Efforts to arrest biodiversity depletion are hampered by a number of factors beyond low public salience. These include uncertainty as to how to measure "biodiversity" and its loss, and as to the costs and benefits of various responses. Moreover, an ideal response requires widespread multilateral cooperation, which, in the light of diverging national priorities, is difficult to achieve. This paper therefore presents a menu of possible reforms in the relevant legal-institutional framework that could be deployed to temper the rate of biodiversity decline. The strategic variables include, among others, subsidy practices, real property protection, intellectual property laws, trade laws, host nation ownership rights, land use restrictions, and taxes.

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I

BIODIVERSITY LOSS AND ITS REDRESS

John Harte eloquently laments biodiversity loss, which he characterizes as "the most intractable" of the dawning century's environmental challenges.¹ I have been asked to review the challenge of preserving biodiversity loss from a legal and institutional perspective.

Much of Harte's focus is on why it is so difficult to stimulate an effectual response to biodiversity loss. He offers, among other explanations, that: (1) the menaces of a thinned biodiversity portfolio do not play on the public's imagination as vividly as those of a disrupted climate or depleted ozone shield;² (2) that the causes of habitat loss are "more multiple" than those of greenhouse warming;³ (3) that there is no "conceivable technological breakthrough" to save us from biodiversity loss;⁴ and (4) that many of the most promising remedies run up against "passionately-held views about rights that accompany land ownership."⁵ The array of impediments Harte comes up with is rich enough that it is tempting to engage each of them point by point. For example, I do not find Harte persuasive that any one global environmental problem has "more causes" than

². See Harte, supra note 1, at 950-51.
³. Harte, supra note 1, at 949-50.
⁴. Harte, supra note 1, at 953.
⁵. Harte, supra note 1, at 955.
another, or that technology has less potential to redress biodiversity loss than to mitigate climate change.

But given the restraints of space, let us put such small quarrels aside and go directly to my own list of hindrances to stimulating extensive institutional reforms, without lingering over possible areas of disagreement. I suspect that the few differences between our "lists" are largely matters of emphasis.

A. The Lack of An Agreed-Upon Biodiversity Indicator (The "Currency" Problem)

Among the relative advantages enjoyed by the Montreal Protocol's negotiators, there was general agreement on the key focal indicator of trouble: the thickness of the ozone shield measured in Dobson units (DUs). There is, however, no comparable index—no analogue to DUs—to guide the parties to the Convention on Biological Diversity (CBD). A single term—
"biodiversity"— is being applied to many distinguishable environmental characteristics.

Indeed, it can be argued that, in the absence of data that would enable us to collapse all values into a unifying metric of utility (see infra box, "Filling the Ark", p. 971), there is no single objective measure of biodiversity— only measures appropriate for particular values and purposes, such as maximizing our (or the total environment's) capacity to adapt to changes. Depending on ones' purposes, values, and conjectures about the future, we might adopt as the “currency” to deposit in the diversity bank: (1) the number of species; (2) some measure of “richness” of genetic information conserved, such as the evolutionary “distance” among the pool of organisms in the portfolio; or (3) some indicator of attributes the genes express, such as morphology (eyes), behavior (burrowing), or ecosystem functions or services (carbon storing).

While Harte maintains that various indicators are “linked,” we should not understand this to mean that they all correlate positively. If we set out to maximize the sheer number of species, preserving prolific rain forests would probably be the highest priority. But some commentators champion grasslands areas, which are typically custodians of “higher taxonomic categories”

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Metrick and Weitzman's model, which on its face ranks individual species, has to account for synergistic values of the services species provide in combinations, for example, of \{a, b, and c\} as compared with \{a, e, and f\}. That is, the ranking has to be flexible enough to account for variations introduced by a combination of species. The survival of a species, too, is heavily dependent on co-existent species admitted to the Ark, another factor suggesting the advisability of evaluating sets of species. I understand the authors to be maintaining that their individual-oriented framework is, indeed, flexible enough to account for effects of combinations. See Andrew Metrick & Martin L. Weitzman, Reply, 13 J. ECON. PERSP. 239, 239 (1999) [hereinafter Metrick & Weitzman, Reply] (explaining that joint serial probabilities can be handled in the Noah's Ark framework).


11. I adopt the image from Williams & Humphries, supra note 10, at 56.

12. Although what constitutes a “species” is itself controversial. For example, "some biologists discern 200 kinds of British blackberry; others might list 20, or 2 or 3." C. Claiborne Ray, Q & A: the Species Census, N.Y. TIMES, Nov. 30, 1999, at F2.


15. Harte, supra note 1, at 951.
notably mammals, which generally store, species for species, more genetic information than the "lower life" forms that dominate the rain forests.\textsuperscript{16}

While the lack of a single indicator is an impediment to institutional progress, it need not be a barrier. This is aptly demonstrated by various regimes currently in place. The Framework Convention on Climate Change (FCCC), for example, faces the fact that each of the various greenhouse gases (GHGs) displays several distinct climate-affecting variables including the wavelengths (window) of the spectrum its molecules block, the aggregate concentrations in that particular window, and the expected atmospheric lifetime.\textsuperscript{18} Together, these variables make it impossible directly to compare the long-term effects of a reduction in methane emissions with a reduction of an equal percentage in carbon

\begin{tabular}{|c|c|c|}
\hline
\textbf{FILLING THE ARK} & & \\
Theoretically, one way to solve the metric problem is to express value in the currency of utility. If we could go straight to the relevant utility information (including that about costs and benefits of preservation measures), the optimal policy for conserving species is suggestively modeled by Andrew Metrick and Martin Weitzman.\textsuperscript{17} They ask us to imagine ourselves operating a Noah's Ark in the face of a species-depleting threat subject to a "budget" in the form of the arc's limited space. We, therefore, cannot save every species. Moreover, even the conservation measure (bringing the species on board) will not guarantee that a candidate species will be "saved," because it might die out irrespective of our protective efforts. The authors' optimal policy would rank the boarding order as follows: where $i$ represents the next ($i$th) species to be boarded from among the waiting set, and
\begin{align*}
D_i & = \text{distinctiveness of } i \text{ (a measure of its uniqueness, which captures some but not all "portfolio" values discussed in the text below)} \\
U_i & = \text{direct utility of } i \text{ (a measure of how much we value } i \text{ per se)} \\
\Delta \rho_i & = \text{how much } i's \text{ chances of surviving are improved by the conservation measure} \\
C_i & = \text{the cost of the conservation measure.}
\end{align*}

Then the priority ranking is:
\begin{align*}
P_i &= \left[ D_i + U_i \right] \left( \frac{\Delta \rho_i}{C_i} \right)
\end{align*}
\end{tabular}


\textsuperscript{17} See Metrick & Weitzman, Conflict and Choices, supra note 9.

dioxide. Nonetheless, the ongoing FCCC negotiations demonstrate that headway depends less upon a single objective standard than upon a common sense of purpose.

B. We Lack Crucial Data the Metrics Offer to Measure

The currency question may prove to be less of a Pandora's box than is the unavailability of crucial data. Harte calls attention to the "ten-fold uncertainty in the total number of species" and the crudeness of our estimates of the unknown—but undoubtedly drastic—decline of species. Indeed, there are gaps in our scientific knowledge of just about everything else we might want to measure. Even with respect to those species whose presence we can locate on a global grid, we have far less knowledge of their abundance locale by locale.

C. We Are Uncertain How to Arrest the Declines

Even if we had an agreed-upon currency, and sufficient data to alert us when we were becoming dangerously overdrawn, it is not always clear what we could do about it. For example, there is wide uncertainty about how much territory and what physical interior and boundary conditions are required to insure preservation of any given species or other coveted environmental feature. At what point of population decline, and under what conditions, will a stock "crash"?

