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The Economic Valuation of Biodiversity In Sri Lanka

By

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B

Executive Summary

Economics can be described as the science of understanding how a society chooses between the many things that it would like and the limited resources available to it. Biodiversity, to the extent it means such "products" as pristine natural areas, undiscovered pharmaceutical products, or a plethora of native rice cultivars, is clearly worth preserving. Yet for these natural products, just as for manufactured products, our options are limited. We cannot preserve all the biodiversity which exists in Sri Lanka today, since, with population growth and the pressures of economic development, parts of it will disappear. This paper reviews the issues which must be considered by society as it faces these choices. The paper proceeds through the following four sections: a review of basic economic principles pertaining to the economics of biodiversity; a brief assessment of the major values linked to Sri Lanka's biodiversity; a review of three important concepts pertaining to biodiversity in Sri Lanka; and a set of conclusions and research/policy implications.

To understand the economist's analysis of biodiversity value, one must understand the marginal value principle, which says in essence that the value of something is determined by the cost of producing one more item of it, not by the total value of all products that have been produced in the past. The economist is interested in what people are willing to pay to have one more unit of something, whether that thing is manufactured or found in nature. Unfortunately, quantifying the amounts people are willing to pay is complicated by the fact that biodiversity "products" come from markets with externalities, which means that market prices for biodiversity products (to the extent they are available on the market) typically do not reflect their true and total value. An important goal of the economist is to ensure that these externalities are reflected in product price, so that consumers of biodiversity will appreciate its true value and act accordingly.

The values derived from Sri Lanka's biodiversity can be placed into three categories. First are the values of goods harvested from natural eco-systems. Included here are such products as timber, wild game and non-timber forest materials. To these can be added the services produced by natural ecosystems which then augment the value of other activities. Examples of these include water and nutrient cycling, erosion control and flood protection. Second are the other use values derived from the ex-situ replication of the products taken from natural ecosystems - otherwise known as bio-prospecting. The paper concludes that bio-prospecting values in Sri Lanka are modest, although it calls for further research into the value of ayurvedic knowledge. In the same vein, the potential value of local endemic agricultural species is found to be negligible. Third are non-use and existence values.

The valuation of biodiversity must be closely linked to policy measures to realize and preserve those values. The paper reviews three such measures: property rights; incentive mechanisms; and measures of aggregate economic performance. If a user does not have an exclusive right to the future output of an asset, that is, if he has weak property rights, he may over exploit the asset in the short run. The paper distinguishes between private goods, which are "excludable" (the owner of the good can exclude others from consuming it), and public goods, which are non-rival (where consumption by one person does not exclude consumption by another) and non-excludable. One goal of the economist is to find ways to assign property rights to non-rival goods so as to exclude unauthorized persons from consuming them. A more optimal assignation of property rights is suggested for glass-bottom boat ownership in Hikkaduwa.

Widening the protection of intellectual property in Sri Lanka might not have much effect on the conservation of natural resources, in particular in the area of bio-prospecting. This is argued for two reasons. First, among nations that have signed the Biodiversity Convention, there is a requirement to obtain "prior informed consent" before acquiring materials. In other words, bilateral contracts may substitute effectively for explicit intellectual property rights. Second, by whatever reasonable method one measures it, the expected value of genetic resources *in situ* is not very large, according to the best evidence now available.

A second policy issue affecting the value of

biodiversity concerns the incentive mechanisms associated with its conservation. Although the current policy debate on biodiversity suggests that conservation incentives may be achieved by subsidizing related economic activities (the so called Integrated Conservation and Development Programs), the paper concludes that the efficacy of these indirect incentives in promoting conservation is limited.

The third and final policy measure covered is "green accounting", or the inclusion of environmental costs and benefits in the national income accounts. Green accounting can be used for management and "score keeping" purposes. "Score keeping" refers to using data from the revised national income accounts to direct future economic policy. The more useful application of green accounting is in management. If the environmental national income accounts show that resources of a certain kind are being rapidly depleted, or that the losses in productivity in one sector outweigh another, this information can be used to make better decisions about the future. Because these national accounting figures are so highly aggregated, the paper argues that a sound basis for them must be found in site or product specific valuation studies.

The paper concludes with recommendations concerning priority valuation study areas, policy issues for immediate attention and capacity building priorities. In discerning priority valuation study areas, an emphasis is placed on issues that are under Sri Lanka's control and for which fairly concrete and reliable answers might be found. The value of local ecosystem services is one of these concrete areas. Included here are the values of services such as pollutant filtration and sequestration, ground water recharge and erosion protection. Although additional valuation work on bio-prospecting is not merited at this point, some follow-up research on the values of ayurvedic medicines may be useful. The paper argues against spending much time and effort looking into global environmental externalities (carbon sequestration and existence values of biodiversity being the leading examples). If the international community is interested in these values, then they should provide the resources to Sri Lankan researchers for them to be valued.

The valuation of biodiversity as an economic exercise contributes to national welfare only if it is used to understand and, ultimately, to alter the incentives for biodiversity management. The process, therefore, must be designed and organized in a proper policy context. Attempts to support the community management of natural resources, such as is happening at Hikkaduwa, provide a good example of where a review of the economics of property rights would be extremely useful.

Although the interest in strengthening the regime of intellectual property rights pertaining to biodiversity is strong in the Sri Lankan and international community, it is doubtful that the extension of these rights to unimproved genetic resources (as is done in bio-prospecting) would have much impact on conservation. Direct incentive mechanisms should be experimented with, in particular subsidies for land conservation, payments for demonstrable assistance to wildlife propagation, tax relief, and similar measures for conserving biodiverse habitats. Experiences with these tools elsewhere can be drawn upon for testing such approaches in Sri Lanka.

In order to meet the technical and policy-making demands identified above, a program of capacity building must be undertaken. While the author is not qualified to say whether there is a shortage of economists in the major universities, there is certainly a shortage of economists working on biodiversity valuation (and environmental valuation). If Sri Lanka is to make conserving and managing biodiversity a priority, then research fellowships and grant funding should be made available to these researchers. In the case of grant funding, the amounts would not be extravagant, but they should be delivered with enough consistency and reliability that they allow researchers to immerse themselves in new research fields. Although the greatest expertise for doing policy-related environmental economics research exists among academic researchers, peer review processes should be strengthened and encouraged. Encouraging support of the Environmental Economics Working Group would be a good means of incorporating such peer review.

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Section 1: Principles of Economic Valuation

Economics is sometimes described as the study of how we choose between the unlimited things that we would like to have given our limited resources for acquiring things. Each of us as individuals face such choices, as we are limited in our spending by the amount of money we earn. Society as a whole also faces such choices, as we are collectively limited by the fact that production of some things excludes production of others. If we define the notions of "having" and "producing" broadly, these considerations apply to discussions of things such as biodiversity as well: we face choices of what to preserve, since we cannot both preserve everything and produce the other goods that we would like to have.

Economic value is determined by scarcity: we place higher values on those things that are in short supply relative to our wants and needs, and lower values on things that are in high supply. In the remainder of this section I will explain this principle in greater detail. I will begin with a discussion of the special meaning of the word "value" as used by economists, and then go on to the principle of marginal valuation, which will explain my emphasis on scarcity as the determinant of value. Next, I will discuss situations in which the value an individual may place of a good for her own use may differ from that society places on the same good. A review of principles confined to a space as short as this introduction must necessarily leave many things out. I will try to give an indication of a couple of the more important things I am excluding before moving on to the discussion of biodiversity values in Sri Lanka in the section 2.

1.1 The meaning of "value"

One source of the misunderstandings that often arise when economists, ecologists, and others discuss the importance of biodiversity is that different people may use the same word to mean different things. Many people use the word "value" in what might be described as philosophical, cultural or religious sense. A value is something fundamental, absolute, and unchanging. An example of this usage is "I act in accordance with my values."

Economists have a very different thing in mind when they talk about value. To an economist, a value is derived rather than fundamental, relative rather than absolute, and often dependent on place, time, and other circumstances. Thus, if I say that "the value of an apple is twice as great as that of an orange," I am not making a detached ethical judgment, but simply saying that, as of now, given my circumstances, I would trade two oranges for one apple, or, equivalently, that I would pay twice as much for an apple as I would for an orange

Such usage makes some people uncomfortable when we talk about the value of something as important as a natural ecosystem or a human life. It is common to hear people say that these things are "just too important to put a price on." There is nothing logically inconsistent in having such views, so long as two or more such absolute values do not come into conflict. One cannot simultaneously say that "all scenic beauty has inestimable value" and "we must build more homes for the homeless" if the only way the homeless will have new homes is by destroying scenic beauty. In short, we can only claim to place absolute priority on something if we are willing to sacrifice everything else for it.

Economists are often criticized for taking no account of intangible factors. It is said, for example, that economists do not take account of esthetic, ethical, or religious feelings in computing values. This is not true. To the extent that people are willing to sacrifice material well-being to gain spiritual satisfaction, spiritual satisfaction has an economic value. Again, however, to the extent that people are unwilling to sacrifice everything for spiritual satisfaction, the economic value of spiritual satisfaction must be considered in the same relative terms as are the other things we care about. Of course, the accuracy of estimated values for things which we rarely or never trade is suspect.

1.2 The marginal principle

The implication of relative valuation is that economic valuation is made in terms of tradeoffs with which people are typically faced. When you buy bread, you are not faced with a choice of whether to buy all the bread you'll ever want to eat. You are, rather, faced with a choice of whether to buy one or two loaves of bread, and one or two

liters or milk, etc. The value of these commodities to you is determined by what you're willing to pay for a little more bread relative to what you would pay for a little more milk, a few more bananas, etc.

In economic terminology, choices are made "on the margin." The implications of this analysis can be illustrated with a famous example. Philosophers who began to think about economic issues were puzzled by the "paradox of value." Water, they noted, is absolutely essential to life. Yet, in most times and places, water can be purchased at a very low price. Diamonds, on the other hand, are of very limited practical use, but can only be acquired at a very high price. This paradox is explained by marginal analysis. Economic value is not determined by the total benefit we derive from something, but rather by what one more unit (the "marginal" unit) is worth. It is true that water is valuable as a means of keeping ourselves alive, but because there is generally so much of it, we could do without the marginal liter without enduring any great hardship. We might also survive quite easily without any additional diamonds, but in the limited applications for which they are used (industrial cutting, impressing our spouses), there are few substitutes.

The notion of substitutes is at the heart of doing practical economic valuation. There is no substitute for water, but one liter of water is chemically identical to any other. Thus, any liter of water is a substitute for any other, and the value of any one liter is low when plenty of others are available.

We may find it difficult to think of biodiversity in similar terms. Every species, in fact, every organism, is a unique piece of creation. There are important ways in which biodiversity is substitutable, however. Different plant and animal species can be used to meet our nutritional needs. Different species may prove to be sources of similar pharmaceutical products. While diverse natural ecosystems provide a number of services, such as water filtration and erosion protection, there are a number of such ecosystems providing such services to a number of geographically distinct areas, which may themselves be substitutes for cultivation, residence, and recreation. Moreover, a number of different species may fill the same ecological niche, so the loss of some biodiversity may not translate into a perceptible reduction in any economically meaningful function.

