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# REGULATING GLOBAL BIODIVERSITY: WHAT IS THE PROBLEM?

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# Regulating global biodiversity: what is the problem?

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**Abstract:**
We distinguish between local problems of biodiversity loss and *global* ones, where international cooperation is required. Global biodiversity regulation involves choosing the optimal stopping rule regarding global land conversions, in order to ensure that some areas of unconverted natural reserves remain to support the production sector that exists on converted lands. The basic difficulty with implementing a solution to this global problem lies in the asymmetry in endowments between those states that have previously converted, and those that have not. We demonstrate that the fundamental problem of global biodiversity regulation is similar to the *bargaining problem* analysed by Nash, Rubinstein and others. There are benefits from global land conversion, and there must be agreement on their distribution before the conversion process can be halted. Since the institutions addressing global biodiversity problems are either highly ineffectual (benefit sharing agreements, prior informed consent clauses) or very extreme (incremental cost contracts), the biodiversity bargaining problem remains unresolved. For this reason we anticipate that suboptimal conversions will continue to occur, as a way of protesting the ineffective and unfair approaches employed in addressing this problem to date.

**Keywords:** Global Biodiversity, International Environmental Policy, Nash Bargaining, Rational Threats

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## I. Introduction

Regulating *global* biodiversity fundamentally concerns the question of how much total habitat conversion we wish to undertake across the globe as a whole (Swanson, 1994). This is a distinct question from how each individual state might view the importance of conservation for its own purpose, or even for the benefit of others. Our question is focused on the impact of the aggregate level of land-based development on earth. This is a global question—from the sustainability perspective—concerning whether the earth's system can continue to extend highly productive land uses (such as agriculture and, hence, the associated human population) without reaching some sort of limit to the aggregate amount of this type of development that the earth's system can sustain. It is very similar to the questions raised in general at the 1992 Rio de Janeiro United Nations Conference on Environment and Development (UNCED)—how is global development to be made consonant with the global environment? In this article we examine the basic structure of the problem that is being addressed in this context, and the range of *international* policies that have been attempted. Finally, we examine why these policies have been less than wholly successful.[1]

We turn now to these issues. First, in section II we set out the stylized facts regarding development and biodiversity—what is the global problem that needs to be regulated? Section III presents the biodiversity regulation problem as a simple land-use model of North–South interdependence in the biotechnology sector, with biodiversity as a global public good. After establishing the efficient allocation we employ Nash bargaining theory to illustrate the factors that determine the cooperative solution within this framework. Section IV discusses the international policies for addressing this problem, the Convention on Biological Diversity and associated institutions, in light of the bargaining framework that we construct. Section V discusses why there are no lasting solutions in place for the global biodiversity problem. A conclusion follows.

## II. When is biodiversity regulation a *global* problem?

The regulation of global biodiversity concerns management of the ongoing practice of land conversion across the globe. This is a practice that commenced about 10,000 years ago, and has been targeted first at some continents and then at others. The first places to experience massive land-use change have been the more temperate areas (Europe, northern Asia, North America), and in some cases the land conversion that occurred long ago is near complete.[2]

[1] We are analysing the problem as one of halting global conversion, and then determining the incidence of such a policy, given that different countries have experienced more conversion than others (for a similar analysis in the context of the Montreal Protocol, see Swanson and Mason (2003)). We argue that the fundamental problem of global biodiversity is the incidence of a policy halting conversion at this juncture, and the perception of the relevant states concerning the unfairness of that incidence.

[2] For example, the proportion of Europe which is "unmodified habitat" (of at least 4000 sq. km. in area) is certifiably zero. In the U.S., the proportion of unmodified habitat of this dimension is down to about 5% of the American land mass. This is to be contrasted with a global average of about thirty percent. [World Resources Institute (1990)].

This has resulted in some striking asymmetries on earth. For one thing, the parts of the earth where the vast majority of biodiversity resides are few. The majority of species on earth are now believed to reside in the final three great tropical rainforest systems (Amazon, Congo, Indonesian). And most indicators of species' continued existence point to the same general locations and nations as the hosts of the remaining diversity.

**Table 1:** Countries with greatest 'species richness' (numbers of species)

| **Mammals** | **Birds** | **Reptiles** |
|---|---|---|
| Indonesia (515) | Colombia (1,721) | Mexico (717) |
| Mexico (449) | Peru (1,701) | Australia (686) |
| Brazil (428) | Brazil (1,622) | Indonesia (600) |
| Zaire (409) | Indonesia (1,519) | India (383) |
| China (394) | Ecuador (1,447) | Colombia (383) |
| Peru (361) | Venezuela (1,275) | Ecuador (345) |
| Colombia (359) | Bolivia (1,250) | Peru (297) |
| India (350) | India (1,200) | Malaysia (294) |
| Uganda (311) | Malaysia (1,200) | Thailand (282) |
| Tanzania (310) | China (1,195) | Papua New Guinea (282) |

*Source*: McNeely *et al*. (1990).

On the other hand, a quick look at the same states indicates that there is an interesting but inverse correlation between species richness and other forms of wealth. Many of the states that are among the wealthiest in terms of biodiversity are also among the poorest in terms of standard measures of income.

**Table 2:** GDP *per capita* (p.c.) in the diversity-rich states

| **Country** | **2003 GDP p.c. (PPP)** | **Country** | **2003 GDP p.c (PPP)** |
|---|---|---|---|
| Tanzania | $600 | Papua New Guinea | $2,200 |
| Uganda | $1,400 | Indonesia | $3,200 |
| India | $2,900 | Bolivia | $2,400 |
| Ecuado r | $3,300 | Colombia | $7,300 |
| China | $5,000 | Brazil | $7,600 |
| World average | $8,200 | | |
| OECD average | $26,300 | | |

*Note*: PPP is purchasing power parity.
*Sources*: World Bank, 2006.

This asymmetry between the holders of biodiversity assets and those holding other forms of assets demonstrates one of the basic problems of managing global resources—the asymmetry in endowments. It makes outcomes difficult to negotiate, when starting points are so far apart.

How did this asymmetry result? The fundamental cause is the order in which states have converted their lands. Some did so thousands of years ago (Europe), others hundreds of years ago (North America), and others over the past few decades (Latin America, south-east Asia). The globe has lost 4 per cent of its forested lands—to agriculture—over the past couple of hundred years. At the same time many of those countries that have

deforested, also advanced their agriculture and other industries dependent upon larger populations and urban densities.[3] In the long view, development has often been initiated with land conversion and agriculture. For this reason, it has long been the case that national incomes have gone up while forested areas have gone down.

From this viewpoint it is possible to view the problem of regulating global biodiversity as one of the regulation of global land-use conversion, where the external costs of conversion are increasing as the conversions continue apace. In this framework the concern over sustainability is that there may be a global—or aggregate—limit to the amount of conversion that could be incurred.[4] Figure 1 gives a depiction of a regulatory scenario for this problem of global land-use conversion. It is a problem of the un-internalized costliness of land conversions.

[INSERT FIGURE 1 HERE]

In Figure 1, the various types of biodiversity problems are segregated: local, regional, and global.

The *lowermost curve* in the diagram represents the perceived marginal cost (MC) of land conversion—as viewed from the perspective of the converting landowner (most often the state or private landowner with jurisdiction over the land).[5] The *dashed line* just above this curve concerns the more generalized or social MC of such land conversions, when the role of that parcel of land is considered as part of a larger eco-system. This social cost represents the local and regional externalities flowing from that particular piece of terrain being converted.

These local and regional costs may not be fully internalized to the decision-maker considering land conversion, because they might flow to the broader watershed community (who receive clean water from the unconverted watershed), or the broader forest community (who may desire a wider range of uses of the land concerned), or even the broader global community (who may hope for large unconverted land areas to support charismatic species, such as the panda or the elephant). These are the problems considered by groups who hope to internalize local and regional values of ecosystems to existing decision-makers (TEEB, 2010). The conversion of any piece of land will involve some externalities (given its role in other systems) but it will not matter much in which order the land is converted; the externalities are borne whenever that piece is lost. For this reason the external cost is represented by a simple vertical shift of the MC curve upwards (a constant cost to any piece of land converted, whenever it is converted).

