective of a modern realization that while the environment is a connected whole, the world's organization is not. When we learn more about a subject that concerns us, we often find that a problem cannot be resolved using the mechanisms that we have traditionally relied upon. Atmospheric issues such as climate change reveal that causation is not directly attributable to the actions of any identifiable structure of authority or responsibility. Scientific data illustrates that our

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4. For an introduction to the international trade regime and the WTO, see MICHAEL J. TREBILCOCK & ROBERT HOWSE, THE REGULATION OF INTERNATIONAL TRADE 38 (1995).

international atmospheric commons is a shared resource that an individual state may abuse at the expense of others.

Part II introduces the concept of an international commons. Part III introduces the theory for predicting rational strategies in a commons. Insofar as decisions involve two exclusive values—for example the benefit of being able to pollute and the benefit of clean air—it becomes easy to mathematically represent the intersection between individual strategies and optimal benefits. Predictably, individual perceptions of interest rarely result in decisions that are most beneficial to the whole, as each individual strategy alters what is available to all. The tragedy of the commons[5] and the Prisoner's Dilemma[6] are examples of situations in which an individual's best strategies (Nash Equilibrium[7]) are inevitably suboptimal for the whole. A dilemma of rationality occurs whenever a game promotes rational strategies that cause irrational results. As with the tragedy of the commons, it is rational for a player to offload costs unto the whole by polluting, but as every player realizes the same rational strategy, the available resources are reduced and everyone is worse off.

Part IV develops a simple game theory model for viewing the dynamics of information assimilation. By comparing individual strategies with knowledge signals in the context of international protocols such as the Kyoto Protocol, we can determine whether players are learning from the consequences of detrimental group behavior. If the distance between individual choice and the benefit to the whole is widening, then actors are not recognizing a new paradigm of thought. In this sense, we may differentiate between situations that call for regulatory change and those that require a paradigmatic shift. Where regulation attempts to alter behavior through traditional adjuncts to game play, a paradigm shift involves environmental protection as a goal that underlies the entire economic game. Instead of modeling the environment as an external appendage to economic market mechanisms, a paradigm shift would ensure that environmental concerns precede the functioning of the market itself. We must create a model for determining when knowledge is incompatible with systemic imperatives. While some systems have the potential to eliminate problems through regulation, this Article addresses

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5. Garret Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243 (1968).

6. The Prisoner's Dilemma is arguably the most famous hypothetical in game theory literature. *See* K.G. BINMORE & KEN BINMORE, ESSAYS ON THE FOUNDATIONS OF GAME THEORY 28 (1990); ROBERT AXELROD, THE EVOLUTION OF COOPERATION 92 (1984).

7. John F. Nash, Jr., *Equilibrium Points in* N*-Person Games and the Bargaining Problem*, *in* CLASSICS IN GAME THEORY (Harold W. Kuhn ed., 1997).

a different question: whether there are problems that simply cannot be surpassed because they are derived from the rules of the game itself.

Beyond the evidence of a continuing dilemma of rationality, Part V of this Article illustrates when a system faces incompatible knowledge. If a system is externally shown to be illogical from the irrational results that it produces, there is a possibility that irrational results will also have implications for the internal logic of the system. A pattern of behavior appears different under the light of new knowledge, revealing that the behavior motivated by one principle is contrary to that defended by another. What occurs is not a sudden vanishing of legal structures such as the state, but rather these structures regressively lose their meaning in the game. If one of the central justifications for the state is to provide a solution to the tragedy of the commons, then what happens to that justification when the state is shown to be worsening that tragedy? The state prevents what it once was: a solution to the commons. It may be impossible to say whether there is a truer or inherently better form for law to take, but one can prove when a legal structure is false based upon its own assumptions. New knowledge can reveal how the irrational tendencies of a system can eventually render its founding principles meaningless.

II. INTERNATIONAL FRAMEWORK—FIRST POSTULATE

When international agreements are derived from scientific advancement they reflect a community's acceptance of new knowledge. Agreements may only be said to reflect changing international norms to the extent that there is an alteration of behavior.

A. Common Resources and Social Divisions

> Picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the commons. . . . As a rational being, each herdsman seeks to maximize his gain. Explicitly or implicitly, more or less consciously, he asks, "What is the utility to me of adding one more animal to my herd?". . . Adding together the component partial utilities, the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd. And another; and another. . . . But this is the conclusion reached by each and every rational herdsman sharing a commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit—in a world that is limited. Ruin is the destination toward which all men rush,

> each pursuing his own best interest in society that believes in the freedom of the commons. Freedom in the commons brings ruin to all.[8]

The tragedy of the commons is a famous concept, effective for its simple imagery and profound universality. Before discussing how the tragedy of the commons is a fluid concept open to scientific discovery, it is pertinent to place the concept in a historical context. Dates and specific events are not essential to this discussion, but the notion of social change and development is. Every arrangement and relationship between the individual and the group must involve some sort of social division. Even if there is no overt decision-making process, every social structure is dependent upon social definition and a tacit understanding of what is an acceptable form of organization and what is not. Social divisions are simpler commonalities that define what certain things—family, prison, property, etc.—look like from afar.

Hardin's passage introduces a dimensional sense of social divisions. The ownership of cattle represents a one-dimensional division. In this sense, society acknowledges that people may individually own things and animals. In the above hypothetical the problem of the commons arises from mixed ownership: one economic form, cattle, is dependent upon another, land, which has no direct economic cost to the cattle owner. It is important to note that the exploited land has an economic value, and an indirect cost, but that these values are obscured when they are borne by society as a whole. Most societies respond to this problem by giving the land a direct economic value by dividing it into private property.

Property, and other territorial divisions such as the state, represents a two-dimensional social division. Unlike one-dimensional divisions that may rely on custom alone, institutions like the state necessarily involve a level of formal organization. The two-dimensional organization is fundamentally engaged in control; a protective function is exercised by an authority over the commons to insure at least a minimal level of future benefit and access. Moving from a one-dimensional division of ownership to a second level of organization sees the free market blended with a social need for control.

Dealing with a commons is reducible to two key elements: (1) the recognition of a system that engenders limitless maximization in a limited context and (2) the imposition of rules to preserve the exploited resource. With each recognition of wider interconnected economic effects the commons necessarily grows, and with it the area of potential

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8. PARTHA DASGUPTA, THE CONTROL OF RESOURCES 13 (1982) (quoting Hardin, *supra* note 5, at 1243-48).

organization. Where a degraded pasture points to the economic activity of one's immediate neighbors, the quality of water that passes in rivers and streams indicates a dependence upon distant communities.

Despite the complexity of modern governments and their international arrangements, the organization of the world remains tied to an antiquated two-dimensional model of territory. Recalling Hardin's famous "tragedy of the commons" and the imagery of a "pasture shared by all," the human experience demonstrates that obligations and restrictions placed on individuals no longer meet the needs of society. As individuals passed from nomadic existence into a settled stationary society, the effects of their behavior became recognizable in their immediate surroundings—the pasture. From the physical observation of the "pasture shared by all," science has now permitted an awareness of the global ecosystem shared by all.

B. Atmospheric Awareness

Perhaps the most striking aspect of modern environmental degradation is the speed with which concerns have outstripped levels of political organization. The central actor in the international system remains the state, meaning that more and more issues which impact individuals are beyond the control of their government. Since climate change was scientifically measured, it has demanded a global view.

In 1896, Svante Arrhenius, a Swedish chemist,

> calculated that a doubling in the atmospheric concentration of carbon dioxide (CO_2), brought about by the burning of fossil fuels, would increase the global mean temperature by about 5 degrees Celsius. In retrospect this was a remarkable prediction, but not until the 1980s did a near consensus begin to emerge about the direction of climate change and the need to reduce growth in atmospheric concentrations of greenhouse gases.[9]

The importance of Arrhenius's calculation should not be underestimated, for a five percent increase in global temperature is more dramatic than the lowly number would indicate. Indeed the effects are likely unquantifiable when considering the unpredictable effects of warmer temperatures and increased water flows upon innumerable sensitive species. Regardless of quantification, the effects are likely to be profound, as the international community began to realize in the late 1980s and early 1990s.

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9. Scott Barrett, *Montreal Versus Kyoto: International Cooperation and the Global Environment*, *in* GLOBAL PUBLIC GOODS: INTERNATIONAL COOPERATION IN THE 21ST CENTURY 196 (Inge Kaul et al. eds., 1999).