I should be clear about what I'm saying above. I am certainly *not* asserting that biodiversity is so plentiful as to be of negligible economic value in Sri Lanka, or elsewhere around the world. In fact, there are a number of areas in which the degradation of natural ecosystems has led to immense economic losses. My point, rather, is that in order to determine whether the further decline of biodiversity in Sri Lanka will have important economic impacts, we must do careful marginal analysis. We must think about how substitutable some components of existing biodiversity are for others.

1.3 Externalities

For many goods economists do not need to go to a great deal of effort in order to estimate economic value. The value to society of the loaf of bread I used in the example above can be pretty accurately measured by the price at which the store sells it (presuming, that is, that the store sets its own prices in competition with many other stores, as opposed to setting prices without competition from other stores, or having prices dictated by the government). The argument for this conclusion goes as follows. Consumers buy bread until they have just that amount of bread for which they are just indifferent between buying another loaf of bread or using the money they could spend on more bread to buy milk, or eggs, or bananas, or whatever else they may desire. Since two or more people cannot eat all of the same piece of bread, each individual makes a decision by which he consumes what he wants to without affecting other people's consumption. Since each individual is making the best decision for herself, and prices tell the relative values individuals place on goods, prices indicate how things like bread are valued both individually and collectively.

Not all things are like bread, however. Consider a tree, for example. It is relatively straightforward to consider the value of tree for the lumber that can be taken from it, or the firewood that it provides. The person using the tree for these purposes may not be the only one affected by its felling, however. The tree may be on a steep slope. When it is felled, it will no longer provide protection against soil erosion. The soil eroded by

more rapid runoff of water may not be entirely confined to property owned by the person who cut the tree. Thus, the harvest of the tree may affect the economic well being of, for example, farmers in downstream areas.

Economists call economic costs and benefits incurred by people other than those who buy or sell particular goods "externalities." Externalities are, by definition, not reflected in the prices people pay or receive for goods. The goal of environmental and ecological economics is to find ways to incorporate, or "internalize" these externalities. This can be done in one of two general ways. First, if the same person owns both the tree and the farm on which erosion occurs in our example she will take account of the effects on the farm in making her decision of whether or not to fell the tree. This is the approach I will discuss below as "assigning property rights." A celebrated result due to Coase (1960) holds that it doesn't matter if the logger has the right to cut trees (and cause erosion) and farmers pay to restrict the logger's right, or if farmers have a right to have their lands free from erosion, and loggers pay farmers to infringe this right by cutting trees. In either case, the logger "internalizes" the full costs of his actions.

The second, and equivalent, way of "internalizing externalities" is to charge a person for the full costs of his actions. In our example above, if the farmer has a right to maintain her soil, she can charge the logger for the damage he does. The government can also do this. For example, the government could impose a tax on each tree cut. If the tax were set correctly, the logger would cut trees only when the benefits he gets from the wood exceeds whatever it costs him to cut trees, plus whatever the tax is.

We do not often see full assignation of property rights. More often, the goal of public policy makers is to determine what the appropriate tax rate should be, and then try to structure policies either to impose a tax, or to structure regulation that would have the same effect as a tax. When we are thinking about the economic valuation of biodiversity, what we are trying to do is to determine what externalities are generated by the destruction of biodiversity, and how these externalities can be internalized using policy instruments.

1.4 Some additional considerations

As I said above, it would be impossible to discuss all of the many factors that complicate economic valuation exercises. Let me briefly discuss two that are very important in discussions of the valuation of ecological assets. The first is uncertainty. There are two reasons for which uncertainty may lead us to make our decisions conservatively. The first is that most of us are risk averse. That is, even if we are offered the chance to make a fair bet (I. e., one for which the odds of winning and losing are the same), most of us would not do so, at least when the amount of money involved is large: most of us prefer modest but certain earnings to large but risky propositions. This explains why most us prefer to carry insurance rather than take our chances of incurring expensive losses, even if the insurance premia are larger than the expected value of the loss we insure against.

The same principle may apply to social decisions concerning the risk of biodiversity loss. Perhaps some of us think that further losses of biodiversity will not have great effects. Many of us, however, are concerned that further damage may result in the "unraveling" of large-scale ecosystems. If there is a small probability of a disastrous event, we may want to "buy insurance" against such an event by incurring some costs of ecosystem preservation.

The second way in which uncertainty may motivate a conservative bias toward biodiversity preservation is when biodiversity loss is irreversible. We may not know now what ecological function a species serves, or what type of new product might be generated from the species in the future. If the species goes extinct, however, we may find in the future that it would have met a demand that we cannot forecast at present. The issue is not one of risk in this case so much as one of irreversibility, and keeping our options open. We may find in the future that we do not really need to preserve some species, but it is often better to wait until we have such information before making irreversible decisions. A combination of these insurance and "option value" conditions have led some economists to suggest that we should adopt a "safe minimum standard," or a level of biodiversity loss beyond which we should not go.

The other complicating issue I would like briefly to touch upon concerns the implicit weighting of different people's desires reflected in economic valuation. The prices of things, and economic valuation more generally, depend on what is referred to in the economics literature as people's "willingness to pay." "Willingness" is perhaps misleading; a more accurate description might be people's "willingness *and ability* to pay." Rich people are more able to pay for things, and thus, their preferences are reflected more in the prices of things and in economic valuation exercises. For this reason, people often complain that economic analyses recommend changes that make rich people better off at the expense of the poor. The economist's usual reply is that if we care about the poor, we should just give them money outright, rather than tailor our policies to better meet their needs. It can generally be shown that redistributing wealth is a better way of achieving social change than is distorting prices. While this redistribution is possible in theory, however, it is almost never accomplished in fact.

Some environmental advocates might agree with Henry David Thoreau's view that "Any man more right than his neighbor constitutes a majority of one"--at least with respect to setting environmental policy. In other words, if society does not make the right decisions concerning the preservation of biodiversity, perhaps it is because people simply don't understand the issues involved. This is a very troubling issue. On one hand, we would not want to trust self-described "experts" to make all of our decisions. On the other hand, however, virtually all of us have the had personal experience of wanting something at one time which we determine at another time to have been a bad choice. In the remainder of this paper, I will implicitly assume that people know what they want for themselves (although they may not take into account the effects of their actions on others). If the things that people want are not, in fact, the things that are best for them, economic analysis may not have much to contribute. We economists typically assume that people do, on average, and perhaps by learning from trial and error, know what is best for them. The study of how to make decisions when this is not the case is an open issue, however.

Section 2: Economic Values of Sri Lanka's Biodiversity

For the purposes of this paper we will consider the conservation of biodiversity as arising as a result of the restriction of human activity. Inasmuch as the human activities that threaten biodiversity would not be undertaken if they did not provide benefits to someone, there are costs inherent in biodiversity preservation. It is often possible to identify specific economic activities that must be curtailed if biodiversity is to be conserved, and to identify specific individuals who will bear the costs of those curtailed activities.

It is often more difficult to identify the beneficiaries of conservation. While the costs of conservation are often borne by local people, the benefits may accrue to quite distant people. Some benefits may even be global in scope. Due in part to the diffusion and spread of benefits, the goods and services produced by diverse natural ecosystems are often not priced and traded in markets. Thus, attempts to value these goods and services must often rely upon indirect measures and techniques that are frequently imprecise and sometimes not yet fully proved. Moreover, diverse natural ecosystems typically provide a number of different goods and services of actual or potential economic value. Even an effort to value the products of a relatively compact ecosystem will not be complete unless it considers the sum of the values that may be generated by the system.

A number of authors have suggested a number of ways to classify the economic values to which diverse natural ecosystems give rise. Distinctions are made, for example, between values in direct and indirect uses, between consumptive and non-consumptive uses, between present and future uses, and between use and non-use (or existence), values.

While these distinctions between types of values are valid, different approaches to classification may be more or less useful for different purposes.

I will suggest a distinction between categories of values based on methods that might be used to estimate them. I suggest a division between use and non-use values, and that a further division be made in the former category. Thus, there are three broad categories of economic values arising from biodiversity:

1. Values arising from the *use of goods and services* created by the functions of diverse natural ecosystems;
2. Values arising from the *replication of goods* derived from diverse natural ecosystems; and
3. *Non-use,* or existence, *values.*

2.1 Use Values Generated by Natural Ecosystems

Under this category of value we would include goods *harvested from natural ecosystems*, such as timber, wild game, non-timber forest products; goods and services *produced by natural ecosystems* which then augment the value of other economic activities, such as water and nutrient cycling, erosion control, flood protection, habitat for pollinating insects and birds, and, at a broader scale, climate moderation and carbon dioxide sequestration; and *non-consumptive services* such as trails hikers may enjoy in nature walks and the scenic beauty afforded by natural landscapes.

2.1.1 Valuation of harvested resources

The valuation of harvested resources is straightforward at one level. Gross revenues can often be generated by multiplying quantities harvested by market price. Costs can sometimes be calculated from recorded data on wages, transportation expenses, etc., and, if not, inferred from observations of wages, transportation costs, etc. in similar contexts. The value of certain categories of harvested biodiversity resources in Sri Lanka are a virtual unknown and demand greater attention. Included here is the collection and trade in ayurvedic medicines. Although it is informally estimated that nearly 70 percent of Sri Lankans make some use of ayurvedic treatment, there has been no serious economic analysis of the size of this market. The value of markets in other harvested products such as rare or disappearing endemic fish species, ornamental plants and even animals demand greater attention.

A paper that has valued harvested resources for non-timber forest products in Sri Lanka is Gunatilake, Senaratne, and Abeygunawardena (1993; see also Gunatilleke, Gunatilleke, and Abeygunawardena, 1993). As these authors note, however, the results of such an analysis does not necessarily give a true measure of economic value.

This procedure would be adequate if the rate of harvest were socially optimal and the resource stock remained constant (that is, if natural growth just balanced the harvest). If the resource stock does not remain constant, current earnings should be adjusted by valuing the change in the stock to calculate investment (or, if stocks are declining, disinvestment).

The rate of harvest may not be socially optimal for at least two reasons, both of which involve economic externalities. The first is if there is a "common pool," or "tragedy of the commons" problem. Every individual harvester might prefer to exploit the stock of resources available at a slower pace if she were assured that others would follow the same rule, but there is no point in preserving a tree this year if one thinks that someone else is going to cut it next year. The second reason that harvesting rates may not be optimal is that ecosystems are, as we have just pointed out, typically sources of a wide range of important goods and services. The simple theory of optimal harvesting, due to Faustman (see, e. g., Samuelson, 1968), prescribes harvesting when the growth of the stock of a resource is increasing at a rate equal to the rate of interest. When the stock of one resource in a complex ecosystem affects the growth of another valuable resource, principles for optimal harvesting become extremely complex. If harvesters of one resource do not consider the effects of their actions on the values of other resources, earnings from harvesting will overstate true values.

The problem of deriving appropriate valuation figures for dynamically optimal harvesting rates can become extremely difficult in practice. One would have to know a great deal about market

demand, incurred and opportunity costs of harvesting, and numbers of actual and would-be harvesters, as well as the biology of resource growth in order to compute the "true" value of a resource that is currently being overexploited, even if there were no externalities extending beyond the industry.