[3] The development gains experienced by the set of countries undertaking conversion are easily listed, in terms of agricultural yields, income growth and general development status. In agriculture, during the period of the massive land use change during the "Green Revolution" (i.e. between 1960 and 1980), world cereal production grew at an average annual rate of 2.7%. (Hazell, P. and Anderson,J. 1989).

[4] We are defining the global problem of biodiversity as that problem that requires international regulation for its resolution. Many other facets of the biodiversity decline may be addressed through appropriate domestic regulation (e.g. watershed management) or bilateral transfers (e.g. payments for parks and protected areas).

[5] We show MC as declining over the entire range of land conversion but the same points (about various forms of externalities) exist if the MC begins to incline at some point in the process.

The problem of regulating global biodiversity is different from this 'local externality' problem, and concerns the potential limits to a particular development strategy, here the practice of land conversion (Swanson, 1995*b*). In Figure 1, this is represented by the uppermost MC curve—where the social marginal cost of continued conversion (beyond some limit) goes to infinity.[6] This rapidly escalating cost of conversion would be the case if there is, indeed, a limit on the total amount of global land-use conversion that is feasible—while retaining a relatively stable and resilient biological system that is capable of maintaining a life system within which humans can survive. [7]

Is sustainability really a problem in this context? There are several reasons why biodiversity may be critical to maintaining the entire production system. First, unconverted lands act as 'firebreaks', to reduce the rate of arrival of new biological problems (Goeschl and Swanson, 2003*a*). When such problems do arise, it is recognized that genetic resources play a crucial role in supplying the options or solution concepts within the life sciences industries Biodiversity does this by supplying genetic resources to R&D sectors supplying the life sciences industries (Sarr *et al*., 2008). It may be possible for technological advance to substitute for biodiversity resources in the long run, but at least at present (and certainly in the past) most problems in the life sciences were dealt with using existing genetic resources. (Swanson, 1995*a*).

Figure 1 also demonstrates the difficulty involved in halting the global land-use conversion process. States and private landowners perceive a marginal cost that enables conversion to take place—and the converted receive an uncompensated flow of benefits from the unconverted, providing further incentive to join the ranks of the converted.[8] If this process continues, the converted system continues to become more unstable and less resilient (as biological problems are a function of scale and contiguity), while the area of unconverted lands (from which solutions must originate) becomes smaller. (Goeschl and Swanson, 2003b). For this reason it is to be anticipated that there is a limit to this process of conversion, after which the costs of ongoing conversion goes to infinity, representing the instability of ongoing aggregate conversions.[9]

## III. Structure of the biodiversity bargaining problem: theory and case study

[6] Bringing to mind the comment attributed to Michael Toman on Constanza *et al.* (1997) that their estimate of natural capital's aggregate value at $33 trilllion dollars p.a. represented 'a very serious underestimate of infinity'.

[7] The global problem has more in common with the problem of climate change than the problem of ecosystem valuation. It is a question of determining whether there is a limit to conversion-based development.

[8] This is the case because the unconverted lands reduce the arrival of problems and provide solutions—but the benefits from these activities are realized by reason of increased production on converted lands.

[9] The global conversión process may continue through to complete conversión – in the scenario depicted in Figure 1 – on account of the privately perceived declining costs of marginal conversions. Usually one would anticipate - in the presence of some fixed factor - that the marginal costs of continued conversions would begin to climb, thereby bringing the conversion process to a halt at some point short of complete conversion. In Figure 1, the fixed factor that causes the MC to climb is the "natural global support system" necessary for sustaining agriculture. The problem demonstrated in Fig. 1 is that no individual or state perceives or receives the opportunity costs of these support systems. Without the recognition of individual impacts upon global systems, the conversión process continues through to completeness.

We have developed the very general argument that land conversion may have a global cost. We will look at a case study of agricultural conversion to demonstrate.

There is substantial evidence that converted agricultural habitats continue to rely upon unconverted ones for their sustainability. Modern high-yielding agriculture relies upon the conversion of lands to mono-cultural crops across large land areas for higher average yields, but also introduces greater variability into the production system. (Hazell and Anderson 1989) This is because these converted lands then provide large pay-offs to the natural selection of pests, parasites, and pathogens that feed well upon them (Goeschl and Swanson, 2003*b*). For this reason, the populations of well-adapted pests can be expected to grow rapidly in the converted areas, rendering the planted varieties unproductive in a matter of a few years (which may be 50–60 generations of pests and pathogens). Modern converted agricultural lands planted with high-yielding varieties must then have ongoing injections of diverse germplasm (genetic resources) from outside the converted area. Otherwise, a high-yielding commercial plant variety is commercially extinct in about 5–10 years on average, and the source of the solution to the pest problem will have to originate from outside the production system (Goeschl and Swanson, 2003*a*).

It is important for both parts of the world—converted (here, North) and unconverted (here, South) to cooperate in the production of global agricultural product through maintaining lands in both sectors, cultivated and natural. The problem is that the North generates the final product in this situation, but does so in reliance in part on the maintenance of a natural habitat sector in the South. Some sort of bargain must be struck in order to share the value of the product, in recognition of the joint production that is occurring. In order to address the problem of biodiversity decline (and provide for sustainability) it is necessary for North and South first of all to reach agreement on this distributional matter—the *biodiversity bargaining problem* (Barrett 1994).

### (i) Biodiversity and biotechnology: an example

The case study captures the asymmetries and mutual dependence in the agricultural plant-breeding sector in a stylized manner.[10] We move the analysis to the level of international bargaining by discussing the industry as consisting of two agents (North, South) who are distinctive in three fundamental respects: capital endowments, industrial structures, and land-use choices. The asymmetry in capital endowments refers to the relative richness of the North in human capital but poverty in natural (genetic) capital, while the South retains its relative richness in genetic capital but without a very rich human capital base. The industrial structure refers to the unique existence of an R&D sector in the North specialized in the production of intermediate goods containing embedded innovations, in contrast to the focus on primary production in the South. The distinct land-use choices refer primarily to the South's unique capacity for supplying a biodiversity reserve sector, but also to the fact that the South's alternative land uses include both an intensive agricultural sector that is technology-dependent and a traditional sector that is not; whereas the North's land uses are relatively undifferentiated and involve mainly various forms of modern intensive agricultural production.

[10] The following section outlines the analysis taken by Gatti *et al*. (2011).

These asymmetries give rise to a coordination problem associated with the mutual interdependence between the North and South. In Figure 2 the arrow running from the reserves sector to the agricultural biotechnology sector reflects that the North uses its relatively abundant human capital within its R&D sector in combination with genetic resources from the South to produce intermediate goods within which innovations are embedded. However, the North has no land-use choice regarding the retention of genetic resource reserves (as losses of genetic resources are irreversible) but only has choices over different productive uses of its own agricultural lands, one use employing the intermediate goods from the R&D sector and the other not.[11]

[INSERT FIGURE 2 HERE]

The South, on the other hand, has a natural capital endowment of reserve lands (*R*) endowed with diverse genetic resources which produce a flow of information which is useful when embedded within the intermediate goods of the R&D sector of the North. The South's land-use choice consists of both reserve retention and two methods of agricultural production, one of which uses the intermediate goods from the North, *s* (arrow running from North to South in Figure 2), and the other traditional production, *t*, which does not.

The transfer of genetic material from South to North, and the transfer of technology from North to South, captures the mutual interdependence arising from these regional asymmetries.[12] The extent of the transfer of these resources depends on the extent of cooperation between the two regions. The global problem now becomes one of optimal allocation of land in the South to reserves, and hence the supply of genetic material to the enhance productivity in the North, and the optimal allocation of technology transfer to the South. Of course, the expansion of intensive agriculture in the South is a means by which cooperative surplus might be shared between the North and the South, but this strategy is potentially in conflict with the objective of retaining maximum amount of genetic resources for the R&D sector. The problem we examine is how the North and

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[11] Gatti *et al*. (2011) represent the northern land endowment as $L_N$ and the output as $y_N = \pi(R)n + b(L_N - n)$, where $\pi(R)n$ is the production function in intensive agriculture which captures the North's dependence on reserves *R* as a productivity-enhancing input, since $\pi(0) = 1$ and $\pi'(R) > 0$. The costs of R&D are assumed to rise with the quantity of the intermediate output, i.e. $c(ns)$. The North can also make a transfer payment, $T$, to the South. Northern utility is then given by: $U_N(n,s,t) = (\pi(R) - b)n - c(n+s) - T + bL_N$.