The Intergovernmental Panel on Climate Change (IPCC) released its first findings in 1990, estimating that emissions of such long-lived gases as CO_2 would have to be reduced by more than sixty percent just to stabilize current levels. Member countries to the Organization for Economic Cooperation and Development (OECD) announced their intention of reducing CO_2 emissions, "[b]ut in contrast to the case of ozone depletion, most countries have not lived up to their unilateral commitments to reduce greenhouse gas emissions."[10] This dichotomy between intention and individual action leads to a question of compliance: if the directives of the Kyoto Protocol only suggest that industrialized members reduce their emissions to 1990 levels, why is it so difficult to translate these comparatively modest intentions into actual behavior?[11]

C. Conceptual Examples

The increased public concern over environmental degradation in recent decades has led to a broad international movement to coordinate responses to the problem of the atmospheric commons. Two agreements in particular, the Montreal and Kyoto Protocols, illustrate the contrasting effectiveness that exists between many modern environmental regimes. The Montreal Protocol, which aims to reduce the use of chloro-fluorocarbons (CFCs), has been quite successful.[12] The Kyoto Protocol, on the other hand, has had no such success in reducing emissions of CO_2 as ratification has been a struggle.[13]

For the Kyoto Protocol to come into force fifty-five percent of countries that produce fifty-five percent the world's CO_2 emissions (the Annex I countries) are required to ratify it.[14] With Russia's recent decision to ratify, the Kyoto Protocol will soon enter into force.[15]

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10. *Id.*

11. *Id.*

12. Protocol on Substances that Deplete the Ozone Layer, Sept. 16, 1987, 26 I.L.M. 1541, 1550 (entered into force Jan. 1, 1989) [hereinafter Montreal Protocol]; Protocol Parties: Adjustments and Amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer, June 29, 1990, 30 I.L.M. 537, *available at* http://www.unep.org/ozone/pdfs/Montreal-Protocol2000.pdf; Barrett, *supra* note 9, at 192; *see* David A. Wirth & Daniel A. Lashof, *Beyond Vienna and Montreal: A Global Framework Convention on Greenhouse Gases*, 2 TRANSNAT'L & CONTEMP. PROBS. 79 (1992); *see also* MICHAEL GRUBB ET AL., THE KYOTO PROTOCOL: A GUIDE AND ASSESSMENT 9 (1999).

13. Barrett, *supra* note 9, at 192. For a chart comparing the Montreal and Kyoto Protocols, see BARRETT, *supra* note 2, at 361.

14. Kyoto Protocol, *supra* note 1, art. 25; GRUBB ET AL., *supra* note 12, at 9.

15. Ratification of the Kyoto Protocol has been passed by both Russia's State Duma and its Federation Council. It now remains for Russian President Vladimir Putin to sign the treaty into law and for delivery of the formal instruments of ratification to the Secretary General of the

However, it remains unclear whether the members will be willing to accept the costs involved and impose penalties upon those who do not. The success of a regime in this regard may be simply defined as the acknowledgement of a problem and the coordination of rules of behavior that are enforced by the membership to further a solution.

The contrast between the Montreal and Kyoto Protocols is more than an issue of time, which admittedly is an unfair test since the Montreal Protocol is a slightly older proposal. More substantively, many argue that once ratified, the Kyoto Protocol will be largely ineffective at reducing world-wide emissions of CO_2.[16] As Barrett notes in his book *Environment and Statecraft*, the Kyoto Protocol was explicitly designed along the lines of the Montreal Protocol, but lacks the essential enforcement and incentive mechanisms found in the Montreal Protocol, which make real progress likely.[17]

Although the Kyoto Protocol contains stringent mechanisms for monitoring whether Annex I members are in fact maintaining their emissions at 1990 levels, it contains no mechanisms for requiring them to do so.[18] Negotiating sessions held in Bonn and Marrakesh in 2001 structured the Kyoto Protocol in a manner that may have created substantial obstacles to its success. An inducement mechanism has been devised in which countries that fail to meet their initial 1990 targets on time are given higher reduction targets for the following measurement period.[19] However, the difficulty remains that compliance under the Kyoto Protocol is not binding.[20] Monitoring organizations may only suggest penalties, and members would have to accept treaty amendments in order to make these penalties binding.[21] If there is no penalty for

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United Nations. Ninety days after Russia's ratification documents are delivered the treaty will enter into force. For more information, see http://unfccc.int/2860.php (last visited Nov. 6, 2004).

16. *E.g.*, BARRETT, *supra* note 2, at 360.

17. *Id.*

18. GRUBB ET AL., *supra* note 12, at 142.

19. AXEL MICHAELOWA, HAMBURG INST. OF INT'L ECON., HWWA DISCUSSION PAPER 152, RIO, KYOTO, MARRAKESH—GROUND RULES FOR THE GLOBAL CLIMATE POLICY REGIME 25 (Dep't World Econ. ed. 2001), *at* http://www.hwwa.de/Publikationen/Discussion_Paper/2001/152.pdf (last visited Oct. 31, 2004).

20. Kyoto Protocol, *supra* note 1, art. 18. The last sentence of article 18 of the Kyoto Protocol states that "binding consequences" of noncompliance may be adopted only by an amendment to the Protocol. *See* Glenn Wiser & Donal Goldberg, *Implementing Kyoto*, 2 INT'L & COMP. L. 1, 14-15 (2002) (advancing a new theory to promote compliance with the Kyoto Protocol).

21. As Jutta Brunnee has observed, members have generally been unwilling to express their views on which compliance structure ought to be set in place, and it is likely that "the question of penalties will be the most fought over issue in the development of the Kyoto Protocol Compliance Regime." Jutta Brunnee, *A Fine Balance: Facilitation and Enforcement in the*

missing targets, it is unclear what effect the addition of higher targets would achieve. As Barrett notes, the success of the Montreal Protocol is due to providing both a "carrot" and a "stick."[22]

The weaknesses of the Kyoto Protocol may be characterized as arising from both the construction of the agreement and the concessions used to induce key industrial signatories. In terms of explicit sanctions, the Kyoto Protocol lacks a mechanism for blocking the trade of goods that are produced in a manner inconsistent with the agreement.[23] Trade sanctions provided an excellent inducement mechanism under the Montreal Protocol because countries could block the entry of goods that continued to use the prohibited CFCs.[24] Countries continuing to use CFCs face a trade burden—in the form of lost access to markets—that significantly outweighs any competitive advantage gained by using the cheaper CFCs. Imposing trade sanctions upon those who do not comply with, or who are not party to, an agreement effectively places a cost upon those not participating.

The Kyoto Protocol imposes no penalties for those members who do not comply with the agreement, nor any external means of placing costs upon those who are not members. The diverse nature of CO_2 production makes selective trade sanctions upon specific goods unlikely, and furthermore, the current structure of the Kyoto Protocol would make such sanctions against noncompliant countries impossible. Many of the world's countries—particularly developing nations—can be party to the Kyoto Protocol without having any commitments to reduce CO_2 emissions.[25] Additionally, the world's largest polluter, the United States, has abstained from participating, and the Kyoto Protocol provides no means to impose a cost upon this nonparticipation.[26] While the Montreal Protocol has allowed members to impose an external cost upon nonmembers, under the Kyoto Protocol costs are borne by developed country-members.[27] That is, the initial costs of the Kyoto Protocol are only to be borne by the industrialized countries that voluntarily ratify the agreement.

The prospect that the Kyoto Protocol will deliver a comparative advantage to those who do not undertake to reduce CO_2 emissions has

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Design of a Compliance Regime for the Kyoto Protocol, 13 TUL. ENVTL. L.J. 223, 247, 255 (2000).

22. BARRETT, *supra* note 2, at 351.
23. *See id.* at 307 (focusing on the use of trade restrictions for deterring noncooperation).
24. *Id.* at 313.
25. *Id.* at 373.
26. *See* Barrett, *supra* note 9, at 215.
27. *See id.*

been a serious concern for many Annex I countries that have contemplated membership.[28] The Bonn/Marrakesh process may demonstrate the reluctance of countries to accept the substantial costs of reducing CO_2 emissions within a framework of uneven implementation.[29] The incentives given to major industrial countries to ratify the Kyoto Protocol not only lessens the cumulative amount of CO_2 reductions required, but introduces a large measure of uncertainty into the process of giving CO_2 emissions a detrimental cost.[30]

As with the Montreal Protocol, the Kyoto Protocol establishes a framework under which countries can trade pollution permits, making a market for pollution that rewards those who more efficiently and "cleanly" compete.[31] The manner in which the agreement is being ratified poses serious questions as to whether there will be sufficient demand to have a functioning market.[32] Russia and other former Soviet republics, such as the Ukraine, have 1990 targets that are substantially higher than their present post-Communist outputs of CO_2.[33] The former Soviet republics will thus have a great surplus to sell on the market. However, as Barrett details, some of the most significant Annex I signatories who have signaled ratification, including Japan, Australia, and Canada, are each entering the agreement with substantial concessions that will lessen their targeted reductions.[34]

Additionally, Canada unilaterally claimed an additional thirty percent credit that was said to account for its exports of "clean" hydroelectric and natural gas energy to the United States, a nonmember.[35] It is difficult to see how an emissions market will work if countries are able to unilaterally determine their own standards. There would be no need to purchase permits from another member when one could simply

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28. BARRETT, *supra* note 2, at 370 (noting that as of March 2001, only one Annex I country—those countries that have to limit their emissions—had ratified the Kyoto Protocol).