2.1.2 Goods and services produced by natural ecosystems

In some respects, it might actually be easier to calculate the external effects that harvesting resources imposes on other economic sectors than to calculate value of optimally harvested resources. The category of use values we are now discussing are values that are, by definition, reflected in some other measurable economic activity. Thus, we might be able to observe the effects of harvesting practices in one sector on values in another. By comparing earnings in one area that is more affected by degradation of natural resources, as opposed to those in another area that is less affected, we could infer the loss in value arising from degradation. The differential in earnings in such areas ought to be wholly accounted for by differences in location, and hence fully captured in differences in land prices. What is known as a "hedonic pricing study" would, in principle, be highly appropriate for use in the estimation ecological values. In a hedonic pricing study, the price of an asset (such as a hectare of land) is explained by its attributes (such as the ecological goods and services that flow to it from surrounding lands).

There are a number of difficulties that may prevent the use of such methods in practice, however. The first is simply that it can be extremely difficult to identify what ecological resources contribute to the value of particular properties, and, by the same token, what properties benefit from the services of a particular ecosystem. To take an extreme example, one could say that every property on earth is potentially effected by the reduction in carbon sequestration occasioned by the felling of any tree, anywhere.

A second issue concerns pricing and market distortions. One cannot observe regular transactions in properties anywhere; there is only limited turnover in land markets during any fixed period of time. Moreover, property is, in most areas, subject to taxes, so one might would want to consider both changes in property values and changes in public revenues in computing values of the diverse natural ecosystems that affect property values. Similarly, restrictions on the pricing of the goods and services provided by the properties that are in turn recipients of ecological goods and services means that some benefits are passed along to consumers (rather than reflected in property prices only), while some potential benefits may be dissipated due to inefficiencies generated by distorted pricing.

2.1.3 Examples of the valuation of ecological products in Sri Lanka

It might be useful if economists around the world, as well as in Sri Lanka, made more attempts to apply empirical hedonic pricing procedures in the estimation of biodiversity and ecological values. There are difficulties inherent in doing so, however. Attempts to value ecological services must often employ different methods. Let me illustrate the challenges that arise in these approaches with a few examples.

The first is taken from Banda and Abeygunawardena's (n. d.) study of the costs of erosion on potato lands. This study is both illustrative and innovative, but may be an exception that proves a rule. These authors are able to make a useful contribution because they can make use of soil erosion model in their calculations. It may be much more difficult to develop and use a "biodiversity erosion model," and link it to losses in production in other sectors. Banda and Abeygunawardena also need to make a somewhat heroic simplifying assumption in order to generate their economic-loss function. They value the loss of soil from erosion as the cost of its replacement or reconditioning. Replacement-cost methods are always somewhat suspect in economic studies, as it is not always clear that replacement is necessary (were the nutrients lost limiting factors in potato growth?) or that replacement would be optimal following damage (might degraded land be devoted to another purpose with greater economic benefits than would be realized by restoring it to its original productivity?).

As was noted above, scenic beauty is also a

service provided by natural ecosystems (and one which we might suppose would be provided in greater quantity by more diverse ecosystems). We could, again, think of hedonic approaches to the estimation of this value. And again, the problems noted above may prevent application of the techniques (government controls on lodging rates, and the difficulties surrounding the current unrest in Sri Lanka would make such an approach even more difficult).

Another technique, known as the travel cost method is closely related to hedonic pricing. Using this method, the economic value of one vacation destination can be compared to another destination (one that may, for example offer less biodiversity), by estimating the amount of additional expense travellers are willing to incur in order to reach the more desirable destination. This approach has been applied by Abeygunawardena and Kodithuwakku (1992) to the valuation of the Botanical Gardens at Peradeniya. This is an important study, and has arguably had an important effect on policy formation by supporting a revision in entrance fees to the Gardens. Similar analyses might be usefully applied to other attractions within Sri Lanka, and perhaps also to the estimation of the market power Sri Lanka enjoys with respect to foreign tourists's other potential holiday destinations.

Contingent valuation (survey) studies have also been conducted of tourists' willingness to pay to see, use, and even be assured of the continued existence of, natural ecosystems in Sri Lanka. Barker (1995; following Vaartjes and Witvliet, 1995) has evaluated tourists' stated willingness to pay to visit the coral reefs at Hikkaduwa. In addition to the general criticism made of contingent valuation studies (see, e. g., Kahneman and Knetsch, 1992; Diamond and Hausman, 1994), however, the survey instrument used in this work is especially problematic. Another study of the same area (Gunawardana, 1995) is less methodologically problematic, but it seems unlikely that the controversies surrounding the use of contingent valuation studies will soon be resolved. If there is any consensus about such studies, it is that if the surveys are to be made reliable, they must be very carefully planned, very carefully administered, and consequently, very expensive. For these reasons, it does not seem reasonable to devote many of the limited funds available in Sri Lanka to these efforts.

2.2 Use Values from the *Ex Situ* Replication of the Products of Natural Ecosystems

Another way in which values can be generated from biodiversity is as a source of new pharmaceutical products. Natural organisms produce a variety of chemicals for use in capturing prey, warding off predators, resisting infection, and enhancing reproduction. If these chemicals can be adapted for human use, they can be of great value in industrial, agricultural, or, particularly, pharmaceutical applications.

2.2.1 The valuation of the "marginal species"

In a recently published paper (Simpson, Sedjo, and Reid, 1996) my colleagues and I used a simple model to describe the value of biodiversity for use in new product research. We examined the incentives in a market for contracts between international pharmaceutical companies and the providers of plant genetic resources. The basic intuition underlying this work is as follows. When one considers the value of a species for use in pharmaceutical (or industrial, or agricultural) research, one must ask not only what the likelihood is that the species under consideration would yield a product of commercial value, but also the likelihood that an equivalent commercial product could be as easily developed from another species. If two or more species are equivalent sources of the same commercial product, the economic value of each is negligible for this use. This is simply an example of the principle of marginal valuation described above. The *total* value of a set of species that yield a new commercial product is great, but the *marginal* value of a redundant source is zero.

Of course, we do not know which species will and which will not prove to be sources of new commercial products. We can, however, suppose that any species chosen for testing has a certain probability of yielding a new product. Suppose that this probability is relatively high. Then it is also likely that two or more species will yield the new product. Conversely, suppose that the probability that any species chosen for testing will yield a new product is relatively low. Then it is unlikely that multiple species will be redundant sources of the new product, but it is also unlikely that *any* species will be a source of the product.

When the number of species is large, the value of the "marginal species" must be low *regardless* of how likely it is that testing will be successful.

2.2.2 An alternative approach

A different approach to the valuation of biodiversity in pharmaceutical research is exemplified in work done on biodiversity prospecting in Sri Lanka by Kotagama and Thusantha (1996), who, following earlier work by Pearce and Puroshothamon (1992), model the process of new product discovery as one in which incremental values are not diminished when additional discoveries are made. While this approach will necessarily lead to an overestimate of value, it is revealing that these researchers have also estimated relatively modest values. In extending their work, Thushantha and Kotagama will yield revised estimates for Sri Lanka by allowing for the possibility of competition between new product.

It is important to consider carefully what it is that is being valued in these studies. The approach in the Simpson, Sedjo, and Reid paper was explicitly on the value of the "marginal species." Other papers (that by Kotagama and Thusantha included) have typically concentrated on the valuation of a particular area, or even of all the world's biodiversity. If the question to be answered is "What is the contribution to value afforded by saving some additional biodiversity from destruction?" then the marginal species approach seems the correct one. Other questions are asked, however, and have different answers. If the question is "If all of Sri Lanka's biodiversity is preserved, what would it be worth as a source of new products?" one would not calculate the value of the marginal species, but rather, the total expected earnings. This presumes, however, that a decision has been made to protect all biodiversity. Presumably, this decision would be made on other non-economic grounds, as available evidence does not suggest that the values generated by biodiversity prospecting would motivate conservation by themselves.

It is worth emphasizing that even if *total* expected earnings from biodiversity prospecting were large, *marginal* incentives for conservation may still be negligible. If our goal is to ensure that international bio-prospecting contracts between foreign firms and Sri Lanka be managed in such a way as to ensure a significant flow of revenues to conserve biodiversity, then we need to reexamine our means for achieving our ends, because results show that the argument for earmarking biodiversity prospecting receipts to finance conservation is a weak one. Charges unrelated to willingness to pay on the margin may as easily discourage biodiversity prospecting all together as encourage conservation.

2.2.3 Valuing a combination of biodiversity and information

Somewhat different conclusions may result, however, when the issue is not the valuation of untested species for their medicinal potential, but rather, valuation of species about which some information is already known. For example, a plant used in traditional medicine will be a much more valuable "lead" for pharmaceutical product research than would be a completely untested species. In such cases, the species to be sampled embodies both genetic information and information that has been derived from traditional use.

Many people in Sri Lanka rely on Ayurvedic medicine for treatment. Although the exact number is unknown, it has been estimated at 70 percent of the total population. The Bandaranaike Memorial Ayurvedic Research Institute undertakes a great deal of work on the use of traditional medicines. Although the Institute's work undoubtedly improves the lives of many users of ayurveda, an important question concerns whether an expansion of the Institute's activities might generate substantial new values through bio-prospecting contracts for pharmaceutical research.

This question does merit additional research, but it is important to think clearly about the relationship between the types of biodiversity the Institute exploits and the incentives for biodiversity conservation more generally. The Institute deals, by and large, with plants whose medicinal uses have been known for quite some time--centuries, in many cases. Some of the plants used in Ayurvedic medicine are cultivated, some are collected from natural, or at least minimally managed systems, and many of the plants are not endemic to Sri Lanka. There is, in fact, international competition, largely between Sri Lanka and India, but involving some

other countries as well, for the supply of these plants. Since collection is very labor intensive, and Sri Lankan labor is more expensive than Indian, nonendemic plants are not likely to generate very large economic returns through bioprospecting contracts for Sri Lanka. (That said, the ayurvedic plants used in Sri Lanka, whether endemic or exotic, provide a valuable service to those millions of users whose health is improved by them.)

Even if a number of ayurvedic species were identified for use in pharmaceutical product development, it is important to ask whether that would lead to improved conservation of the habitats where such plants are currently found. If a plant were identified for use in pharmaceutical research, then the need for plant material would be great, and the incentives for cultivation of the plant *ex situ* would grow. It is important to recognize that plants that are cultivated *ex situ* provide no continuing incentives for the preservation of the natural ecosystems from which they were first taken. Only those plants currently harvested from natural ecosystems provide ongoing incentives for the maintenance of those ecosystems. Thus, while increasing the earnings of Ayurvedic medicine may be a useful development objective, the conservation consequences could prove disappointing.

2.2.4 Valuation of biodiversity for use in agricultural improvement

An activity closely related to biodiversity prospecting is the use of local land races and wild relatives in crop improvement programs. Similar modes of analysis can be employed (e. g., Brown and Goldstein, 1984; Simpson and Sedjo, 1996; see also Evenson, 1995) in approaching the problem. Sri Lanka has a very large diversity of rice cultivars for a country of its size (Wijesinghe, *et al.*, 1993). It is encouraging to note that a study of the values of this genetic diversity is currently underway. Nevertheless, it is likely that the values identified here might be negligible for the reasons outlined above with respect to pharmaceutical product development.