[12] The South is endowed with land, $L_S$ which is originally rich in genetic material. It can be maintained as Reserves with area $R$, or converted to either a traditional sector, $t$, or to an intensive agricultural sector using seed imported from the North, $s$. The traditional sector incurs a labour-related cost $k(t)$ ($k(0) = 0, k'(\cdot) > 0, k''(\cdot) > 0$). Lastly, land can be used in an intensive sector which, like in the North, is augmented by the presence of Reserves, $R$: $\pi(R)s$. Therefore, Southern utility is then given by: $U_S(n,s,t) = \pi(R)s + t - k(t) + T$, where *T* is any transfer from the North.

South might simultaneously determine land uses to maximize global surplus and distribute this surplus within such an asymmetric bargaining environment.[13]

This defines the asymmetric environment over which bargaining can take place in relation to global biodiversity and raises one fundamental question: how should the shares of the parties be determined in order to allow joint production (cooperation) to proceed? In order to answer these questions we describe the *biodiversity bargaining problem.*

**(ii) The framework of the North–South biodiversity bargaining problem**

We now place the biodiversity bargaining into the general structure of the bargaining problem, as defined in the literature stemming from Nash (1953) and Rubenstein (1981). The outcomes of any bargaining problem among rational agents are confined by two important limits: the conflict point and the bargaining frontier. These measure the outcomes for each agent in the absence and presence of cooperation. The conflict point provides the benchmark against which all bargaining solutions are measured, whereas the bargaining frontier represents all possible distributions of the cooperative surplus between the negotiating parties. Figure 3 provides a general illustration of this framework.

[INSERT FIGURE 3 HERE]

**Figure 3:** A bargaining game—defined by conflict point and cooperative frontier

On each axis is measured the outcomes for two agents, here the North and South, in terms of 'utility': $U_S$ and $U_N$. The conflict point reflects their respective levels of utility in the absence of cooperation, and is represented by point $U^a$. In this case the North and South receive low levels of utility given by $U_N^a$ and $U_S^a$ respectively. The bargaining frontier is shown by the thick black line running between $\left(U_N^E, U_S^a\right)$ and $\left(U_N^a, U_S^E\right)$. Rational agents will not accept any bargaining outcome with a lower pay-off than at the conflict point, since non-cooperation is always available to them. The limit of the cooperative possibilities is give by the bargaining frontier. These points define the limits of the bargaining possibilities. (In Figure 3 we illustrate how two such bargaining games might be defined around distinct conflict points—each conflict point defining a completely distinct game.)

We are interested in the outcome of the bargaining game described above over global biodiversity. So how is the conflict point and the bargaining frontier defined in this case? We assume that the conflict point is an autarkic state in which there is no exchange of biotechnological outputs—that is, new plant varieties—and no transfers are used to transfer any surplus or contract over or coerce land allocations. When cooperation fails, the South benefits only from traditional agriculture. Reserves which contain genetic material are simply a residual land allocation since the South does not

[13] As will become clear, this is in effect an assumption of a linear bargaining frontier with perfect transfers of surplus. Miller *et al*. (2000) discuss some of the implications of this assumption in relation to the Pacific Salmon Treaty. We avoid this discussion here.

internalize their value embedded in new technologies or receive any related payments. For this reason there is under-supply of the global public good.[14]

The North, on the other hand, still benefits from the presence of any residual reserves ($R$) due to spillovers arising from their public-good nature. So, despite being autarkic, the non-excludable nature of genetic resources contained in the reserves is captured in this solution. Modelling the conflict point in this way captures the fact that the North is dependent upon the South's selection of reserves to generate productivity in the intensive sector, while the South has no reason to supply reserves in the absence of a flow of intermediate goods or contracted payment from the North. Acting in isolation, the South makes land-use decisions which lower the marginal productivity of the North's intensive sector, ($n$). This stylization of the conflict point represents the solution in the absence of a cooperative agreement, with the South undersupplying reserves since it has no reason to consider the positive externality on the North, and the North benefitting from Southern biodiversity as a spillover from residual lands only.

This allows us to define the bargaining frontier as the solution to the 'social planner problem': the integrated or cooperative solution for this industry. This is akin to solving the production problem of a single vertically integrated industry in which the issues of sovereignty and asymmetry are ignored, and all cooperative opportunities are exploited. The solution maximizes the global surplus and the bargaining frontier, then reflects all the Pareto efficient shares of the global surplus between North and South. This is shown by the thick line between $\left(U_N^E, U_S^a\right)$ and $\left(U_N^a, U_S^E\right)$ in Figure 3.[15] The triangle formed by the bargaining frontier and the conflict point is called the bargaining set, and reflects all the possible cooperative agreements that could arise, making each party at least as well off as in conflict.

Given the positive social value of genetic diversity in the biotechnology sector, the globally efficient solution would result in more southern land allocated to reserves than under autarky ($R^* > R^a$). In short, to attain the Pareto optimal bargaining frontier requires greater levels of conservation.

In some instances these regions specialize completely, with the South specializing in the provision of reserves, and the North in R&D and intensive production.[16] Specialization here results from the fundamental asymmetries: the fact that only the South can provide reserves, while the value from intensive production may be pursued in either region. Although both are necessary for the production of joint surplus, under these conditions the emphasis is on the South providing that which only it can provide (i.e. reserves). This is indicative of the importance of cooperation in this context: when acting separately, each pursues a similar mix of relatively unproductive activities; when acting cooperatively, the two generate a vertical industry in which the South specializes in reserves and the North specializes in final production. The incentive to cooperate is

[14] We assume that the North and the South are single entities. This reflects the idea that the countries in the South are sufficiently large to influence the North in the bargaining solution.

[15] The social planner problem is defined as follows (Gatti *el al.*, 2011):

$$\max_{n,s,t} U(n,s,t) = U_S + U_N = \pi(R)(n+s) - bn + t - c(n+s) - k(t) + bL_N$$

$$s.t.\ R = L_S - s - t \text{ and } l = L_N - n \text{ and } s,n,t,l,R \geq 0$$

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found in the enhanced productivity emanating from the industry. We turn now to defining the level of that cooperative surplus.

**(iii) The cooperative surplus**

In terms of Figure 3, the optimal welfare under the social-planner solution is given by any value of $U_S + U_N$ on the bargaining frontier. Suppose that negotiations result in an agreement at $U^*$. In that case optimal welfare is given by $U^* = U_N^* + U_S^*$. A comparison with the outcomes of the conflict point provides a definition of the cooperative surplus, $U^C$, as the difference between the welfare under the social planner and that under autarky, $U^C = U^* - \left(U_N^a + U_S^a\right)$. Since the social planner is always able to select the autarky/non-cooperative outcome, it is safe to say that the social planner solution will yield positive gains from cooperation: $U^C \geq 0$.

Now that the nature of the biodiversity bargaining problem has been established, the indeterminacy of the solution is obvious. Each one of the points along the efficiency frontier can be sustained as the Nash equilibrium of a cooperative bargaining game. We turn now to the theoretical solutions to this problem and then to their relation to existing institutions.

**(iv) The Nash solution—agreements on distributional rules or norms**

Now that we have laid out the fundamental structure of the biodiversity bargaining problem, we can move towards a discussion of how the resolution of this problem might be determined. To this end we first illustrate the family of solutions to a conventional Nash cooperative bargaining game (NCBG). In Nash cooperative bargaining theory, there are primarily two determinative characteristics of the outcome to any bargaining game: (*a*) the parties' respective conflict points; and (*b*) the parties' respective bargaining powers. The key insights from the Nash bargaining solution are first that rational agents will attain a Pareto optimal solution. That is, they will agree on some point on the bargaining frontier such as $U^*$ in Figure 3. This indicates the set of outcomes that can be eliminated from consideration. Second, the specific solution depends on the bargaining power of the respective parties. If bargaining power is not determinate, then any point on the bargaining frontier can be a solution to an NCBG.[17]

Bargaining strength may derive from many factors that are characteristic of the agents. The parameter $\alpha$ represents a 'sharing rule' or norm that determines the share of the overall cooperative surplus that will accrue to each party. In the original Nash formulation, in which individuals were considered, the sharing norm was implicitly

[17] Formally, the general solution to an asymmetric NCBG is given by the maximization of: $(U_N - U_N^a)^{\alpha}(U_S - U_S^a)^{(1-\alpha)}$ s.t. $U_N + U_S = U^*$, where the parameter $\alpha \in [0,1]$ is an index of relative bargaining power. The outcomes of this bargaining problem for the North and the South are then: $U_N^* = (1-\alpha)U_N^a + \alpha(U^* - U_S^a)$ and $U_S^* = \alpha U_S^a + (1-\alpha)(U^* - U_N^a)$. See, for example, Nash (1953).

assumed to be 50:50.[18] Various norms have been adopted in international negotiations over rivers, fisheries, and other resources (Barrett, 2002). The main point is that some sort of norm or agreed sharing mechanism must be observed in order to achieve a resolution to the bargaining problem. The 'sharing rule' must be accepted by both parties (or able to be imposed by one) in order to be a lasting resolution. We term this a 'fair' resolution to the bargaining game (and return to this discussion in section V).