29. *Id.* at 371-74. For a discussion on the concessions sought and achieved by various Annex I countries, see generally Wiser & Goldberg, *supra* note 20, and Matthew Coghlan, *Prospects and Pitfalls of the Kyoto Protocol to the United Nations Framework Convention on Climate Change*, 3 MELB. J. INT'L L. 165, 180 (2002).

30. BARRETT, *supra* note 2, at 370-71.

31. On trading within the Montreal Protocol, see Wirth & Lashof, *supra* note 12, at 105. In terms of the Kyoto Protocol, see Coghlan, *supra* note 29, at 173. For a discussion on pollution trading in general, see Thomas Schelling, *What Makes Greenhouse Sense—Time to Rethink the Kyoto Protocol*, 81 FOREIGN AFF. 5 (2002).

32. BARRETT, *supra* note 2, at 382.

33. GRUBB ET AL., *supra* note 12, at 214.

34. BARRETT, *supra* note 2, at 371-74. Barrett notes that because the Kyoto Protocol does not constrain emissions, countries like Russia will have little incentive to sell their surplus entitlements, and may choose to "bank" them. *Id.* at 374.

35. *Id.* at 373.

declare a new emission standard that reveals targets to be suddenly met.[36] Without the demand for emission permits, the price of CO_2 will provide no incentive for countries to lessen their production.

The Kyoto Protocol may eventually exert considerable influence over the behavior of state actors. The international trade regime has developed gradually, moving from the General Assembly on Tariff Trade (GATT)[37] to the present WTO, while slowly gaining greater influence and membership. Perhaps developing countries, generally the most rapidly growing producers of CO_2, will eventually be included within the regime's requirements. Perhaps the United States will one day ratify. Hopefully the countries that have ratified the Kyoto Protocol because it was of no present cost to them will bear the burden of future reduction targets.

A salient issue of the Kyoto Protocol's success is whether a limited Annex I membership will continue to accept the idea of competing with the numerous countries that have not agreed to, or are not required to, reduce their CO_2 levels. The Kyoto Protocol provides neither the mechanisms to ensure that they do, nor the incentives for inducing others to join the treaty. In the end, for the Kyoto Protocol to be considered a success, a majority of states will have to agree that it is worth the cost.

Atmospheric environmental issues provide an excellent example for this investigation, because they represent a clear connection between new information and the need for competition to adjust based on the new information. The Montreal and Kyoto Protocols further illustrate that there are instances where a game adapts to new information, as with the Montreal Protocol, and instances where competition is much more difficult to alter, as with the Kyoto Protocol. Yet the Montreal and Kyoto Protocols are only examples used to illustrate how differing models of success may exist within similar issue areas. Ultimately, this Article is not about environmental agreements, the Kyoto Protocol, or even international law; it is about proposing a different way to view the law as an instrument for informing competition.

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36. *See, e.g.*, Henry D. Jacoby et al., *Kyoto's Unfinished Business*, 77 FOREIGN AFF. 64 (1998) ("Kyoto is likely to yield far less than the targeted emissions reduction. That failure will most likely be papered over with creative accounting, shifting definitions of carbon sinks, and so on.")

37. For an interesting discussion on the origins of GATT and its relation to the postwar international system, see John Gerard Ruggie, *International Regimes, Transactions, and Changes: Embedded Liberalism in the Postwar Economic Order*, *in* INTERNATIONAL REGIMES 209 (Stephen D. Krasner ed., 1983).

D. Compliance and Consensus

The provision of public goods is constantly at odds with the tendencies of individual actors to seek benefits without paying their requisite share of the costs, a phenomenon known as "free-riding."[38] Indeed one of the historical motivations for the formation of the state was a response to the dilemma of public goods, in that everyone would benefit from a certain service which no one individual would be willing to supply.

Without a world government the issue of free-riding remains salient in the international system. Free-riding requires that enforcement and compliance mechanisms arise directly from the collective membership and that these mechanisms are created and adhered to. While the former imputes the present and the latter the future, the distinction is artificial in that they both represent the same normative value. Normative values are represented by what the collective is willing to submit to in order to achieve the stated results.[39] As such, weak enforcement mechanisms not only predict future failures; they also reflect the present state of value preferences. If a large membership is willing to bind itself to a system of defined accountability, then it follows that strong international support for the initiative exists.

The grandest pronouncements remain hollow if there are no consequences for failing to meet common objectives. This statement is especially true for environmental agreements which deal with the interplay of inconsistent political and economic values. Environmental agreements often represent a collection of good intentions that have good rhetorical value, but they also involve making domestic policy decisions that likely have a significant short-term economic cost. Therefore, short-term economic costs must be counterbalanced by the costs of noncompliance imposed by the membership. As stated by Professor Barrett, in his article *Montreal Versus Kyoto: International Cooperation and the Global Environment*:

> Perhaps the Kyoto agreement can, with time, be amended to resemble the Montreal agreement. Putting the right words down on paper is not the problem, however. Rather, it is making the required mechanism credible.

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38. The problem of free-riding has received significant attention from scholars in the field of international relations. *See* Robert O. Keohane, *Reciprocity in International Relations*, 40 INT'L ORG. 1, 12-13 (1986); *see also* Robert Axelrod & Robert O. Keohane, *Achieving Cooperation Under Anarchy: Strategies and Institutions*, 37 WORLD POLITICS 226, 234-38 (1985).

39. *See* Brunnee, *supra* note 21, at 269.

> A threat is credible only if everyone believes that, when push comes to shove, it will be carried out.[40]

The inherent flaws of the Kyoto agreement may very well have a spiraling effect: the absence of free-riding sanctions encourages noncompliance, so every party that fails to meet its commitments in turn reduces the value of compliance to the rest of the membership.

While Barrett perceptively analyzes the potential consequences arising from the differing mechanisms of the Montreal and Kyoto Protocols, this may be a somewhat hasty evaluation. Before credible threats can be agreed upon, there must be a stable consensus on the merits of participation. The skewed application of the Kyoto Protocol, which only covers developed country members, might well provide for continuing domestic criticism of the Kyoto Protocol as a source of competitive disadvantage.[41] Given the costs of increased environmental regulation, it is plausible to assume that industry may attempt to avoid these costs by relocating to countries not bound by the treaty.[42]

Concerns over competitive disadvantage may be characterized as examples of dependent reasoning. In this form of dependent reasoning it is not the central idea that is contested, in this case reducing CO_2 emissions to mitigate against climate change, but rather the imagined benefits to competitors. If one assumes that another country may benefit by avoiding the costs of the Kyoto Protocol, by attracting industries that wish to avoid further environmental regulation for instance, then it follows that membership may be viewed as a competitive disadvantage. What is most troubling about this form of dependent reasoning is that it is completely rational only so long as no one else follows the same reasoning. For example, it would be cheaper for country *A* not to ratify the Kyoto Protocol; therefore, it would be cheaper for every country not to ratify the Kyoto Protocol. The result of dependent reasoning in this instance is that no country would ratify the Kyoto Protocol, but the future costs borne by everyone would be greater.

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40. Barrett, *supra* note 9, at 216.

41. The developed country signatories are those listed in Annex I of the Kyoto Protocol. Kyoto Protocol, *supra* note 1, art. 25.1.

42. Developing countries are not bound by the 1990 targets set by the treaty. Nonmembers, most notably the United States, are obviously not covered by the treaty either. *See* BARRETT, *supra* note 2, at 371-74. On the concerns of U.S. nonparticipation and the potential competitive disadvantage faced by Canada, see R. Fife, *Premiers Ambush Chretien on Kyoto*, NAT'L POST, Feb. 28, 2002, at A1. *See also* Philip Barton, *Economic Instruments and the Kyoto Protocol: Can Parliament Implement Emissions Trading Without Provincial Co-operation?*, 40 ALBERTA L. REV. 418 (2003).

III. THEORETICAL FRAMEWORK—SECOND POSTULATE

It is possible to mathematically represent the evolving relationship between individual decisions and common benefit.

A. Game Theory

A game is played by a group of individuals whenever the fate of an individual in the group depends not only on his own actions, but also on the actions of other individuals in the group.[43] The most obvious examples of games are parlor games such as checkers, chess, and poker. In these games the play of *A* is dependent upon the plays, both past and anticipated, of players *B*, *C*, and so on. The essential point is that individual strategies do not arise independently, but instead are contingent upon the behavior of others.

Von Neumann and Morgenstern first introduced the notion that it is possible to systematically extrapolate the model of parlor games to more interesting social phenomena.[44] At first glance, it seems trite to correlate the socially significant with trivial games intended for amusement, but the perceptiveness of Von Neumann and Morgenstern lies in realizing that the same basic premises apply to both. Two general conditions exist: dependent strategies and individual rationality.

Rationality is the key to the mathematical model of game theory.[45] Without the notion of individual rational actors, it is impossible to have any predictive or explanatory model whatsoever. Irrational decisions are inherently unpredictable. It is important to note, however, that rational does not denote a quality but rather a function; rational decisions in this sense are not necessarily perfect or even logical, only consistently self-interested.

