

Effectiveness of international environmental regimes: Existing knowledge, cutting-edge themes, and research strategies

Oran R. Young¹

Donald Bren School of Environmental Science and Management, University of California, Santa Barbara, CA 93106-5131

Edited by William C. Clark, Harvard University, Cambridge, MA, and approved November 2, 2011 (received for review July 28, 2011)

International environmental regimes—especially those regimes articulated in multilateral environmental agreements—have been a subject of intense interest within the scientific community over the last three decades. However, there are substantial differences of opinion regarding the effectiveness of these governance systems or the degree to which they are successful in solving the problems leading to their creation. This article provides a critical review of the literature on this topic. It extracts and summarizes what is known about the effectiveness of environmental regimes in the form of a series of general and specific propositions. It identifies promising topics for consideration in the next phase of research in this field. Additionally, it comments on the research strategies available to pursue this line of analysis. The general conclusions are that international environmental regimes can and do make a difference, although often in conjunction with a number of other factors, and that a strategy of using a number of tools combined can help to improve understanding of the determinants of success.

institution | problem solving | fit | interplay | scale

A common observation among those people concerned with solving environmental problems and more generally, promoting sustainability in human–environment relations is that governance systems work relatively well at the national level but poorly or not at all in efforts to solve international, transnational, and especially, global problems (1).^{*} Although the state is a positive force in managing natural resources and regulating pollution in domestic settings, the anarchic character of international society treated as a society of sovereign states constitutes a barrier to successful governance at the international level. However, both elements of this argument are open to question. Failures to tackle environmental problems effectively, much less to achieve sustainability in human–environment relations, are common not only in societies facing severe problems of poverty and hunger or saddled with the curse of natural resources but also in advanced industrial societies (3). Although efforts to address the grand challenges of climate change, loss of biological diversity, and degradation of ecosystem services leave a great deal to be desired, international environmental governance does not present a uniform picture of failure.

Some international environmental governance systems or as they are commonly called, international regimes are successful in the sense that they contribute to solving international problems. Arrangements widely regarded as effective in these terms include the regime created to protect the stratospheric ozone layer, the governance system applicable to Antarctica, and the multilateral arrangement established to clean up the Rhine River.[†] The lack of

efficacy or relative failure of other regimes created to deal with large-scale environmental problems is equally evident. Prominent examples include the climate regime, the arrangement created to combat desertification, and some (but not all) of the regional fisheries management regimes. Many regimes fall between these polar categories. They achieve a measure of effectiveness, although it is often hard to place them precisely along a continuum ranging from total failure to clear-cut success. Cases that fit this description include the regime dealing with pollution of the sea from ships, the regime focusing on pollution in the North Sea, the regime governing trade in endangered species, and the regime articulated in the Great Lakes Water Quality Agreement. Not surprisingly, some regimes are successful for a time but subsequently decline or even collapse (e.g., the regime for North Pacific fur seals), whereas others are slow to gain traction but become more effective with the passage of time (e.g., the transboundary air pollution regime in Europe).

How can we account for this mixed record in efforts to address problems of environmental governance in international society? Are there identifiable factors that contribute to success or cause failure? Can we formulate conclusions that will be of interest both to those people responsible for implementing the provisions of environmental regimes and those people engaged in efforts either to strengthen existing arrangements or create entirely new ones? In this article, I address these questions in four steps. The first step involves conceptual and definitional issues; it focuses on clarifying the meaning of effectiveness with regard to environmental

regimes. The second step centers on identifying and discussing the most important things that we have learned about the determinants of institutional effectiveness. Step three features an exploration of cutting-edge themes or areas ripe for increased attention on the part of researchers going forward. The fourth step turns to a discussion of the tools available for tackling these themes and recommends strategies likely to produce policy-relevant results. The article highlights findings about the determinants of effectiveness in environmental regimes that are relevant to efforts to strengthen existing regimes or create new ones. The take-home message is one of cautious optimism. There is much that we can do to add to our understanding of the effectiveness of international environmental regimes, despite the impacts of some obvious as well as some more subtle limitations on the methods available for pursuing this goal.

Author contributions: O.R.Y. designed research, performed research, and wrote the paper.

The author declares no conflict of interest.

This article is a PNAS Direct Submission.

¹E-mail: Oran.Young@gmail.com.

^{*}Some observers adopt a more radical stance, asserting that the existing approach to environmental governance, which emphasizes distinct initiatives at different levels of social organization and focuses on intergovernmental agreements at the international level, is fundamentally flawed and bound to fail (2).

[†]There are dissenters even in these cases. Some people see evidence that countries have reduced emissions of chlorofluorocarbons voluntarily and point to the fact that healing the ozone layer will take decades (4). Others emphasize the role of nonregime factors in the effort to clean up the Rhine and comment on the slow pace of negotiations in this case (5, 6).

What Do We Mean by Effectiveness?

The concept of effectiveness as applied to environmental regimes is complex and subject to a variety of formulations (7, 8). Perhaps the core concern is the extent to which regimes contribute to solving or mitigating the problems that motivate those people who create the regimes (9). However, there are other ways of thinking about effectiveness that are both less ambitious and more ambitious than this focus on problem solving. Less ambitious conceptions of effectiveness direct attention to what are known as (i) outputs or regulations and infrastructure created to move a regime from paper to practice and (ii) outcomes or changes in the behavior of actors relevant to the problem at hand (10). Success in these terms does not guarantee progress in solving the relevant problems. More ambitious conceptions seek to assess the performance of regimes relative not only to the probable course of events in their absence (i.e., the no-regime counterfactual) but also to some conception of an ideal outcome known as the collective optimum. The effectiveness of a regime (E) is then measurable as the location of actual performance (AP) on the spectrum ranging between the no-regime counterfactual (NR) and the collective optimum (CO) or (Eq. 1)

$$E = \frac{AP - NR}{CO - NR} \quad [1]$$

Normalizing this equation by setting NR equal to zero and CO equal to one produces a way to compare and contrast the effectiveness of different regimes on a common scale that is conceptually attractive but hard to operationalize (11–14).

Several other aspects of effectiveness deserve notice at the outset. A regime's participants may differ both in the importance that they attach to the problem and in the way that they frame it for consideration in policy forums. Those people who create regimes may harbor unstated goals that differ significantly from those goals spelled out in constitutive documents. The effectiveness of regimes may vary through time. Some regimes go from strength to strength with the passage of time. Others are relatively ineffective at the outset but gain strength over time or vice versa. Many of those people seeking to assess the effectiveness of regimes add other measures of success to the core concern of problem solving, including economic efficiency, various measures of fairness or equity, some criterion of sustainability or resilience, and one or more considerations embedded in the idea of good governance (8).

