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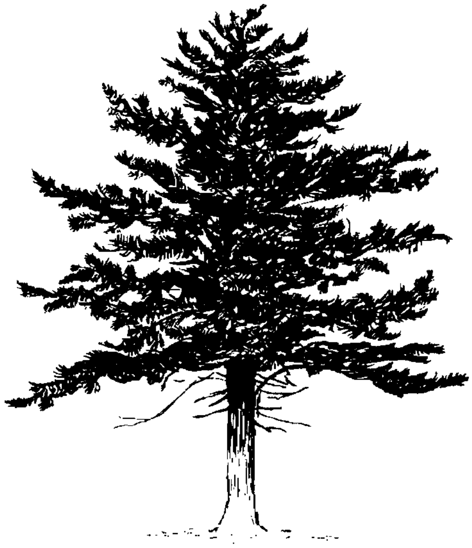

# Is Bioprospecting A Viable Strategy for Conserving Tropical Ecosystems?

Christopher B. Barrett and Travis J. Lybbert

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Abstract

This paper explores whether bioprospecting can reasonably be expected to change rural incentives to conserve tropical ecosystems. Bioprospecting advocates posit that the prospect of discovery of biota of immense commercial worth offers an avenue to increase the valuation of nature and endogenously reduce consumptive use of habitat. We consider the microeconomic mechanisms by which bioprospecting might affect incentives and the distributional consequences of these effects.

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Christopher B. Barrett

and

Travis J. Lybbert

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Seniority of authorship is shared equally. The authors are associate professor and graduate student, respectively, in the Department of Agricultural, Resource, and Managerial Economics, Cornell University, Ithaca, NY 14853-7801, USA. We thank participants at the March 1999 Cornell University conference on "Owning Nature" for helpful comments. All remaining errors are ours alone.

## Is Bioprospecting A Viable Strategy for Conserving Tropical Ecosystems?

Many prominent scientists avidly advocate bioprospecting, the systematic search for new commercial applications for hitherto unstudied species, as a mechanism for inducing tropical biodiversity conservation by making it commercially attractive (Wilson 1992, Reid et.al. 1993, PAHO 1996, Weiss and Eisner 1998). Bioprospecting's premise is that nature contains hidden assets of potentially huge, yet unknown magnitude to humankind that can motivate and even finance biodiversity conservation in the tropics. This undiscovered genetic or biochemical information is commonly framed in the context of potential improvements in medicine or food, thus defining a massive global population of potential beneficiaries. It is further argued that bioprospecting can effect social and economic development in developing countries by rewarding biota-rich but income-poor tropical communities that preserve and wisely manage their genetic resources. The premise of bioprospecting, coupled with the claim that practically all of humankind stands to benefit, and perhaps most especially the poorest of the poor, naturally leads to an urgent desire to conserve tropical biodiversity in order to enable discovery, extraction, and value-adding transformation of hitherto unexploited tropical biota.

Specifically, it is claimed that bioprospecting stimulates conservation through two mechanisms. First, bioprospecting firms should be willing to pay to preserve biodiversity for its innovation option value since they stand to reap direct financial benefits from any marketable discoveries. Second, conditional on an increase in life sciences firms' willingness to pay for conservation, local inhabitants' and landholders' valuation of biodiversity will change to the extent that they, as stewards over biodiverse habitats, are compensated for their contribution to bioprospecting activities. To date, most attention with respect to bioprospecting has focused on the first of these mechanisms and on resolving issues of property rights allocation prerequisite to internalizing the spillover benefits of discovering valuable information in nature. The international Convention on Biological Diversity (CBD) is essentially a Coasian solution to this problem in that it grants to host nations sovereign rights over the genetic resources contained within their borders. The widespread misimpression is that all we need do is get the property rights to biota and their derivatives right both *in situ* and *ex situ*, effectively creating a market for biodiversity, and the rest will fall into place. The attractive intuition of such arguments is deceptive, however, and the purported ability of bioprospecting to translate into conservation is economically naïve.