D. We Do Not Know the Cost of Any Decline (the Exchange Rate Problem)

We cannot calculate with any confidence how much the loss of a species or ecosystem costs. A major—perhaps the major—accounting problem is that we do not understand the links between the loss of any particular ecosystem feature and human well-being. Some ecologists confess that "for many ecosystem functions, such as nutrient cycling and decomposition, there [is] next to no clear evidence about the role of species diversity."22
When we exchange a tropical acre that supported one thousand species for an acre that produces one strain of barley and a few dozen species of soil life, how do we tally the apparent gains and losses? Harte's tick-eating fence lizard serves well as a cautionary tale, but the moral is not self-evident. The question is whether the benefits of preserving the lizard (the positive but uncertain impact on Lyme disease) offset the costs of eliminated housing. Can anyone say?

In the face of uncertainties about the costs of losing any given species, Harte raises the stakes, claiming that "the health of the human economy is dependent" on "ecosystem integrity." But what does this really mean? Of course, one can imagine extreme changes in the ecosystem that would have cataclysmic impact on humanity, such as a radical increase or decrease of atmospheric oxygen. But fabulous cataclysms aside, Harte's invocation of the health of the human economy is too easy for skeptics to turn on its head. The health of human economies appears to have depended precisely upon humankind's far-reaching revampings of ecosystems. We have reshaped the landscape, transformed microclimates, and fostered the spread of cultivated and domesticated species (whose mutations have become as dependent on us as we are on them). And it is this history, compounded with the first three impediments, that would undermine a proposal for widespread, diversity-optimizing restrictions on private land, at least equally with the "passionately held" attitudes towards private land use rights that Harte cites.

For Harte, the case for conservation rides, in part, on technological pessimism: the less adequately technology can compensate for the depletion of biodiversity (somehow measured), the higher the costs of each lost habitat. Harte labels as "illusion" the belief that genetic engineering can wean species has been reached. See id. at 203; see also Jocelyn Kaiser, Rift over Biodiversity Divides Ecologists, 289 Sci. 1282 (2000) (questioning whether data on biodiversity is robust enough to inform public policy).

23. See Harte, supra note 1, at 951 (housing development that eradicates lizard will increase risk of Lyme disease).
24. Harte, supra note 1, at 930.
27. While Harte is right that property owners are less likely to change at any call for (as I shall interpret the proposal) uncompensated environmental servitudes, "passionately held" attitudes towards private property would not explain efforts to enfeebles the ESA in its applications to public lands. Harte, supra note 1, at 955.
humanity "off its historic dependence on wild plants and animals" for food and medicines. But is a decline in our historic dependence really "illusory"? To a considerable extent reliance on laboratory-concocted "designer genes" is reducing the need to scout up natural samples. The technical advances are far from eliminating the value of natural genetic in situ libraries, which offer "survival tested" templates, as Harte says, particularly where accompanied by the knowledge of indigenous peoples. Indeed, new pharmaceutical techniques, by reducing the cost of assaying natural materials, might even raise the value of natural inventories in the short term by increasing demand. But there is no reason to doubt that, over time, advances in technology will reduce the costs to humankind of a dwindling biodiversity inventory that is measured in lost inputs to pharmaceuticals, cosmetics, and so on. At the least, because we cannot anticipate how far technology can substitute for natural inputs, any proposed conservation policy faces considerable uncertainty in assigning costs.

E. The Problem Requires Global (or Broadly Multi-Lateral) Solutions

One reason Harte thinks other challenges "pale in comparison" to biodiversity loss appears to be based on a global-local distinction. As an illustration, consider climate change. The problem is global in that a molecule of carbon dioxide emitted from an automobile in Los Angeles has the same impact on the world's climate as one emitted from a land clearing in Lahore. "In contrast," Harte says, "the environmental effects of land use practices are highly dependent on the locations and [the] specific nature of those practices." It is true that restraining biodiversity loss forces us to grapple with local practices and local phenomenon since the loss of the last member of a species occurs in a specific locale. But I am not sure that this global-local distinction between species loss and climate change is valid. We cannot restrain greenhouse gas emissions without confronting local practices also. In some

30. Harte, supra note 1, at 956.
31. Harte, supra note 1, at 932.
32. Harte, supra note 1, at 950.
countries, heavy reliance on automobiles is the issue; in others, land clearing and agricultural practices are critical. There is a further parallel in the fact that just as carbon congestion affects the whole world, regardless of where the molecule originated, the loss of a species affects the whole world’s inventory wherever the last member died. Indeed, while Harte emphasizes the local features of biodiversity loss and finds in them the impediments to repair, I am inclined to emphasize the opposite—the global dimensions of biodiversity loss and our need to respond to them with multilateral cooperation.

**THE NEED FOR GLOBAL COOPERATION**

To illustrate the virtues of global participation, suppose that the currency question is resolved in favor of conserving the set of attributes \( \{a, b, c, d, e, f, g, \ldots, z\} \). A network of areas has to be assembled and maintained that embraces, at a minimum, at least one member each of those attributes; the set has to be complete. A budget in excess of what is required for a fully inclusive set may foster subsets that account for varying values that we place on preserving different members: we may want twice as many stores of \( a \) as of \( b \).

Assume the distribution of the first seven members to be (in varying abundance): The United States \( \{a, b, c\} \), India \( \{a, b, c, d\} \), Costa Rica \( \{d, e, f\} \), Greenland \( \{g\} \). Assume that while other countries are required to fill out the full set with \( h, i, j, \ldots, z \), the four named countries exclusively offer the first seven members. Given that distribution, note that participation by both Greenland and Costa Rica is indispensable to the formation of a fully representative set of all attributes, since \( f \) and \( g \) will go otherwise unrepresented. Although India is not indispensable, India might provide \( b, c, \) or \( d \) at a lower cost, and at higher levels of security and abundance than the U.S. and Costa Rica, respectively. If so, freeing up \( b \)-supporting land in the U.S. in exchange for securing \( b \)-supporting land in India is superior within the budget. And this is true whatever the attributes being portfolioed: genes, morphological features, ecosystem types, species, an index for species “distance”, or whatever.

Import policies of other countries on the other side of the world. Third, one of the greatest threats to biodiversity, the introduction of alien species, is in many ways exacerbated by increasing trade. A mollusk hitchhiking in freighter ballast from Asia is certainly no less a threat to the Great Lakes, and quite possibly a greater one, because it is more “alien,” than a cousin mollusk
emigrating from the Atlantic coast. Fourth, whatever the currency favored, the underlying goal of biodiversity policy is presumably to safeguard a portfolio (or, within budget constraints, portfolios) of areas that, taken together, most completely and efficiently represent the attributes we seek to conserve. Because of regional redundancy and specialization, it is ideal to have the whole globe as a source from which to assemble "investments." As a consequence, any conservation plan that commands less than global participation will be suboptimal.

Hence, world-wide cooperation reduces the land costs of assembling portfolios. And it is also required for optimal distribution of benefits. In terms of the illustration, the readiness of the United States to allocate to India the conservation of b and d—the efficient solution—depends on whether the United States finds it credible that India will share in the benefits of b and d when and if the need for them should arise. Without strong assurances that cooperation will be forthcoming, each nation will be hesitant to accept the globally ideal land use pattern. Concerned nations will be faced with the need to establish more costly domestic portfolios, thereby producing redundancies where the optimal result would be accomplished with fewer providers. This is not to undermine Harte’s call for local action. But it reminds us, in one more way, that an ideal response to biodiversity loss requires no less multilateral cooperation than does climate change.