Evaluating the effectiveness of environmental regimes is a challenging task under the best of circumstances (7). In every case,

we want to compare the actual course of events regarding the relevant problem with what would have happened in the no-regime counterfactual. Although this comparison is easier to do with regard to some measures of effectiveness (e.g., outputs) than others (e.g., problem solving), documenting the consequences resulting from the creation and operation of a regime is always demanding. Additionally, regimes invariably operate in complex settings in which a variety of other forces are at work. Separating the signal attributable to the operation of a regime from the noise associated with a variety of other forces at work at the same time is a difficult task. I will discuss tools available to those people endeavoring to address these issues in the last section of this article on methods available to those people seeking to augment our current understanding of the effectiveness of regimes. Suffice it to say for now that some differences of opinion regarding the effectiveness of regimes are more apparent than real in the sense that they are artifacts of the definitions of effectiveness selected or the procedures used to evaluate effectiveness rather than substantive disagreements about the actual performance of specific regimes.

What Do We Know About Effectiveness?

Scientists understandably focus on cutting-edge questions that constitute the frontiers of research in their areas of interest, a practice that directs attention to issues that we do not understand or at least, do not understand well. However, in this discussion of the current state of knowledge regarding the effectiveness of environmental regimes, it is appropriate to begin with an account of what we have learned so far about this subject. I address this topic under three headings: general findings about effectiveness, findings about specific determinants of success, and findings about institutional interplay.

Three distinct bodies of evidence deserve attention in assessing this subject: qualitative case studies typically carried out by analysts trained as political scientists (15–19), quantitative case studies most often produced by analysts with a background in economics (4, 20–23), and quantitative analyses that seek to develop generalizations about effectiveness drawing on evidence from sizable universes of cases (24–26). The conclusions emerging from these bodies of evidence overlap, but they are not entirely compatible. Those people who have carried out the qualitative case studies, perhaps reflecting a positive attitude to political institutions common among political scientists, tend to find evidence of the significance of regimes in addressing environmental problems. The quantitative case studies,

arguably reflecting skeptical attitudes to governance systems common among economists, typically raise doubts about the roles that regimes play. The large *N* studies have sought to move beyond this divide, endeavoring to discriminate among cases in which regimes matter a lot or a little and seeking to identify the determinants of success and failure.

General Findings. Although it may be a source of frustration to those people hoping for simple generalizations regarding the determinants of effectiveness, differences in the findings flowing from the three bodies of evidence are understandable. In virtually every case, a regime constitutes only one of a number of distinct but interacting forces influencing the course of human–environment relations. What is notable is that there are some general findings about the effectiveness of environmental regimes arising from the research carried out so far. In this subsection, I comment on what seem to me to be the most important of these findings.

Some regimes matter in the sense that they make a (sometimes sizable) difference not only in terms of outputs and outcomes but also in terms of solving the problems that lead to their creation. It is easy to overestimate the success of environmental regimes. Quantitative case studies, rooted in a rational choice paradigm, have suggested that key actors may reduce emissions of ozone-depleting substances or airborne pollutants voluntarily, that nonregime factors may account for as much or more of the success in dealing with water pollution as the operation of the regime, and that actual outcomes fall short of the collective optimum in most cases. However, in-depth qualitative case studies, making extensive use of procedures like process tracing and thick description, have concluded that regimes have contributed to the development of social practices that have played important roles in dealing with long-range transboundary air pollution in Europe (16), the depletion of the stratospheric ozone layer (17), the control of pollution in the North Sea (18), and the management of commercial fisheries in the Barents Sea (19). In an effort to reconcile these findings, several teams of researchers have created databases containing sufficiently large numbers of cases to allow for the development of empirical generalizations about the effectiveness of environmental regimes. The work by Miles et al. (24), drawing on a dataset including 37 cases, reports that 50% of these regimes produced behavioral changes and 35% played a significant role in terms of problem solving (p. 59 in ref. 7). The work by Breitmeier et al. (25), using a dataset encompassing 172 cases,

reports that, in situations where problems improved slightly or considerably, regimes had a significant or very strong influence 52% of the time (p. 59 in ref. 7).[‡] Environmental regimes can make a difference. However, they do not always work, and they never operate in a vacuum devoid of other causal forces (26).

Anarchic character of international society is not always an obstacle to the capacity of regimes to contribute to problem solving. Many observers regard the absence of a government at the international level as a severe impediment to the establishment of effective regimes, primarily because it rules out the use of enforcement mechanisms of the sort that states use to induce their subjects to comply with systems of rules and regulations. Although this lack of government is certainly a concern in some cases, it does not loom large in situations where compliance on the part of most members of the group is unnecessary, the parties to environmental agreements have no incentive to cheat, factors other than sanctions in the ordinary sense provide subjects with good reasons to comply, or various forms of private or hybrid governance are able to exert pressure on subjects to comply (9, 27). There is no basis for complacency here when it comes to dealing with the great issues of our times, such as climate change and the loss of biological diversity. However, neither is there a basis for dismissing the capacity of regimes to contribute to solving a range of problems.

Regime design is often a more significant determinant of effectiveness than some measure of whether the problem is benign (i.e., easy to solve) or malign (i.e., hard to solve). Poorly designed regimes can produce disappointing results, even in cases where problems are straightforward and relatively easy to solve; well-designed regimes can produce positive results, even in dealing with problems that are widely regarded as malign. This problem has given rise to a stream of research on what has become known as the issue of fit (28) together with a growing interest in institutional diagnostics (29–31). Whereas the effort to conserve Atlantic tunas among generally friendly states has produced poor results, leading states were able to join forces to launch a successful regime for Antarctica during the height of the Cold War.

Sizable proportion of the success of environmental regimes is attributable to activities that are not regulatory in the ordinary sense.

There is a strong tendency to think of regimes in regulatory terms. The pro-

mulgation and implementation of prescriptive regulations setting forth prohibitions, requirements, and permissions are important functions of many regimes. However, these institutional arrangements regularly perform other functions as well (9). Regimes may perform procedural functions (e.g., setting total allowable catches in fisheries on an annual basis or establishing phase-out schedules for ozone-depleting substances), and they often oversee programmatic activities (e.g., carrying out remedial action plans aimed at alleviating the effects of pollution in lakes or marine systems). Often overlooked is the function of regimes in generating knowledge about the problems to be solved and contributing to a shared understanding of the issues at stake among participating actors (25).