**(v) Sealing the deal: contractual solutions to rational bargaining**

To settle on the outcome is not enough in practice, of course. To uphold the solution will require the conclusion of some sort of a contract between the North and the South, and the agreement of its terms. This contract will then specify the precise point within the NCBG that is agreed to be the implemented outcome.

The 'general' contracts of implementation must specify the efficient land allocations and contain a number of transfers to place the parties at the indicated point along the bargaining frontier. Assuming the North offers a contract to the South, for instance, the contract would contain three components. First, the North, as residual claimant, claims the surplus accruing in the South from the intensive agriculture sector. Second, the South is compensated for the costs of participation in the agreement. This involves compensation for the lost output from the traditional sector incurred as a consequence of the efficient, rather than autarkic, land allocation. Together these two components place the South back at the conflict point in terms of welfare, albeit with efficient land allocations. In Figure 3 this is reflected by a point such as $\left(U_N^*, U_S^E\right)$. Lastly, the contract must contain a component which transfers the agreed share of the global surplus back from North to South.[19] An analogous contract can be specified for the same agreed bargaining solution, only with the South as residual claimant.

There are, of course, two *special cases* of this general contract which reflect the complete absence of bargaining strength for one or other party. These 'extreme point' contracts, in which one or other party receives the entire cooperative surplus would simply place the South at point $\left(U_N^*, U_S^E\right)$ in Figure 3 if it had no bargaining strength, or North at point $\left(U_N^E, U_S^*\right)$ in the opposite case.[20] Therefore, extreme point contracts support distributions that correspond to the limits of the bargaining frontier, in which one party is devoid of all bargaining power $\left(\alpha = 1 \text{ or } \alpha = 0\right)$, and such contracts must only satisfy the participation constraint: the contracted pay-off must be greater than or equal to the conflict pay-off $\left(U_S^a, U_N^a\right)$.

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[18] See, for instance, Bowles and Gintis (2000), who discuss norms in the context of the ultimatum game. Here large deviations from a 50:50 split are frequently rejected.

[19] Gatti *et al.* (2011) specify the general North–South contract as follows:

$$T_N(t) = \underbrace{\int_t^{t^a} \left[1 - k(z)\right] dz}_{\text{Compensation for costs of participation: Lost traditional production.}} \underbrace{- \pi(L_S - s^* - t)s^*}_{\text{Residual claimant (North) repatriates surplus}} \underbrace{+ (1-\alpha)U^C}_{\text{Residual claimant transfers agreed share of cooperative surplus}}$$

[20] The extreme point contract supporting $\left(U_N^*, U_S^E\right)$ in Figure 3 is therefore: $T = T_N(t) = \int_t^{t^a} \left[1 - k'(z)\right] dz - \pi(L_S - s^* - t)s^*$.

It is important to realize that all of these contracts are in fact 'efficient' in the sense that they allow the agents to attain the bargaining frontier. It is obvious, however, that not all international negotiations are approached and resolved by reference to a rational bargaining process, or lead to an obvious solution to the bargaining game. So, although any point on the bargaining frontier is, indeed, an efficient solution to the game, it might not be a 'fair' one in the sense of achieving a lasting resolution to the bargaining problem. We return to the delineation of the determinants of this distinction in section V.

## IV. Addressing the biodiversity bargaining problem: international policies

### (i) The Convention on Biological Diversity and national sovereignty

Now that we have set up the problem of regulating global biodiversity as a Nash bargaining problem, it is straightforward to analyse the observed outcomes within the perspective afforded by this framework.

The main international agreement concerning biodiversity conservation is the Convention on Biodiversity (CBD). The issue of providing for shares is a fundamental principle of the framework convention. Indeed, 'benefit sharing' is the third objective of the Convention on Biodiversity:

> the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and how benefits are shared based on a set of agreed norms and principles derived from ethics and equity. (UNEP, 2008)

In addition, the preamble of the CBD makes clear that genetic resources represent the sovereign resources of individual states, and removes any question regarding the possibility of unlicensed expropriation or global free-riding. The preamble of the CBD provides that domestic regimes have absolute sovereignty over their genetic resources. Article 3 provides that 'states have . . . the sovereign right to exploit their own resources pursuant to their own environmental policies'. Article 9 provides that any use of or access made to a state's domestic resources must be in accord with the principles of informed consent and equitable benefit sharing. Hence, the first point to make is that the CBD does emphasize at its core the importance of addressing and resolving the biodiversity bargaining problem.

### (ii) An international fund mechanism for biodiversity?

The Convention on Biological Diversity also addresses the question of the mechanism by which this sharing is to be accomplished. This is provided for in sections 2 and 4 of Article 20 of the CBD, as below:

> 2. The developed country Parties shall provide new and additional financial resources to enable developing country Parties to meet the agreed full incremental

> costs to them of implementing measures which fulfil the obligations of this Convention.
>
> 4. The extent to which developing country Parties will effectively implement their commitments under this Convention will depend on the effective implementation by developed country Parties.

The mechanism by which such transfers are to occur is also indicated under the terms of the Convention. It further provides in section 1 of Article 21 that: 'There shall be a mechanism for the provision of financial resources to developing country Parties for purposes of this Convention on a grant or concessional basis the essential elements of which are described in this Article.'

These provisions of the CBD create the potential for a financial mechanism by which North–South transfers might occur. To some extent, this mechanism has come into existence through grants under the Global Environment Facility (GEF), but no independent 'green development mechanism' has yet to come into existence (King, 1994). To this point transfers under the aegis of the CBD continue on a more *ad hoc* basis.

More crucially for our purposes, the motivational principle under this part of the convention is about compensation of costs. This approach misconceives the basic nature of global public-good provision. The CBD describes the reason for payments to those states providing biodiversity services as one of compensation for burdens undertaken, not of the sharing of surplus generated. In the next section we provide the reasons why this is not the correct approach to the problem of biodiversity regulation.

**(iii) Incremental costs contracting: an 'extreme point' contract**

The contractual solution applied to the biodiversity bargaining problem can be found under the terms of the CBD and its financial instrument the (GEF in the form of the concept of *incremental costs* (IC): '[the North] *shall provide new and additional financial resources to enable* [the South] *to meet the agreed full incremental costs to them of implementing measures which fulfil the obligations of this Convention*' [Art. 20, CBD].

The meaning of the term 'incremental costs' is further defined within the founding instrument of the GEF as:

> [the costs of] additional national action beyond what is required for national development of [the baseline] that imposes additional [or incremental] costs on countries beyond the costs that are strictly necessary for achieving their own development goals, but nevertheless generates additional benefits that the world as a whole can share.[21]

So, where does the IC contract place the negotiating parties in the bargaining set? In terms of the preceding analysis, the IC contract requires the North to compensate the South for the additional costs it incurs by electing the cooperative development path

[21] GEF/C.7/Inf.5: para.2 & GEF/C.2/6 para.2, see King (1994).

rather than its baseline development strategy.[22] (Cervigni 1998) There is no allusion to or provision for enhanced sharing by the South in the cooperative surplus by reason of this election, but only provision for the compensation of its costs incurred to generate additional benefits that the world as a whole can share. Importantly, neither does the contract condition payment on the level of the South's reserves.