II

Biodiversity Loss as an Object of Law

We all agree on some basic and disturbing points, including: (1) that the world is undergoing a rapid diminution of biodiversity; (2) that the benefits from many of the activities that cause the losses are less than the costs when biodiversity losses

33. This is essentially the basis of the WORLDMAP project being conducted by P. H. Williams and his team centered at the Natural History Museum's Biogeography & Conservation Lab in London. The project and its progress in sorting organism occurrence within grid cells and polygon sub-areas of the world is described at http://www.nhm.ac.uk/science/projects/worldmap/ (last visited Nov. 4, 2000). Regarding the task of combinatorial "scoring" of efficient sets, see http://www.nhm.ac.uk/science/projects/worldmap/priority/steps.htm (last visited Nov. 4, 2000).

34. See illustration in box, infra p. 975 (based upon an analysis of R. I. Vane-Wright, Identifying Priorities for the Conservation of Biodiversity: Systematic Biological Criteria Within a Socio-Political Framework, in Biodiversity: A Biology of Numbers and Differences, supra note 10, at 309-44).
are accounted for; and (3) that it is difficult to mobilize the political process to implement remedies. The tough question remains, if we could animate that process and elect, as Harte demands, politicians who are responsive to the problem, what is it we would have the politicians do?

When we turn to the legal options, biodiversity loss appears difficult to address because it comes at us, as Harte says, in so many forms and from so many directions. Some of the losses are the unintended side-effects of beneficial activities, such as mining and agriculture. Other losses are inflicted intentionally, if not always wisely, such as through the eradication of unwanted plants ("weeds") and animals ("pests").

An overview of the law reveals different strategies for the protection of living resources according to whether the perils addressed are: (1) losses of specific, highly valued species, such as tigers or rhinos; (2) bio-invasion, that is, environmental havoc due to the introduction of exotic species, such as the zebra mollusk into the Great Lakes; or (3) impairment of (true) biological diversity, where the attention is directed less towards specific selected creatures or species than towards a portfolio of species or genes valued for their synergistic effects or as insurance against declines in beneficial services and interactions.

III

BIO-SPECIFIC LOSSES

Most of the current bio-specific measures aim at protecting endangered or threatened species, such as the United States' Endangered Species Act (ESA). Other laws, such as the Marine Mammal Protection Act (MMPA), step in to protect particularly favored species, even in the absence of evidence that the species is imperiled. And still other laws—indeed, some of the oldest international treaties—aim to conserve animals selected for their contribution, direct or indirect, to the human diet.

The measures these laws deploy vary and suggest options for protecting biodiversity. Some laws operate by creating protected

habitats, others establish genetic storage, such as seed banks and zoos. Still others ban activities, ranging from local hunting ordinances to the International Whaling Commission's (IWC's) moratorium on commercial whaling. Another approach, exemplified by the Convention on International Trade on Endangered Species of Flora and Fauna (CITES) operates by dampening demand.

IV
BIO-INVASION

Bio-invasion occurs when alien species transform ecosystems by driving out indigenous organisms. This phenomenon, accelerated by increasing global trade and travel, could therefore be treated under the general heading of habitat loss. But, from a legal point of view, bio-invasion has at least one distinct feature. "Ordinary" habitat loss raises no question of liability because it is self-imposed, as when Nation A decides to convert forest land to housing (considered below). But aside from the exceptional but not rare case where the host country deliberately introduces the novel species and thereby brings a catastrophe on itself, the introduction of the exotic species in one nation is frequently caused by actions in another nation. Where, for example, insects from Nation B "hitch-hike" into A in the crates of B's exports, B might be viewed as the cause of A's losses. In such cases, bio-invasion has much in common with

39. A measure more readily achievable when the locus is the range of giraffes rather than of faceless germplasm. Animal parks can bring in eco-tourists.


41. Convention on International Trade on Endangered Species of Flora and Fauna, Mar. 3, 1973, 27 U.S.T. 1087, 993 U.N.T.S. 243, reprinted in 12 I.L.M. 1085 (1973) (entered into force July 1, 1975) (CITES). As a trade measure, CITES serves as a useful back-up if the nation with jurisdiction over the species fails to take adequate action. But trade measures have distinct drawbacks. They raise the economic return of illegal harvesting for those willing to take the legal risks. At best, CITES can only affect takings motivated by the international trade it seeks to cut off; it does not address depopulation for the local market or habitat destruction incidental to conversion of habitat to incompatible uses.

42. For example, the European rabbit introduced by Australia. See JARED DIAMOND, GUNS, GERMS AND STEEL 209 (1997). Or, for another example, the African honey bee. The African honey bee was brought to Brazil by geneticist Warwick E. Kerr in 1956 as part of an experiment to breed a more productive bee that was better adapted to neotropical climates than native or European varieties. Inadvertently released, these more aggressive bees (dramatized by the media as "killer bees") have spread throughout the South American continent and have reached as far north as the American Southwest. See U.S. Geological Survey, Africanized Bees in North America, at http://biology.usgs.gov/s+t/noframe/x189.htm (last visited Jan. 18, 2000).
trans-boundary pollution, and international liability could, theoretically, be established. On the other hand, given the feebleness of international law and the difficulties of proof, liability is not likely to be a successful deterrent. There are, however, some incentives to reduce accidental "exports" of alien species. First, nations that persistently maintain "clean" exports may reap reputational benefits; second, the WTO provides wide latitude for import restrictions based on avoiding tangible phylo- and phytosanitary threats. But in the main, the "polluter"— the source of the alien species— is under little pressure to inspect and abate. The onus falls almost entirely on the potential victim, who may or may not be the most cost-effective monitor.

All this simply underscores the need to press for solutions. The 157 member International Maritime Organization (IMO) has proposed a draft text for addressing aquatic organisms in ballast waters, and negotiations are under way to adopt alien species sensitive annexes to the 1978 MARPOL Agreements. The outcome of these proposals remains in doubt, and they deserve support. But regardless of how the negotiations turn out, the control of bio-invaders demands vastly enhanced inspection and eradication procedures to restrict both the international and intra-national transport of nonnative colonizers.

V

DIMINUTION OF BIODIVERSITY THROUGH HABITAT LOSS

In many ways, it is more complicated to protect biodiversity than it is to protect a particular organism or species, such as whales. This follows from reasons raised earlier: there is considerable uncertainty as to how losses in "biodiversity" are to

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be measured, valued, and avoided. We therefore cannot agree on the constituents of an ideal portfolio of reserves, much less determine how extensive and untouchable its components must be. Prioritizing the most species-rich "hot spots" is not as obvious a choice as it may sound, inasmuch as two such spots may be largely redundant in their offerings. The aim is to preserve not only species favored in their own right, but to preserve sets of attributes ideal for synergistic interactions and "insurance" purposes. Thus, a relatively "thin" area offering genetic material or other attributes not available elsewhere has a value not offered in two "rich" but redundant sites.

Given all the uncertainties, I will proceed on the plausible assumption that, absent special "gaps" in the portfolio (which would warrant special supplemental strategies targeted to fill them), the less humans alter the planet, the better off we are from a biodiversity perspective. In other words, the default assumption is that virgin forest is to be preferred over developed forest. On the other hand, from an economic perspective, preservation has its price—forgone development—the more virgin forest, the less farmland. Thus, the legal issue becomes finding which institutional mechanisms are available to preserve diversity efficiently, that is, in a manner such that the social costs of preserving biodiversity do not exceed the benefits.