Environmental regimes are dynamic in the sense that they change continually after their initial formation. After established, institutional arrangements do not remain static over time. Environmental regimes wax and wane in terms of their capacity to solve problems. Some take on roles or are brought to bear in efforts to address problems that were not on the agenda at the time of their creation. It is possible to identify a number of patterns that constitute common pathways of institutional development and that take the form of emergent properties (32). Some regimes (e.g., the ozone regime) go from strength to strength. Others (e.g., the Antarctic Treaty System) develop by fits and starts in a pattern of punctuated equilibrium. Still others (e.g., the climate regime) run into roadblocks that produce a pattern of arrested development.

Success of environmental regimes is highly sensitive to contextual factors. Context matters as a determinant of the effectiveness of regimes. An arrangement that works perfectly well in one setting may fall flat in another setting. It is always important to think about scope conditions in assessing propositions about the effectiveness of environmental regimes. Some of the most notable features of the ozone regime, for instance, are unworkable in addressing the problem of climate change. This issue explains the importance of the propositions that we must go beyond panaceas in devising regimes to address real world problems (30) and that it is essential to adopt a diagnostic approach in efforts to design regimes to solve specific problems (29–31).

Specific Findings. Beyond these general findings, regime analysis has generated a variety of more specific propositions about the effectiveness of environmental regimes. Some of these findings are negative in the sense that they disconfirm popular notions about requirements for

success. Others are positive, pointing to factors that are commonly associated with success.

Active participation on the part of a single dominant actor (commonly known as a hegemon) is not a necessary condition for success in solving international environmental problems. Dominant actors are important, especially when they value a regime's products more than the cost of supplying them, making the relevant social system what is known as a privileged group (33). However, the absence of an engaged hegemon does not spell failure in this realm. What does seem important is the existence of a coalition of influential actors prepared to take the lead in jump-starting a regime at the outset and to provide an extra push at critical junctures along the road to success (34).

Success in the implementation of international regimes is likely to require the establishment and maintenance of maximum winning coalitions rather than minimum winning coalitions. Regimes are public goods, although individual members of the group of subjects may value them differently. In the extreme, some may regard them as public bads. This issue makes it desirable to maximize the size of coalitions supporting regimes rather than form minimum winning coalitions of the sort common in domestic legislative settings (35). Given the existence of the temptation to free ride, leading actors will have an incentive to make participation attractive to others rather than minimize the number of those groups entitled to a share of the joint gains. This finding is particularly true where regimes require ongoing implementation on the part of individual members.

Maintenance of feelings of fairness and legitimacy is important to effectiveness, especially in cases where success requires active participation on the part of the members of the group over time. Neorealist perspectives suggest that both the formation and implementation of regimes are about power—perhaps including soft power as well as hard power—all of the way down (36, 37). The role of power is not only important in such settings, but it is also a topic requiring more intensive analysis on the part of those people interested in international regimes. However, this issue does not eliminate the role of considerations of fairness and legitimacy (38, 39). Given the underdeveloped character of enforcement procedures at the international level, it is hard to elicit compliance on an ongoing basis from actors that do not accept a regime's prohibitions and requirements as fair and legitimate.

Casting arrangements in the form of legally binding conventions or treaties do not ensure higher levels of compliance on the part of subjects. Many analysts assume that the normative pull associated with legally

[‡]In both studies, cases are defined in such a way that they include regime elements or components rather than discrete regimes. The climate regime, for example, encompasses three components in the study by Breitmeier et al. (25).

binding arrangements will have a positive effect on compliance. However, the available evidence does not support this proposition (25). Although hard law arrangements may be desirable for other reasons, there is often a price to be paid for pursuing such arrangements in terms of the depth of the substantive provisions adopted.

Arrangements featuring private governance and hybrid systems encompassing both public and private elements can solve some types of environmental problems. It is easy to exaggerate growth in the role of nonstate actors (e.g., multinational corporations and environmental nongovernmental organizations) at the international level as well as the emergence of global civil society (40). However, although nation states remain core actors, other actors are gaining ground. This finding opens up opportunities to solve problems through the development of hybrid systems (e.g., the system for classifying ships) and even private regimes (e.g., the Forest Stewardship Council) rather than limiting the roles of nonstate actors to efforts to influence the operations of intergovernmental regimes (41).

Multiple pathways can lead to success in efforts to solve many environmental problems. It is generally a mistake to assume that there is one true path that must be identified and followed in efforts to solve specific environmental problems. Alternative solutions may vary in terms of other considerations, such as fairness or various notions of good governance. However, what systems theorists call equifinality is a common phenomenon in the realm of environmental governance. This proposition applies with particular force to the selection of policy instruments (e.g., incentive systems vs. command and control regulations).

Findings About Institutional Interplay. Environmental regimes often interact with both one another and regimes operating in other areas like trade and finance. The growth of interest in what is now known as institutional interplay is a recent development fueled by the observation that the number of distinct regimes operative in international society has grown rapidly in recent decades (42, 43). A simple point of departure in thinking about interplay, pioneered by the long-term project on the Institutional Dimensions of Global Environmental Change, features two primary distinctions: one between horizontal and vertical interactions and the other between functional (or unintended) and political interactions (44). Because much of the responsibility for implementing the provisions of international regimes falls to their individual members, it is essential in thinking about effectiveness to consider vertical interplay (often known as multi-

level governance) as well as interactions among distinct institutional arrangements operative at the international level (45). Similarly, there is an important distinction between interplay that is largely unintended and often unforeseen and interplay involving intentional moves on the part of actors desiring to either manage interplay to promote problem solving or exploit interplay to advance their individual interests (29). Others have moved on from this point of departure. Particularly important in this regard are Stokke's (19, 46, 47) accounts of the mechanisms of cognition, obligation, and utility maximization as determinants of the effects of interplay on problem solving and Rautiala and Victor's (48) concept of institutional complexes as loosely coupled sets of arrangements operating in a single issue area. Although the study of institutional interplay is a central concern at the domestic level, it constitutes a relatively new area of research at the international level. Nevertheless, some findings are already emerging from analyses of such matters (49, 50).

Institutional interplay is just as likely to produce positive or even synergistic results as it is to lead to interference between or among regimes. This stream of analysis arose from a concern that tensions or even open conflict between or among distinct regimes would become an increasingly prominent feature of the institutional landscape in international society (42). The logic underlying this concern is simple. As the number and variety of regimes operating in a given social space grow, the overlap between and among them will increase. Because this overlap is typically unintended and often unforeseen in nature, it seems reasonable to expect that tensions will ensue (51). However, the research done so far on institutional interplay fails to confirm this expectation. Interactions may generate tensions. However, institutional interplay often produces positive results and may even prove synergistic, like in the case of the regulation of substances under the ozone regime that are also greenhouse gases (49, 52).