In short, the IC contract does not bear any of the hallmarks of the efficient contract that would be anticipated to arise out of a resolution of the NCBG. Instead, the IC contract is a straightforward offer of the extreme point contract, in which the North offers the South compensation for its costs incurred in participating in the cooperative outcome. In terms of Figure 3, the IC contract places the parties at point $\left(U_N^*, U_S^E\right)$, in which the North receives the entire global surplus.

Of course, the IC contract is, on the face of it, cost effective. That is, it appears to obtain the biggest 'bang for the buck', since the North pays the lowest possible level of compensation to the South. (Labatte, 2008) The question for analysis is whether such a bargain—albeit efficient—can, indeed, be a final resolution to the biodiversity bargaining game. We return to this question in section VI.

**(iv) Access rights and ABS—can property rights solve this?**

As mentioned above, the third objective of the CBD is to ensure benefit sharing in accordance with some international norms. As mentioned above, Article 9 provides that any use or access made to a state's domestic resources must be in accord with the principles of informed consent and equitable benefit sharing. Article 15 provides for the idea that traditional knowledge and information is to be compensated. The Bonn agreement of 2004 outlines mechanisms and instruments (such as up-front payments, revenue-sharing rules, and royalties) that can be used to facilitate benefit sharing. It is widely agreed that these mechanisms are very much in their infancy in terms of efficacy (UNEP, 2008). [23]

This is a private or market-based approach to creating a negotiated solution to the bargaining problem.[24] North and South can solve this problem at many different levels, one of which might be through negotiations between private firms in the two spheres. Such an approach hinges upon the agreement of a transaction regarding joint production, based on property rights transfers between each.

The basic difficulty with a property rights-based resolution is that there are no agreed property rights at the international level with regard to natural biological materials—and this means that firms in the South have no foundation from which to negotiate. To obtain internationally recognized property rights to the information contained within biological materials it is necessary either to improve them, or, at a minimum, to demonstrate the scientific process or method by which they may be used to generate an

[22] In terms of the model, choosing the efficient land allocation, $t^*$, rather than $t^a$.
[23] Too often a genetic access regime is more like a legal checklist than a licensing agreement.
[24] In general there is nothing inefficient about having private bargaining determine the distribution of benefits resulting from the achievement of the socially optimal outcome *à la* Coase (Coase, 1960).

innovation.[25] Without a recognized property right, bargaining cannot commence (Sarr and Swanson, 2011).

So, for these reasons, it remains difficult to initiate any sort of private bargaining over joint production with genetic resources. This will be the case so long as rights in the informational values of natural capital are non-existent (Swanson, 1995*a*). Even if these rights are established, the private approach to bargaining must necessarily remain only a partial solution. While these private values are thought to be significant they do not capture the full social value of the stock of genetic resources arising from its ability to overcome well-known phenomena associated with pathogen adaptation and resistance.[26]

### (v) Whatever next? The Nagoya Protocol on benefit sharing

Most recently—in the 2010 CBD Conference of the Parties held in Nagoya—the parties proposed the text for a new Protocol on Access to Genetic Resources and Benefit Sharing (the Nagoya Protocol). This Protocol makes more explicit many of the terms previously contained within the Articles of the Convention.

For example, the Nagoya Protocol Article 5 on Fair and Equitable Benefit Sharing provides in part as follows:

> In accordance with Article 15, paragraphs 3 and 7 of the Convention, benefits arising from the utilization of genetic resources as well as subsequent applications and commercialization shall be shared in a fair and equitable way with the Party providing such resources that is the country of origin of such resources or a Party that has acquired the genetic resources in accordance with the Convention. Such sharing shall be upon mutually agreed terms.

Similarly, Articles 6 and 7 of the Protocol provide that the access to genetic resources and traditional knowledge should be regulated by each party, and that it should occur on the basis of prior informed consent.[27] Prior informed consent (PIC) is a doctrine that is important to use in any context in which private bargaining is taking place over social values. For example, in the original context in which PIC was used (acceptance of hazardous waste shipments), it makes a lot of sense to create a structure whereby the state is informed about the transactions being undertaken by any private agents capable of having a substantial impact upon social outcomes. It simply provides the mechanism by which a state is informed about such private negotiations, and is given final authority over the conclusion of such private negotiations (and the information under which to

[25] The CBD creates an internationally recognized right to the physical genetic resources themselves, but is silent on the question of the informational values that originate from such resources. Since information flows freely, it is a relatively straightforward matter to become acquainted with that information without the transfer of physical materials themselves. (It is akin to becoming acquainted with the recipe, without having to take possession of the cake itself.) A large amount of effort has been expended upon the creation of analogous rights in information from purely genetic resources from agricultural plant breeding—so-called Plant Breeders' Rights—but very little effort has been made to resolve the problem of unrecognized rights in useful biological resources more generally.

[26] On the social value of biodiversity see Goeschl and Swanson (2002), Sarr *et al*. (2008).

[27] The doctrine of 'prior informed consent' was first developed in the context of the Basel Convention on Transboundary Shipments of Hazardous Wastes and provides the basis for bargained-over solutions within an environment of complete and shared information.

undertake its own decision-making process).

The difficulty with establishing a well-informed bargaining environment within which negotiations are to occur is that there remains nothing as yet over which to bargain. As described in the preceding section, the basis for bargaining would have to be a recognized right to the information emanating from natural genetic resources (prior to improvement) and this does not yet exist. Informed bargaining is important once the foundations for bargaining are already in place. This is not yet the case with regard to the informational values of genetic resources.

Another approach is taken to the biodiversity bargaining problem in Article 10 of the Nagoya Protocol. That Article is entitled 'A Global Multilateral Benefit Sharing Mechanism', and provides as follows:

> Parties shall consider the need for and modalities of a global multilateral benefit-sharing mechanism to address the fair and equitable sharing of benefits derived from the utilization of genetic resources and traditional knowledge associated with genetic resources that occur in transboundary situations or for which it is not possible to grant or obtain prior informed consent. The benefits shared by users of genetic resources and traditional knowledge associated with genetic resources through this mechanism shall be used to support the conservation of biological diversity and the sustainable use of its components globally.

No concrete details emerged on the mechanism. The creation of a benefit-sharing mechanism is one issue that continues only in the abstract of biodiversity bargaining. The intimation in Article 10 is that we should await the establishment of a Protocol to the Protocol for the establishment of this fund.

In short, the Nagoya Protocol has yet to add anything of real substance to the previous solution concepts under the CBD. The fundamental problem of using private bargaining as a resolution concept lies in the absence of internationally recognized rights in the informational values flowing from unmodified genetic resources. The Nagoya Protocol has created a more formal structure for making access to such resources, but it has done nothing to address the fundamental property right failure that lies at the base of this problem.

### (vi) Outside the box? The use and usefulness of REDD

One of the more substantial efforts to deal with the creation of a mechanism for managing deforestation and land conversion remains 'outside the box'; it is the so-called programme for the reduction of emissions from deforestation and land degradation (REDD). REDD had its initiation in the Bali Declaration at the United Nations Framework Convention on Climate Change (UNFCCC) conference there in 2007 (COP13). At that meeting a roadmap was agreed for the adoption of a Bali Action Plan for compensating forested countries for activities designed to prevent their deforestation or degradation. The Copenhagen Accord of December 2009, adopted at COP15, then incorporated the recognition of a responsibility of developed countries to compensate developing countries for the avoidance of deforestation and degradation. A formal resolution was then adopted at COP16 providing for the establishment of *avoided deforestation* as one of many acceptable mitigation strategies under the

UNFCCC. This constituted the formal initiation of the so-called REDD+ programme of mitigation measures.

This has resulted in a plethora of international programmes targeted at the creation of mechanisms for transferring funding from developed to developing countries, in return for credits to be usable under an emissions-restriction programme under the UNFCCC. Much of the activity is still within the pilot phase of these programmes, but the basic outline of transferring funds in exchange for carbon credits is clear. The precise mechanism for ascertaining baselines, or determining the level of credit achieved, remains to be determined; however, the idea of paying for non-deforestation is becoming entrenched via these REDD programmes.[28] It is stated on the UN REDD+ site that it is hoped that US$30 billion should be transferred annually from developed to developing country parties under the auspices of the REDD+ non-deforestation programmes.