This essay focuses on the likely microeconomic effects of increased demand for tropical biota, and asks the key bottom line question: is bioprospecting a viable strategy for inducing endogenous conservation of tropical ecosystems by local inhabitants? Biodiversity conservation has fundamental economic drivers. Marginal forest, wet, and desert lands get converted to agricultural, industrial, and residential uses rather than left in their undeveloped state because the opportunity cost of conservation is simply too high to the people who control the land. The value of the land is greater when put into consumptive uses even recognizing that conversion may destroy species and disrupt delicate ecological balances. In much of the world, the simple but intractable causal factor is asset poverty (Reardon and Vosti 1996). When the poor depend inordinately on the consumptive use of bioassets (e.g. soils, forests, water, wildlife) to produce the entitlements necessary to ensure their survival from day to day, biodiverse habitats fall under constant pressure. This pressure can have devastating and widespread impacts on tropical ecosystems hosting small holder agricultural systems. Such areas are of particular relevance to an analysis of bioprospecting as a conservation strategy since they seem to be among the most promising and popular bioprospecting sites.

The key question is therefore whether bioprospecting can reasonably be expected to change rural inhabitants' incentives to conserve tropical ecosystems. This can be usefully reduced to considering the effects on the relative opportunity cost of converting or conserving unspoiled land. The opportunity cost of conversion is the sum of two components: the stream of income associated with keeping the ecosystem in its natural state (e.g., income from ecotourism, bioprospecting, environmentally conditional aid, etc.), and the cost of the conversion process. It is posited by bioprospecting advocates that biotechnology and the prospect of discovery of macro- or micro-biota of immense worth offer an avenue to increase the valuation of nature, thereby tipping the opportunity cost scales against habitat conversion and inducing local conservation efforts. Under what conditions might this claim be valid?

**Firms' ambiguous incentives**

Most of the economic literature on bioprospecting has focused on firms' incentives to undertake costly bioprospecting in the face of uncertain benefits. The first such inquiries estimates firms' willingness-to-pay for conservation by multiplying the probability of discovering a commercially valuable lead by the value of the discovery. These estimates range from $44 (Aylward, et.al. 1993) to $23.7 million per untested species *in situ* (Principe 1989). Recognizing flaws in this methodology, Simpson, Sedjo and Reid (1996) (SSR) illustrated that, although the aggregate benefits to biodiversity conservation for the as-yet-unknown genetic information contained in nature may be huge, the bioprospecting firm will consider the value of the marginal species. In the SSR analysis, the firm accounts for the possibility of redundant species and adjusts its valuation of biodiversity accordingly by asking the question, "How will this particular untested species incrementally contribute to our probability of making a profitable discovery?" With this adjustment for redundant species, the expected marginal returns to commercial bioprospecting seem too modest to reasonably expect much activity by profit-minded firms.

In a pair of recent papers (1998, 1999) (RS), Rausser and Small expand on the SSR model by allowing concentration of research effort towards leads showing the highest expected productivity based on prior information on the 'quality' of a given site and positing "patent races" between bioprospectors. Under such circumstances, firms may be willing to pay more than only the marginal value of an untested species in order to reduce the risk that a competing firm will preempt its innovation efforts by making a prior discovery.

So which argument is most compelling? The $1.1 million contract between Merck Pharmaceutical and Costa Rica's INBio could be interpreted as evidence in support of the RS position. On the other hand, the fact that such contracts are uncommon and that most firms have shown only limited interest in directly paying for conservation could be seen as support of the SSR position. Reasonable disagreement exists as to whether and under what conditions firms might have a rational interest in significant investments in biodiversity conservation for the purpose of bioprospecting.

The above, *ex ante* analyses focus on the firms' willingness-to-pay to preserve bioprospecting options. As such, these estimates likely generate upper bounds on any actual payments from firms to tropical communities for biodiversity conservation. Furthermore, direct payment for conservation is likely only in those sites containing particularly promising biota which a prospecting firm believes will be lost without some intervention on its part. Recognizing these caveats and the continuing debate on the bioprospecting value of biodiversity, it is unclear how much additional conservation can reasonably be expected as a result of a firm's desire to preserve bioprospecting options.