There is generally scope for resolving actual or potential conflicts between regimes through negotiations leading to mutual accommodation rather than by subordinating one regime to the other. For the most part, resolving such conflicts is not a matter of applying legal doctrines involving criteria like specificity and temporal sequencing to determine which regime should take precedence in the event of conflict between distinct arrangements. Rather, it is a matter of negotiating workable compromises that allow the regimes in question to operate effectively without undue interference in each other's domains (50). The most striking examples involve interplay be-

tween the global trade regime and a variety of multilateral environmental agreements involving the use of trade restrictions as a policy instrument (e.g., the regimes dealing with endangered species, hazardous wastes, protection of the stratospheric ozone layer, and climate) (53, 54). The central challenge is to work out a modus vivendi allowing individual regimes to make progress toward solving the problems motivating their creation.

Regime complexes offer a way forward in situations that do not lend themselves to the creation of a single integrated governance system. Many issue areas (e.g., climate, biodiversity, and marine pollution) feature networks of distinct regimes or "loosely coupled set [s] of specific regimes" (p. 7 in ref. 55) that grow up over time in the absence of an overall blueprint. Such complexes may range along a continuum from comprehensive and integrated governance systems for entire issue areas to total fragmentation (55). Regime complexes offer the advantage of being more flexible across issues and adaptable over time than more tightly coupled governance systems. They may be easier to create than fully integrated systems and more resilient to the sorts of stresses occurring at the international or global level today. Regime complexes are likely to be common in many areas during the foreseeable future.

What Are the Cutting-Edge Issues in This Realm?

Taken together, these findings derived from hundreds of individual studies have significant implications for policy. It is worth bearing in mind, for instance, that not all regimes are regulatory in character, that legally binding arrangements are not always preferable to softer arrangements, that institutional interaction sometimes produces synergistic results, and that regime complexes may prove more successful than fully integrated regimes. Above all, it is critical to understand the problem of fit and as a result, discard hopes for panaceas and sharpen the skills needed to engage in institutional diagnostics.

At the same time, there is much more that we can learn about the effectiveness of environmental regimes that will be of interest to policymakers. This section identifies a series of topics that constitute cutting-edge concerns in this field (56, 57). There is no need to forge a consensus regarding the precise content of the research agenda. However, it is helpful to get a sense of where we are headed regarding research on the effectiveness of environmental regimes.

Deep Structure. Environmental regimes are specialized arrangements embedded in and reflecting the deep structure of

international society (7). To be effective, such arrangements must be generally compatible with the essential features of the prevailing deep structure (58). There is little point, for instance, in creating a regime complex for climate that requires the imposition of fundamental restrictions on the sovereignty of member states or the creation of enforcement mechanisms that rely on severe sanctions to elicit compliance with the regime's rules. However, it is easy to carry this line of thinking too far. The deep structure of international society is not static (59). The familiar power structure of the postwar era is shifting dramatically. We need to recognize the growing importance of nonstate actors and the emergence of global civil society and think about the implications of these developments for perspectives built on the assumption that environmental governance is largely a matter of intergovernmental relations (60–62). As long as the normative gap is not too great, the development of innovative regimes can play a role in driving the evolution of the deep structure of international society. What we need to know in this realm is more about the constraints and opportunities associated with deep structure as they pertain to the operation of governance systems for specific problems like climate change and the protection of biodiversity.

Problem Structure. It is intuitively appealing to adopt the view that some environmental problems are harder to solve than others or to use the terminology in the work by Miles et al. (24), that we can locate specific problems on a benign–malign spectrum. Climate change is a more challenging problem than the depletion of the stratospheric ozone layer. However, what exactly are the factors that make environmental problems harder or easier to solve, and can we devise a metric for assessing problems in these terms (9)? Underdal (63) argues that environmental problems are hard to solve to the extent that they (*i*) are “long-term policy problems with time lags between policy measures . . . and effects,” (*ii*) “are embedded in very complex systems” clouded by uncertainties, and (*iii*) “involve global collective goods” not subject to single best effort solutions (63). These factors do pose important challenges for those people seeking to solve environmental problems. They go some way, for example, to explaining why it is so hard to come to grips with the problem of climate change. However, there is considerable evidence to suggest that solutions to seemingly easy or benign problems can prove elusive and that groups sometimes succeed in banding together to make a serious effort to tackle seemingly hard or malign problems. What

we need to know here is whether we are doomed to suffer the consequences of hard problems like climate change or whether we can come up with innovative strategies to address such problems given the emergence of effective leadership and the will to collaborate on the part of key actors.

Power. The role of power as a determinant of regime effectiveness is complex and contested, especially if we construe power to encompass soft as well as hard power, cognitive as well as structural power, and issue-specific as well as general power (64). Critics of regime analysis have sometimes dismissed institutions as epiphenomena that reflect underlying distributions of power and that change as these distributions shift (36). Those people studying regimes sometimes seem to ignore or at least, marginalize the role of power as a determinant of the capacity of these arrangements to solve problems. How can we come to terms with these diverging perspectives on the role of power? Regimes are embedded in overarching political orders, and they reflect the general principles of political discourses dominant at the time of their creation. However, this finding does not mean that they are of no significance in their own right, especially when treated as intervening forces that form links between the underlying drivers of human behavior and the outcomes flowing from human–environment interactions (65, 66). What we need to know here is how to think about the role of power as a driving force in world affairs that does not blind us to the significance of other forces.

Participation Vs. Depth. Because participation in international environmental regimes is voluntary, there is a tendency to settle for arrangements that are shallow in terms of substance to make them palatable to all relevant actors. This concern is what Underdal (67) and others have described as the law of the least ambitious program. The logic of those people who advocate going forward even when commitments are shallow is that it is important to get the ball rolling and that institutional evolution will lead to a deepening of commitments over time. This argument is intuitively appealing, and examples like the regime for the protection of stratospheric ozone and to a lesser extent, the regime dealing with long-range transboundary air pollution in Europe suggest that such a dynamic occurs under some conditions. However, there is no reason to assume that such an evolutionary process will occur in all cases (68). The contrast between the regime for stratospheric ozone and the climate regime is striking in these terms. Not only has the stratospheric

ozone regime proved effective in reducing drastically the production and consumption of ozone-depleting substances, it has also proven more effective in reducing emissions of greenhouse gases than the climate regime itself (69). What we need to know in this case centers on scope conditions. Under what conditions is it realistic to expect institutional evolution to work as a mechanism for deepening commitments in a manner required to ensure success in efforts to solve problems?

