London Environmental Economics Centre

REPRINT

THE ECONOMIC VALUE OF SPECIES INFORMATION AND ITS ROLE IN BIODIVERSITY CONSERVATION: COSTA RICA'S NATIONAL BIODIVERSITY INSTITUTE

Bruce A Aylward
Jaime Echeverria
Liza Fendt
Edward B Barbier

Discussion Paper Series

DP 93-06

December 1993

iied

International
Institute for
Environment and
Development

THE ECONOMIC VALUE OF SPECIES INFORMATION AND ITS ROLE IN BIODIVERSITY CONSERVATION: COSTA RICA'S NATIONAL BIODIVERSITY INSTITUTE

Bruce A Aylward
Jaime Echeverria
Liza Fendt
Edward B Barbier

Discussion Paper Series

DP 93-06

December 1993

This paper is based on research conducted for the Swedish International Development Authority (SIDA) by the London Environmental Economics Centre in collaboration with the National Biodiversity Institute of Costa Rica and the Tropical Science Center.

London Environmental Economics Centre

This Centre was established in 1988 and operates as the Economic Programme of the International Institute for Environment and Development (IIED). Its aims are the furtherance of policy relevant research in the field of environmental and natural resource economics, particularly in the context of developing countries.

The Authors

Bruce Aylward
Research Associate
London Environmental Economics Centre
IIED
3 Endsleigh Street, London WC1H ODD, UK
Tel: (071) 388-2117, Fax: 388-2826, Email: leecuk@gn.apc.org

Jaime Echeverría
Economist
Tropical Science Center
Apdo. 8-3870, C.P. 1000
San José
Costa Rica
Tel: (506) 25 26 49, Fax: 53 49 63, Email: ebonilla@ucrvm2.bitnet

Liza Fendt
Independent Consultant
Apdo. 385-1005
San José
Costa Rica
Tel: (506) 97 11 71, Fax: 97 12 31

Edward Barbier
Senior Lecturer
Dept. of Environmental Economics and Environmental Management
University of York
Heslington
York Y01 5DD
United Kingdom
Tel: (0904) 434-060, Fax: 432-998

Table of Contents

List of Figures, Tables and Boxes

Boxes

Figures

Tables

1. BACKGROUND[1]

Two national meetings held in Costa Rica in late 1988 and early 1989 led to the recommendation that a National Biodiversity Institute be created and charged with the following tasks and responsibilities:

- to develop a strategy for initiating an inventory of Costa Rican Biodiversity
- to develop and house national reference collections
- to develop a national biodiversity library and register of information regarding research on the country's biodiversity
- to develop a mechanism for rendering biodiversity information accessible and useful to Costa Rican society and international users

Further to these initial meetings, a June 1989 a decree issued by President Arias of Costa Rica created a national planning commission to explore these issues further. The commission affirmed that a national institute for biodiversity be developed and that its primary objective be the integration of biodiversity with society for intellectual and economic purposes. The means of accomplishing this goal was to be the dissemination of knowledge regarding the identity, geographic distribution and economic uses of Costa Rican species.

The National Biodiversity Institute (INBio) was formally registered in Costa Rica on the 24th of October 1989 as a private, non-profit association of public interest and service. Initial funding came from a variety of (mainly) external donors including the US Agency for International Development, the Swedish International Development Authority (SIDA) and US foundations. The objectives set forth by the planning commission empower INBio to accomplish the "knowing" and "using" stages of biodiversity conservation. In the first few years of its existence INBio began preparations for a national biodiversity inventory, entered into a number of innovative arrangements aimed at prospecting for sustainable uses of biodiversity and continued the process - begun at the Neotropica Foundation - of developing a database of information about Costa Rican biodiversity.