B. Nash Equilibrium

While the work of Von Neumann and Morgenstern was revolutionary, its initial application was limited. The first theory of games was based upon "two person cooperative games" (cooperative meaning binding agreement and not working together) that have zero-sum results.[46] As in chess, an advantage or gain by one player results in a

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43. BINMORE & BINMORE, *supra* note 6, at 1.

44. JOHN VON NEUMANN & OSKAR MORGENSTERN, THEORY OF GAMES AND ECONOMIC BEHAVIOR 47 (1944).

45. SCOTT GATES & BRIAN D. HUMES, GAMES, INFORMATION, AND POLITICS 8 (1997).

46. *Id.*; *see also* ALEX TALBOT CORAM, STATE ANARCHY AND COLLECTIVE DECISIONS (2001).

corresponding detriment to the other. A zero-sum game could be simply illustrated as follows:

> Beginning of Game: $a = 1$, $b = 1$
> Result of Game: if $a = 2$, then b must $= 0$

As most real life situations do not neatly correspond to defined zero-sum situations, the limits of cooperative games are obvious. A more applicable model may be found in noncooperative games that have n players (where $n>2$), as these games have no binding agreements and recognize multiple players. John Nash introduced the distinction between cooperative and noncooperative games, which is a central concept behind analyzing the strategic complexity of competition among multiple participants.[47] Without binding agreements dictating the course of the game, players' decisions are more flexible, less predictable, and more realistic.

Unlike two person games such as chess, which have alternating sequences, games such as poker require that multiple players simultaneously determine their play. The requirement of simultaneously determined strategies is arguably the most interesting facet of games, for it demands that players choose their strategies in anticipation of their opponents' strategies. Put simply, a player's best strategy is based upon the anticipation of others' best strategies. Nash Equilibrium is the point when all of the best strategies converge, namely when no player's best strategy can be bettered without a change in the strategies of others.

C. Nash Equilibrium Versus Pareto Optimum

The concept of Nash Equilibrium transformed economic theory and has been applied to fields as diverse as trade negotiations and evolutionary biology.[48] While Nash Equilibrium is a concept that has had undeniable prescriptive success, it is also illustrative of the potential inefficiencies of individual strategies. This introduces a sort of paradox of rationality in which there is a dichotomy between optimal strategies and optimal effects. The theory of Pareto Optimum, which represents the point at which "there is no other feasible alternative allocation which makes everyone better off,"[49] contrasts with the Nash Equilibrium of strategies. There are situations, or games, that find the best competitive

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47. Nash, *supra* note 7, at 25; *see also* John F. Nash Jr., *The Bargaining Problem*, *in* CLASSICS IN GAME THEORY, *supra* note 7, at 5.

48. Eric Talley, *Interdisciplinary Gap Filling: Game Theory and the Law*, 22 LAW & SOC. INQUIRY 1055 (1997).

49. DASGUPTA, *supra* note 8, at 25.

strategy for each individual—Nash—which is a different point than the strategy that would have realized the best result—Pareto. That is, the situation is suboptimal as the best rational strategy does not translate into the best possible outcome.

The well-known Prisoner's Dilemma is a classic example of when the rational strategy of each individual leads to a suboptimal result.[50] The game generally describes two accomplices to a crime who face the temptation to inform on each other. An interrogator addresses each detainee in isolation and offers them a similar deal. The deal is that if one confesses and informs on their partner they receive a light sentence. If they do not confess and their partner informs on them they receive the maximum sentence. Fearing that the other will inform, and that they will suffer by receiving the maximum sentence, each prisoner predictably informs on the other. The best result for both individuals would occur if neither informed, and yet the best independent strategy for both would be to inform.

Implicit in game situations is the idea that individuals must hedge against the potential costs of the other's strategy. Ideal or optimal outcomes are unlikely to occur for fear that other players will free-ride and not restrain their strategies for the benefit of everyone. Distrust or skepticism of others informs our decisions, which informs the decisions of others, which further informs our decisions, and so on.

D. Game Theory and the Environment

Game theory models of global environmental issues provide some of the clearest examples of rational contradictions within the market system of rational self-interest. The market produces results that are contrary to the longstanding doctrine of individual self-interest by producing results that are best for everyone.[51] Hardin's tragedy of the commons resembles the Prisoner's Dilemma, where "[e]ach man is locked into a system that compels him to increase his herd without limit—in a world that is limited."[52] In the context of game theory, Hardin's use of "compel" may be seen as an example of Nash Equilibrium in that each herdsman's best strategy would be to graze more and more cattle.

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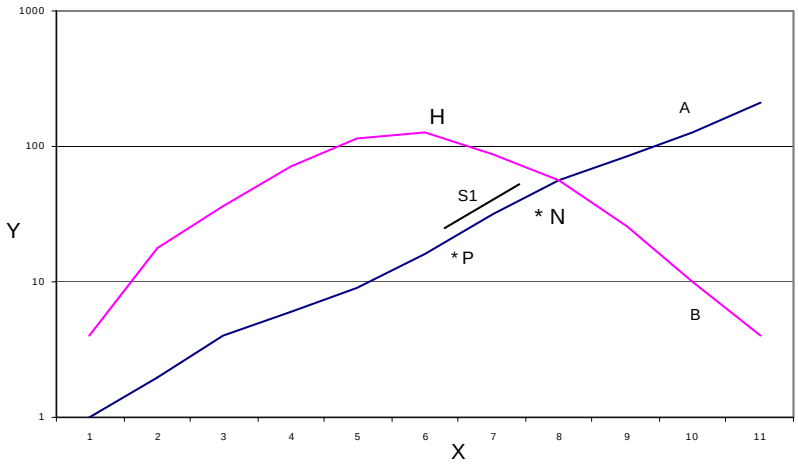
50. BINMORE & BINMORE, *supra* note 6, at 32-33; *see* ALEX TALBOT CORAM, STATE ANARCHY AND COLLECTIVE DECISIONS 26-29 (2001) (describing the Prisoner's Dilemma).

51. Adam Smith's famous "invisible hand of the market" postulates that the best results for society as a whole occur when everyone pursues their own self-interest. ADAM SMITH, THE WEALTH OF NATIONS 572 (Edward Cannan ed., Modern Library 1994) (1776).

52. Hardin, *supra* note 5, at 1244.

The figure that follows is a hypothetical illustration of the relationship between economic competition and environmental resources. Drawing upon a model constructed by the economist Partha Dasgupta in his work *The Control of Resources*,[53] this Article uses Dasgupta's example of an international fishery to discuss problems of common resources and market failures.[54] It is not difficult to discern an analogy to Hardin's pastoral commons, or for that matter, the case of the atmosphere and the climate change regime. Simply exchanging the hypothetical fishing waters for the atmosphere achieves the desired result. The tendency illustrated in Dasgupta's international fishery is analogous to the case of greenhouse gas emissions, as each country conducts an internal cost-benefit analysis in which the benefit from a minimal increase in pollution outweighs the damage incurred. Indeed this national cost-benefit analysis is explicitly mentioned in Barrett's article on the Montreal and Kyoto Protocols.[55]

Figure 1



Legend:

X axis—Amount of Pollution.
Y axis—Amount of Fish.
A—Marginal Damage: the pollution that each offloads into the commons.
B—Mutual Benefit: the mutual benefit from common resource.
N—Nash Equilibrium: the most rational strategy for each individual.
P—Pareto Optimum: the optimal strategy for mutual benefit.
S1—Distance between N and P.
H—Highest Point of Resource.

53. DASGUPTA, *supra* note 8, at 19-24.
54. *Id.* at 19-20.
55. Barrett, *supra* note 9, at 202.

The above illustration represents economic strategies and their results; it does not represent the environment itself. The figure illustrates the underlying method of game theory. The game theory method predicts rational strategies and compares them to corresponding outcomes. The idea of correspondence is central to predicting and interpreting competitive games. For example, the Prisoner's Dilemma has two strategies, "inform" and "not inform," with a hypothetical correspondence of 0, 5, and 15 years. When strategies are combined, they find their corresponding outcome. Therefore, if both players choose "inform," the result is that each receive 5 years. If *player one* chooses "inform" and *player two* "not inform," *player one* receives 5 years and *player two* receives 15. If neither player informs, both are set free.

When considering an environmental commons the potential strategies are more numerous than the Prisoner's Dilemma; Figure 1 attempts to represent these options along a continuum that is line *A*. As the Prisoner's Dilemma had the options of "inform" and "not inform," this international fishery model would have options that represent the pollution that each emits into the water, "1 unit," "2 units," "3 units," and so on. The countries consider how much effluent to discharge into the commons in view of the potential detriment that results.[56] Each level of pollution along line *A*, or marginal damage committed by each country, corresponds with a point on line *B* of mutual benefit.

The strategies of pollution are an economic consideration and not merely a byproduct of competition.[57] Pollution is a cost that countries may offload into the commons, thereby avoiding the expense of recycling or waste management. The reasoning of each country involves considering how much economic benefit is available through their marginal damage before the value of their share in the mutual benefit is diminished. Dasgupta's calculations reveal a Nash Equilibrium of *N*, at which point each actor has concluded that polluting any more would be offset by their subsequent loss in fish catch.[58] The difficulty, however, is that each strategy is contemplated independently while the results are dependent upon the strategies of all others considered together. When all strategies are combined the result is that the Nash Equilibrium point is suboptimal. Each player would have been better off choosing the point *P*, where the number of fish caught is maximized by restraining marginal damage.