Compliance. We already know a lot about the sources of compliance (70–72). Because many observers regard compliance as the Achilles heel of international governance, however, this subject remains on the list of research priorities. The absence of a government in the ordinary sense in international society makes it hard to use sanctions—graduated or otherwise—effectively as a means of persuading or compelling those people subject to a regime's rules to comply with their obligations. However, is this flaw fatal (9)? In single best effort situations where one or a few actors can solve the problem, compliance is not a critical issue (27). Compliance is not a concern with regard to regimes that are not fundamentally regulatory in character. Even in regulatory settings, a management approach is sometimes more effective than an enforcement approach as a means of maximizing compliant behavior on the part of a regime's subjects (73). Other factors, such as the extent to which subjects have engaged actively in the process of regime creation and the extent to which they feel that a regime constitutes a fair deal, can make a big difference in inducing actors to comply with a regime's rules and regulatory measures. What we need to know here is more about the sources of compliance (74). Because the emphasis must be on governance without government for the foreseeable future, we have a particular need to deepen our understanding of mechanisms that can produce compliant behavior in the absence of the sorts of sanctions that we generally associate with the idea of enforcement (75).

Fairness and Legitimacy. Despite the finding reported in the preceding section, there is substantial variation in the views that analysts have expressed regarding the roles of fairness and legitimacy as determinants of the effectiveness of international regimes. Those people who follow the logic of consequences (76) and frame issues in collective action terms have a tendency to dismiss or downplay the role of fairness, equity, and other normative concerns in thinking about the success or failure of environmental regimes (77). Those people

who think in terms of the logic of appropriateness (76) and approach issues in social practice terms, by contrast, are more receptive to the idea that such considerations are important determinants of effectiveness (38, 78). This divergence is not peculiar to the analysis of governance systems or regimes. It mirrors a larger and ongoing debate about the role of normative considerations as driving forces in global society. We do not need to resolve this overarching debate in analyzing the effectiveness of international environmental regimes. However, we do need an understanding of the conditions under which fairness and legitimacy are significant forces in this realm. This knowledge will have important implications for those people designing regimes to address specific environmental problems, such as climate change or loss of biological diversity.

Policy Instruments. The ideas of those people who espouse incentive mechanisms, such as tradable catch shares or carbon taxes, in contrast to the more traditional mechanisms that we generally lump under the heading of command and control regulations have dominated the discussion of policy instruments for several decades (79). Clearly, the emphasis on such mechanisms has been salutary. Incentive mechanisms can alleviate the dynamic giving rise to the tragedy of the commons; they also can give subjects reason to focus on innovation on an ongoing basis. However, it would be unfortunate if this issue were to lead to a situation in which one set of tools dominates our thinking about governance to the exclusion of others. There are important cases (e.g., climate change) in which it is difficult to make calculations regarding both the costs of leaving the problem unattended and the costs of taking effective action to alleviate the problem. There are also cases in which we have good reasons to override the use of discount rates of the sort commonly considered in conjunction with incentive mechanisms. It may make good sense in such cases to use command and control measures in place of or as a supplement to incentive mechanisms. Maintaining a well-stocked toolkit is clearly a good idea (80). What we need to know in this regard is more about the conditions under which specific policy instruments are likely to prove effective and how to make use of diagnostic procedures to bring this knowledge to bear on specific cases (31).

Interplay Management. Institutional interplay is on the rise. Whatever the attractions of creating comprehensive and integrated governance systems to address problems like climate change and loss of biological

diversity, we must prepare for a world that features rising levels of interplay between and among distinct regimes. As Keohane and Victor (55) observe, regime complexes or loosely coupled sets of specific regimes dealing with broad and complex issues like climate change may well prove advantageous in terms of flexibility across issues and adaptability over time (47). The implication of this proposition is that we must shift our attention from intensive studies of individual regimes to more expansive accounts of institutional interactions and especially, regime complexes. Long familiar in domestic systems, this perspective is relatively new at the level of international society. What we need to know here is more about the conditions leading to synergy rather than interference in institutional interactions and the conditions under which regime complexes produce flexibility and adaptability rather than chaos and confusion (50).

Nonlinearity. As we move deeper into a world of human-dominated ecosystems, the need to improve our understanding of thresholds and tipping points triggering nonlinear changes has become urgent (81, 82). Nonlinear changes are often abrupt, irreversible, and nasty from the perspective of human welfare. This finding makes it important not only to devise procedures to provide early warning regarding the onset of such changes but also, to create governance systems able to adjust nimbly to the impacts of these changes. The trick is to create governance systems that have the staying power to be effective combined with the adaptability to adjust quickly to changing circumstances. A regime that changes too readily and therefore, lacks resilience cannot be effective. However, a regime that is too rigid in the sense that it is unresponsive to major changes in the socioecological environment will be vulnerable to forces leading to institutional collapse in a world in which nonlinear changes are common. What we need is a major step forward in our understanding of how to structure governance systems to maximize resilience, while at the same time, including procedures allowing for timely adjustments of the sort needed to maintain a good fit between socioecological conditions and institutional arrangements (83, 84).

Scale. Scale in this context is a matter of the generalizability of findings regarding the effectiveness of governance systems across levels of social organization (23). To what extent do findings about issues like avoiding the tragedy of the commons derived from analyses of small-scale or local cases apply to comparable issues at the international level and vice versa (85–87)? There are clear parallels between small-

scale systems and large-scale or global systems with regard to the need to produce governance without government (88). However, there are also differences between these settings. Although many analysts use the term international community in discussing global issues, for example, there are major differences between local and global systems with regard to what is meant by the idea of community. What we need to know here is more about the limits of generalizability across levels of social organization regarding factors that determine the effectiveness of governance systems.

What Are the Most Promising Research Strategies?

What tools are available to those people desiring to tackle these themes? How can we use these tools to greatest effect to deepen our understanding of the determinants of regime effectiveness and generate conclusions that will prove helpful to those people responsible for designing and administering these arrangements? The proper response to this question is to think in terms of a methodological portfolio or toolkit containing a range of distinct but complementary modes of analysis and urge those people seeking to understand the effectiveness of regimes to use multiple methods whenever possible (41, 43, 89). Taking this proposition as a point of departure, several specific observations about strategies for analyzing the effectiveness of environmental regimes come into focus.