REDD+ is a programme that has developed out of a very different set of motivations for the prevention of deforestation, relative to the biodiversity regulation problem. It is a programme based on the observation that approximately one-quarter of all carbon emissions result from deforestation rather than fossil fuel consumption. This means that it is critical for any solution to the climate change problem to incorporate some means for regulating land use as well as fossil fuel use, in order to control carbon releases.

The primary problem with REDD as a biodiversity regulation mechanism is that it is an instrument that is targeting a related but not perfectly correlated objective, i.e. the sequestration of carbon in the biosphere. There are many examples of carbon sequestration schemes that would, in fact, be entirely destructive of biodiversity goals while advancing carbon sequestration, e.g. seeding of oceans. There are even examples of schemes that would advance forestation while diminishing diversity, e.g. mono-cultural plantation forestry. These are extreme examples, but illustrative of the fact that the two goals do not necessarily go hand-in-hand.

In general, all policy economists know that it is best to have as many instruments as there are objectives being pursued. If the goal is to pursue both maximum carbon sequestration in the biosphere *and* maximum biodiversity, then the best way to do so is to have an instrument targeting each individually.

Of course we live in the world of the second-best, and so the real question for consideration is whether REDD+ is a mechanism that might potentially afford the needed mechanism for doing deals in non-conversion. That is, could the problem of a global biodiversity regulation mechanism be shoe-horned on top of this mechanism created for the purposes of carbon sequestration?

First, the problem is one of identifying the correct bargaining frontier of the problem that is being confronted. States that are attempting to purchase the development rights of others with regard to fossil-fuel-based development are purchasing one thing. States that are attempting to purchase the development rights of others with regard to land conversion are purchasing another. We would argue that both the bargaining frontiers exist and are distinct from one another. The distributional problems to be resolved are

[28] Examples of the facilitators of various REDD programmes include: UN REDD; GEF; Norwegian Forestry Plan.

two—one concerns the value of the life sciences industries and the other concerns the value of fossil-fuel-based industries. There is a natural inclination to want to combine the two problems—since the purchase of non-conversion rights is one possible solution to both—but this both conflates two distinct bargaining frontiers as well as unnecessarily narrowing the range of potential solution concepts for carbon sequestration.

In short, if the problem is biodiversity, then it makes sense both to fashion its own instrument and to face its own bargaining frontier. REDD appears to be an attempt to hit two targets with a single payment, i.e. to purchase two objectives at the price of a single transfer. There may be a very small set of lands where the optimal use is both carbon sequestration and biodiversity conservation, but in general it is likely that the two goals will lead towards very different targets.

## V. Reframing the game: rational threats as a response to unfair bargaining

The litany of unproductive approaches to the biodiversity bargaining problem should make clear that the authors believe that little if any real progress is being made towards the underlying problems of global biodiversity regulation. So what? What if the countries are not yet ready to get serious about real bargaining over biodiversity (or real solutions to the bargaining game)?[29] In this section we describe the uncooperative outcomes likely to result when unfair bargaining is pursued.

### (i) Rational threats

Nash (1953) addressed this issue in his seminal contributions to bargaining, in addressing the notion of so-called *rational threats*. Let us reconsider the way in which the South might respond to the imposition of the IC. In terms of the bargaining framework, the IC contract leaves the South indifferent between cooperation and non-cooperation. Indeed, the South is free simply to revert to 'autarky' and select the conflict point—it is indifferent between all of these outcomes. But are there any strategies or responses available to the South that can improve on this outcome? By analysing this negotiation from a bargaining perspective it is possible to show that the answer to this question is to be found in the asymmetries between the North and the South.

First, note that the sharing norms or bargaining power shown to be important by bargaining theory, and represented by the parameter $\alpha$, determine the solution on the bargaining frontier from any given conflict point. However, in the case of the Nash solution, the ability to shift the conflict point by one or other party confers the ability to 're-frame' the bargaining game to their own advantage. Nash (1953) analysed precisely this type of problem in which shifting the conflict point, or threatening to do so, can be

[29] Inequitable distributions such as this are frequently at the bottom of non-cooperation, as in the case of the Pacific Salmon Treaty, the European Sulphur Protocols of the late 1980s, and so on (Miller *et al.*, 2000).

a rational bargaining strategy.[30] In short, the ability to reframe the bargaining problem represents another form of bargaining power.

More specifically, one feature of many solution concepts to bargaining games, including the NCBG, is that the value received by one player, say the South $\left(U_S^*\right)$ is not only increasing in the value of any outside option available to that player, that is, the conflict outcome $U_S^a$, but it is also increasing in the maximum value of cooperation to the *other* player, the North $\left(U_N^* - U_N^a\right)$. In essence, any actions available to one player that can increase the value of cooperation to the other player,[31] without a negative impact upon their own outside option, increase the pay-offs to that player within the cooperative bargaining game. In essence, such a strategy would reduce the other player's potential benefits more than their own, if the game were to be played non-cooperatively, and so makes it possible to use this threat as the basis for more power within the cooperative game. Figure 4 illustrates how this might work. In this case the South now threatens to push the conflict point from $U^a$ to $U^D$, reducing the North's conflict pay-off without affecting its own. Reframed in this way, the Nash solution now becomes $\left(U_N^T, U_S^T\right)$ which confers a greater share of the global surplus to the South. Such threats are not made because of an interest in the conflict outcome, but rather because of their impact on the agreed bargaining solution.

[INSERT FIGURE 4. ABOUT HERE]

**Figure 4:** The bargaining problem with strategic threats

So, how is bargaining power of this type distributed in the case of global biodiversity? Our portrayal of a 'gene rich' South and a 'technology rich' North is one of specialized yet interdependent regions. At first glance it would appear that the asymmetric endowments would result in equivalent and reciprocal threat capacities: the North could threaten to reduce R&D, while the South could threaten to limit the supply of reserves,[32] resulting in no real bargaining advantage. However, this ignores the question of credibility. In any application of the NCBG, parties must be able to commit to their threats, via irreversible actions.[33] One obvious means of making a credible commitment

[30] The strategic use of rational threats to maximize pay-offs in this way was first analysed by Nash (1953) but has been extended in the cooperative bargaining literature in several directions. Whereas Nash's 1953 paper looked at the role of threats in improving the bargaining outcomes on the efficient bargaining frontier, more recent work in cooperative game theory has focused on dynamic games, with inefficient outcomes such as equilibrium unemployment and, *inter alia*, strategic destruction of the bargaining surplus. Indeed, Busch *et al*. (1998) examine the equilibrium strategies arising from an asymmetric case in which one party has the capability of credibly destroying the cooperative surplus. Such an asymmetry is likely to be unusual in real bargaining problems and yet, as we explain below, appears to be precisely the asymmetry that exists in the context of North–South bargaining over global biodiversity. That is, the asymmetry of capital endowments may well mirror the bargaining structure, and consequently bargaining power, elaborated by Busch *et al*. (1998).

[31] Or, equivalently, increase the costs of disagreement.

[32] Parallels can be easily drawn between this type of threat for the North and the trade restrictions and limitations on technology transfer that have been the focus of the strategic trade literature (e.g. Krugman, 1979; Lai and Qiu, 2003).

[33] Whereas the original exposition by Nash (1953) involved an imaginary 'umpire' to ensure the credibility of the threats, any application of this model requires that the threats are credible.

is for the party concerned to threaten destruction of the required assets, should the parties fail to reach agreement on the basis for cooperation. Here there is a clear asymmetry in bargaining capacities: the South can credibly threaten destruction of its environmental resources, but the North cannot credibly threaten to destroy human capital or information. Furthermore, the assumption of irreversibility means this threat contains a 'natural' commitment mechanism. In short, the asymmetry in capital endowments means only the South can satisfy the necessary conditions for a credible threat in this bargain, and it is a threat of strategic destruction.

**(ii) Strategic destruction as a rational threat**

While the destruction of resources as a bargaining ploy sounds alarming, it has been noted in other contexts as a ploy to secure bargaining power.[34] Nevertheless, what can strategic destruction mean in the context of biodiversity? For concreteness, strategic destruction of reserves can be understood as a literal threat to destroy resources, as witnessed in Latin America (World Bank, 2003). Here, farmers offered an IC contract in Latin America retorted 'bueno, corte todo' when no compensation was offered for the existing stock of forest resources. More generally, in the case of global biodiversity, strategic destruction could be understood as a threat to allow ongoing and irreversible land conversion in the absence of cooperation.