More recently, Gámez *et al.* (1993) define INBio's immediate objectives as :

- undertaking a total inventory of the biodiversity of Costa Rica between 1993 and 2003
- placing the resulting information in a computerized and physical format that Costa Ricans and others will find easy to use
- insure the preservation into perpetuity of the National Biodiversity Inventory Collections resulting from this activity

[1]We would like to thank Dan Janzen, Jorge Jimenez and Ana Sittenfeld for their comments on previous versions of this paper.

- facilitating access by national and international users to information related to Costa Rica's wildland biodiversity

- greatly increasing local "biological literacy" by providing information and fostering its use.[2]

This paper reports preliminary results from a collaborative research effort conducted by LEEC, INBio and the Tropical Science Center. The research examines the economic aspects of INBio's operations. A number of methodological concerns and caveats are worth mentioning at the outset. During the 1992-93 period - in which the research for this paper was conducted - the organizational structure of the Institute changed several times as INBio continued to evolve as an institution. As a result, the paper encounters the inherent difficulty of focussing on a moving target. Second, viewed from an economic perspective the objectives of INBio are necessarily long-term objectives. As this paper can assess only the first few years of operations it should in no way be taken as an evaluation of the failure or success of INBio in its chosen mission. Third, the short-run nature of the results to date and the continuing evolution of activities at INBio indicate that INBio should not be viewed as a "model," but rather as an example - perhaps the first of many - of a developing country institution attempting to integrate biodiversity with society (Gámez 1991). Finally, the nature of INBio's mission means that it is an institution that is part of the larger process of conservation activities in Costa Rica. In order to restrict the analysis to a manageable discussion of the economics of species information it was necessary to draw a somewhat artificial distinction between INBio activities and those of the national park system. For the purposes of this analysis, then, INBio is considered to be an incremental project that is added to the existing system of Conservation Areas.

The objective of this paper is to use the tools of economic analysis to demonstrate both the economic costs and benefits - the implicit trade-offs - of undertaking such a novel venture in the development and marketing of species information. In Section 2, an overview and classification of the economic activities underway at INBio is presented. Section 3 builds on this classification by developing a detailed analysis of the financial expenditures and economic costs of the functional units and activities. Data limitations and the short life-span of the institution thus far, necessitate an initial focus on costs incurred during the 1990-91 period. This section reports on a preliminary application of cost-effectiveness analysis to INBio's investment in the development of species information.

Section 4 presents a description and classification of the economic benefits generated by INBio. The analysis of benefits covers the period through the end of 1992. At this early stage, INBio had yet to accomplish its main objectives so it is impossible to quantify the benefits that could result. However, it is possible to discuss and categorize - at least in theoretical terms - the expected benefits that will be generated. In addition, there are a number of benefits already being realized that can be explored in more detail. These are covered in Section 5. Quantification of benefits is limited to an examination of the human

[2]Gámex *et al.* (1993) and Sittenfeld and Gámez (1993) provide a detailed description of INBio's development and activities. A number of other publications provide descriptive background on INBio's development including Gámez (1991), Harvard Business School (1992), Janzen (1991), Lewin *et al.* (1992), Sandlund (1991) and Umaña and Brandon (1992).

capital formation benefits generated through the parataxonomist program. In addition, the educational role of parataxonomists in their local community and the potential production benefits from new applications of biodiversity's chemical properties are examined in qualitative terms. The effect of local intellectual property protection on investments in the development of species information is also briefly examined. Finally a summary and analysis of the contract between INBio and Merck & Co. is provided. Conclusions and recommendations of the paper are presented in Section 6.

2. AN OVERVIEW OF ACTIVITIES AT INBIO

The organizational structure of INBio has changed a number of times during the period from start-up in 1989 through early 1993. For the purposes of the analysis that follows INBio's activities are classified as belonging to one of four major areas:

- the inventory - consisting of collection and curation activities
- information management and dissemination
- biodiversity prospecting
- general administration

The Inventory comprise a range of collection and curation activities including the generation of information on species identification, distribution, natural history, as well as the development of a reference collection of Costa Rican biodiversity. These activities began in 1989 (in fact they pre-dated the official creation of INBio) and are currently organized under the Inventory Division. Collection activities include the training of parataxonomists and the operation and the management of the biodiversity field offices. Curation activities include the activities of the Botanical and Arthropod Curation Units.