As in other fields of study, finding ways to combine quantitative and qualitative methods is a priority in studies of effectiveness. Quantitative procedures produce measures of association but are limited in terms of their capacity to reveal the causal mechanisms underlying the relationships identified. Theoretical case studies, by contrast, can probe the causal forces at work in specific situations but do not produce results that are easy to generalize (10). The mainstream of research on environmental regimes consists of studies that provide in-depth analyses of individual regimes or a handful of regimes examined from a common perspective. There is every reason to continue to nurture this flow of research (90). A priority is to build up the stock of large *N* quantitative studies to facilitate triangulation in efforts to enhance our understanding of the determinants of effectiveness (91). Research of this type has already yielded insights regarding the importance of knowledge production as a source of regime effectiveness, the role of pushers vs. laggards in making regimes effective, and the occurrence of synergy in contrast to interference in situations involving institutional interplay (26, 49). Small

universes of cases impose limits on what is possible in this realm. However, they do not rule out progress in applying quantitative methods to develop empirical generalizations about effectiveness (92).

Another priority is to devise methods that can shed light on the role of complex causality as a determinant of effectiveness. Complex causality occurs when clusters of causal forces interact with one another in ways that make it difficult to pull them apart through the use of normal statistical procedures (66, 89). What is needed to illuminate situations of this kind are methods that direct attention to (i) conjunctural causation (e.g., Ragin's qualitative comparative analysis) (93, 94), (ii) emergent properties of complex systems (e.g., simulations using agent-based modeling) (92), and (iii) recurrent relationships that become apparent in examining large numbers of comparable case studies (e.g., metaanalysis) (95). Whereas reductionist methods are especially useful in separating out the effects of individual variables and assigning weights to them as distinct factors in accounting for outcomes of interest, methods focusing on causal clusters concentrate on identifying combinations of interacting forces that together constitute necessary or more often, sufficient conditions to produce results like the success of environmental regimes in solving problems (89). We need to pursue both pathways in examining the sources of effectiveness.

Another method that has proven helpful in studies of regime effectiveness is formal modeling. Modeling of this sort is based on a strategy of abstracting away many factors to highlight the core logic of social relationships in contrast to developing directly testable hypotheses. A particularly productive effort of this sort focuses on understanding dilemmas of collective action, like the tragedy of the commons and free ridership in the supply of public

goods, as outcomes of interdependent decision making in which participants select strategies that seem rational in individualistic terms but that lead to socially undesirable outcomes (27, 34). The facts that the dynamic of the tragedy of the commons can be represented in terms of the game theoretic construct known as prisoner's dilemma and that the choice generally labeled defect constitutes a dominant strategy for each participant do not allow us to predict that actors relying on common property arrangements to manage the use of common pool resources are bound to come to grief. Taking this concern as a point of departure, analyses of real world cases make it clear that the tragedy does not always occur (96). However, using the prisoner's dilemma to model such interactions has sharpened our understanding of the issues involved. Similar remarks are in order regarding the role of privileged groups, coalitions of pushers, and burden-sharing arrangements in situations involving the supply of things like clean air, which can be construed as public goods (33, 34).

Research carried out by individual scholars will always play an important role in this field. However, research teams and networks are becoming more important as we endeavor to use this toolkit to increase understanding of the effectiveness of international environmental regimes. The works of Miles et al. (24) and Breitmeier et al. (25) resulted from the efforts of integrated teams. More recently, researchers have focused on the development of larger and looser networks of individuals working independently but adhering to a common science plan. The project on the Institutional Dimensions of Global Environment Change (1998–2007) (56) and the Earth System Governance project (2009–) (57), both core projects of the International Human Dimensions Program on Global

Environmental Change, exemplify this strategy.

Moving to Pasteur's Quadrant

Research on the determinants of effectiveness in international environmental regimes constitutes a young field. However, it has already generated results of interest both to practitioners charged with administering regimes dealing with specific problems and analysts seeking to understand the nature of governance, particularly in social settings where there is no government in the ordinary sense of the term. My own experience has convinced me that many rewards flow from a strategy of working back and forth between the worlds of analysis and praxis. It would be naïve to suppose that this line of research can reveal simple solutions to the great issues of our times, like controlling climate change and preventing loss of biological diversity. However, it would be equally inappropriate to dismiss the role of environmental regimes, because they do not provide us with simple solutions to such overarching concerns. The way forward in efforts to enhance our understanding of the determinants of effectiveness is to make use of a suite of complementary modes of analysis. When the results converge, our confidence in the relevant findings rises. When they diverge, we are presented with puzzles of the sort on which science thrives. With persistence and a certain amount of good fortune, we will succeed in producing results that are of interest to analysts and practitioners alike and as a result, that land us squarely in the domain of Pasteur's Quadrant (97, 98).

ACKNOWLEDGMENTS. I thank Bill Clark, Ron Mitchell, Matthew Stilwell, Arild Underdal, Durwood Zaelke, and three anonymous reviewers for helpful comments on earlier drafts of this paper.

1. Speth JG (2004) *Red Sky at Morning: America and the Crisis of Global Government* (Oxford University Press, New York).
2. Park J, Conca K, Finger M (2008) *The Crisis of Global Environmental Politics: Towards a New Political Economy of Sustainability* (Routledge, London).
3. Collier P (2008) *The Bottom Billion: Why the Poorest Countries Are Failing and What Can Be Done About It* (Oxford University Press, Oxford).
4. Murdoch JC, Sandler T (1997) The voluntary provision of a public good: The case of reduced CFC emissions and the Montreal Protocol. *J Public Econ* 63:331–349.
5. Bernauer T (1996) *Protecting the Rhine River Against Chloride Pollution in Institutions for Environmental Aid*, eds Keohane RO, Levy ML (MIT Press, Cambridge, MA), pp 201–232.
6. Bernauer T, Moser P (1996) Reducing pollution of the River Rhine: The influence of international cooperation. *J Environ Develop* 5:389–415.
7. Underdal A (2008) *Determining the Causal Significance of Institutions: Accomplishments and Challenges in Institutions and Environmental Change*, eds Young OR, King L, Schroeder H (MIT Press, Cambridge, MA), pp 49–78.
8. Mitchell R (2008) Evaluating the performance of environmental institutions: What to evaluate and how to evaluate it? *Institutions and Environmental Change*, eds Young OR, King L, Schroeder H (MIT Press, Cambridge, MA), pp 79–114.
9. Young OR (1999) *Governance in World Affairs* (Cornell University Press, Ithaca, NY).
10. Young OR, ed (1999) *The Effectiveness of International Environmental Regimes: Causal Connections and Behavioral Mechanisms* (MIT Press, Cambridge, MA).
11. Helm C, Sprinz D (2000) Measuring the effectiveness of international environmental regimes. *J Conflict Resolut* 44:630–652.
12. Hovi J, Sprinz D, Underdal A (2003) The Oslo-Potsdam solution to measuring regime effectiveness: Critique, response, and the road ahead. *Glob Environ Politics* 3:74–96.
13. Young OR (2003) Determining regime effectiveness: A comment on the Oslo-Potsdam solution. *Glob Environ Politics* 3:97–104.
14. Hovi J, Sprinz D, Underdal A (2003) Regime effectiveness and the Oslo-Potsdam solution: A rejoinder to Oran Young. *Glob Environ Politics* 3:105–107.
15. Haas PM, Keohane RO, Levy ML, eds (1993) *Institutions for the Earth: Sources of Effective International Environmental Protection* (MIT Press, Cambridge, MA).
16. Wettstead J (2002) *Clearing the Air—European Advances in Tackling Acid Rain and Atmospheric Pollution* (Ashgate, Aldershot, United Kingdom).
17. Parson EA (2003) *Protecting the Ozone Layer: Science and Strategy* (Oxford University Press, New York).
18. Skjaerseth JB (2000) *North Sea Cooperation: Linking International and Domestic Pollution Control* (Manchester University Press, Manchester, UK).
19. Stokke OS *Regime Effectiveness in International Governance* (MIT Press, Cambridge, MA) in press.
20. Murdoch JS, Sandler T, Sargent K (1997) A tale of two collectives: Sulphur versus nitrogen oxide emissions reduction in Europe. *Economica* 64:281–301.
21. Finus M, Tjøtta S (2003) The Oslo protocol on sulfur reduction: The great leap forward? *J Public Econ* 87: 2031–2048.
22. Ringquist EJ, Kostadinova T (2005) Assessing the effectiveness of international environmental agreements: The case of the 1985 Helsinki Protocol. *Am J Pol Sci* 49:86–102.