In fact, this question can be rephrased as: can the South increase the value of cooperation to the North? Given the interdependence of the North and South in the biotech industry, it seems unlikely that the South could gain from this exercise, and likely that this will be an extremely stringent condition. Nevertheless, Gatti *et al*. (2011) show that this will be the case if the social marginal value of reserves increases rapidly as reserves become scarce. Specifically, the social marginal value of reserves must be higher in conflict than on the bargaining frontier. This is an extremely plausible condition. A Nash bargaining solution with credible strategic threats could be represented by a point such as $U_S^T$ in Figure 4, where this yields a larger share of the surplus than in the absence of threats, $U_S^*$, as the South's ability to reframe the bargaining problem is remunerated. Another implication is that if the South satisfies the no 'shooting-oneself-in-the-foot' conditions for strategic threats, this opens up the possibility that *actual* destruction would increase the benefits of cooperation for the North, therefore increasing the pay-off for the South in any subsequent Nash bargaining game. That is, conditions exist in which destruction might be undertaken, rather than simply threatened.[35]

In sum, from the perspective of a bargaining problem, strategic destruction can be a rational response to an inequitable bargaining solution, such as the IC contract of the CBD. Each party brings asymmetric yet complementary inputs to the negotiating table.

[34] For instance Karp (1996) provides a theoretical analysis of the incentives for strategic destruction by a monopolist producing a durable good. This draws from a wider literature in industrial organization. Stranlund (1999) and Jerrell and Stranlund (1997) discuss an analogous case in which the bargaining outcome is influenced by strategic sunk investments.

[35] Busch *et al*. (1998) show that this kind of outcome can be an equilibrium strategy in a sequential game with trigger strategies.

This in itself suggests an equitable resolution to the bargaining problem. An inequitable outcome would leave one party, the North, vulnerable to strategic destruction in the South (Gatti *et al*., 2011).

Have we witnessed any such responses from southern countries? The answer to this is yes, we have. Furthermore these cases can easily be interpreted from this bargaining perspective. The best documented examples concern the governments of Cameroon and Ecuador. In Cameroon in 2008 the Minister of Forestry, Joseph Thatta, made a clear statement of what the government perceived to be the fair share of the cooperative surplus, while effectively redefining the conflict point in the negotiations with international conservation organizations over the Ngoyla-Mintom forest. An annual fee of US$1.6m for 830,000 ha of biodiverse tropical forest was requested to prevent the concessions being sold to logging companies.[36] Rough calculations suggest that the global value in terms of carbon sequestration alone doubles the value of the logging concessions, so conservation is on the bargaining frontier.[37] In the absence of any offers, in March 2009 the government made good on its threat and the process of determining forest concessions began. In terms of the bargaining framework, the process appears to be stuck at the conflict point.

Similar threats were issued by President Rafael Correa of Ecuador in relation to the Yasuni National Park at a meeting of the United Nations in September of 2007. Again, the conflict point and the share of the surplus were clearly defined, albeit under different circumstances to Cameroon. The conflict point was defined as the development of the oil fields beneath the National Park. The share of the cooperative surplus, arising from leaving oil in the ground, included compensation for lost oil revenues from the international community, which resembles the incremental cost component, and carbon credits amounting to the forgone carbon emissions, reflecting a payment for the stock of carbon.[38] This contractual solution bears more than a passing resemblance to the optimal contract under strategic threats. This approach has been more successful than in the case of Cameroon, and has received numerous pledges of finance. Nevertheless, to date the threat remains on the table until sufficient finance is attracted.

Both of these examples represent attempts to dislodge the status quo and certainly represent active use of threats or, at the very least, a laying bare of the structure of the bargaining game. Threats are not the only responses to the status quo that have been witnessed in the realm of biodiversity. The formation of the Group of Like Minded Mega-diverse Countries (LMMC) represents an alternative means by which to garner bargaining power, dislodge current solutions and improve benefit sharing. In the context of the bargaining problem discussed here, this could represent an attempt to develop a credible threat, or an attempt to influence the sharing rule, $\alpha$. In sum, these recent responses support the main finding here, that current solutions are unlikely to be long lasting despite ostensibly solving the externality problem for now.

[36] See 'The price of conservation: the unkindest cut', in *The Economist* (print edition), 14 February 2008.
[37] The 830,000 ha of forest in the Ngoyla-Mintom store over 200m tonnes of carbon dioxide (assuming a conservative 250 tonnes of carbon dioxide/ha). Assuming conservation reverses the 1 per cent trend in deforestations, and assuming emissions of 160 tonnes of carbon dioxide/ha from logging, at US$3 /tonne of carbon dioxide, payments for carbon through the REDD scheme would generate credits with a net present value of US$64m (over 30 years at 5 per cent discount). This exceeds the US$26m in logging concession fees (*The Economist*, 14 February 2008).
[38] It is estimated that leaving the oil undeveloped would result in permanently sequestering nearly 436m tonnes of carbon dioxide in the ground.

## VI. Conclusion

We have several conclusions to report from this discursion on the problem of and policies for regulating global biodiversity.

First, it is important to recognize that the problem of global biodiversity regulation is distinct from many of the smaller externality-driven policies regarding land-use management and conservation. These are local, regional, and national biodiversity policies addressed to the internalization of the broader values of unconverted lands. There is a function to be served by sharing information widely on cost-effective local policies, but this has nothing to do with global biodiversity regulation—a different problem.

Second, the problem of global biodiversity regulation has foundered over the past 20 years. There have been a few attempts at creating policies for conservation under the broad rubric of the CBD: principally incremental cost contracts and benefit-sharing regimes. We have argued here that the former represent an attempt to place the providers on their participation constraint, while the latter has accomplished nothing to date at all.

Third, the most promising regime for land conversion at the global level exists at present under the climate change regime. REDD+ provides a basic mechanism for making transfers to developing countries in exchange for carbon credits, and it has been ushered in rapidly to great fanfare. The problem with using a carbon sequestration mechanism for regulating land conversion is that these are two distinct problems. At a minimum there is the argument that two policy objectives warrant two distinct instruments. At worst, there is the possibility that the biodiversity problem is being subsumed into the climate change problem, i.e. it is assumed that it is solved when the climate change land-use problem is addressed. Nevertheless, these are theoretical issues at present, and it is interesting to note the recent developments under the UNFCCC regarding deforestation issues, and to ponder why the major efforts at global land-use regulation have occurred in the context of a climate regime (rather than the biodiversity one).

Fourth, we have described in passing the manner in which a global land-use policy mechanism should operate. A transfer mechanism needs to be put into place that enables payments to those countries in correspondence with their conserved lands and for each year in which they do not convert areas of existing natural habitats. This implies a long time horizon of ongoing payments for unconverted lands, but this is precisely the sort of mechanism which the biodiversity bargaining problem describes as its solution. There needs to be some means of sharing the benefits of land-based development between those states that have converted and those which have not.

It is important to begin thinking more generally about the great environment and development conventions as questions of cooperation over the production of joint surplus from such industries. The climate change regime should probably be thought of as a problem of deciding how to distribute the gains from fossil-fuel-based development

between those who have had it, and those who never will. Similarly, the *global* problem of biodiversity regulation has little to do with internalizing local or regional externalities (such as watersheds) or with conserving amenities (such as elephants). The international policy problem of regulating global biodiversity concerns the determination of the total converted land area that will provide the optimal ratio of inputs to and outputs from biological industries. Again the fundamental problem at its heart concerns determining the distribution of gains between those states that have previously developed their lands, and those who agree never to do so. The realization of real policies on global biodiversity regulation awaits the recognition of these fundamental bargains that must be made. Until then, our analysis (and the current record) demonstrates that we can expect to see continuing conversion and deforestation in those countries that are going uncompensated—according to their perceptions of fairness.