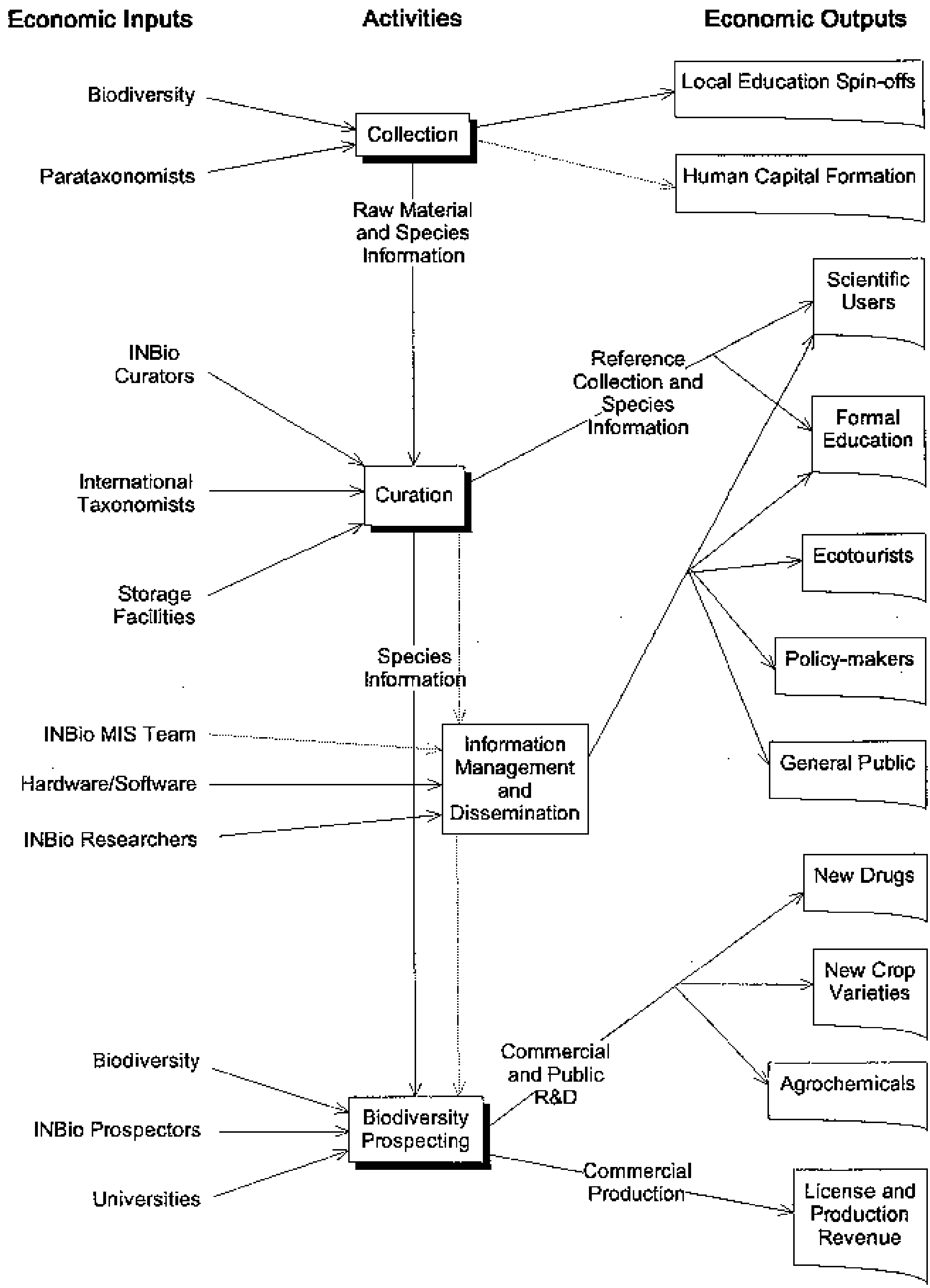
Activities in the area of biodiversity prospecting began in 1991 and are currently administered by the Division for Biodiversity Prospecting. Prospecting activities involve the actual marketing of biodiversity and species information to commercial or non-commercial users for the purposes of research into new and sustainable uses of biodiversity. During the period studied, biodiversity prospecting at INBio has largely centered around the exploitation of the biochemical potential of biodiversity.