23. Bernauer T, Siegfried T (2008) Compliance and performance in international water agreements: The case of the Naryn/Syr Darya Basin. *Glob Governance* 14:479–501.

24. Miles E, et al. (2002) *International Regime Effectiveness: Confronting Theory with Evidence* (MIT Press, Cambridge, MA).

25. Breitmeier H, Young OR, Zürn M (2006) *Analyzing International Regimes: From Case Study to Database* (MIT Press, Cambridge, MA).

26. Breimeier H, Underdal A, Young OR The effectiveness of international environmental regimes. Comparing and contrasting findings from quantitative research. *Int Stud Rev* 13:1–27.

27. Barrett S (2007) *Why Cooperate? The Incentive to Supply Collective Goods* (Oxford University Press, Oxford).

28. Galaz V, et al. (2008) *The Problem of Fit Among Biophysical Systems, Environmental and Resource Regimes, and Broader Governance Systems: Insights and Emerging Challenges in Institutions and Environmental Change*, eds Young OR, King L, Schroeder H (MIT Press, Cambridge, MA), pp 147–186.

29. Young OR (2002) *The Institutional Dimensions of Environmental Change: Fit, Interplay, and Scale* (MIT Press, Cambridge, MA).

30. Ostrom E (2007) A diagnostic approach for going beyond panaceas. *Proc Natl Acad Sci USA* 104: 15181–15187.

31. Young OR (2008) Building regimes for socioecological systems in institutions and environmental change: Institutional diagnostics. *Institutions and Environmental Change*, eds Young OR, King L, Schroeder H (MIT Press, Cambridge, MA), pp 115–144.

32. Young OR (2010) *Institutional Dynamics: Emergent Patterns in International Environmental Governance* (MIT Press, Cambridge, MA).

33. Olson M (1965) *The Logic of Collective Action* (Harvard University Press, Cambridge, MA).

34. Schelling TC (1978) *Micromotives and Macrobbehavior* (WW Norton, New York).

35. Riker W (1962) *The Theory of Political Coalitions* (Yale University Press, New Haven, CT).

36. Strange S (1982) Cave! hic dragones: A critique of regime analysis. *Int Organ* 36:479–497.

37. Mearsheimer JJ (1994) The false promise of international institutions. *Int Secur* 19:5–49.

38. Franck TM (1990) *The Power of Legitimacy Among Nations* (Oxford University Press, New York).

39. Coicaud JM, Warner D, eds (2001) *Ethics and International Affairs: Extent and Limits* (UNU Press, Tokyo).

40. Kaldor M (2003) *Global Civil Society: An Answer to War* (Polity Press, Cambridge, United Kingdom).

41. Delmas M, Young OR, eds (2009) *Governance for the Environment: New Perspectives* (Cambridge University Press, Cambridge, UK).

42. Brown Weiss E (1993) International environmental issues and the emergence of a new world order. *Georgetown Law J* 81:675–710.

43. Underdal A, Young OR, eds (2004) *Regime Consequences: Methodological Challenges and Research Strategies* (Kluwer, Dordrecht, The Netherlands).

44. Young OR, et al. (1999) *Institutional Dimensions of Global Environmental Change IHDP Reports No 9* (IHDP, Bonn).

45. Enderlein H, Wälti S, Zürn M, eds (2010) *Handbook on Multi-Level Governance* (Edward Elgar, Cheltenham, UK).

46. Stokke OS (2001) *The Interplay of International Regimes: Putting Effectiveness Theory to Work, Report No 14* (Nansen Institute, Lysaker, Norway).

47. Stokke OS (2011) *Interplay Management: Niche Selection, and Arctic Environmental Governance in Institutional Interaction and Global Environmental Change*, eds Oberthür S, Stokke OS (MIT Press, Cambridge, MA), pp 143–170.

48. Raustiala K, Victor DG (2004) The regime complex for plant genetic resources. *Int Organ* 55:277–309.

49. Oberthür S, Gehring T, eds (2006) *Institutional Interaction in Global Environmental Governance: Synergy and Conflict Among International and EU Policies* (MIT Press, Cambridge, MA).

50. Oberthür S, Stokke OS, eds (2011) *Institutional Interaction and Global Environmental Change* (MIT Press, Cambridge, MA).

51. Lovejoy T, Hannah L, eds (2005) *Climate Change and Biodiversity* (Yale University Press, New Haven, CT).

52. Oberthür S (2009) Interplay management: Enhancing environmental policy integration among international institutions. *Int Environ Agreement Polit Law Econ* 9: 371–391.

53. Jinnah S (2010) Overlap management in the World Trade Organization: Secretariat influence on trade-environment politics. *Glob Environ Polit* 10:54–79.

54. Faude B, Gehring T Institutional ecology and the evolution of broader structures in regime complexes: The trade and environment overlap. *Glob Governance*, in press.

55. Keohane RO, Victor DG (2011) The regime complex for climate change. *Perspect Politics* 9:7–23.

56. Young OR, King L, Schroeder H, eds (2008) *Institutions and Environmental Change: Principal Findings, Applications, and Research Frontiers* (MIT Press, Cambridge, MA).