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56. DASGUPTA, *supra* note 8, at 19-24.
57. *Id.*
58. *Id.* at 22.

With no regulation of the commons, the intuitive sense to restrain pollution is lost to the competitive fear that others will cheat first. The strategy to cheat, or "free-ride," becomes more rational as a player becomes less competitive compared to those able to offload more of their pollution costs into the commons. Recalling the dynamic of dependent strategies discussed *infra* Part III.A helps illustrate how a rational independent strategy considered in isolation may nevertheless lead to an irrational or suboptimal result when the strategies of everyone are combined. If a single country determines that it would be beneficial to increase its marginal output of pollution, every other player is certain to operate under the same assumptions. Comparing *N* with that of the optimal point *P* shows the predictable result that best strategies will not equal best outcome. The best solution for each country would have occurred if each country had opted for restraint.

As with the Prisoner's Dilemma, the inefficiency of the economic commons is a result of competitive necessity rather than pure information. Both prisoners could easily envision that two strategies of "not inform" would result in zero penalties, and countries in the hypothetical fishery could equally infer that if all restrained their marginal damage their fish catch would be maximized. Restraint does not occur in either game for fear that others will benefit by maximizing their own self-interest. This creates a suboptimal equilibrium: the strategy that none find ideal but that each fears another will choose.

IV. PARADIGM CHANGE—THIRD POSTULATE

> *If common benefit is associated with developing knowledge then it is possible to mathematically represent the social acceptance of a new paradigm of thought.*

A. Environmental Economics

> Environmental Economics is generally regarded as a branch of the economics of externalities. More particularly, environmental problems are commonly associated with the failure of market institutions. The starting point of this literature is the observation that in many cases the malfunctioning of market forces can be ascribed to the fact that for certain commodities and services, competitive prices simply do not exist.[59]

Essentially, the environment is one of the few domains that have yet to be successfully given a value. Environmental economic theory

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59. Partha Dasgupta et al., *Introduction* to THE ECONOMICS OF TRANSNATIONAL COMMONS 1 (Partha Dasgupta et al. eds., 1997) (internal citations omitted).

advocates attempting to modify maladjusted market institutions by giving the environment an economic price.[60] The most common suggestions for adjusting the market inevitably involve giving environmental degradation a monetary value.[61] For example, tradable emission permits (in essence tradable licenses to pollute) are a popular proposal.[62] Some of these programs have been successful; however, this Article considers situations in which emission permits may be ineffective.

The traditional view of the environment as an externality needs to be reconceived if answers to these fundamental challenges are to be offered. The predominant economic view that environmental goods have no value is illogical from a more abstract vantage point. Game theory represents strategies, and strategies entail decisions, so there must be situations in which two or more values are compared. While simple games such as chess are only about the competitive dynamic, social games may involve much more profound decisionmaking. When a game reflects social choice, the outcome will reflect societal values. Thus, there is a value ascribed to the environment, and it is located directly beneath that of the economic equilibrium. The problem is not that the environment lacks an economic value, but rather that economics prioritizes greater social value.

B. Theories of Change

Let us consider two different forms of societal change. The first is developmental or endogenous, and it involves incremental legal adjustments to the changing perceptions of society and its members. In the endogenous model, law is a reflection of the ideas that already permeate society. The second form of change, called revolutionary or exogenous, occurs when the law encourages the acceptance of new ideas. Revolutionary does not imply political upheaval or bloodshed, but rather an idea that offers a break with the previous paradigm. A new idea emerges, for instance Svante Arrhenius's prediction regarding CO_2 emissions and climate change, but does not initially take hold.[63] The dominant paradigm of economic exploitation continues on for decades despite this small blip of a discovery. However, more and more

60. *Id.* at 1-2.

61. *See* BARRETT, *supra* note 2, at 374.

62. *See* GRUBB ET AL., *supra* note 12, at 89-90; *see also* Schelling, *supra* note 31, at 5.

63. Barrett, *supra* note 9, at 196 (discussing Svante Arrhenius's calculation regarding climate change due to fossil fuel burning).

anomalies arise which the dominant paradigm cannot explain. The question then becomes what to do with this new information?

C. Solving the Commons Problem?

Recent scholarship in several fields has explored how cooperation can be explained as a product of self-interested competition.[64] The premise of self-interested cooperation or "reciprocal altruism" generally holds that while individuals are inherently self-interested, the best strategy for each individual need not necessarily be aggressive or antagonistic.[65] Instead of one basic strategy of competition like zero-sum rivalry, there are instances when the most self-interested strategy would lead to cooperation. If individuals are persuaded that others will cooperate with a measure aimed at furthering collective benefit, then their own self-interest will direct them to do likewise. This is an interesting perspective that contains a measure of both cynicism and optimism. If an altruistic quality of human nature is being discounted, so too are notions of a predetermined form of self-interest. Self-interest is assumed to be the primary impulse of humans, one that remains open to the possibility of individuals cooperating to solve collective problems.

Game theory methods are obviously signaled in the language above, and indeed game theory has informed much of the literature on self-interested cooperation. As always, the Prisoner's Dilemma is a central example of this interdisciplinary approach, helping to illustrate how suboptimality is a feature of communication rather than a predetermined outcome of human nature. "If the rules for exacting confessions from apprehended suspects are structured differently, then isolated prisoners have very different optimal strategies and there is no dominance of individual (Pareto inferior) strategies."[66] The argument is that the tendency of individuals to "snitch" within the Prisoner's Dilemma should not be viewed as an inevitable result of human selfishness but rather as the structure of the game itself.[67] Therefore, changing the rules of the game may then lead individuals to prefer different strategies.

As with the Prisoner's Dilemma, the tragedy of the commons has been rejected by many for not accurately reflecting the varying

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64. *See* RICHARD DAWKINS, THE SELFISH GENE (1976); JOHN MAYNARD SMITH, EVOLUTION AND THE THEORY OF GAMES (1982); *see also* ROBERT AXELROD, THE EVOLUTION OF COOPERATION (1984).

65. BARRETT, *supra* note 2, at 55.

66. Daniel Bromley, *The Commons, Property, and Common-Property Regimes*, *in* MAKING THE COMMONS WORK: THEORY, PRACTICE, AND POLICY 5 (Daniel Bromley et al. eds., 1992).

67. *Id.*

possibilities of self-interested human nature. Elinor Ostrom is at the forefront of a school of interdisciplinary scholars who have criticized Hardin's famous tragedy of commons with the aid of empirical counterexamples.[68] As opposed to Hardin's description of common pastures before the enclosure movement and the shift to private ownership of those lands, Ostrom and others have pointed to communities that have solved the "tragedy" without having to resort to private property or other forms of centralized governance.[69] This has been called the "middle-way approach" as it sits between two poles: that of unchecked self-interested competition, as in the tragedy of the commons, and the imposition of legal institutions.[70] As Ostrom writes, these cases "illustrate situations in which individuals *do* talk with one another about the long-term condition of their shared resource and take account of one another's actions when deciding on their own."[71]

Essentially, the middle-way approach argues that there is evidence that individuals have been able to communicate to establish norms of restraint and enforcement within the community itself. In terms of the Prisoner's Dilemma, a community of accused individuals comes together to agree upon the suboptimality of "informing" and then organizes penalties for those who transgress this norm. The significance lies in change arising from within the community membership, as opposed to without, which may be identified with the imposition of legal institutions that either organize or divide up the resource.[72] This distinction between intrinsic and extrinsic is equivalent to the concept of endogeneous and exogeneous change proposed earlier.

The examples of communities able to orchestrate a solution to the problem of commonly held resources are generally small and rural locations, ranging across time and geographic space. For example, Margaret McKean chronicles the case of various medieval Japanese villages between the thirteenth and sixteenth centuries.[73] The village inhabitants, dependent upon the same common resources for a variety of

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68. Elinor Ostrom, *Rudiments of a Theory of the Origins, Survival, and Performance of Common-Property Institutions*, *in* MAKING THE COMMONS WORK: THEORY, PRACTICE, AND POLICY, *supra* note 66, at 293.

69. Nives Dolsak & Elinor Ostrom, *The Challenges of the Commons*, *in* THE COMMONS IN THE NEW MILLENNIUM: CHALLENGES AND ADAPTATION 5-8 (Nives Dolsak & Elinor Ostrom eds., 2003); Bromley, *supra* note 66, at 2-3.