2.3 Nonuse, or Existence, Values

Pure existence values -- values placed on resources even if the person placing the value has never used and will never use it -- are felt by many people. We place value on knowing that a coral reef exists or that a certain forest remains pristine. We may feel it keenly when a species exists no longer in the country or in the world. In spite of the importance we may give to existence values, measurement of such values presents formidable challenges. Some studies have considered existence values for resources in Sri Lanka (see Abeygunawardena, n. d.). The only way to estimate existence values is by the contingent valuation method, however, and the criticisms mentioned above certainly apply.

It seems unlikely that one could empirically distinguish between Sri Lankans' willingness to pay for use and nonuse values, and it does not seem constructive to try. People elsewhere in the world may place some value on the continued existence of diverse natural ecosystems in Sri Lanka. To ask even a representative sample of people from around the world how much they would be willing to pay seems an expensive exercise. Until the rest of the world acts upon its willingness to pay to preserve resources in Sri Lanka, Sri Lankans ought not to feel themselves obliged to maintain their resources for others' benefit.

Section 3: Property Rights, Incentives, and Measurement

The valuation of biodiversity must be closely linked to policy measures to realize and preserve those values. In this section we will consider three such policy-related matters:

1. Property rights--under which we will distinguish between physical and intellectual property rights
2. Incentive mechanisms
3. Revised measurement of aggregate economic performance, or "green accounting"

3.1 Property Rights

3.1.1 Property rights and conservation

If a user does not have an exclusive right to the future output of an asset, he may over exploit the asset in the short run. Incentives to save productive assets for use in the future are lessened to the extent that the person undertaking the sacrifice inherent in saving will not be the only beneficiary of having saved. Economic analysis typically makes a distinction between private and public goods. Private goods are goods that are rival. This means that one person's consumption makes another's logically impossible: you and I cannot both eat all of the same apple. Private goods are also excludable: it is possible to physically prevent someone from consuming a good for which she has not paid.

Public goods are goods that are non-rival and non-excludable. The process of assigning property rights to non-rival goods is essentially a matter of excluding unauthorized persons from consuming them.

Before discussing this process of imposing exclusivity on non-rival goods--the leading example being the award of intellectual property rights--let us digress slightly to think about the assignation of property rights to physical assets. It can be argued that natural ecosystems are, when population and economic pressures on them are relatively low, like non-rival goods. This is not technically true: if I fell a tree and use it to construct my house, or if I catch a fish and feed my family with it, you cannot use the same tree, or eat the same fish. When levels of use are relatively low, however, it will be approximately as easy for you to find a suitable tree for your house, or catch a similar fish. The rival character of natural ecosystems becomes more apparent when pressures on these systems increase. The more people there are logging and fishing, the less likely it is that each will find a tree or fish of the same quality. Competition between rival loggers and fishers can, then, lead to a "tragedy of the commons" in which each harvests without consideration of the impact of her actions on others, and, from a social perspective, too much logging and fishing take place.

The economic analysis of property rights (see, e. g., Barzel, 1989) predicts that property rights in natural ecosystems come into being when the social benefits of their definition exceed the costs of their enforcement. The benefits are those to which we have alluded above: avoiding the "tragedy of the commons" (Hardin, 1966) and allocating resources efficiently. There are costs to the assignation of property rights, however. The costs arise from allocating resources to enforcement.

Traditionally, property rights have been assigned when "improvements" have been made in property. That is, when land is cleared, structures built, or areas fenced. The rationale for this approach is that society ought to provide incentives (in this case, property rights) for people to undertake such "improvements." We are increasingly faced with situations in which this logic is reversed. Society may now wish to provide incentives for people not to undertake degradation of natural ecosystems. Whereas traditional property right law has emphasized the alteration of landscapes as a basis on which to claim rights in them, it may be more important now to award rights in properties in return for promises *not* to alter them.

There are examples of situations in Sri Lanka in which the establishment of property rights--or at least the enforcement of some exclusions--might be of social benefit. One such case is the coral reefs at Hikkaduwa. At present, a number of hotels rely on the reefs as attractions for their guests; a number of glass-bottom tour boat operators offer excursions to the same guests; and a number of fishing boats

moor in the area, competing for space with both tourists and the glass-bottom boats, and contributing to the pollution of the area. The assignation of property rights in the reef (meaning, in practice, the ability to exclude some would-be users) could well lead to a situation in which all parties are made better off. According to the "Coase theorem," (Coase, 1960) it should make little difference to whom the property rights are assigned: hoteliers could pay glass-bottom boat operators to limit their use, or the glass-bottom boat operators could have the right to restrict access to the reef areas. The ownership rights could also be assigned to local or national government, who could then allocate access to competing users by setting fees and terms of access.

As a practical matter, however, it may be important exactly who has the property rights. On one hand, allocation of rights is a potential source of revenue for government. On the other hand, whoever is given property rights initially can realize earnings from their exercise or sale. Cooperation might be better achieved by assigning property rights (or, more specifically, boat operation permits) to existing operators.

3.1.2 Intellectual property rights

Intellectual property is non-rival. There is no physical or logical reason for which two people cannot have exactly the same idea. Thinking of new ideas is, however, an economic activity like any other: inventive activity responds to economic incentives. If, once new ideas are made public, they can be copied by anyone who has a use for them, there will be little reward for innovation, and, hence, little incentive to innovate.

Intellectual property law--the law applying to patents, copyrights, trademarks, trade secrets, etc. has traditionally balanced two considerations. First, there is the provision of incentives to innovate we have discussed above. Offsetting this incentive, however, is a reluctance to grant unwarranted monopolies. This latter consideration has traditionally motivated the exclusion of certain types of "intellectual property" from protection: these have included discoveries concerning the fundamental laws of nature and mathematics, and unimproved natural products. The latter exclusion has been motivated by the view that there is often not any important human input in such discoveries (or that such discoveries were first made long ago), and hence little need to provide incentives.

This view is also changing as human impact on the natural world increases. While the question of *inventive* activity in the creation of new products from natural ecosystems may remain open, there is also an issue of the costs of conservation. The stock of potential ideas may be limitless, but the stock of natural products from which products can be adapted is limited, and, in the estimation of some, rapidly decreasing. As we have noted, conservation involves both pecuniary and opportunity costs, and those who incur these costs require incentives if they are to continue conserving resources.

It has been suggested that strengthening intellectual property rights, and extending the range over which they are applied may generate stronger incentives for conservation. While this argument may be true, the magnitude of the effects to which it would give rise is very much in doubt. The issue with regard to conservation incentives concerns the magnitude of the payments that might be made *for the conservation of the diverse natural ecosystems* in which new products may be found. While the Simpson, Sedjo, and Reid (1996) and Thushantha and Kotagama (1996) studies differ in their methods, neither suggests that willingness to pay for the conservation of endemic species *in situ* is likely to be very high. Inasmuch as the establishment of intellectual property rights (as with any other type of property rights) has costs (the costs of maintaining registries, and of legal proceedings in the event of infringement, for example), these costs need to be considered before making decisions to expand the scope of property right protection

It is not likely that widening the protection of intellectual property rights in Sri Lanka will have much effect on the conservation of natural resources. I say this for two reasons. First, among nations that have signed the Biodiversity Convention (UNEP, 1992), at least (and prominent non-signatories, such as the U. S., who would still likely be bound by its provisions), there is a requirement to obtain "prior informed consent" before acquiring materials. In other words, bilateral contracts may substitute effectively for explicit intellectual property rights. Moreover,

such bilateral contracts were developed (e. g., the celebrated agreement between Merck and Costa Rica's *Instituto Nacional de Biodiversidad*) prior to the signing of the Biodiversity Convention, and, arguably, such contracts obviate the need for the Convention's explicit terms.

My second reason for skepticism concerning the effects of stronger intellectual property rights in Sri Lanka concerns the underlying value of the resources. By whatever reasonable method one measures it, the expected value of genetic resources *in situ* is not very large. There is much emphasis in the literature on appropriating all of this expected value (Pearce and Puroshothamon, 1992), or even on augmenting it by undertaking more "value adding" activities domestically (Reid, *et al.*, 1993), but the best evidence now available (see, in addition to the papers on valuation cited above, Aylward, 1993; Artuso, 1994; and Mendelsohn and Balick, 1995) suggests that even fully appropriated expected values would be modest. Strengthening intellectual property rights, therefore, would be expected to improve conservation incentives only marginally. Nevertheless, the government may have other, and entirely valid, reasons for strengthening intellectual property regimes. Among these reasons could be included compliance with the recommendations of the Convention that such regimes be strengthened among all signatories.

As was noted above, there may be more money to be made in the development of Ayurvedic products. These products are also, like "unimproved" natural products, typically not eligible for protection as intellectual property (the argument being that their use in traditional medicine has placed them "in the public domain"). The ability to acquire patent or similar intellectual property coverage for these products might generate higher earnings for Sri Lanka, but, as in the earlier discussion, it is important to think about what the implications might be for biodiversity conservation.

3.2 Incentive mechanisms

The property rights issues discussed above are examples of incentive mechanisms. By assigning rights in properties, we may increase the incentives of their owners to conserve them. The assignation of rights in properties without imposing any other restrictions does, however, grant to owners the right to do with their properties as they please. In many cases an owner may be unable fully to appropriate the value of preserving biodiversity on her property (when some of the benefits are enjoyed by visitors who do not pay for access, by farmers downstream who do not pay for flood and erosion protection, or by the international community). In these cases, owners much be given additional compensation if they are to conserve the biodiversity on their properties.

I have discussed some issues in valuation above. Valuation of diverse natural ecosystems is intended to provide estimates of the amount by which owners should be compensated if they are to preserve the natural assets they control. There is, however, considerable ongoing controversy about how best to convey incentives to owners. In what follows, I will consider two general categories of approaches, indirect and direct. While the latter would seem to be the more economically straightforward and reliable, the former has achieved surprising prominence, and I will discuss it first.

3.2.1 Indirect approaches to financing conservation

By indirect approaches, I mean approaches that attempt to provide incentives for conservation by subsidizing related economic activities. Many of these approaches can be classified under the rubric of "integrated conservation and development programs" (ICDPs; see Wells and Brandon, 1992; Ferraro and Kramer, 1995; Simpson, 1995; Simpson and Sedjo, forthcoming). Examples include schemes for the commercialization of non-timber forest products (NTFPs), "sustainable" timber harvesting, ecotourism, and biodiversity prospecting (for an analysis of the applicability of these strategies in Sri Lanka, see Steele and Kathiravelu, 1996).

In each of these cases, increased incentives for conservation will result if investments in assets used in these activities are complementary with preservation of natural assets. The notion of economic complementarity can be made precise, and could be of considerable value in clarifying discussions concerning the impacts of, for example,

ecotourism. There is considerable controversy about what exactly is, and what is not, "ecotourism". Do large hotel complexes qualify as "ecotourist" facilities? Foreign-run tours? Activities involving motor transport as opposed to movement on foot? Let me suggest that the relevant distinction should be whether or not activities, regardless of their format, do or do not create greater incentives for the preservation of biodiversity. The provision of travel services combines natural assets (e. g., forests, mountains, coral reefs) with human inputs (e. g., labour, vehicles, structures). Formally, investment in the human inputs employed in the tourism (or NTFPs, or biodiversity prospecting) is complementary with natural assets if it results in the marginal product of natural assets increasing. This increasing marginal product translates into greater incentives for conservation. Now it may be difficult to define the natural assets whose conservation is intended to be encouraged, and to measure their marginal products, but this definition is at least conceptually straightforward.