Information management and dissemination activities consist of a host of research, management and marketing functions that draw on biodiversity information generated from the inventory and other sources. During the period up through the beginning of 1993, information activities were largely confined to activities connected with the Conservation Database. This database was transferred to INBio from the Neotropica Foundation in 1989. As the Conservation Database operated largely independently from the inventory during this period, its hypothesized link in the internal flow of information is indicated by a dotted line. However, INBio is actively engaged in an expansion of its information activities. In early 1993 INBio created separate Divisions of Information Management and Information Dissemination.

In addition to the functional Divisions described above, INBio maintains a general administration unit that carries out the general financial, administrative and management activities required by an institution of this size. Although the specific activities of this unit are not discussed further in this paper, the cost analysis undertaken in Section 3. does incorporate the indirect costs of this activity.

The three Divisions listed above are classified as *functional* areas by this study as they have clearly definable economic inputs and outputs. Figure 1 provides a general schematic overview of these functional areas and their principal inputs and outputs. Each of the major activities - collection, curation, information management and dissemination, and biodiversity prospecting - in the economic process consume inputs and generate benefits. These economic

Figure 1 INBio as an Economic Activity



Box 1 Species Diversity in Costa Rica

GROUPS	ESTIMATED	DESCRIBED
Viruses, Bacteria	34,350	383
Fungi	65,000	825
Algae	5,350	503
Plantae	13,02110,353	
Protozoa	8,000	670
Arthropoda	366,000	67,000
Other Invertebrates	10,962	2,187
Vertebrates	2,981	2,616
	505,664	84,392

Source: Government of Costa Rica (1992)

transactions are represented by the arrows going from left to right. In addition there are internal flows of species information and physical specimens between the activities (represented in Figure 1 by the downward arrows). In practice these flows are two-way, reflecting the interactive nature of the activities. However, for illustrative purposes the downward arrows indicate the accumulation of value.

The diagram indicates that the collection process combines biodiversity and parataxonomist inputs in generating valuable species samples (the "raw material") and species information. The addition of curation inputs adds further value to the species information and the reference collection of species. The solid lines emanating from the curation activities indicate that - during the period reflected in the research undertaken for this paper - species information flowed directly to either internal or external users. In the case of the Biodiversity Prospecting Division, the information contributed to the development of biochemical research efforts undertaken in collaboration with commercial and public partners. Meanwhile, external access to the "outputs" - the reference collection and species information - involved direct interaction with the collection and the curation staff and databases. The dotted lines in the figure indicate that with additional information management and dissemination inputs currently being put in place, INBio expects that access to species information by internal and external users will flow through these new Divisions.

As background to the analyses of costs and benefits provided in subsequent sections a brief summary is provided of the activities underway in each of the three functional areas.

Inventory Activities

A recent report prepared by the Government of Costa Rica suggests that Costa Rica may contain 500,000 species (see Box 1). In order to "facilitate" the sustainable use of biodiversity INBio's is preparing for a national inventory of the country's biodiversity. In order to carry out this mission, biodiversity specimens must be collected, sorted and identified to species level. Due to the lack of local taxonomic expertise, INBio has divided

Box 2 Information Requests Recorded by the Conservation Database in 1992

User	Nationals	Foreigners
Government	145	8
Autonomous Organizations	17	
Universities	177	9
Schools/High Schools	7	-
NGOs	89	58
Private Business	6	-
Ecotourism	12	1
General Public	3	-
Total	490	77

Source: INBio

the activities usually undertaken by taxonomists into two different steps: the collection of species and the taxonomic curation and identification process (referred to hereafter simply as curation).