70. Matt Ridley & Bobbi S. Low, *Can Selfishness Save the Environment?*, ATLANTIC MONTHLY, Sept. 1993, at 76-86.

71. Ostrom, *supra* note 68, at 297.

72. Dolsak & Ostrom, *supra* note 69, at 5-8.

73. Margaret A. McKean, *Management of Traditional Common Lands (Iriaichi) in Japan*, *in* MAKING THE COMMONS WORK: THEORY, PRACTICE, AND POLICY, *supra* note 66, at 65-90.

their everyday needs and sustenance, came to develop highly effective social norms of restraint.[74] Beyond the simple recognition of the need to protect the common resource, the villagers ostracized those found cheating, and further instituted schemes of alternating patrols drawn from the ranks of the community's young men to ensure compliance.[75]

McKean details how the character of each village was itself a substantial mechanism of enforcement, since "all potential violators of rules knew that those near them had strong incentives to advocate compliance as a general rule—or, when persuasion failed, to snitch on one's colleagues rather than be implicated with them."[76] Although living in such an observant community might seem oppressive, the point is that individual self-interest is directed toward furthering the benefits of the collective.

Although articulated differently, the principle used in the middle-way approach is the same as in the Prisoner's Dilemma; its tendencies have neither been solved nor overcome, but have been steered toward a different goal. The Prisoner's Dilemma is optimal for society at the expense of the individuals accused: the accused receive greater sentences than if they had acted with restraint and society increases the odds of gaining confessions and convictions.[77] Similarly, the individual who "snitched" on their neighbor in the medieval Japanese village may have done better by keeping quiet, as they could have received more goods by colluding with or blackmailing the person they caught cheating. Thus a tragedy of the commons situation is avoided by invoking the Prisoner's Dilemma to ensure that the competitive insecurity of each individual serves the collective. The middle-way approach acknowledges self-interest and argues that communities take advantage of it for the benefit of society as whole.

Despite the promise displayed by the middle-way approach, questions remain as to whether it can stand as a coherent theory. Two substantial problems exist: scale and indeterminacy. Dealing first with the issue of scale, it appears that a few isolated examples of rural responses to the problem of common resources may not translate to global environmental problems like the atmosphere. As Dolsak and Ostrom explain, "[g]roups with longer traditions of mutual trust and

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74. *Id.* at 63.
75. *Id.* at 81.
76. *Id.*
77. This of course assumes that a greater conviction rate is a desirable social good. Those living under a despotic government, for example, would certainly disagree. The middle-way approach necessarily contains an aspect of paternalism or communitarianism, for it is the social good that individual self-interest is made to serve.

close knit communities that enable resource users to reciprocate in behavior are more likely than other groups to succeed in devising and sustaining successful institutions."[78] And as Ostrom further acknowledges, "[f]or large and amorphous resources, such as ocean fisheries . . . it is extremely difficult, both technically and economically, to exclude potential beneficiaries from obtaining benefits from them."[79] When considering these statements it is difficult to see how the middle-way approach would yield answers to sophisticated atmospheric issues that exist on a level where people do not physically see those who are degrading the commons, and are not in connected relationships with those needed to help enforce a solution.

The middle-way approach finds its strongest connection with the international realm in the work of Robert Keohane.[80] Keohane's work in international regime theory, unsurprisingly, sits between two diametrical theoretical positions: realism and cognitivism.[81] While the realist school believes that states are self-interested and only concerned with their survival and relative strength in relation to other states, the cognitivist school places a priority on learning, as state interests are thought to be formed through social interaction.[82] Keohane's "neo-liberal" theory assumes that each state is self-interested, and that this self-interest can sometimes lead to cooperation and coordination through agreements of mutual benefit.[83] Analogous to the middle-way approach, Keohane claims that an international membership of states can develop means of communication and enforcement when it is in their best interest to cooperate within a given subject area.[84] Self-interest causes states to agree upon certain norms and the sanctions for violating these norms, thereby imposing a cost to "free-riding" in the absence of sovereign authority.[85]

While Keohane's regime theory may provide a transition to the international level that is arguably missing with the empirical work of

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78. Dolsak & Ostrom, *supra* note 69, at 6.

79. Ostrom, *supra* note 68, at 295-96.

80. *See, e.g.*, ROBERT O. KEOHANE, AFTER HEGEMONY: COOPERATION AND DISCORD IN THE WORLD POLITICAL ECONOMY 1 (1984) (arguing that in the international realm, cooperation, rather than discord, is scarce because the interdependence of international economies has created more points of friction).

81. ANDREAS HASENCLEVER ET AL., THEORIES OF INTERNATIONAL REGIMES 3 (1997).

82. *Id.* at 3-5.

83. Reciprocity, in the fashion of Robert Axelrod's initial articulation, *supra* notes 6, 38, 64, is central to Keohane's theory of international cooperation. KEOHANE, *supra* note 80, at 75-78; *see* Keohane, *supra* note 38, at 12-13; *see also* Axelrod & Keohane, *supra* note 38, at 234-38.

84. KEOHANE, *supra* note 80, at 63.

85. *Id.* at 150.

Ostrom and others, the more substantial question of indeterminacy remains. The middle-way illustrates that there are different possibilities for effective social organization without explaining how these possibilities come about. The middle-way ardently claims that the tragedy of the commons is not a monolithic constant, which is easy to concede, but the empirical evidence that it raises does not give us a new rule, only the rare exception to it. For every obscure example of an ancient fishing village that was able to enforce economic restraint through community observance, there remain myriad cases that do conform to the tragedy of the commons. As Ostrom writes, "[t]hree broad forms of ownership can govern a common-pool resource: government, private, or common-property ownership . . . there is no consistent evidence that any one of these regimes is best suited for all types of common-pool resources."[86]

As often happens with models designed to explain human behavior, each theory is destined to remain an incomplete picture. While Keohane's neo-liberal regime theory explains certain endeavors of international cooperation, other aspects of his model manifest the characteristics of *realpolitick* and the aggressive self-interest of the state. As applied to this Article, Keohane's theory explains why environmental agreements like the Montreal Protocol have succeeded, but remains silent on why the Kyoto Protocol has not.

If self-interest is the constant assumed by academics like Keohane and Ostrom, why do results vary so much within the same issue area? An answer to this politically charged question is not attempted in this Article. Rather, the insights and inconsistencies of various contrasting theories are assumed to be inevitable, making the objective to determine which may best characterize interest perception and competition within a given case. I propose that through the measurement of rational strategies over time we may judge which model of common resources most accurately defines a specific system. In this way we may determine whether self-interest is developing new directions based upon membership communication, as if organically from within the game, or whether more ambitious legal reforms are needed to encourage new possibilities of communication and cooperation.

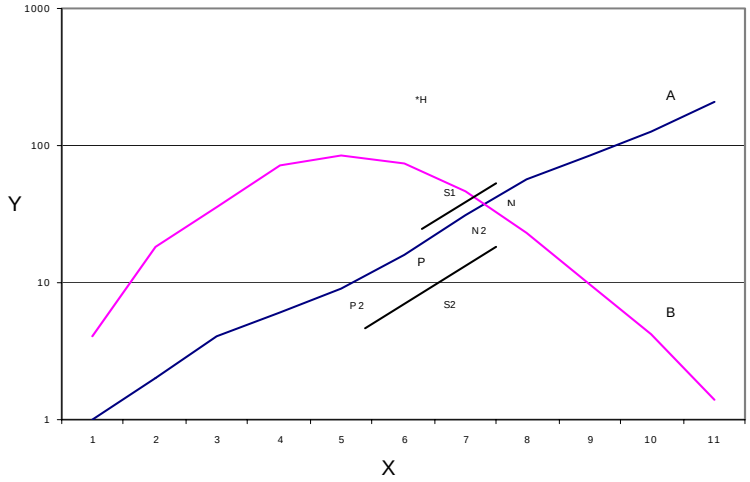
D. Variations on Game Theory

Having viewed the problem with the help of game theory, it is possible to gain the hint of a solution there as well. Figure 2 below is a

86. Dolsak & Ostrom, *supra* note 69, at 8.

hypothetical continuation of Figure 1.[87] The two figures represent a repeating game, with Figure 2 showing a subsequent turn or later point in time. This notion of time is important for a game involving an environmental value in order to account for exhaustible and finite resources. The results of round one, *N*, *P*, and *S1*, have been included with those of the imagined second round for comparison. The results of round two contemplate a worsening situation, and as such the curve of mutual benefit has diminished (compare with the previous peak of *H*). This reflects the fact that in the previous turns the players had a suboptimal equilibrium: they polluted too much and now there are fewer resources available.

Figure 2



Legend:

X axis—Amount of Pollution.
Y axis—Amount of Fish.
A—Marginal Damage: the pollution that each offloads into the commons.
B—Mutual Benefit: the mutual benefit from common resource.
H—Highest Point of Resource: in this instance, found in round one.

Current Round:

N2—Nash Equilibrium: the most rational strategy, current round.
P2—Pareto Optimum: the optimal strategy, current round.
S2—Distance between N and P: current round.

Previous Round:

N—Nash Equilibrium: the most rational strategy, from round one.
P—Pareto Optimum: the optimal strategy, round one.
S1—Distance between N and P: round one.