I am sceptical regarding the efficacy of indirect incentives in promoting conservation. My doubts can be summarized in the following rhetorical questions (Simpson, 1995):

1. If commercial activities intended to promote biodiversity conservation would be profitable, why are not private businesses already taking advantage of the opportunity?
2. If commercial activities will not be profitable, then, by definition, more money will be spent on subsidizing projects than will be generated from them; if this is the case, why not take the amount of money that would be used to subsidize a project and devote it to direct payments for conservation?

It could be true that market failures--lack of credit, information problems, and problems of joint action--mean that potentially profitable opportunities are not acted upon in the private market. I have argued elsewhere (Simpson, 1995; Simpson and Sedjo, forthcoming) that these same considerations may also make it difficult to implement indirect payment plans. In any event, schemes for the public subsidization of non-timber forest product collection, ecotourism, and biodiversity prospecting in Sri Lanka should only be implemented after very careful thought concerning their practicability and their merits relative to more direct payment plans.

It is also worth mentioning that indirect incentive programs run a high risk of being counterproductive with respect to conservation objectives. Such programs are suggested because it is believed that not enough is being done to conserve biodiversity. This must be because there are benefits that are not being realized by existing landholders, workers, etc. To encourage these individuals to pursue more intensively those activities in which they do realize private benefits may often be to encourage them to degrade their biodiversity further.

It may be useful to consider these issues with respect to ideas currently being discussed to have Sri Lankan park authorities administer tourist accommodations and facilities. It is worth remembering that parks are designated as parks precisely because society determines that they should be protected from (at least some) commercial uses. One can argue that park authorities may be better placed to prevent excesses than are outsiders, but making park budgets reliant on the provision of commercial services does create potential conflicts of interest. These conflicts appear to be resolved in some nations. In the United States, for example, the Park Service sells the right to operate concessions to private firms. The Park Service then oversees operations to assure that they are ecologically sound. A similar arrangement might be instituted in Sri Lanka. This issue deserves further study, but it should always be remembered that the need to preserve natural ecosystems will put constraints on the earnings that can be realized from them.

3.2.2 Direct approaches to financing conservation

The considerations discussed in the paragraph above suggest that direct approaches may be more effective in encouraging conservation. If what we want to do is to encourage people to maintain a forest or a coral reef, we should pay them for not cutting trees or not mining coral. This approach

will require the establishment of property rights--people who receive payments for maintaining biodiversity must be able to exclude other people from destroying it. On one hand, however, the existence of payments for maintaining biodiversity is likely to lead to the establishment of property rights. On the other hand, indirect payment schemes may be no less dependent on the establishment of property rights for their success.

I have not had the opportunity to study whatever direct payment schemes may exist in Sri Lanka. I would, however, suggest that consideration be given to tax relief and conservation payment programs here. Experience in, for example, the United States with Conservation Reserve Programs and private wildlife recovery programs, in Indonesia with social forestry programs, and in Zimbabwe with wildlife ownership and management (the CAMPFIRE program--see Steele and Kathiravelu, 1996) might be investigated for their applicability in Sri Lanka. Inasmuch as the benefits of such programs may largely accrue to foreigners (through existence values, global biodiversity benefits, and carbon sequestration) while the government subsidizes them, efforts should be made to collect foreign donor support for these direct programs.

3.3 The Measurement of Ecological Economic Performance

One of the objectives of the Biodiversity Action Plan preparation process is to consider how best to integrate economic values of biodiversity into national planning. There has been considerable recent interest around the world in "green accounting;" that is, the incorporation of environmental performance into the calculation of national income and product accounts. A very useful contribution has been made recently to green accounting in Sri Lanka by da Silva and Kotagama (1996).

It is important to think about the uses to which national accounts are to be put, however. Henry Peskin, who has made seminal contributions to the subject, distinguishes between the uses of accounting for "management" and "score keeping" (Peskin, forthcoming). The latter involves using aggregate figures as a measure of overall economic performance. While it is interesting to learn whether the economy has done better or worse than it did in the past, getting this information after the fact is of limited use. In fact, very few important decisions are made on the basis of aggregate economic performance as recorded in national accounts. Rather, people make important economic decisions on the basis of the prices they face and the benefits they receive.

Thus, as Peskin points out, the more important function of national income accounting is not in generating more accurate "scores," but rather, in learning what can be done to improve management so as to increase the "scores" in subsequent periods. Thus, improving national accounting is identical with improving valuation methods.

It may be useful to briefly describe some principles of valuation and accounting to underscore the above point. In contrast, perhaps, to many non-economists' understanding, there is a sense in which many environmental values *are* reflected in national income and product accounts. We noted above that many of the economic values provided by diverse natural ecosystems are embodied in economically measurable production. To the extent that measured production changes in response to changes in environmental conditions, these values of changes in environmental conditions will be reflected in national accounts.

While these values will be reflected in national accounts, there are two problems with the way they are reflected. First, economic damage induced by environmental degradation is not contemporaneous with the environmental degradation. National income, properly measured, considers not only current benefits, but also changes in (both manufactured and natural) capital that can be used to provide future benefits. So, although environmental damage will eventually be reflected in the measured output of those sectors of the economy that rely on natural resource services, when we measure the value of natural assets, we would like to reflect their *current* impact on *future* earnings.

The second problem with relying upon current aggregate measures of economic performance is precisely that they are aggregate measures. To return to Peskin's management analogy, the important consideration is not necessarily to know what is happening to aggregate performance, but rather to know how changes in the value of one

asset impact on the earnings of another. That is, we need to perform valuation activities in order to better form public policy toward the preservation of natural resources.

I would suggest that emphasis might better be placed on deriving precise estimates of the values of some things than imprecise estimates of the value of everything.

Section 4. Priorities for Research, Policy Making, and Capacity Building

In this section I will suggest priorities with respect to three issues:

1. Areas on which to conduct economic valuation, including suggestions of both issues to be addressed and tools to be used in addressing them;
2. Priorities for incorporating economic values into national and local decision making; and
3. Institutional issues to consider in building domestic capacity to do more sophisticated and reliable economic valuation.

4.1 Priorities in conducting economic valuation

I suggest that attention be devoted to those issues that are under Sri Lanka's control and for which fairly concrete and reliable answers might be found. These criteria argue against spending much time and effort looking into global environmental externalities (carbon sequestration and existence values of biodiversity, as the leading examples). There are also instances in which valuation effort in Sri Lanka may be obviated by developments in world markets (the examples in the above parenthetical remark might apply, as may biodiversity prospecting). Finally, I am going to argue against putting much effort into measuring local existence values.

I argued above that the definition of property rights imposes costs as well as providing benefits. Similarly, economic valuation activities can only be accomplished at a cost. These costs should only be incurred if the information likely to be provided can reasonably be expected to have an impact on decision making and would not be forthcoming from other sources.

4.1.1 Issues

Biodiversity prospecting

While there appears to be an emerging consensus that the values of biodiversity for use in new product research are modest, the issue still generates considerable discussion and interest in Sri Lanka. It would be useful to continue work in this vein both to refine estimates for Sri Lanka and to demonstrate the possibility of doing rigorous economic valuation. The Thushantha and Kotagama paper (1996) makes a good start on doing this. The revisions I have discussed with the authors will increase the accuracy of the work, and should advance the state-of-the-art in doing this type of valuation.

As I discussed above, values may be greater when we are considering contributions from Ayurvedic medicine rather than from wild species sampled at random. Ongoing research should consider these distinctions, and estimate the higher values that should result when additional information is available. As also noted above, these higher values may not necessarily translate into greater conservation incentives, and an analysis of conservation incentives should accompany the analysis.

Further valuation efforts on both untested resources *in situ* and organisms now used in Ayurvedic medicine can have direct and timely impact on policy formation. With respect to the value of resources *in situ*, more concise estimation will tell how much conservation can be motivated by pharmaceutical research demand, and how much will need to be financed from other sources.

With respect to both "biodiversity prospecting" and Ayurvedic leads, it is true that purchasers will pay more for "finished products" than they will for raw materials. This does *not* mean that performing more "value-adding" activities in Sri Lanka is necessarily advisable. What the lay person may

think of as "value added" is, to an economist, often an accurate measure of "cost incurred." Value added is the revenue from finished products less the costs of materials. The difference between these quantities is not necessarily economic profit, but rather, payment to labour and return on investment. Unless the return on investment is greater than the cost, the investment is economically unwise. This must be borne in mind whenever contemplating the gains to commercially exploiting biodiversity.

Further work comparing returns to "biodiversity prospecting" with Ayurvedic development may also shed light on another important and policy-relevant distinction. The willingness of international purchasers to pay for access to Sri Lanka's biodiversity can be calculated at a couple of levels. On a *per contract* level, payments might prove substantial. For the reasons discussed above, however, this may not translate into very large payments *per hectare* of natural habitat now serving to support biodiversity. Payments made for knowledge concerning the use of a species now cultivated *ex situ*, for example, will have no direct effect on conservation.

Local ecosystem services

A potentially important source of value is the interrelationship between area preserved in natural habitat, biodiversity, and the provision of services such as pollutant filtration and sequestration, ground water recharge, erosion protection, and so forth. Information concerning these relationships is of the essence in setting policy for land use planning, and in determining the need to strengthen community management. It seems that these ecosystem services could, at least in principle, be valued by either hedonic methods or simulations on the basis of hydrological or other natural science modelling (an effort to do this in one area is represented by Banda and Abeygunawardena, n. d.). A number of such investigations might be undertaken and used to direct development activities. To give one example, da Silva and Kotagama (1996) have considered the value of water purification services in one section of their paper on green accounting. This work might usefully be expanded into a stand-alone study. Its output would be helpful in determining appropriate rates of deforestation, and in quantifying the impact of rural activities on municipal areas.

Another particularly interesting and timely study in the Sri Lankan context might be of the relationship between the health and biodiversity of natural and managed forests, water run-off, and recharge of hydroelectric reservoirs. The Battagalla and Kotagama (1996) and da Silva and Kotagama (1996) papers provide starts toward both data collection and modelling approaches. More generally, standard hedonic approaches (as described in, for example, Freeman, 1993) might be applied to ecosystem valuation issues in Sri Lanka in the same way as they have been in numerous studies in the U. S.

Finally, the case study planned on the valuation of coral reef fisheries under different management regimes is very timely. Discussions with residents and experts suggest that the value of the aquarium and consumption fisheries might be improved substantially by initiating more effective community management. The work proposed, performing economic analysis on data provided by marine biologists and government sources, could have an immediate and important impact on coastal resource management.