To approach this issue, consider Figure 1. Figure 1 accompanies the following story about nation N's tropical forests. N has jurisdiction over a quantity of forest acreage that exists in a richly covered "original" condition (F°). The left abscissa in Figure 1 represents the benefit of the land in the "natural" (original) state F°. The benefit is the sum of the net

47. An analogous story could be told about N's marine wetlands, dry lands, and so on. The assumptions on which the narrative operates are less than ideal. The choice between sustainable use of F° and alternative uses is not a choice between a biologically abundant and a biologically barren use of the land. The demand for timber, meat, etc. results in conversion of "fully" covered forestland into more thinly-covered land, by degrees. Even land that is totally "cleared" in the popular sense is not going to be stripped of all valuable biodiversity. Unfortunately, too, the relationship between the "consumption" of F° and the "consumption" of biodiversity is not easy to specify. That follows from the preliminary observations on the "currency" problem. Inasmuch as there is no consensus on which biodiversity metric to maximize, we cannot confidently assert a linear relationship between the degradation of F° acreage and the degradation of biodiversity. Indeed, it is unlikely that the supply of biodiversity in any metric will be co-linear with the supply of F°. For example, the decline in species, or abundance of any species, is more likely to remain relatively flat across some margin of F° decline, and then to decline more sharply, even collapse. Thus, the consumption of F° has to be offered, uneasily, as a rough surrogate for a number of possible measures of biodiversity loss.
present value of the expected income stream of goods (for example, latex and nuts) and services that the natural landscape provides if managed "sustainably" plus public goods benefits of the portfolio retained. The right abscissa represents the price for an acre converted—the "clearing price"—which captures the demand for converted uses such as farming, timber, and mining. The distance between abscissas is equivalent to the total original quantity $F^0$, a state of total conversion at the left and total retention at the right. $DC^0$ is the demand curve for converted land, the shape and slope of which is derived from world demand for corn, beef, etc. The demand for unconverted land varies, as we shall see, with the legal regime.

**FIGURE 1**

CONVERSION OF "NATURAL FOREST" AS FUNCTION OF LEGAL REGIMES

Figure 1 portrays the demand for $F^0$ under the initial (and unfavorable) legal constraint of "open access" (where "open" suggests open access to the fruits of the land). That is, as a starting point, we assume that the land is held in common, either *de jure* or *de facto*, owing to feeble enforcement of the owner's right to exclude trespassers and poachers. $D^{OPEN}$ is the

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48. The sequence of "reforms" in the text is adopted for pedagogical purposes, and does not necessarily reflect the ideal practical or political ordering.
demand for virgin forests under these feeble ownership conditions. Property owners who convert their land use to grazing and other uses will purchase as long as the price of $C^o$ exceeds the price of $F^o$, so that equilibrium is reached when the price of $F^o$ is $P^{con}$. The balance between pure and converted forest is struck at $Q^{con}$.

VI
THE LEGAL-INSTITUTIONAL VARIABLES

Using this framework as a basis, I will proceed to describe how a series of variations in the legal-institutional environment can temper the rate of conversion to successively more “efficient” levels. I do so with reference to seven “zones” of legal influence. Each zone reflects the influence of a related basket of legal strategies.

A. Zone 1: The Elimination of Subsidies

The first legal measure and the clear starting point for conservation reform is to eliminate subsidies that aggravate the demand for virgin forest by artificially fostering conflicting uses, such as agriculture and logging. Subsidization need not take the form of overt payments to converters, but can include favorable tax incentives and insufficient charges for use of public lands, such as inadequate grazing and stumpage fees. The illustration in Figure 2 assumes, for simplicity, a per acre subsidy to convert. The equilibrium with subsidies to converters relocates at $Q^{sub}$, indicating an even higher conversion than under our baseline “open access” regime. It probably is not necessary to elaborate that such subsidies are suspect, and are candidates for elimination no matter how biodiversity is defined and valued. In terms of Figure 2, elimination of subsidies will shift the equilibrium to the right—towards a higher retention.

49. Some Canadian journalists have come out openly in favor of withdrawing farm subsidies and returning the affected land to wilderness. See James Brooke, *Down and Out in Rural Canada*, N.Y. TIMES, Dec. 19, 1999, at C1.

50. We might well group with “subsidies” government policies that condition transfer of public lands to claimants who mark it, for example, by burning.

51. For the sake of simplicity, the costs of conversion are unaccounted for in the narration.

52. While agricultural subsidies are presumptively suspect, not every such subsidy is socially indefensible. If there are genuine benefits in farming not captured in market prices, such as food security, the case for subsidies to farmers is not necessarily weaker than subsidies that I advocate below, such as to biodiversity and the environment.
As for the legal-institutional options for achieving this shift, weaning dependency upon subsidies is, unfortunately, largely an internal political matter that is not easily accomplished. But there is at least one international instrument of considerable potential. The Uruguay Round to the General Agreement on Tariffs and Trade (GATT) added a Subsidies and Countervailing Measures Code (SCM) that provides a foundation for challenging trade in subsidized natural resources and their products within the WTO framework. If the SCM were to be well-deployed, the WTO could become a major factor in preserving terrestrial and marine environments.

B. Zone 2: The Securing of Real Property Rights

With the elimination of subsidies, the equilibrium would shift right from $Q^{\text{open}}$ to $Q^{\text{open}}$. A further shift in the direction of conservation is possible through reforms in property laws.

The more assurances the jurisdiction provides owners of untouched land that they will be able to capture the income generated, the less land will be shifted to converted uses. For example, the more forcefully the state supports the owner's power to exclude poachers of virgin forest products, the higher will be the price of the land in its "natural" state. This is true because, for example, the production of nuts, latex, and other sustainable uses will be a more profitable investment. The effect of defining and protecting the landowner's property interest is displayed in Figure 3 as an upward rotation in the demand curve for untouched land, $D^{\text{open}}$ being replaced by $D^{\text{closed}}$. The equilibrium accordingly shifts right to $Q^{\text{closed}}$, reflecting the reduced conversion to other uses, such as agriculture.

Turning to the legal instruments that this shift requires, we are talking about nothing more radical than instituting laws of trespass, conversion, and the right to convey good title. But the costs of enforcement—particularly in remote, thinly populated, unmarked regions—may be considerable. It is one thing for the law to protect a coal mine or an oil field since "poaching" of extractive minerals requires the establishment of plainly visible, expensive structures and continuous activity. In this situation, the wrongdoing is easy to spot. But it is another thing to monitor the biodiversity value of the virgin forest, such as may be contained in compounds or genes of a promising twig or leaf. These can be smuggled out surreptitiously. For example, legend has it that all it took to break China's silkworm monopoly was a

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56. Other property interests would include protection of the owner's land title, the right to convey it, and the right to be compensated for government "takings."

57. The increased steepness of the demand curve reflects the fact that at any price for virgin land, less will be sold to a competing use as the ownership rights are secured. The reason the curve rotates around the point $C^0 = 0$ is that it is the limiting point at which all land is converted.

58. Note that the strength, and even direction, of a rotation from $Q^{\text{open}}$ to $Q^{\text{closed}}$ is dependent on circumstances. A general, across-all-lands, increase in protection against trespassers will not only raise the value of $F^0$; it will also raise the value of $C^0$ in as much as grazers and others stand to benefit from protection also. The illustration in Figure 3 assumes that the forest-conserving effects will dominate the forest-converting effects, as it likely would, for example, in the common case where the jurisdiction previously instituted monitoring and policing of land already transformed to common commercial uses, but has been slow to institute protection of the land in an original fully covered state.
few eggs bootlegged in the clothes of two Nestorian monks. The small size of the New World vanilla market made it easy for the monks to escape detection. Mexico lost its monopoly over vanilla beans in 1800 when a priest, defying an export ban, smuggled out a vanilla orchid to Tahiti. The high cost of policing is therefore a non-trivial impediment to incorporating the full value of biodiversity into the market valuation of the forestland.