57. Biermann F, et al. (2009) *Earth System Governance: People, Places, and the Planet, IHDP Report No. 20* (IHDP, Bonn).

58. Conca K (2006) *Governing Water: Contentious Transnational Politics and Global Institution Building* (MIT Press, Cambridge, MA).

59. Buzan B (2004) *From International to World Society* (Cambridge University Press, Cambridge, UK).

60. Wapner P (1997) *Governance in Global Civil Society in Global Governance*, ed Young OR (MIT Press, Cambridge, MA), pp 65–84.

61. Betsill M, Corell C, eds (2007) *NGO Diplomacy: The Influence of Nongovernmental Organizations in International Environmental Negotiations* (MIT Press, Cambridge, MA).

62. Biermann F, Pattberg P, eds, *Global Environmental Governance Reconsidered* (MIT Press, Cambridge, MA), in press.

63. Underdal A (2010) Complexity and challenges of long-term environmental governance. *Global Environ Change* 20:386–393.

64. Nye JS (2011) *The Future of Power* (Public Affairs, New York).

65. Krasner SD (1983) *Structural Causes and Regime Consequences: Regimes as Intervening Variables in International Regimes*, ed Krasner SD (Cornell University Press, Ithaca, NY), pp 1–21.

66. Young OR (2002) *Are Institutions Intervening Variables or Basic Causal Forces? Causal Clusters vs. Causal Chains in International Society in Millennium Reflections on International Studies*, eds Brecher M, Harvey F (University of Michigan Press, Ann Arbor, MI), pp 176–191.

67. Underdal A (2002) *One Question: Two Answers in International Regime Effectiveness*, eds Miles EL, et al. (MIT Press, Cambridge, MA), pp 3–45.

68. Barrett S (2003) *Environment and Statecraft: The Strategy of Environmental Treaty Making* (Oxford University Press, New York).

69. Velders GJ, Anderson SO, Daniel JS, Fahey DW, McFarland M (2007) The importance of the Montreal Protocol in protecting climate. *Proc Natl Acad Sci USA* 104:4814–4819.

70. Young OR (1979) *Compliance and Public Authority: A Theory with International Applications* (Johns Hopkins University Press, Baltimore).

71. Mitchell RB (1994) *International Oil Pollution at Sea: Environmental Policy and Treaty Compliance* (MIT Press, Cambridge, MA).

72. Raustiala K, Slaughter A-M (2002) *International Law, International Relations and Compliance in Handbook of International Relations*, eds Carlsnaes W, Risse T, Simmons BA (Sage, London), pp 538–558.

73. Chayes A, Chayes A (1995) *The New Sovereignty: Compliance with International Regulatory Agreements* (Harvard University Press, Cambridge, MA).

74. Victor DG, Raustiala K, Skolnikoff EB, eds (1998) *The Implementation and Effectiveness of International Environmental Commitments* (MIT Press, Cambridge, MA).

75. Skjaerseth JB, Stokke OS, Wettstad J (2006) Soft law, hard law, and effective implementation of international environmental norms. *Glob Environ Politics* 6:104–120.

76. March JG, Olsen JP (1998) The institutional dynamics of international political orders. *Int Organ* 52:943–969.

77. Victor DG (2011) *Global Warming Gridlock: Creating More Effective Strategies for Protecting the Planet* (Cambridge University Press, Cambridge, UK).

78. Franck TM (1995) *Fairness in International Law and Institutions* (Oxford University Press, New York).

79. Cole DH (2002) *Pollution and Property: Comparing Ownership Institutions for Environmental Protection* (Cambridge University Press, Cambridge, UK).

80. Zaelke Z, et al., ed (2005) *Making Law Work: Environmental Compliance and Sustainable Development* (Cameron May, London).

81. Lenton TM, et al. (2008) Tipping elements in the Earth's climate system. *Proc Natl Acad Sci USA* 105: 1786–1793.

82. Carpenter SR, et al. (2009) Science for managing ecosystem services: Beyond the Millennium Ecosystem Assessment. *Proc Natl Acad Sci USA* 106:1305–1312.

83. Galaz V, Duit A, Eckberg K, Ebbesson J (2010) Governance, complexity, and resilience. *Glob Environ Change* 20:363–546.

84. Young OR *Navigating the Sustainability Transition in Global Environmental Commons*, eds Brousseau E, Dedeuwadre T, Jouvet PA, Willinger M (Oxford University Press, Oxford), in press.

85. Keohane RO, Ostrom E, eds (1995) *Local Commons and Global Interdependence* (Sage, London).

86. Dietz T, Ostrom E, Stern PC (2003) The struggle to govern the commons. *Science* 302:1907–1912.

87. Cash DW, et al. (2006) Scale and cross-scale dynamics. Governance and information in a multilevel world. *Ecol Soc* 11(2): article 8.

88. Young OR (2005) *Why Is There No Unified Theory of Environmental Governance? Handbook of Global Environmental Politics*, ed Dauvergne P (Edward Elgar, Cheltenham, UK), pp 170–184.

89. Young OR, et al. (2006) A portfolio approach to analyzing complex human-environment interactions. *Institutions Land Use Ecol Soc* 11(2): article 31.

90. Andresen S, Wettstad J (2004) *Case Studies of the Effectiveness of International Environmental Regimes in Regime Consequences*, eds Underdal A, Young OR (Kluwer, Dordrecht, The Netherlands), pp 27–48.

91. Mitchell RB (2004) *A Quantitative Approach to Evaluating International Environmental Regimes in Regime Consequences*, eds Underdal A, Young OR (Kluwer, Dordrecht, The Netherlands), pp 121–149.

92. Poteete AR, Janssen MA, Ostrom E (2010) *Working Together: Collective Action, the Commons, and Multiple Methods in Practice* (Princeton University Press, Princeton).

93. Ragin CC (2000) *Fuzzy-Set Social Science* (University of Chicago Press, Chicago).

94. Stokke OS (2004) *Boolean Analysis, Mechanisms, and the Study of Regime Effectiveness in Regime Consequences*, eds Underdal A, Young OR (Kluwer, Dordrecht, The Netherlands), pp 87–120.

95. Rudel TK (2005) *Tropical Forests: Regional Paths of Destruction and Regeneration in the Late 20th Century* (WW Norton, New York).

96. Ostrom E, et al., ed (2002) *The Drama of the Commons* (National Academy Press, Washington, DC).

97. Stokes D (1997) *Pasteur's Quadrant: Basic Science and Technological Innovations* (Brookings Institution, Washington, DC).

98. Clark WVC (2007) Sustainability science: A room of its own. *Proc Natl Acad Sci USA* 104:1737–1738.