Global benefits

I understand that the World Bank has recommended to IUCN and the government that Sri Lanka estimate the global benefits of its biodiversity resources. This makes little sense to me. If the rest of the world comes to appreciate these values, the rest of the world can pay for them. If not, Sri Lanka would not be well advised to sacrifice its welfare in order to avoid a contribution to global costs that would be infinitesimal in relation to the contributions of others (including those who nations that profess to have the greatest concerns). Sri Lanka might also be well advised to free ride off the research contributions of other nations. A ton of carbon dioxide has the same effect on global climate, wherever it is emitted. Thus the global willingness to pay per ton of emissions is the same everywhere. If the international community decides to purchase carbon reductions, Sri Lanka may then evaluate its physical capacity to implement sequestration. At this point, however, the analysis required would be a biophysical, rather than an economic one. It may

be wise for Sri Lanka to be prepared with such biophysical figures in order to "market" its carbon sequestration services, but Sri Lankan estimates of global benefits would only replicate figures being assembled in other countries anyway.

4.1.2 Methods of analysis

I believe that priority should be given to using the more standard methods of economic analysis. By this I mean hedonic and "production function" approaches. The methods for applying these techniques are relatively well developed. They are also the techniques most appropriate to the valuation of the local and national contributions of biodiversity on which I believe Sri Lankan studies should be focussed. I would not recommend doing contingent valuation studies. Multi objective programming approaches may sometimes be useful to frame issues, and but not to resolve them.

Hedonic and production modelling

As I suggested above, I think that a number of questions might be addressed by considering the ways in which ecological services enter measured economic activity and asset values. Whether empirical results are to be estimated econometrically or simulated using numerical models calibrated with limited data, careful conceptual modelling should be done. In particular, researchers must be careful to insure that they are actually modelling values on the margin, and that the full range of substitutes is considered. For example, if a researcher were estimating the value of erosion protection provided by diverse natural ecosystems, she would want to value the incremental contribution of a particular natural system to erosion protection, not the value contributed by all the soil that could possibly be eroded away. Similarly, if one were estimating the value of nutrients lost to erosion in the same study, she would want to consider all possibilities for compensating for the loss of the nutrients, as well as the possibility of switching to alternative land uses.

Ideally, there would be adequate data for doing careful econometric studies, and hypotheses could be tested in formal statistical models. Economic data can serve as very convenient "sufficient statistics" for the ecological services provided by one area to another. For example, one need not know exactly how much purified water natural ecosystem A provides to agricultural area B in order to estimate the economic value of A to B. The price of land in region B reflects the value of economic production that can take place in B. Changes in A change the value of production that can take place, and hence, the value of land. If the effects of changes in A on values in B can be observed, economic values can be estimated statistically. In many cases, these statistical models could be estimated using the most basic techniques (in econometric terminology, "ordinary least squares"). Training in the application of this technique is common in graduate, and, increasingly, undergraduate economic curricula. Most statistical packages, and even spreadsheet programs can handle the calculations. More difficult problems sometimes arise, and require more advanced techniques (e. g., "generalized least squares," "instrumental variables," "switching regimes"). More complete statistical packages offer options for these procedures. The problem is typically more one of *when* to use different estimation procedures than *how*, however. Advice on these matters can be obtained when articles are reviewed upon submission for publication. This is rather late in the process, however. It is hoped that advice on estimation can be solicited in discussions with colleagues in economics and statistical faculties, and in E-mail and other correspondence with international colleagues.

Regrettably, lack of data and difficulties in defining regions over which causes and effects are felt may limit the ability to do formal statistical work, but conceptual models calibrated to figures provided by biologists and other natural scientists can provide estimates that might at least be used to identify areas of concern. An example of this is the paper by Banda and Abeygunawardena (n. d.) that I have mentioned above. In this case, a model of soil erosion is coupled with economic data to estimate the values of preventing erosion.

Similarly, biological models could be used in estimating values. To give an example, we have discussed methods of inferring the value of coastal reefs for aquarium and other fish collection with marine biologists Dr. Alan White and Mr. Wickramaratne of the Coastal Resources

Management Project and Dr. S.U.K. Ekaratne of the University of Colombo. These discussions have led to the design of a case study comparing the benefits arising from improved management of coastal reefs. Extensions of this study could be pursued by soliciting more data from the biologists and using standard techniques from the fisheries economics literature, as presented in the Dasgupta and Heal text (1979), for example.

Contingent valuation (CV) methods

I would advise against doing much work with contingent valuation (survey) methods. I say this for a number of reasons:

1. The method is highly controversial, and of dubious reliability, even when practised by experts;
2. The only consensus on its use seems to be that to do it right one must go to considerable time, effort, and expense;
3. While CV may be applied to any value one might wish to estimate, less controversial methods exist for valuing, for example, recreational demand; and
4. Existence values are the only area in which CV is the only relevant method. If the majority of people who hold high existence values for Sri Lankan biodiversity are foreigners, Sri Lanka ought not to incur a great deal of expense in learning those values.

Multi objective programming

At least two existing papers apply Multi objective programming to the valuation of biodiversity in Sri Lanka (Battagalla and Kotagama, 1996; Pathirana and Kotagama, 1996). This seems to me a better method of framing than of resolving issues. It may be useful to use Multi objective programming models to illustrate possibilities, but once a researcher inserts *ad hoc* weights in balancing objectives against one another, he is inserting his own judgment concerning relative values for any indication from economic data. I would suggest that the use of Multi objective programming be restricted to the presentation of alternatives, with greater emphasis being placed on economic valuation to make final decisions.

4.2 Priorities for policy making

There seem to be a couple of "low apples" that might be picked with fairly simple and inexpensive regulation. Other policy measures under discussion may be less desirable. The greatest gains may be realized by extending physical property rights and providing direct incentives for conservation. Extension of intellectual property rights may be of less value. Any steps taken to implement the types of indirect incentive programs we have discussed above should be taken with extreme caution.

4.2.1 Organizing communities for more effective use of resources

I have been impressed that many of the problems facing Hikkaduwa reef could be solved by restricting the number of boats there. Congestion, collisions, pollution, and reef damage would all be reduced. As a consequence, the destination would be more attractive to tourists, hotel profits would increase, and, in all probability, tourist boat owners' total earnings would increase, although fewer people might be sharing those earnings. What would be required to implement this solution would be a restriction on the number of boats allowed and enforcement of penalties against unauthorized boaters. There is some evidence that enforcement of restrictions on other illegal activities (coral damage and mining, for example) is already having beneficial effects. Regrettably, attempts at regulating boating activity have had little effect. The National Aquatic Resources Agency proposed that access be restricted to ten tourist boats. Local boat owners and operators themselves suggested restrictions to forty, and then fifty boats. At last count, some seventy boats were operating. Inasmuch as boat operators themselves recognize the need for restrictions, one would hope that the problems of coordination and enforcement that have prevented effective control to date would soon be corrected. One useful, and relatively inexpensive, way to motivate this would be to undertake a study of the optimal number of boats to operate in the area. While it might be difficult to generate exact numbers, such a study should at least demonstrate

that large gains can be realized by more effective community management.

While the Hikkaduwa Reef is a sanctuary, similar licensing and restriction schemes for other types of activities at other reefs--and other areas more generally--could generate benefits both for biodiversity and those involved in live fish harvest for aquarium and restaurant markets. The advantage of all these approaches is that market participants might be enlisted in enforcement. Those who are legally offering boat rides, or legally collecting fish, will have an incentive to report those who are doing so illegally.

Of course, the problem will be that, when access is restricted, there will be incentives to participate illegally. The only solution is to enforce rules strictly. It is also somewhat troubling to suggest solving problems by creating and enforcing a cartel -- the situation may evolve from maintaining a resource to a conspiracy against the public to keep prices high. The latter seems the lesser of two evils, however. Whatever the precise system used to restrict access, it will require high-level political support and insulation from local or national political interference.

There is also an issue of how to allocate rights to participate. As noted above, any party could be assigned property rights, or they could be purchased from the government. While government sales of permits might be preferred as a means of generating revenues, providing permits for free might better ensure cooperation in enforcement.

The case study of the more efficient use of coral reefs mentioned above will address the issues I have raised here concerning allocation of permits, distribution of revenues, community cooperation in enforcement, and effects on both economic efficiency and biodiversity conservation. I anticipate that the results of this study will have an important and tangible impact on policy formation.

4.2.2 Extension of intellectual property rights

A strong and predictable system of intellectual property rights is useful for several reasons (not the least of which is assuring those who export technology to Sri Lanka of security), but, for the reasons I outlined above, I doubt that efforts to extend intellectual property rights to unimproved genetic resources would have much impact. Again, Ayurvedic medicine could be a different matter, but I am not optimistic that large gains could be generated by attempting to expand intellectual property protection. For better or for worse, products whose medicinal potential is known are in the public domain. Extension of intellectual property right protection to such products in Sri Lanka can be expected to have no effect on the production elsewhere. Inasmuch as it can be difficult to draft such statutes, I am not confident that the benefits of doing so would exceed the costs.

4.2.3 Indirect incentive mechanisms

Indirect approaches are attempts to provide incentives for conservation by subsidizing related economic activities. Examples include schemes for the commercialization of non-timber forest products (NTFPs), "sustainable" timber harvesting, ecotourism, and biodiversity prospecting. In each of these cases, increased incentives for conservation will result if investments in assets used in these activities are complementary with preservation of natural assets. I am extremely sceptical regarding the efficacy of indirect incentives in promoting conservation. In analysing such proposals, one has to wonder why any additional impetus is needed if such projects are profitable. If such projects are not profitable, then, by definition, more money will be spent on subsidizing them than will be generated from them. If this is the case, why not take the amount of money that would be used to subsidize a project and devote it to direct payments for conservation?

4.2.4 Direct incentive mechanisms

If the national benefits of such things are established, Sri Lanka may wish to experiment more broadly with subsidies for land conservation, payments for demonstrable assistance to wildlife propagation, tax relief, and similar measures for conserving biodiverse habitats. Experience in, for example, the United States with Conservation Reserve Programs and private wildlife recovery programs, in Indonesia with social forestry programs, and in Zimbabwe with wildlife ownership and management (the CAMPFIRE

program--see Steele and Kathiravelu, 1996) might be investigated for their applicability in Sri Lanka.

4.3 Local capacity building

Sri Lanka can draw on some impressive expertise among its environmental economists. The number of qualified people in the field is still rather low, however, and there are more challenging and important projects than there are local experts to work on them. I have very much enjoyed meeting and working with some very promising students. It takes quite some time for these students to really learn how to do state-of-the-art work independently. Thus, it will be a while yet before sufficient local expertise exists to address all the pressing issues. Some priorities need to be decided, then, for developing local capacity to do studies.

Most importantly, the level of commitment to undertake long-term, high-quality work in the economic valuation of biodiversity and ecological goods and services more generally must be decided. Hasty, careless studies will only add noise to the policy-making process, and may be worse than doing no economic analysis at all. Doing economic valuation of such poorly understood resources correctly takes time and money. Any expenditure of time and money should be subject to a cost-benefit analysis itself. I have not assessed the "value of measuring values," but this is an important issue. If it is determined that economic valuation is an essential part of the biodiversity strategy, adequate resources must be provided to do economic valuation carefully.

It is also worth pointing out that the field of environmental economics, and even more so the "sub-field" dealing with ecological valuation is rapidly evolving, and there is considerable disagreement even among experts on priorities, methods, and findings. Work on biodiversity valuation is very much on the cutting edge. That a country such as Sri Lanka is investigating these issues is remarkable.