87. It is important to note that this hypothetical continuation is not meant to imply scientific data or a reflection of reality. The selected points of the second figure show a worsening situation, but it may equally show an improvement. The point of this investigation is to explain the potential process for examining results, not produce the results.

Comparing the equilibrium and optimum points for multiple rounds in time provides an interesting perspective for viewing systemic developments. For instance, contrasting *P* and *P2* shows how an exhaustible resource may be depleted to the point where a reduction in use is needed to simply maintain the already suboptimal condition. Recall the IPCC findings which estimated that emissions of CO_2 would have to be reduced by more than sixty percent just to stabilize current concentrations.[88] The value *H*, representing the point of highest resource abundance from the previous figure, is also worth noting.

Perhaps the most intriguing idea in this theoretical example is the value of *S*. Quite simply, *S* is the distance between the equilibrium and optimum points. In and of itself *S* may be insignificant; but when considering the potential normative implications of a social game, the impact increases. With respect to the first turn of the game, the equilibrium is suboptimal to the value of *S1*, the distance from the optimum point. Suboptimal means only that the collective strategies resulted in an equilibrium that was not ideal, but it says nothing about how far from ideal the course of action was. Therefore, *S* is a measurement of how near individual strategies were to the best for the whole.

Taken over time the value of *S* becomes increasingly significant.

> Suppose in turn one:
> $N = 10$ and $P = 6$, therefore $S = 4$
> In turn two:
> $N1 = 13$ and $P1 = 5$, therefore $S1 = 8$
> End of game:
> $S2 - S1 = S$

If *S* is a positive number the situation is deteriorating despite the previous turn. This implies that the players are *not* learning from their previous interaction. If the distance is closing one could infer that the players *are* learning from previous suboptimal results.

E. Systemic Observation

By comparing equilibrium and optimum points we may gain insight into how a system of rules reconciles the competing rationalities of individual and collective interest. As demonstrated above, the dilemma of rationalities present in a commons is not a competition among equally viable options, but rather a competition between perceived and actual benefit. Both the individual and the entire collective are served by behavior commonly employed. The task of a legal system is to mitigate

88. Barrett, *supra* note 9, at 196.

against the tendency of actors to profit from behavior that, if taken by others, would be detrimental to everyone. In essence, the objective is to promote restraint and engender a way of thinking that makes individuals elevate their concerns above the immediate pay-off from cheating the whole.

The value of *S* is thus a hypothetical measurement of social learning, or the cognitive development triggered by social forms and the awareness of interconnected consequences arising from behavior. If game theory models give us a theoretical vantage of rational strategies and collective benefit, then the value of *S* is merely a simplistic attachment added to highlight the dynamics of systemic inputs. In essence, *S* is a measurement of the distance between two figures over a series of landscape snapshots. If Figure 1 shows a suboptimal relationship between two figures or points, then Figure 2 shows us whether or not surrounding forces are bringing the two figures together. By measuring the fluid relationship between knowledge and behavior, we may objectively view when the conditions for radical paradigmatic change are in place and are ultimately necessary.

F. The Montreal and Kyoto Protocols

The Kyoto and Montreal Protocols are similar in their atmospheric focus but differ significantly in their actual effect. Where the Montreal agreement has encouraged an alteration in behavior, and made a significant advance toward the elimination of CFCs, the Kyoto Protocol has not had a discernible impact upon climate change. To place the Kyoto and Montreal Protocols into the theoretical framework developed above, the Kyoto Protocol would have an increasing *S* value while the Montreal Protocol would have a decreasing figure. Essentially, CFC usage would be seen to be declining toward the collective or social optimum and away from the Nash Equilibrium point, and thus the declining amount for *S* is a signal of social learning. Conversely, the likely increase in *S* value under the Kyoto Protocol illustrates that individual actors are not learning from past suboptimal results; despite the evidence of collective harm, individual maximization continues.

There has been much criticism of the science of climate change and the uncertainty that necessarily surrounds future estimates of environmental decline.[89] Fundamental advancements in knowledge must

89. Dennee A. Diluigi, *Kyoto's So-Called "Fatal Flaws": A Potential Springboard for Domestic Greenhouse Gas Regulation*, 32 GOLDEN GATE U. L. REV. 693, 697 (2002). This article summarizes the combination of a broad consensus on observable effects with intense debate of

be open to future qualification, as Newtonian governing dynamics was to Einstein's theories of relativity. Uncertainty need not bar conservative human action for the sake of future security. Consider the words of Richard Benedick, the chief U.S. negotiator at the Montreal Protocol talks:

> We seem to have forgotten that [the case for the Montreal Protocol] was completely theoretical. Measurements did not in fact record any thinning of the ozone layer, except over Antarctica, a seasonal occurrence which scientists at the time considered a special case, and for which there were numerous theories. There was, moreover, no evidence that CFCs were responsible. Finally, there was no sign of increased ultraviolet radiation actually reaching the Earth.[90]

Assuming a similar level of objective knowledge for both climate change and ozone depletion, we may infer that dissimilar implementation is not based on a scientific or logical method but rather the pragmatic realities of maintaining the status quo.

There are times when a legal system may quite admirably incorporate new information into social norms of behavior. What is less clear, however, is the capacity of a system to solve problems that go to the heart of the way economic competition is defined. While the Montreal Protocol involves a single replaceable component in the economic process (CFCs), the Kyoto Protocol, by addressing the burning of fossil fuels, involves far greater implications for society's functioning. For instance, consider the differing impact of replacing an ingredient in production (CFCs) with the lifestyle implications of reducing our dependence on fossil fuels.

The Kyoto Protocol involves such great costs compared to the relatively unremarkable replacement costs of CFCs, that bearing these costs will inevitably undermine the social fictions under which we currently live. Solving climate change requires acknowledging a global issue and, most importantly, acting fully on the knowledge that the world's divisions may be limited and are not expressly natural. If the Montreal and Kyoto Protocols pose problems of comparable form, it is the breadth and intensity of a required response that reveals the inability of systemic development.

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the causes. *Id.* "While scientists generally agree that global warming is occurring, some hotly debate the cause of global warming, as well as its potential impacts on the planet." *Id.*

90. Barrett, *supra* note 9, at 193.

G. A New Paradigm?

The measure of behavior that is implicit in the value of *S* helps illustrate the state of a paradigm. By contrasting collective action with that of collective benefit it is possible to interpret the extent to which new ideas are either taking hold or are simply ignored. The essential quality is that of an idea, an extension of knowledge which is not compatible with the existing paradigm. As the detriment to society increases by maintaining traditional assumptions, it becomes clear that those assumptions must be altered if the best interest of everyone is a desired result. The pattern of individual choice is an indication of how fundamental a solution needs to be.

If the distance between the equilibrium of strategies and the optimal outcome for all is closing over time, it follows that the new form of knowledge is being incorporated into the existing paradigm. This endogenous form of change exhibits the existence of a developing consensus and does not require a drastic solution. In this instance, law may be used to augment the impetus already present within society so as to minimize the gap between knowledge and behavior. Where ambitious endeavors are not demanded, environmental issues may be regulated as an economic accessory with such measures as tradable emissions permits.

In contrast, a dramatic break with tradition will be required in the face of impeded knowledge. Without consensus, endogenous legal change cannot occur, and the incorporation of environmental protection into the existing game remains fruitless if the players refuse to acknowledge any added dimensions. In cases such as these, the desired knowledge must precede the playing of the game itself. To illustrate the difference between endogenous change and a paradigm shift, consider the differing implications of tradable emissions permits compared with requiring each country to satisfy high levels of environmental protection before gaining access to the benefits of international trade. Rather than viewing CO_2 emissions as a regulatory footnote to competition, a paradigm shift would require that environmental protection precede the market itself.

V. DECLINE AND LOST MEANING—FOURTH POSTULATE

In circumstances where there is no authority for imposing change, logic may nonetheless indicate when a system's underlying principles have become meaningless.

A. Assumptions and Perception

A system breaks down when its underlying assumptions are premised upon patterns that cannot adapt to new information. Game theory helps illustrate the incongruence between developing perception and the rules left over from a previous way of viewing the world. A system may contain assumptions in combination that remain logically sound so long as new patterns are not perceived. The sequence 1, 2, 3, 4, 5, 6, appears to be a minimal progression if we do not know of prime numbers, which automatically differentiates 2, 3, 5, as belonging to a separate category. Once we possess the knowledge of prime numbers, a new pattern appears within the previous assumption and the sequence is not as simple as it first appears. As with prime numbers, climate change is a pattern found within a previously complete system. It is as if our sight has suddenly become three-dimensional while the world's organization remains two-dimensional.

The awareness of damage to a global commons like the atmosphere goes beyond differing levels of perspective: it can undermine an entire edifice that is built on false assumptions. Developing knowledge of the surrounding world has the dual effect of initiating new information structures while simultaneously undermining the old. In keeping with the simplistic numerical sequence mentioned above, environmental awareness has not only revealed a pattern previously unseen, but illustrates, as with the introduction of prime numbers, that operations developed upon past patterns and assumptions are inconsistent.