**The effect on local conservation incentives**

The existence of nontrivial value to bioprospecting is merely a necessary condition to tropical biodiversity conservation. The key question still surrounds the calculus of land and labor use in fragile ecosystems. Assume for the moment that either RS are correct or that fabulously profitable, serendipitous discoveries occur in spite of meager *ex ante* bioprospecting incentives, so that real commercial value exists from a tropical ecosystem. Do the resulting *ex post* conditions favor conservation by local residents? As a rule, to which there are almost surely exceptions, the answer is either "no" or "not without imposing a significant cost on the most vulnerable members of a host community".

It is important at this juncture to distinguish between two different sorts of use: single-shot extraction for subsequent *ex situ* laboratory production and ongoing *in situ* extraction. Single-shot extraction is conceptually simpler. In this case, valuable biochemical material is discovered, extracted, and then reproduced *ex situ*. Perhaps the host receives compensation, perhaps not. Whether the host receives compensation and the extent of that compensation may depend largely on intellectual property rights, as conferred by the CBD. But while the CBD explicitly requires the equitable benefit sharing *between* nations (although no enforcement mechanisms exist), it only encourages equitable benefit sharing *within* nations. We are unaware of any study that examines the actual distribution of bioprospecting benefits and costs among the inhabitants and landholders who live within or near targeted biodiverse habitats.[1] Yet if these subpopulations are important agents (and often victims, too) of ecological degradation, the incentives facing them play a crucial role in tropical biodiversity conservation.

[1] There have been several studies commissioned by the secretariat of the Convention on Biological Diversity (available on the World Wide Web at http://www.biodiv.org/chm/techno/gen-res.html#cases), but none of these address local, intra-community issues of benefit-sharing. The benefit sharing questions have thus far remained issues of distribution between the community in aggregate and outsiders.

Two considerations deserve mention here: prospective (perhaps delayed) income effects of bioprospecting receipts and the time consistency of firms' demand for bioprospecting-induced conservation. In single-shot extraction, once a discovery is made, the option exercised, and the genetic material extracted, the firm's willingness-to-pay almost surely falls. Past payment for conservation will have income effects that may lead to renewed, even increased local consumptive pressure on the resource if the demand for bioprospecting-motivated conservation falls off. Whether the income effects of the transfer favor conservation or increased consumptive use (e.g., by stimulating greater fuelwood or wildlife consumption) is an open, empirical question that will likely vary across sites. Would environmental conservation in Madagascar be appreciably different today had the rosy periwinkle extracts used to design leukemia drugs been appropriately compensated? We suspect not.

The key problem in single-shot extraction is the time inconsistency of bioprospecting as a basis for conservation. The idea of bioprospecting rests on a form of what economists call quasi-option value, the informational value associated with maintaining flexibility in the face of temporal uncertainty. Uncertainty surrounding the future commercial value of the genetic material of a natural resource creates an incentive to conserve it (Arrow and Fisher 1974, Henry 1974). The permanence of these altered incentives ultimately depends on the expected profitability of continuing to prospect. When uncertainty regarding the habitat is resolved (i.e., once the genetic material of a habitat has been screened), that particular quasi-option value of resource conservation falls to zero. Since past payment doesn't change current valuation, the incentives to conserve tropical ecosystems vanish. Bioprospecting can therefore do little more than buy time to find a more durable solution. The case of Shaman Pharmaceuticals, Inc. is instructive. The firm rewarded indigenous peoples, typically via in-kind compensation, for their participation in drug discovery from tropical ecosystems, tipping local incentives to inhabitants in favor of conservation. By February 1999, however, Shaman apparently realized it had overestimated the expected returns to "indigenous knowledge directed" bioprospecting and announced that it would cease operation of its pharmaceuticals business because it proved unprofitable. Without a direct, external source of conservation-related benefits, it is unlikely that the conservation incentives Shaman was able to effect in its host communities will persist. Bioprospecting for single shot extraction - the aim of most life sciences multinational firms today - thus can only encourage conservation until discoveries are made, at which point the value of biodiversity collapses with the commercial success of the bioprospecting operation.