4.3.1 Basic education in economics

As in most such matters, the benefits to having many people know something about a subject may be greater than would be the benefits of having a few people know a great deal about the subject. Undergraduate education in economics is important for this reason. My impression has been that the universities are providing this service.

4.3.2 Advanced education in economics

As noted, the supply of senior research expertise to address issues in environmental economics is inadequate to meet current demand. If the emphasis on environmental and ecological valuation is to continue in the long run, more senior researchers will have to be trained. In the short-to-medium run, students working on dissertations can both acquire expertise and contribute useful research results as they complete their work. While graduate students can typically be imposed upon to work inexpensively, some support must be provided.

Graduate research fellowships and grants that senior researchers may pass on to their students will help accomplish the objectives of both encouraging research and educating new researchers. Such research fellowships and grants represent a relatively small investment, especially for foreign donor organizations, but may generate substantial long-run payoffs.

4.3.3 Collaboration among domestic researchers

My impression has been that the greatest expertise for doing policy-related environmental economics research exists among academic researchers. This should not, of course, rule out collaborations between academics and employees of the Ministries. In particular, the Environmental Economics Group retained by the Ministry of Transport, Environment, and Women's Affairs can provide peer reviews that are extremely useful in evaluating and improving ongoing work (although this group is composed, by and large, of academics, and is thus not within the Ministry itself). I would anticipate that the day-to-day responsibilities of the latter would preclude their substantial involvement in research projects (although people in government are likely to be sources of data; in the reef management project mentioned above, some very useful information on live fish exports may come from the Customs office). Given these

circumstances, as well as the need to develop more expertise to which I referred above, channelling funding through the universities seems wisest.

While the education of students in environmental economics is important, some additional expertise may be found among other economists already on university faculties. I have not had the opportunity to speak with a large number of economists on Sri Lankan university economics faculties, but one would generally expect that individuals doing research in agricultural, fiscal, industrial, and other subdisciplines of economics might make relatively easy transitions into environmental and resource economics, if additional funding were available for such work. It may be necessary to provide some "bridging" funding for a wider range of researchers to begin working in environmental economics. This might be less expensively accomplished by reviewing new grant applications more for general expertise than specific experience, although providing funding for a wider variety of scholars to do things such as attending the Harvard Institute for International Development's short courses might also be a cost effective strategy for widening involvement.

Interdisciplinary collaboration is essential in valuing biodiversity, and from what I have seen, such contacts are frequent and fruitful. Both the continuing work on biodiversity prospecting I have described above and the study of reef fisheries management will involve considerable cooperation between natural scientists and economists. Funding of other such activities will certainly be beneficial.

Coordination between donors is also important. Many donors are getting into the environmental economics area now, and there is thus great potential for overlap.

4.3.4 Collaboration with foreign researchers

It can be useful for researchers from the rest of the world to collaborate with their Sri Lankan colleagues in environmental valuation work, and vice-versa. Inasmuch as there is government, international, and NGO interest in these issues, Sri Lanka may be an attractive place for visiting scholars to undertake research. Most senior scholars from Western universities, research institutions, and governments are simply too expensive to be financed from domestic funds. Some international funds might be used to finance short visits, and, of course, foreign researchers with their own funding ought to be welcomed. With E-mail, the world is becoming much smaller, and researchers who have come for short visits may be able to maintain long-term collaborations at relatively low cost (as I hope to). In order both to get work done efficiently and to develop local expertise, however, it makes more sense to use the great majority of funds devoted to valuation exercises in Sri Lanka to finance domestic researchers.

4.3.5 Long-term funding

As I emphasized above, work in ecological economics is very preliminary around the world. Researchers hoping to make useful contributions must have substantial support in relatively long term (often multiple-year) research projects. If further developments are to be sustained in the area of ecological economics, financial support for peer-reviewed research grants should be explicitly called for in the Biodiversity Action Plan.

References

Abeygunawardena, P., no date, "Total Economic Value of Forests: The Case of the Sinharaja Reserve in Sri Lanka," Working Paper, Facultry of Agriculture, University of Peradeniya, Kandy, Sri Lanka.

Abeygunawardena, P., and K. A. S. S. Kodithuwakku, 1992, "Economics of Recreational Value of Peradeniya Royal Botanical Gardens," Journal of Agricultural Economics 1 (1) (University of Peradeniya, Kandy, Sri Lanka), 184-195.

Artuso, Anthony M., 1994, An Economic and Policy Analysis of Biochemical Prospecting, unpublished Ph. D. dissertation, Department of Economics, Cornell University.

Aylward, Bruce A., 1993, "A Case Study of Pharmaceutical Prospecting," Part III of Bruce A. Aylward, Jaime Echeverria, Liza Fendt, and Edward B. Barbier, The Economic Value of Species Information and its Role in Biodiversity Conservation: Case Studies of Costa Rica's National Biodiversity Institute and Pharmaceutical Prospecting, Report to the Swedish International Development Authority (London: London Environmental Economics Centre).

Banda, Amarakoon, and P. Abeygunawardena, no date, "An Economic Assessment of On-Site Effects of Soil Erosion in Potato Lands in Nuwara Eliya District," Working Paper, Facultry of Agriculture, University of Peradeniya, Kandy, Sri Lanka.

Barker, Virginia, 1995, "Economics of Sustainable Ecotourism Development in Hikkaduwa: Analysis of a Special Area Management Plan," Working Paper No. 06/1995, Coastal Resources Management Project, Colombo, Sri Lanka.

Barzel, Yoram, The Economic Analysis of Property Rights (Cambridge: Cambridge University Press) 1989.

Battagala, Nirosha, and Hemasiri B. Kotagama, 1996, "Impact of Economic Policy on Human Interfered Biodiversity Systems," working paper, University of Peradeniya, Kandy, Sri Lanka.

Brown, Gardner M., Jr. and Jon H. Goldstein, 1984, "A Model for Valuing Endangered Species," Journal of Environmental Economics and Management 11 (December), 303-309.

Coase, Ronald H., 1960, "The Problem of Social Cost," Journal of Law and Economics 3 (October), 1-44.

Dasgupta, Partha, and Jeffrey Heal, 1979, Economic Theory and Exhaustible Resources (Cambridge: Cambridge University Press).

da Silva, Saliya and Hemasiri B. Kotagama, 1996, "Integrating Forest Values to National Income Accounting," working paper, University of Peradeniya, Kandy, Sri Lanka.

Diamond, Peter A., and Jerry A. Hausman, 1994, "Contingent Valuation: Is Some Number Better than No Number?" Journal of Economic Perspectives 8 (Fall), 45-64.

Evenson, Robert E., "Economic Valuation of Genetic Diversity for Agriculture," working paper, Yale University, 1995.

Ferraro, Paul J., and Randall A. Kramer, 1995, "Affecting Household-Level Behavior to Promote Rain Forest Conservation in Madagascar," Report submitted to the EPAT program of Winrock International.

Freeman, A Myrick, III, 1993, The Measurement of Environmental and Resource Values: Theory and Methods (Washington: Resources for the Future).

Gunatilake, H. M., D. M. A. H. Senaratne, and P. Abeygunawardena, 1993, "Role of Non-Timber Forest Products in the Economy of Peripheral Communities of Knuckles National Wilderness Area of Sri Lanka: A Farming Systems Approach," Economic Botany 47 (3), 275-281.

Gunatilleke, I. A. U. N., C. V. S. Gunatilleke, and P. Abeygunawardena, 1993, "Interdisciplinary Research Towards Management of Non-Timber Forest Resources in Lowland Rain Forests of Sri Lanka," Economic Botany 47 (3), 282-290.

Gunawardana, Mudalige C. M., 1995, Management of Coastal Resources with Special Reference to Hikkaduwa Marine Sanctuary, Unpublished Masters Thesis, Postgraduate Institute of Agriculture, University of Peradeniya, Kandy, Sri Lanka.

Hardin, Garrett, 1966, "The Tragedy of the

Common," Science 162, 1243-1248.

Kahneman, Daniel, and Jack L. Knetsch, 1992, "Valuing Public Goods: The Purchase of Moral Satisfaction," Journal of Environmental Economics and Management 22 (January), 57-70.

Kotagama, Hemasiri B. and Neil Thushantha, 1996, "Pharmaceutical Value of Natural Forest Biodiversity: Sinharaja Forest" working paper, University of Peradeniya, Kandy, Sri Lanka.

Meier, P., and Munasinghe, Mohan, 1992, "Incorporating Environmetal Concerns into Power-Sector Decision-Making: A Case Study of Sri Lanka," Research Report, Environment Department, The World Bank, Washington, DC.

Mendelsohn, Robert, and Michael J. Balick, 1995, "The Value of Undiscovered Pharmaceuticals in Tropical Forests," Economic Botany 49 (June), 223-228.

Munasinghe, Mohan, 1993, "Environmental Economics and Biodiversity Conservation in Developing Countries," Ambio 22 (2-3, May) 126-135.

Pathirana, Samantha and Hemasiri B. Kotagama, 1996, "Measurement of Sustainable Use of Coastal Ecosystems: An Index Approach," working paper, University of Peradeniya, Kandy, Sri Lanka.

Pearce, David, and Seema Puroshothamon, 1992, "Preserving Biological Diversity: The Economic Value of Pharmaceutical Plants," Discussion Paper 92-27, CSERGE London.

Peskin, Henry, " Green Accounting for the Chesapeake Bay," in R. David Simpson and Norman L. Christensen, Jr. (editors), Ecosystem Function and Human Activities: Reconciling Economics and Ecology (New York: Chapman & Hall) (in press).

Reid, Walter V., Sarah A. Laird, Carrie A. Meyer, Rodrigo Gamez, Ana Sittenfeld, Daniel H. Janzen, Michael A. Gollin, and Calestous Juma, 1993, "A New Lease on Life," Chapter 1 in Biodiversity Prospecting: Using Genetic Resources for Sustainable Development edited by Walter V. Reid, Sarah A. Laird, Carrie A. Meyer, Rodrigo Gamez, Ana Sittenfeld, Daniel H. Janzen, Michael A. Gollin, and Calestous Juma (Washington: World Resources Institute).

Samuleson, Paul A., 1976, "Economics of Forestry in an Evolving Society," *Economic Inquiry* 14 (December) 466-492.

Simpson, R. David, 1995, "Why Integrated Conservation and Development Programs May Achieve Neither Goal," Resources for the Future Discussion Paper 95-20.

Simpson, R. David and Roger A. Sedjo, 1996, "Paying for the Conservation of Endangered Ecosystems: A Comparison of Direct and Indirect Approaches," Environment and Development Economics (in press).

Simpson, R. David, Roger A. Sedjo and John W. Reid, "Valuing Biodiversity for Use in Pharmaceutical Research," Journal of Political Economy 104 (February, 1996), 163-185.

Steele, Paul, and H. Kathiravelu, 1996, "The Importance of Economic Incentives for Conserving Biodiversity: Some Recommendations for Sri Lanka," working paper, Ministry of Transportation, Environment, and Women's Affairs, Colombo, Sri Lanka.

United Nations Environmental Program (UNEP), 1992, Convention on Biological Diversity (United Nations, Nairobi).