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**Figure 1:** Global regulation of biodiversity—optimal land-use conversion

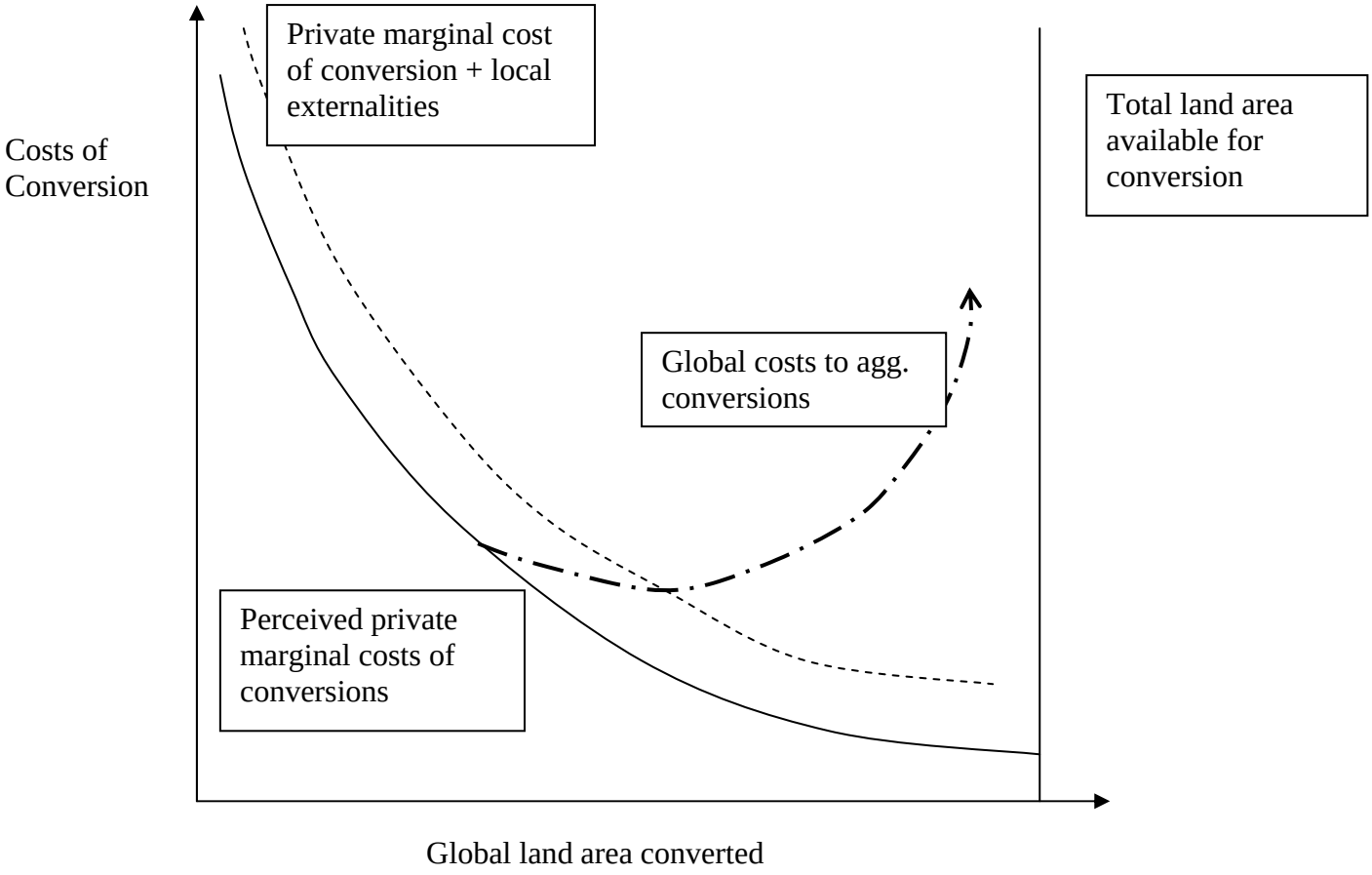

**Figure 2:** Schematic representation of the biotech industry

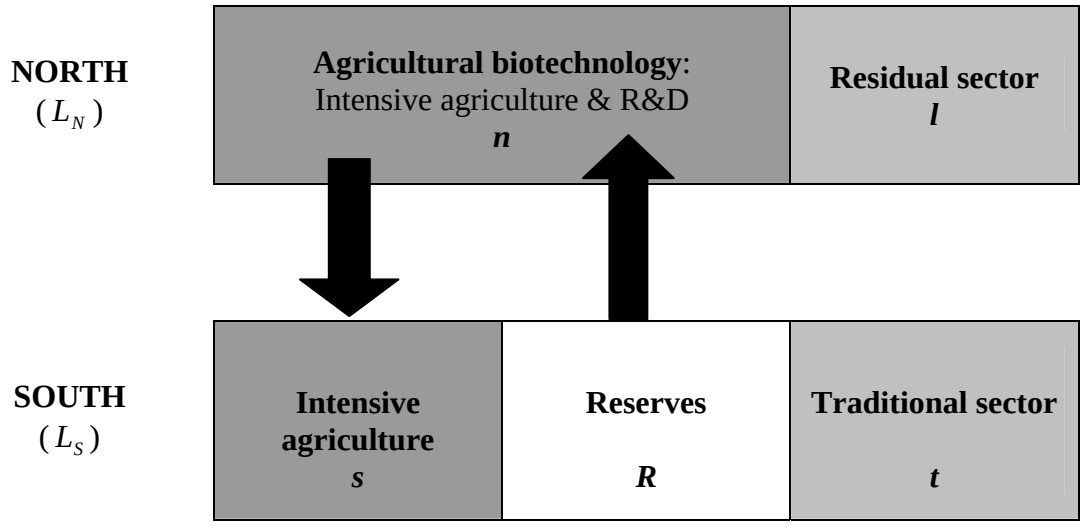


**Figure 3:** Conflict point and bargaining frontier

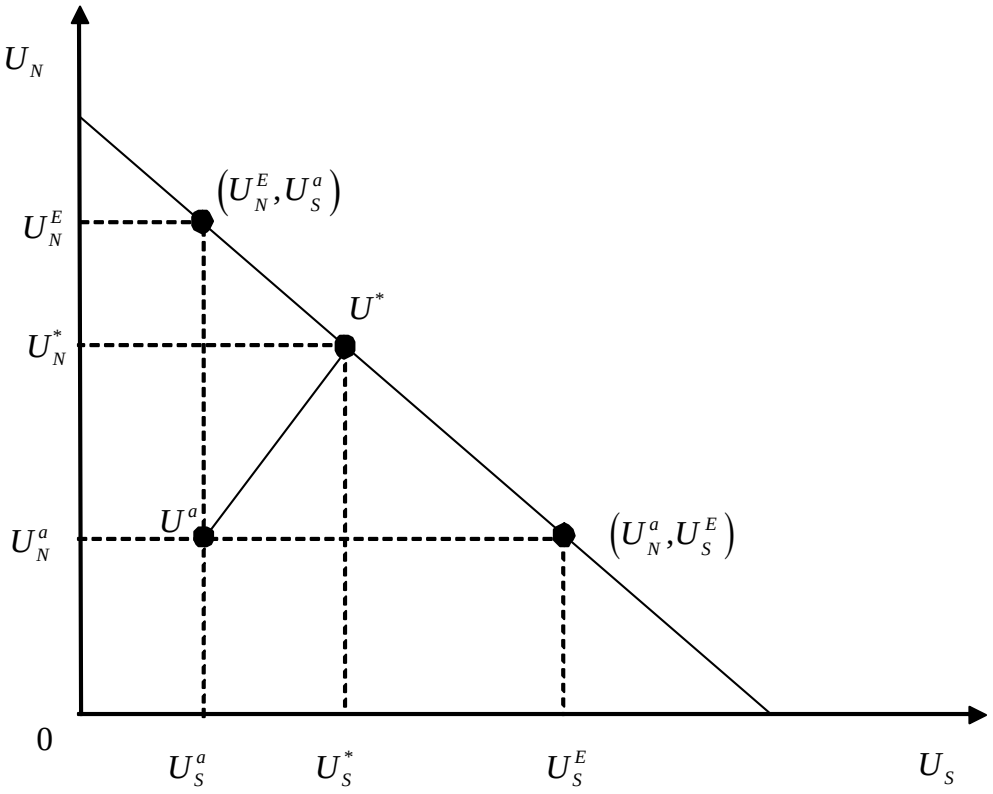

**Figure 4:** The bargaining problem with strategic threats