In the case of ongoing extraction, *in situ* production yields a stream of revenues in cash or in kind (e.g., as schools, health clinics, etc.) and stimulates demand for local labor, both of which are tied to ongoing production and therefore to the maintenance of the biodiverse habitat. But who gets these revenues and who benefits from the additional employment? The distribution of transfer payments at this local level depends on the local governance structures. If the existing literature on the distribution of nonfarm income and transfer payments is any indication, such payments commonly disproportionately benefit local elites, not the poor.[2]

Labor demand likewise tends to be for relatively skilled labor—educated folk who can communicate with western businessmen, scientists, and lawyers, either to organize local extraction and/or processing or simply to provide services when outsiders visit. In this way, the process is rather akin to eco-tourism, an overhyped path to biodiversity conservation with sometimes disturbing local distributional consequences (Brandon and Wells 1992, Barrett and Arcese 1995). There is precious little solid empirical evidence of the benefits of biochemical discoveries filtering down to the poorer segments of host communities. If that conjecture is true,

[2] Moreover, the level of the transfers is an issue. The first known case of commercial payment to an indigenous community for a commercial product based on bioprospecting results occurred only in March 1999, amounting to only $21,000 (Bagla 1999). Without a substantial increase in the sums involved, it is

then to a first-order approximation, the opportunity cost of habitat conversion doesn't change among the poor. And so the pressure to convert habitat remains among the poorer subpopulations in communities in or surrounding biodiverse areas. If the poor are among the principal agents (as well as victims) of tropical ecological degradation (Barrett 1996), bioprospecting then fails to alter the incentives of those whose behaviors most need to be changed.

Of course, instead of tinkering with the incentives to local inhabitants, marginal populations can simply be forced off protected lands in order to preserve the innovation option value of biodiversity. This route is commonly taken, if often only implicitly. Property rights originate in creation, discovery, improvement, purchase, or conquest.[3] The redefinition of indigenous property rights to suit western models of private, transferable rights too commonly involves, *de facto*, the creation of property rights by conquest. The gazetting of state-owned protected areas for conservation or of concessions for sale or lease to companies for biological or geological mining, and even the clear definition of previously fuzzy rights commonly extinguishes rights (in particular state-contingent options) held by the relatively powerless. The Ogoni of southeastern Nigeria offer a chilling example, as do pastoral peoples in east Africa and native American communities in the 19th and early 20th century United States. Moreover, since tenurial regimes typically respond endogenously to changing incentives, bioprospecting windfalls may well induce redistribution of resource rights, and rarely in a distributionally progressive manner (Platteau 1996). When trees become more valuable, the powerful tend to find ways to crowd the poor out.

Even when not forced off the land, however, the poor can suffer from a bioprospecting-based boom in the extraction of genetic or biochemical resources. There are three basic mechanisms by which this occurs. First, there is a booming sector phenomena (also known as Dutch disease)

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hard to imagine individuals in poor rural communities receiving transfers sufficient to induce them to desist from consumptive use of proximate habitats.

familiar from open economy macroeconomics. By bidding up the price of some factors of production (e.g., transport, skilled labor), the biotech industry gains at the cost of other producers who purchase those same inputs (e.g., traditional healers, local light manufacturing). These subjective valuation differentials and price effects may subsequently result in a significant reallocation of productive resources, causing changes in returns to factor owners. These changes in factor returns and the induced changes in local prices largely determine the distribution of gains and losses from a resource boom (Cassing and Warr 1985). Second, increased aggregate local income stimulates demand for and thereby the relative price of nontradable goods and services (e.g., local roots, tubers, coarse grains), which tend to be consumed disproportionately by the poor.