B. The Minimizing Game

Territorial divisions are now unable to protect against despoiling the commons because they are now part of the problem. Just as the one-dimensional level of ownership of cattle created an open imperative for individuals to impose ceaselessly upon the commons, the state is now the means for one-directional impositions upon the global environment. The state provides the impetus for individual conduct and precludes accountability for that same behavior. While assimilating the various social progressions from previous commons, the state is now the greatest manifestation of that first level of ownership without responsibility; it encourages wasteful use of resources without answer.

Considering the second theoretical figure again reveals that continuing suboptimal outcomes not only represent a lack of cognitive learning, but also reveal a game's uppermost imperatives. With new information, previously consistent objectives separate and one course of

action must be chosen at the expense of another. As mentioned before, the environment is not without economic value, for we may infer that its deemed value is below that of the chosen alternative. When *S* is an increasing value, players' best strategies are neither best for the group nor themselves; and competitive motives squeeze group concerns out of the game.

The concept of state sovereignty has evolved through time and it may need to evolve further to be able to maintain the demands of democratic representation. Even the most minimal definitions of liberal democratic government, such as Locke's famous "night-watchman" state, are premised upon the protection of the individual.[91] When the state itself is an impediment to realizing a solution to harm, serious questions of future legitimacy are triggered. The state has regressed to a one-dimensional organization like that of the herdsman on the open pasture. Without collective authority or individual restraint to protect the commons, each actor operates without accountability. When there is no balance between the freedom of autonomy and the freedom from the acts of others, the process of wealth creation is no longer promoting individual liberty.

C. The International Race

Looking to the international system it is evident that sovereignty is not an absolute quality, and that a truly autonomous state cannot exist. Some degree of sovereignty is surrendered when international agreements are reached, but the power imbalance created by the integration is a cause for concern. While international regimes such as the WTO have been remarkably successful at facilitating norms of economic participation, there has been no comparable advance toward integration in other fields. It is encouraging in that the WTO illustrates that international integration is indeed possible, but the minimal content that the regime engenders is hardly a cause for celebration. The WTO represents an essentially negative system, fostering the removal of state imposed barriers to trade while containing no normative content other than that trade is good.[92] The member state is theoretically left to develop its own unique social policies, yet this occurs less and less in a game that by its very nature can recognize no motives outside of economic

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91 For a modern expression of libertarian political philosophy, see ROBERT NOZICK, ANARCHY, STATE, AND UTOPIA (1974).

92. For a discussion on the form and tendencies of the WTO, see generally TREBILCOCK & HOWSE, *supra* note 4. For an interesting examination beyond the usual market perspective, see generally AMARTYA SEN, DEVELOPMENT AS FREEDOM (1999).

competition. Anything that may be ascribed a cost may make an individual state uncompetitive compared with another who chooses not to pay.

The project of trade liberalization has become completely ascendant. As a consequence, little room has been left for considering options that do not conform to the liberal orthodoxy of diminishing regulation. The call for efficiency has become so pervasive that it appears to have attained the status of myth, meaning none but the foolish dare interfere. The doctrine of efficiency follows the reasoning that government regulation causes inefficiency, and inefficiency is competitive suicide.[93] But if the market determines inefficiency, or at least measures it, then inefficiency is a value dependent upon the market. If no market exists then there are no competitive forces with which to quantify the value of an object. If regulation precedes, or confines, the operation of the market, then talk of inefficiency is pointless as competition would only occur after the obligation has already been imposed. Is it not conceivable that instead of a competitive system of diminishing regulation, a regulatory system exists where objectives are met before the market is entered?

John Gerard Ruggie has called the post-WWII international system one of "embedded liberalism," a systemic compromise between the needs of furthering international stability and domestic intervention in the economy to ease the effects of capitalism.[94] Embedded liberalism reflects a shared belief in the need to promote international stability through transparency and predictability, while at the same time maintaining the ability of states to pursue what Ruggie terms "legitimate social purpose."[95] While policymakers have given up on the ideal of compromise, it is possible to conceive of a system that has been built on socially determined policies instead of one that competitively strips them away.

D. Considering Change

The transition from our current regime and its dilemmas of decisionmaking to considerations of new arrangements under the game theory model I propose involves changing the information signals provided by the rules of the game. A hypothetical card game illustrates

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93. *See, e.g.*, SEN, *supra* note 92, at 111 ("Any pointer to the defects of market mechanism appears to be, in the present mood, strangely old-fashioned and contrary to contemporary culture (like playing an old 78 rpm record with music from the 1920s).").

94. Ruggie, *supra* note 37, at 209.

95. *Id.*

the potential of game theory in this regard. Imagine a general card game, similar in style to poker or rummy, which has defined rules of card value and betting money for each hand. By way of a simple analogy, the rules of play would be the law and the environment would represent the money that each competes with and for. Suppose that the problem with this game is that the pot never increases beyond three coins, or the first round of anteing up, so that the game never goes anywhere and is uninteresting.

As with environmental damage, by looking only at the pot of money it is apparent that there is a problem with the game. Where the environment is being degraded, the difficulty facing the card game is that the pot is never increasing. Looking around the room at other card games reveals that this problem is not universal, so what is it about this card game, this market mechanism? A focus on superficial results, the pot of money or environmental data alone, will not indicate the actual cause of events. An intuitive sense of the problem may indicate that the players are boring or lack the will to act differently, but a game theory analysis reveals underlying structural flaws, and the potential for moving beyond these flaws.

Modeling the best plays for each person reveals that the game is forcing the players to end quickly and never proceed through successive rounds of betting. It becomes evident that the rules of the game favor speed over card value too much. The consideration of individual strategies reveals the reasoning that follows from the rules of card play. Player *A* keeps winning the pot in the first round. She is being rewarded for laying down her hand quickly, but never has anything more than a face card. Players *B* and *C* have been repeatedly penalized for taking longer while trying to develop more complex card combinations. Players *B* and *C* must then conform to *A*'s strategy in order to be competitive, as they must play their hand as fast as possible without regard to the contents of their hand. This explains the current international environmental commons problem.

By modeling strategies under different rules it is possible to see different ways of directing play to achieve a bigger pot and a more interesting game. Changing the rules to require three rounds of betting would obviously lead to larger pots. Alternatively, the rules might be altered to place a higher priority on rewarding card valuation rather than speed. Quickly laying down a hand with little consideration as to its contents would suddenly become a detriment rather than an advantage. The competitive strategies of individuals would continue to guide the game, but the rules would lead to fuller, more interesting results.

E. Considering International Change

The current WTO system encourages states to reduce barriers to their markets, but why not invert this relationship and instead concentrate on the behavior of the actor trying to gain access to the market? Imagine a system in which every state could have prohibitive tariffs and that the membership agrees as to which social goals could objectively be used as exemptions to the tariffs. For example, cutting CO_2 emissions in half, or a significant increase in literacy would trigger a previously agreed upon reduction in the tax imposed upon that state's goods by the membership. By requiring social goals be achieved as a part of successful competition, the state retains a social role that is lost when only maximization is rewarded. The competitive strategies of individual states would continue to guide the game, but the rules would lead to fuller, more progressive results.

VI. CONCLUSION

The Kyoto Protocol does not conform to what many would think of as a law. But the fact that the Kyoto Protocol is without express authority does not necessarily mean as much as we have been led to believe. The Kyoto Protocol tells us what definitely cannot be, and it does so as unequivocally as many other traditional laws. The Kyoto Protocol is like the law of contradiction, wherein both *a* and *b* cannot simultaneously be true. A state makes a statement just as loudly by ignoring the Kyoto Protocol as by ratifying it.

In representing new information, the Kyoto Protocol is fundamentally an issue of change. Because awareness of atmospheric degradation has an impact on the world, the question becomes how organizations will respond to this change. Organizations must either adopt to meet modern realities or these organizations simply cannot be what they claim. The state must grow or decline; it is not permitted the luxury of remaining the same.

The recognition of a new commons produces a situation in which the assumptions that underlie state sovereignty are not possibly consistent. In essence, the harmony of a social division is disrupted by the revelation of contradictory information. If institutions such as the state are to retain the social legitimacy that comes from controlling the market, the state structure will have to be reconnected with a means of accountability. The Kyoto Protocol thus signals whether the direction of state movement is toward accountability or toward continued decline into mere economic agency.

Too often what has *been* is taken for granted as currently *being*. The attempt here has been to illustrate how information may allow us to logically deconstruct a system. While there is an unfortunate tendency to conceive of social fictions as social truths, using more objective tools from other fields can help demystify our legal structures. Regardless of our faith in longstanding legal fictions, scientific discoveries may reveal that our way of looking at the world is flawed. And as with scientific theories, new knowledge may prove previously seamless legal principles to be suddenly inconsistent.

The awareness of a global commons has rendered the state a sentimental hangover from a time when the world did not appear as one. Scientific awareness has made ancient problems new again, and rolled back our past solutions into a larger modern concern. The global commons will remain a dilemma of rationality so long as there is no collective response to divided responsibility. Either the state moves to redefine itself or it will be left as nothing more than a cow on the commons.