C. Zone 3: Strengthening the Exploiter's Economic Interests

Biodiversity conservation can also be enhanced by increasing the demand for non-consumptive uses of the forest, such as leads for food additives, cosmetics, and pharmaceuticals. The higher the profitability of biodiversity prospecting (a non-consumptive use), the more money biodiversity prospectors will bring to the table when negotiating prospecting rights. The higher the price that prospectors will

offer for rights to biodiversity-rich land, the less untouched land will be converted.

In terms of legal devices, any number of intellectual property right (IPR) laws (principally patent laws) affect the rewards of those who screen for and exploit potentially valuable species or chemicals. But because legal systems vary, perhaps most crucially with regard to the requirements for innovativeness and originality, it remains an open question how far the law is prepared to extend IPR protection to forms of plant and animal life and their genetically engineered derivatives.

To illustrate the problem of providing incentives to prospectors through IPRs, imagine a firm that, following native "leads," identifies a leaf with medicinal properties. If the firm can identify the active compound, can it reap the benefits of a patent? The patent might be challenged on the grounds that naturally occurring compounds are unpatentable per se, even if synthetically produced. It may also be argued that, in light of native knowledge, the benefits of an extract, even if so concentrated as to constitute an advance of sorts, fall short of an "unexpected properties" requirement. If the firm cannot patent the product, it may get a patent on the process of synthesizing the compound. But a competitor, now knowing the value of the end-product, may respond by designing its own non-obvious way of extracting or synthesizing the same compound. Alternatively, if the original firm can get a patent on the compound, its competitors may respond with a "copy cat" product that has the same desired properties but tweaks the chemical in ways that give the appearance of a structure "new"

63. "Nonobviousness," one of three basic conditions of patentability, precludes a patent if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious to a person having ordinary skill in the pertinent art at the time the invention was made. 2 DONALD S. CHISUM, CHISUM ON PATENTS § 5.01 (14th ed. 2000). One way for a patent applicant to rebut a prima facie case of obviousness is to make a showing of "unexpected results," i.e., to show that the claimed invention exhibits some surprising or unexpected superior property or advantage. See In re Soni, 54 F.3d 746, 750 (Fed. Cir. 1995).
64. A product that occurs naturally does not fall within statutory patentable subject matter even though the applicant may be the first to identify the product. However, an applicant may claim a purified or altered form of a natural product or a process defined as the method of using the newly-discovered product to achieve a useful result. 1 DONALD S. CHISUM, CHISUM ON PATENTS § 1.02[7] (14th ed. 2000).
enough not to infringe on the patent. Moreover, even if the original firm does get a patent protecting its rights in the United States, many countries do not recognize IPRs (particularly where living things are involved) or do not enforce them reliably.

The patent picture is thus, to say the least, cloudy. The European Community and the United States have been moving in slightly different, but probably converging, directions. Much of the worldwide enforcement picture is still unclear; its future depends on the outcome of international trade law protection such as The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). TRIPS could, if broadly adopted, globalize standards not incompatible with those of the United States.

Without confronting each and every detail, one can say that clarifying ambiguities and developing the law in favor of patent protection would have the effect depicted in Figure 4: some upward rotation of demand for $F^o$ to $D^\omega$. The new equilibrium between converted and unconverted acreage is $Q^\omega$. That is, the shift is in the direction of retarding conversion. But the extent of the shift that can be induced through firm-favoring IPR reform is probably limited.

There are several reasons to be skeptical about the extent of IPR influence. First, even where legal protection is available in theory, the costs of proving infringement against, for example, the rival who copy-cats a "look alike" product undermine the economic value the IPRs might inject into the conservation equation. The erosion is likely to be most pronounced in suits to protect naturally occurring compounds and their derivatives, that will inevitably excite novel—meaning more costly and uncertain—litigation. Ironically, even the Convention on

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66. Most dramatically, just as the United States has allowed patent of a genetically modified mouse (the "Harvard Mouse"), see U.S. Patent No. 4,736,866 (issued Apr. 12, 1988), so, too, has the European Union, see European Union Patent No. 0169672, subject only to individual EU member objections. See generally Barbara Looney, Note, Should Genes Be Patented? The Gene Patenting Controversy: Legal, Ethical, and Policy Foundations of an International Agreement, 26 LAW & POLY INT'L BUS. 231, 265 & n.139 (1994).


68. See generally Kadidal, supra note 65, at 244 (exploring features of existing patent law that might protect a natural product's chemical structure patent against "semi-synthetic pretenders").
Biological Diversity (CBD) undermines the incentivizing potential of IPRs by suggesting that the patent-holder might be put under an obligation to share benefits or technology with countries that hosted the original resource on "an equitable basis."\(^69\)

**FIGURE 4**

**EFFECTS OF FIRMING UP INTELLECTUAL PROPERTY INTERESTS**

Second, even if IPR protection were reformed—made advantageously ironclad and global—the fullest IPR protection imaginable is not likely to translate into an appreciable damper on land-use conversion. Laboratories are not the only alternative that an acre of species-rich land must compete with. The world remains a store-room of natural compounds, on land and in water (and in ex situ storage sites), that is vast relative to foreseeable sampling demand and capacity. In these circumstances, the chances that any landowner's acre will harbor a profitable "lead" is miniscule; the remote chances that any lead it does harbor will be unique to her land (that is, not duplicated on some ecologically similar patch in Georgia or Guatemala) reduces the value further.\(^70\) Thus, to any given landowner, the discounted present value of the slim probability

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of a future offer from a bio-prospecting firm is not likely, by itself, to outweigh any positive offer a timber firm might make. This is not to say that, in the future, exciting natural compound discoveries will not be made across the world. It is only to point out that the commercial value of biodiversity prospecting is not likely to be a significant factor in conserving land, even with the most favorable reform of IPR laws.\textsuperscript{71} In terms of Figure 4, the rotation across Zone 3 is not apt to be appreciable.\textsuperscript{72}

D. Zone 4: Strengthening the Host Nation’s Commercial Interests

Another layer of strategies aims directly at solidifying the property interests of the nation in which the resource originated (also known as Country of Origin (COO)). The idea is that if the COO’s interests in the commercial value of undeveloped land can be strengthened, the COO will be motivated to undertake reforms that will retard land conversion. Such reforms would include withdrawing perverse subsidies, increasing enforcement of land laws, and creating conservation zones.\textsuperscript{73} Several different “property rights,” broadly understood, can be enlisted in the campaign to solidify the COO’s interests. Essentially, these rights parallel the devices that enhance the value of biodiversity to private land-owners (above), simply raised to the national level.

For example, just as it may advance conservation to clarify and improve the private landowner’s powers to exclude

\textsuperscript{71}. For a recent analysis confirming that the marginal value of a species for pharmaceutical research is apt to be small, see Amy B. Craft & R. David Simpson, The Value of Biodiversity in Pharmaceutical Research with Differentiated Products (Sept. 2000) (unpublished manuscript, available from the author at simpson@rff.org). But see Gordon C. Rausser & Arthur A. Small, Valuing Research Leads: Bioprospecting and the Conservation of Genetic Resources, 108 J. POL. ECON. 173 (2000) (offering a model that suggests somewhat higher values than Craft and Simpson’s).