Third, if markets are heterogeneous in information, influence (i.e., primary producer-intermediary relations), communication, producer capacity or infrastructure, then price signals are also likely to be heterogeneous and those with access to favored activities often gain at the expense of the asset poor (Carter and Barham 1996). In this case, even if an ongoing extraction creates significant opportunities of local inhabitants, only those with access to technology, credit or land may be able to respond, leading to "highly regionalized or class specific" growth (Barrett and Carter 1998). For example, in so far as any processing of the extracted biochemical product is done locally, there may be induced technical change in processing that displaces some. As a case in point, the oil extracted from the fruit of the Morocco's argan tree has valuable chemical properties that have made it a popular additive to cosmetic moisturizers in Europe. Demand pressure has increased the price of argan oil in the rural Moroccan communities in or adjacent to the argan forest. As a result, male outsiders with access to working capital are displacing women's artisinal oil extraction with new investments in mechanical presses that yield higher volumes of purer oil. Local women are vocally displeased by this change.

[3] We are indebted to Norman Uphoff for this useful taxonomy.

The basic point here is that by any of several different channels, growth due to bioprospecting windfalls may be exclusionary or even regressive, not fundamentally changing the calculus of habitat conversion for the poor without forcible exclusion of poor consumptive users of biodiverse habitats from their traditional lands. Unless one is prepared to defend regressive intragenerational redistribution in the name of intergenerational equity, such effects should be troubling.

**Some Alternatives**

The need to conserve precious biodiversity is clear, especially as we begin to appreciate the magnitude of the spiritual, social and economic services it provides. But bioprospecting is an unpromising base on which to rest the economic rationale for conservation. Rather, in so far as increasing the economic value of biodiverse habitat is central to stemming conversion of marginal lands, then we should emphasize three alternatives.

First, help host communities better understand their fundamental dependence on ecosystem services and therefore to value those services and protection of the providing ecosystems more highly. While recent efforts at valuing ecosystem services are understandably contentious, the indisputable point is that the sums involved are huge, far beyond what most people would guess (Costanza, et al. 1997). Basic science and education are necessary if people are not to take nature so much for granted. At present, virtually all humans underestimate the opportunity cost of conversion because we undervalue the services ecosystems provide.

Second, we need to emphasize the necessity for wealthy western communities that recognize and value biodiversity in distant lands to pay for its conservation, playing up the aesthetic, cultural, and ethical reasons to value biodiversity conservation (Simpson 1999). It costs Kenya, for example, approximately 3% of its meager GDP annually to protect habitat for the benefit of humanity more broadly (Norton-Griffiths 1995). When western communities recognize that environmental conservation is as important to the future of humanity as is promotion of democracy and human rights, perhaps we'll spend one-quarter as much on Kenya as we're now spending on Kosovo. It is unrealistic to expect continued highly regressive financing of global conservation efforts on anything approaching the scale ecologists recommend. The environmentally aware upper and upper-middle classes of the high income world are the moral equivalent of deadbeat dads, failing to make appropriate support payments to the ones we've left to care for nature.

Third, we need to raise the opportunity costs of conversion by increasing the productivity of the poor's labor applied elsewhere. This requires basic public investments in child health, nutrition, and education and in rural institutional and physical infrastructure necessary to induce private agricultural intensification and investment in value-added manufacturing, processing, and distribution in rural towns. The best way to keep the poor from clearing the forests and transforming coastal swamps and reefs is to provide productive opportunities elsewhere (Reardon and Barrett forthcoming). As labor productivity and wages rise and become more stable, the incentives to draw down bioassets diminish because the opportunity cost of conversion becomes too great. Not only good is this development policy, it's good conservation policy too.

All three of these are challenging tasks, with considerable political obstacles remaining to be overcome. But slow progress is being made on all three fronts. We must not relent in tackling these challenges, especially not to be drawn off by seductive but economically naive approaches to changing the calculus of ecosystem conversion so as to maintain necessary biodiversity.

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