Varrthjes, J., and M. Witvliet, 1995, "A Contingent Valuation Method Study on Hikkaduwa s Coral Reef and Beach," unpublished report submitted to the Coastal Resources Management Project, Colombo, Sri Lanka.

Wells, M. and K. Brandon, with L. Hannah (1992), People and Parks: Linking Protected Area Management with Local Communities, Washington: The World Bank.

Wijesinghe, L.C.A. de S., I.A.U.N. Gunatilleke, S.D.G. Jayawardana, S.W. Kotagama, C.V.S. Gunatilleke, 1993, Biological Conservation in Sri Lanka: A National Status Report, IUCN-The World Conservation Union, Sri Lanka Country Office.

Terms of Reference
for the Consultancy by
Dr. Simpson

Terms of Reference for Consultancy
on
Valuation of Biodiversity

Background and Justification: Terms of Reference (TOR) #6 of the Strategy for the Preparation of a Biodiversity Action Plan for Sri Lanka calls for a consultancy to:

> Develop criteria for the valuation of biodiversity and make recommendations to incorporate these criteria into the national development, accounting and planning system.

The Natural Resources and Environmental Policy (NAREPP/IRG) Project has agreed to support the Biodiversity Unit at the Ministry of Transport, Environment and Women's Affairs (M/TEWA) in completion of this TOR.

Although economists and planners in Sri Lanka have been exposed to the theory of environmental economics and the valuation of non-market goods, few have experience in applying these theories and methods (see partial list of references below).

This lack of experience is particularly evident in the area of valuing biodiversity. The valuation of biodiversity per se must be distinquished from the broader environmental valuation. The value of diversity is measured through the contributions of diversity to maintaining sustainable biological systems, and thus is concerned with the functional benefits of diversity. Although these functional ecosystem benefits have not yet been value in Sri Lanka, there have been quite a few studies in which the physical sites where biodiversity exists (e.g., forests, gardens) have been valued for their recreational, existence, option or other values. The primary objective of this consultancy is to extend the understanding and use of biodiversity valuation methods and applications.

In light of this situation, a consultancy is sought which will meet the requirements of the TOR #6 above while ensuring that analysts gain concrete practical experience in the application of biodiversity valuation tools and methods.

One prefered means for gaining practical insight is to carry out case studies. Since a national biodiversity valuation effort needs to be built from the ground up, such case studies will ultimately contribute to development of criteria and a program for national planning. Case studies have been begun in the following areas: the value of medicinal plants from Ritigala/Sinharaja; the value of biodiversity on Kandyan forest gardens; and the recreational value of Horton Plains. But each of these case studies is at an early stage and could benefit from refinement.

During preparatory discussions to the proposed consultancy, organizers identified two areas in which case studies on valuation would be particularly useful: indigenous medicines and coastal resources. In spite of the value of coastal resources for the tourism and fisheries industries, there have been no major economic valuations completed for areas outside

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Hikkaduwa. The importance of biodiversity in coastal areas makes an analysis of the value of those resources urgent.

NAREPP/IRG's recent work in the area of environmental valuation training and development has shown that, at this early stage of a complex process, the development of valuation tools is more appropriately done with university experts than with government practioners. As the corpus of materials on biodiversity valuation grows, and the use of valuation tools becomes more widespread, adoption of valuation results for use in government planning will become more widespread.

Summary of Activity: The Consultant will suggest strategies and specific techniques for the valuation of biodiversity in Sri Lanka. In cooperation with local counterparts, he will design approaches for valuation of biodiversity under 2 case studies. He will develop a framework for the medium- to long-term institutionalization of biodiversity valuation in national planning.

Approach/Qualifications Needed: The Consultant should have a thorough and up-to-date knowledge of the theory and practice of biodiversity valuation.

Tasks for Completion by the Biodiversity Cell of M/TEWA and NAREPP/IRG Prior to Consultant's Arrival:

1. Solicit Participation: Members of study teams will be contacted or identified. Other members of the environmental network will be contacted and informed of the objectives of the upcoming consultancy.

2. Literature Review and Collection in Sri Lanka: A list will be prepared of literature available in Sri Lanka on biodiversity valuation and environmental valuation. This list will be forwarded to the Consultant.

3. Purchase of Reference Materials Identified by Consultant: IRG/Washington may purchase select materials on biodiversity valuation identified by the Consultant (see item #1 below) and approved by the NAREPP/IRG Coordinator. These materials should be purchased and sent out to Sri Lanka with the Consultant.

4. Prepare Seminar Sites: Sites will be identified and reserved for seminars (see item # 3 below); participants will be invited.

Itemization of Tasks for Consultant:

Prior to Departure for Sri Lanka

1. Gather Reference Materials: Because of his area of expertise, the consultant is expected to have ready access to relevant journal articles, unpublished manuscripts, and other materials not accessible through regular distribution channels in Sri Lanka. The NAREPP Coordinator will prepare and forward a list of subject areas in which additional reference materials are needed in Sri Lanka. The Consultant will then gather

and photocopy relevant materials and bring them with him. In addition to gathering and preparing materials, the Consultant should indicate to IRG/Washington which additional reference materials they should purchase.

2. Prepare Seminar Lectures: Preparations for the presentation of a paper at three different seminars (see item # 3 below) will need to take place before arrival in Sri Lanka.

Upon Arrival in Sri Lanka

3. Seminars: The Consultant will present the keynote lectures on biodiversity valuation at gatherings for the following three groups: (1) senior-level government officials concerned with biodiversity management; (2) academics from the Centre for Environmental Studies and the Post Graduate Institute for Agriculture in Kandy; and, (3) academics from the University of Ruhuna. The general topic of these lectures will be "Economic Incentives for the Conservation of Biodiversity: The Case of Indigenous Medicines". The purpose of the lectures is to raise awareness about the potential applications of biodiversity valuation tools. The lecture to senior government officials will include implications for national planning, as developped under the Concept Paper (see item # 7 below).

4. Review of Research Design of Case Study on Indigenous Medicines: A study is currently being undertaken on the value of indigenous medicines in Ritigala and Sinharaja forests. The Consultant will work closely with the researcher to refine and extend his approach to the study. The Consultant will take part in refining research hypotheses, approach and methods.

5. Design of Case Study on Value of Coastal Resources: The larger part of biodiversity valuation work already completed or under way concerns terrestrial issues, yet coastal resources generate significant revenue. The Consultant will assist in the design of a study concerning the value of coastal resources. It is expected that a single site will be selected to demonstrate the use of applied methods. The valuation of coral reefs is a likely area for this work.

6. Participation in Workshop to Review Ongoing Biodiversity Valuation Studies in Sri Lanka: A workshop will be organized during the Consultant's stay at which the authors of all on-going biodiversity valuation studies will be asked to present the current status of their work. The Consultant will be a member of an advisory panel reviewing the studies. The Consultant will provide written and oral review of the design of each study with suggestions for improvement.

7. Concept Paper on The Economics of Biodiversity: The period of two weeks allotted for this consultancy is not sufficient to develop a detailed concept paper and action plan for the extension of biodiversity valuation activities and their incorporation into national planning. Nevertheless, the Consultant will submit a concept paper which will: (1) assess the current status of biodiversity valuation activities; (2) make general recommendations

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for the further development of biodiversity valuation; (3) identify institutions that should play an important role in valuation activities; and (4) recommend issues to consider in incorporating valuation activities into national planning efforts, including extended benefit/cost analysis and green accounting. This Concept Paper is expected to be an important contribution to a chapter on economics in the Biodiversity Action Plan.

8. Debriefing Seminar(s): Prior to his departure, the Consultant will debrief the Ministry of Transport, Environment and Women's Affairs, USAID/Sri Lanka and select members of the university research community on the findings of the consultancy.

After Departure from Sri Lanka

9. Final Edits to Concept Paper, Case Study Design and Research Review Documents: The Consultant may make final edits to these documents and forward all final products to NAREPP/IRG by June 18, 1996.

10. Continuing Contact with Study Team: The Consultant will continue to provide ad hoc advice to researchers on the indigenous medicines and coastal resources case studies as they are carried out in the months following his departure.

Outputs: Four tangible outputs are expected from the Consultant:

1. Packet of current literature on biodiversity valuation, with particular emphasis on the following four areas:
   a. Value of medicinal plants and indigenous medicines
   b. Value of germ plasm
   c. Value of coastal resources, particularly coral reefs and coral reef systems
   d. Methodology for the development of contingent valuation surveys

2. Written critique of case study on indigenous medecines, including recommendations for alterations in study design, if necessary.

3. Research design for case study on the value of coastal resources. This research design will include review of relevant available literature, precision of hypotheses, methodology, and data collection approach.

3. Concept paper on the economics of biodiversity (see explanation of contents above).

Level of Effort and Timing: The Consultant's total number of days on this assignment will be 13.

Cooperating Agencies: Mr. Gamani Gamage of the Biodiversity Cell of the Ministry of Transport, Environment and Women's Affairs; and the Post Graduate Institute of Agriculture of the University of Peradeniya.

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NAREPP Coordinator: Philip J. DeCosse, Natural Resources and Environmental Policy Advisor. Dr. Hemasiri Kotagama (PGIA&NAREPP/IRG) will serve as technical counterpart to the Consultant and Dr. Sarath Kotagama (the Open University of Sri Lanka and NAREPP/IRG) will provide additional advice and technical support.

USAID Coordinator: Avanthi Jayatileke, NAREPP Project Officer.

References:

Abeygunawardena, P. And K.A.S.S. Kothiduwakku
1992 "Economics of Recreational Value of Peradeniya Royal Botanic Gardens". Journal of Agricultural Economics. Volume 1, Number 1. Kandy: University of Peradeniya. Pp. 184-195.

Abeygunawardena, P.
no date "Total Economic Value of Forests: The Case of Sinharaja Reserve in Sri Lanka". Unpublished manuscript. 25 pages.

Banda, Samarakoon and P. Abeygunawardena
no date "An Economic Assessment of On-site Effects of Soil Erosion in Potato Lands in Nuwara Eliya District". Unpublished manuscript. 18 pages.

Barker, Virginia
1995 "Economics of Sustainable Ecotourism Development in Hikkaduwa: Analysis of a Special Area Management Plan". Working Paper No. 06/1995. Coastal Resources Management Project, Sri Lanka.

Gunatilake, H.M., D.M.A.H. Senaratne and P. Abeygunawardena
1993 "Role of Non-timber Forest Products in the Economy of Peripheral Communities of Knuckles National Wilderness Area of Sri Lanka: A Farming Systems Approach". Economic Botany 47 (3) pp. 275-281.

Munasinghe, Mohan
1993 "Environmental Economics and Biodiversity Management in Developing Countries". Ambio. Vol. 22, No. 2-3. May. Pp. 126-135.

Samarasekara, Vikhisha N.
1994 "The Impact of Agriculture and Industry on a Wetland Ecosystem: The Case of Koggala Lagoon, Sri Lanka". Coastal Management in Tropical Asia, September. Rhode Island: University of Rhode Island.

Steele, P. And H. Kathiravelu
1996 "The Importance of Economic Incentives for Conserving Biodiversity: Some Recommendations for Sri Lanka". Forthcoming in Soba.

Attached: Photocopy of Terms of Reference # 6 from the Strategy for the Preparation of a Biodiversity Action Plan for Sri Lanka.