\textsuperscript{72}. As evidence that the once celebrated profits firms supposedly stood to make from bio-prospecting are simply not materializing, Merck’s much publicized 1991 bio-prospecting agreement with INBio of Costa Rica garnered a lot of publicity, but has yet to turn up anything of value. See Michele Zebich-Knos, Preserving Biodiversity in Costa Rica: The Case of the Merck-INBio Agreement, 6 J. ENV’T & DEV. 180, 181 (1997) (stating that “[t]o date, no drugs have been formulated as a result of” the agreement). Similarly, Shaman Pharmaceuticals Inc., another touted bio-prospecting firm, has dropped out of the hunt for ethno-pharmaceuticals. See also Jon Christensen, Scientist at Work: Mark J. Plotkin: A Romance with a Rain Forest and Its Elusive Miracles, N.Y. TIMES, Nov. 30, 1999, at F3. A successor company is concentrating on dietary supplements.

\textsuperscript{73}. On the theoretical basis for solidifying the COO position, see generally Roger A. Sedjo, Property Rights, Genetic Resources, and Biotechnological Change, 35 J.L. & ECON. 199 (1992).
trespassers, so the national interest in inventorying biodiversity may be amplified by securing its territorial property interest over the resources of interest. The CBD makes a somewhat ambiguous gesture in this direction, enjoining COOs, on the one hand, to facilitate access by other parties to their genetic resources, and, on the other, providing that such access shall be “subject to prior informed consent” and “on mutually agreed terms.” In other words, while original host countries are “not to impose restrictions that run counter to the [CBD’s] objectives,” negotiations between foreign commercial exploiters of biodiversity potential and the host countries are clearly encouraged, with the goal of tilting some power towards the COO. A number of nations have, in fact, adopted measures controlling access to genetic resources and demanding compensation. Others have eliminated the export of designated native seed and germplasm, a maneuver that is probably lawful, although certainly disputable both under the GATT and, ironically, even under the CBD. But putting aside minor challenges to the legitimacy of embargoes, there are larger questions both of whether such embargoes can effectively (as a manner of policing) or ought (as a matter of good policy) to be implemented.

The question of effectiveness has already been raised: smuggling samples such as eggs and twigs is almost impossible to restrain. The difficulties of control at the border reinforce arguments for awarding patent (or comparable IPR) protection to the COO, on the grounds that IPRs would provide some extra-territorial recourse against anyone who had succeeded in spiriting the material out of the country and was on the verge of exploiting it abroad.

74. See CBD, supra note 69, art. 15, § 2.
75. Id. art. 15, §§ 4, 5.
76. Id. art. 15, § 2.
78. See Macilwain, supra note 29, at 536, 538.
79. An embargo could be challenged as a quantitative restriction. See WTO Agreement (GATT): General Agreement on Trade in Services, Apr. 15, 1994, Annex 1B, art. 11. On the other hand, if an absolute embargo should prove unlawful, the COO could probably invoke an export tax high enough to throttle exports without violating any provision of the GATT.
80. An embargo would appear to conflict with the CBD’s obligations to “facilitate access to genetic resources” and “not to impose restrictions.” CBD, supra note 69, art. 15(2).
81. See supra notes 59-60 and accompanying text.
Putting aside the nest of practical problems associated with administering patents on naturally occurring substances, there are policy reasons to be ambivalent how far to fortify COO IPRs in genetic information. The use of genetic material—not the trivially damaging removal of the physical sample, but the reproduction of the embedded information—is nonrivalrous. Moroccan exploitation of a plant that happened to be discovered in Guatemala does not make it any less available to Guatemalans. Why then should Moroccans be forced to pay? Throughout history, the world has benefited from a traffic of seeds and stock passing freely between continents. An advocate for now putting a price on nature’s seeds and so on might argue that the awards to the COO would produce an upward rotation in the demand curve in the direction of D’ (Figure 4)—for the same reasons that the copyright laws incentivize an increase in the supply of plays. But in reality, given the doubtful magnitude of the commercial value, the impact on acreage conserved is not likely to be appreciable. A strengthened property regime will, to some extent, “reward” COOs with a patent monopoly, not as a return on investment in conservation, but simply as a windfall for not having gotten around to converting an area that turned out to harbor a useful compound. Moreover, the bureaucratic and negotiating costs of protecting COO interests, even under the relatively unintrusive CBD regime, are turning out to be nontrivial. There is evidence that as national efforts become more stringent, the interest of bioprospecting firms may wane, resulting in fewer prospecting agreements, and further substitution of “designer genes” for natural products.

Nonetheless, government “ownership” of genetic resources is a genuine issue. After all, even the United States has taken a step in this direction by licensing bio-prospecting for microbes

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82. Guatemala might argue that its preservation of gene sites, in the face of competing demands for the land, was an “investment” policy that required incentives.

83. The birth and eventual dominance of Southeast Asian rubber plantations traces to British agents spiriting 10,000 rubber tree seeds out of Brazil in 1876. Brazilians “still speak of the ‘rubber theft’ as a moment of infamy,” one ethnobotanist notes, “conveniently forgetting that their entire agricultural economy is based on six imported plants—African oil palm, coffee from Ethiopia, rice from India, cacao from Columbia and Ecuador, soybeans from China, and sugarcane from Southeast Asia.” BRENT DAVIS, ONE RIVER 304 (1996). The whole world is in much the same mutual debt.

84. Assume for example that the actual costs of a natural compound are less than a synthetic substitute; the monopoly-imposed costs will shift some production towards the synthetic, even at higher social costs.

85. See Pollack, supra note 77, at A1.
from Yellowstone National Park's geysers. But even if we were to extend and strengthen government "ownership" in various ways, how effective would it be? The equilibrium would shift toward $Q^*$, but it is hard to imagine that the shift would be substantial. Genetic resources would be more valuable to the government, but gains would be restrained by many of the same factors we saw in Zone 3 that make the contribution of bio-prospecting to land value a modest sum under most favorable circumstances.

E. Zone 5: Subsidizing Biodiversity as a Public Good

However we measure the social value of biodiversity, it plainly exceeds the commercial value that the law can secure to private parties and host governments, even under the most conservation-fostering reform of property laws in Zones 1-4. This is true because the full value that people across the world place on biodiversity conservation—on a broad genetic portfolio and on endangered charismatic species—cannot be fully captured by patent royalties and fees charged at the entrance to wild animal parks. The additional value is a public good that cannot be transferred to the landowner by markets. The institutional issue is how to inject this value into the landowner's retain/convert deliberations.

Basically, there are two choices: sticks and carrots. On the sticks side, nations objecting to another country's destruction could sanction excessive conversion by refusing to buy (or imposing a high import tax on) exports that result from the degradation. But the potential of such trade sanctions is limited. Unless the sanction is backed by a multilateral framework, such as CITES, it is subject to challenges before the WTO. The scope of a special Article XX defense by the nation refusing to import (the subject of the appellate ruling in the Shrimp-Turtle

88. Article XX of the GATT provides a WTO Member charged with otherwise impermissible trade measures a number of listed defenses, such as that its measure was related "to the conservation of exhaustible natural resources." General Agreement on Tariffs and Trade (GATT): Final Act Embodying the Results of the Uruguay Round of Multilateral Trade Negotiations, Marrakesh, Apr. 15, 1994, Article XX(g).
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controversy) is a subject of considerable uncertainty. But even if, as I believe, the ruling leaves the door ajar to environment-protecting trade measures, the potential is limited. At their best, trade sanctions may exercise leverage against degradation tightly linked to an export good (as in the avoidable killing of endangered turtles to supply shrimp to world markets). But conversion from activities that are not linked to an export market, such as the clearing of forest for lumber and other products to be consumed domestically, leaves no target for the import ban or tax.

Thus, as a practical matter, on the multi-national level we are left with subsidies rather than sanctions. The ideal subsidy would collect a sum equivalent to the aggregate benefits from each of those who benefit from the conservation, each contributing in proportion to its true willingness to pay, and deliver it to the owner. The result, in terms of our sequence, is to rotate the demand for converted land upward to $D^*$, as seen in Figure 5. The rotation reflects the fact that, in light of the subsidies to conserve, the value of the unconverted land rises. The acreage left unconverted rises accordingly to $Q^*$.

What are the right subsidy instruments and how can we implement them? A subsidy can take the form, at one extreme, of the benefitees purchasing the land in fee so as to turn the land into a fully untouchable reserve owned by the purchaser (either a government or NGO). But an efficient subsidy policy would, in all likelihood, involve a mix of environmental servitudes that leave ownership in private hands and condone mixed uses, compensating the owner for the opportunity costs associated with an appropriate conservation measure. Indeed, because forest cover per se is a weak surrogate for any measure of biodiversity, it may be best to assemble optimal portfolios by targeting subsidies to fill out fully representative sets of desired attributes, rather than by general incentives to maximize virgin acreage of forest.

Subsidization of biodiversity does occur at the national level with, for example, the establishment of national parks. At the global level, the CBD anticipates subsidies to protect biodiversity

90. See Harte, supra note 1, at 954.
91. See supra notes 33-34 and accompanying text, and box, "The Need for Global Cooperation," supra p. 975.
flowing from developed to developing countries.\textsuperscript{92} The restructured Global Environment Facility (GEF) has been assigned to collect and distribute funds to cover "the agreed incremental costs" of measures dedicated to biodiversity-advancing projects.\textsuperscript{93} But the funding for biodiversity, through these public channels at least,\textsuperscript{94} has been modest. The GEF has expended only U.S. $353 million in 1991-99, an average of U.S. $40 million annually.\textsuperscript{95}

Why has the effort to extract funding fallen so short? There are several possible explanations. As Harte says, dwindling

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure5.png}
\caption{EFFECTS OF SUBSIDES TO CONSERVE ACREAGE}
\end{figure}

\begin{flushright}
Q*=equilibrium with subsidies for biodiversity externalities
Q**=equilibrium with additional subsidies for associated public goods
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\textsuperscript{92} See CBD, supra note 69, art. 20(2) (mandating that developed nations that are parties to the agreement provide new and additional financial resources to developing nations to enable them to meet the incremental costs of implementing the convention).


\textsuperscript{94} A number of NGOs are important conduits to channel funds to conservation.

\textsuperscript{95} The GEF has, however, been spending more on biodiversity than on climate change ($248 million) and ozone ($156 million) in the same period. All figures exclude co-funding. See \url{http://www.undp.org/gef/portf/global.htm} (last visited Nov. 4, 2000).
biodiversity is not high on the public agenda. Even if we can excite a higher level of motivation, any effort to get parties to collaborate on the supply of a public good has to overcome the incentives each party has to pay less than its fair share.\textsuperscript{96} Further, there are honest differences in opinion among nations as to the urgency of biodiversity conservation relative to other public projects—education and public health, for example. More virgin forests may mean fewer schools. And even within a budget for biodiversity protection, there are large differences in opinion as to spending priorities. One option is to maximize \textit{in situ} “richness” of some sort by, for example, emphasizing parks with highly diverse species. Another is to cross-index those life forms (1) most critical to human needs, such as grain, and (2) most vulnerable to foreseeable hazards, such as climate change, and to build \textit{in} and \textit{ex situ} portfolios skewed to insure against their loss or corruption.\textsuperscript{97} The lack of consensus on what path to take is another factor that may undermine collaborative multinational efforts.

\textbf{F. Zone 6: A Complementary (Co-Benefit) Public Goods Strategy}

The next step is to depart from a pure biodiversity strategy to safeguard biodiversity indicators as part of an umbrella policy that advances a number of goals that are positively linked with biodiversity. For example, forests not only harbor biodiversity, they offer watershed services, recreation, living space for indigenous peoples, and carbon storage (which mitigates climate change). This raises the question: is there any way to exploit this overlap?

It is clear that if, in negotiating for preservation of a particular site, we can add to the subsidy calibrated for biodiversity benefits additional subsidies appropriate for the other services the site provides, including carbon storage, we can increase the attractiveness of conservation. In effect, we would rotate the demand curve further up from \(D^*\) to \(D^{**}\), as seen in Figure 5. The quantity of land left undisturbed increases accordingly to \(Q^{**}\).

\textsuperscript{96} For example, each beneficiary may understate how much value it places on a solution ("concealment of preferences"), seeking to shoulder a disproportionate share of the costs on the others who are benefiting (to "free ride").

\textsuperscript{97} For background on global change and vegetation, see Rik Leemans, \textit{Biodiversity and Global Change}, in \textit{Biodiversity: A Biology of Numbers and Differences}, \textit{supra} note 10, at 367-87.
The potential for a joint benefits approach has not gone unnoticed. For example, The Nature Conservancy, which has assumed a leadership role in this area, and three U.S. corporations have agreed to sponsor the Bolivian government adding 5 million acres of forest land to a national park as part of a plan to sequester carbon, preserve biodiversity, foster eco-tourism, and address other community values.98

But there is, as yet, no international agency assigned to administer such a joint product approach on a systematic basis. By and large, efforts to maximize the public good benefits of conservation operate independently, even when there may be overlapping benefits. For example, the CBD fosters conservation based on maximizing biodiversity.99 The Framework Convention on Climate Change (FCCC)100 supports measures aimed at mitigating climate change, which might include awarding carbon credits in proportion to standing forests.101 But while forests preserved through CBD efforts presumably mitigate climate change, and forests preserved through carbon credits presumably advance biodiversity, the exploitation of any joint benefit is ordinarily fortuitous.

This gap could soon be filled. A recent GEF proposal would authorize GEF to expend some $200 million for “integrated ecosystem and natural resource management,” that is, for plans that could, among other things, demonstrate “multiple global benefits.”102 This idea deserves support. The virtues of the strategy, however, are not as straightforward as might first appear, and implementation will require considerable ironing out. The problem stems from the fact that some of the multiple beneficial uses can be regarded as competing. For example, if we set out under a budget constraint to maximize for biodiversity, it is unlikely we would assemble the same acreage as would be assembled were we to maximize for carbon sequestration. Specifically, from the perspective of carbon sequestration, the


99. See CBD, supra note 69, art. 1.


101. See id. arts. 3, 12.

ideal is a fast growing plantation forest, which ranks low in biodiversity richness. On the basis of such considerations, Jeffrey R. Vincent and Clark S. Binkley have pointed out that given a number of forest areas to select from, the maximization of different values is more likely to be achieved not by multiple-use forests, which seek to optimize across a balanced set of values, $a$, $b$, $c$—but by selecting a value best suited for maximization in each of a number of forests. That is, ideally, we should dedicate Forest $A$ to the maximization of $a$, Forest $B$ to the maximization of $b$, and so on.103

The prospect that each of many areas will have a comparative advantage for one or the other variable suggests that, given an adequate supply of acreage to choose from, specialization would dominate. On the other hand, it is possible that there are potential synergies and even cost-saving opportunities, in the multiple-use strategy. For example, the transaction costs of acquiring and monitoring three separate parcels of 1,000 acres each are likely to be higher than the costs of acquiring and monitoring one 3,000 acre bundle. Moreover, the budget may itself be variable; there may be donors willing to fund multiple-use preserves who would not contribute if the only options were single-use projects. In other words, while there are ambiguities, there is good reason to expand conservation options to include some joint-benefit strategies. Doing so means there will be some cases where we will be able to make holders of forestland an offer that adds to the biodiversity value the value of jointly supplied co-benefits; because the offer to conserve will thus be sweetened, some acreage that otherwise would have been converted will be preserved.

G. Zone 7: Restricted Use and Other Taxes

Rather than to subsidize (that is, compensate landowners for not converting land that displays certain desirable properties),104 it is possible for national and local governments to dampen land conversion by taxing owners if they eliminate those properties. The ESA, which Harte discusses, can be viewed as a limiting case in which the tax is infinite, that is, conversion is simply prohibited.105 Taxing (or prohibiting) land use increases retention in an undeveloped state by making conversion more expensive.

104. See supra Zone 5, p. 992.
105. See Harte, supra note 1, at 943-45.
Moreover, taxes are essentially symmetrical with subsidies, in that any desired level of retention can be achieved either by subsidizing owners who leave their land unconverted or by taxing them if they do convert. This raises the question: under what circumstances might one prefer to conserve through subsidies\(^{106}\) rather than through "taxes"?\(^{107}\)

The considerations are too complex to confront fully, but I would like to indicate at least one factor that militates towards subsidies. The landowner, who faces a monetary tax— or "tax" in the form of foreclosed development opportunities—if a rare species makes an appearance, has no incentive to report its presence. He or she may indeed, as an illustration of Harte's suggests,\(^{108}\) prefer to "shoot, shovel and shut up."\(^{109}\) On the other hand, if the landowner faces a benefit in the form of payment for an environmental servitude, the incentive to eradicate is neutralized. Furthermore, total monitoring costs would, in all likelihood, decline. Under the tax system the burden falls largely on public authorities overseeing antagonistic landowners. Under a subsidy system, if the rewards are fair, the landowners should be agreeable to self-monitor for suffering conditions for which they will be compensated.

CONCLUSION

In the final analysis my sympathies are entirely with Harte. We are squandering the Earth's endowment of biological riches. That much follows from the almost universal failure to account for, or accurately to price, habitats that humankind crowds out, consumes, and eradicates. The widespread subsidization of biodiversity-winnowing activities, such as massive public support for fishing and agriculture, is an extreme illustration of doubtfully defensible "development" policies.

Should humanity acquire the will and understanding, we can retard much of the loss. One path is through technology, about which I am somewhat more optimistic than Harte. The second path is through the seven levels of legal-institutional

106. \textit{See supra} Zones 5-6, pp. 992-997.

107. For the purposes of this discussion we can include as a "tax" any legally imposed servitudes that lower the value of the affected land by inhibiting conversion.

108. \textit{See} Harte, \textit{supra} note 1, at 944.

reforms I have outlined. These, if implemented, will dampen the
consumption of living resources and their portfolios by more
accurately accounting for the costs and benefits of human
activity. The pressure to tear down a forest reflects the prices of
market measured products—of the timber and expected farm
produce; so, too, should we "price," on the other side, the various
goods and services of the forest left standing. So much has been
said often and well before. My legal-institutional analysis is
merely a useful way to sort out the policy options for further and
deeper discussion.

Most important, we should be mindful that the aim is to
safeguard ideally representative sets, whatever they may be.110
Although preservation of "hot spots" may represent an
acceptable foundation for biodiversity conservation, it is not,
alone, the optimal strategy. First, protecting areas is at best a
rough surrogate for protecting species or other attributes,
because the decline of an area is not directly proportional to the
decline of contained species. Second, the most species-rich (hot
spot) areas may be largely redundant in their offerings. If the aim
is to preserve not merely species favored in their own right, but
also to preserve wide sets of attributes ideal for portfolio
purposes, at some point we may have to trade off biodiversity-
rich areas for relatively sparse areas offering desired genetic
material or other attributes not available elsewhere. Moreover,
several distinct sets are defensible each on its own grounds,
such as a portfolio designed to minimize the risk of collapse of
cultivars crucial to human diet. Efforts supplemental to hot spot
policies will be required in order to fill "gaps." These efforts will
presumably be based on subsidy mechanisms or, more
problematically, on tax mechanisms. Whatever and wherever the
sets, institutions should be developed to assure universal, fairly-
priced access to the benefits.

To foster the collection of sets, I favor increased emphasis on
the complementary goods subsidizing strategy of Zone 6 even
though, by optimizing for joint goods, it is inherently sub-optimal
for expanding along any biodiversity metric. A collection of the
most biologically rich areas guarded under Zone 6 strategies
would have to be complemented by assemblies of land that,
although thinly populated overall, support species or genes not
represented in "richer" sets. Some of the supplemental effort will
almost certainly involve fostering ex situ collections and

110. See supra notes 33-34 and accompanying text, and the box "The Need for
Global Cooperation," supra p. 975.
appropriate technology. The optimal policy will be a highly mixed approach.

At the close, I regret the gaps in my presentation. I have emphasized throughout the need to retard "consumption" of biodiversity to a level adjusted to the most evident human needs—food, medicine, and so on. We can and should account for the prospective use values of biodiversity. But, as indicated, I find many of them—the pharmaceutical potential, most notoriously—to have been conveniently exaggerated. They have been exaggerated by well-intentioned academics, like myself—people who want to say more, but are not certain how to say it in the languages we train in, dominated, as they are, by the sturdy idioms of "use value" and welfare. To do justice to our worthier thoughts, we have to proceed across a sloppier terrain of awe and wonder.

An ecosystem— all of life's intricacies—are awesome and wonderful, the way the cave paintings at Lascoux, the Poseidon, the Sphinx, and the temples at Angkor Wat are awesome and wonderful. They enthrall. One wants to rejoin: there are many ecosystems, but only one cave at Lascoux, one Poseidon, and so on. But that is not quite right, either. There are many souvenirs of prehistory, many antiquities, but just as each is a wonderful and distinct souvenir or antiquity, so is each of the various ecosystems wonderful and distinct in its own right. We should react to the destruction of the Amazon with the same horror with which we receive news of cathedrals bombed in wartime.

The fact that biodiversity is so aptly likened to a library brings to mind a scene in George Bernard Shaw's *Caesar and Cleopatra*. During the battle for Alexandria, Shaw has a messenger come to Caesar quite agitated. Caesar is relieved to learn it is only the 'library burning' ("Is that all?") and wonders that anyone should "plead for a few sheepskins scrawled with errors." Caesar had a point. Most of what fed the Alexandrian flames must have been impractical nonsense; certainly nothing was lost in which moderns would have found the equivalent of good "leads" in the pharmacological sense. But we look back on their ruin as nonetheless a tragedy. Perhaps it comes down to, or goes back to, the claim that knowledge is a basic good—good for its own sake. Its loss is a bad. This is true even of the loss of knowledge that merely satisfies the curiosity, such as the knowledge of our predecessors' follies or of how extinct plants

112. See *John Finnis, Natural Law and Natural Rights* 59-76 (1980).
evolved. Granted, we cannot escape the question at the margin: When we have to choose, how many sources of awe, wonder, and so on are we to hang onto when the cost of hanging on reduces welfare as the majority would probably calculate it? Questions of incommensurable goods are never easy. But that is what our choices in this area are finally about: What planetary and ideational furniture will be our legacy?