Collection of specimens is carried out in Costa Rica's Conservation Areas by specially trained parataxonomists. INBio selects people who live in the communities around the Conservation Areas and provides a six month training course in the basics of biological sciences with an emphasis on field techniques of biodiversity collection.[3] Upon completion of the course, the parataxonomists are assigned to Biodiversity Field Offices located in or near the Conservation Areas adjacent to the parataxonomists' communities. At their field offices, parataxonomists are charged with collecting botanical and arthropod specimens. By 1992 there were 28 biodiversity offices located in and around eight of Costa Rica's nine Regional Conservation Areas.

At the end of each month, the parataxonomists transport the collected material to INBio's headquarters in Santa Domingo de Heredia. At INBio the material (or box of material) is labelled with a number and a tag that specifies places of origin and the identity of the collector. While visiting INBio, curators often review progress on sorting and identification of previously collected material with parataxonomists. This "in service training" allows the curator to provide feedback to parataxonomists regarding which species should be collected and how parataxonomists' work may be improved. Parataxonomists also attend occasional specialized courses on particular taxonomic groups lead by INBio curators and international experts.

The curation of arthropod specimens takes place at INBio headquarters with assistance from international experts based at institutions in North America and Europe. In the case of the botanical inventory, INBio is fortunate to house a project of the Missouri Botanical Garden (begun in 1987) that is developing a manual of the flora of Costa Rica. Originally, the

[3]For a report on the first two parataxonomist training courses see Janzen and Hallwachs (1991).

herbarium collection from the National Museum was moved to INBio, however, in 1992 the collection was shifted back to the Museum. Nevertheless, by early 1993 INBio had managed to collect and curate 8,000 species - almost the full number of species described to date (Hamel pers. comm. 1993). For both inventories the specimen classifications are then recorded and the specimens stored in collection lockers. A full list of the collection and curation outputs is found later on in the paper in Table 1.

Biodiversity Prospecting

The principal objective of the Biodiversity Prospecting Division is to carry out INBio's mandate to demonstrate the economic value of biodiversity. The long-term manifestation of this objective is to create financial revenues which can flow back into biodiversity conservation (Sittenfeld 1992). In developing economic uses for biodiversity samples and species information, prospecting activities seek to link the industrial and conservation sectors and make the connection between basic biological science and biotechnological applications. The activities of this Division are by no means exclusively commercial in orientation. A local catalytic role is also envisaged in which INBio assists in the development of local scientific and technical capacity in the general area of biotechnology. This objective is attained through the development of collaborative research programmes and the inclusion of training programs and technology transfer agreements in research contracts supported by commercial partners.

To date the Division has engaged in two major collaborative research projects - one funded by the MacArthur Foundation and the other by Merck & Co. The Rockefeller Foundation has provided INBio with funding for technical assistance in developing a business strategy for the Division. An additional project is underway in conjunction with the British Technology Group (BTG). The INBio - Merck & Co. arrangement and the BTG contract are described further in Section 5.

In late 1990, the MacArthur Foundation approved a joint research proposal by Cornell University and INBio to develop a research program aimed at screening Costa Rican organisms for valuable medicinal properties. Four research products and one thesis were financed by INBio on different uses of biological products. The research projects are aimed at screening biodiversity for biochemical activity against malaria, nematodes, viruses and hemorrhages, coagulation and inflammatory processes.

In coordinating this research, INBio has acted as a catalyst by building on the skills and knowledge developed by local research institutions such as the University of Costa Rica and the National University. INBio entered into arrangements with both institutions in order to obtain access to the accumulated knowledge, skills, laboratory facilities and experience of these institutions. This has enabled these institutions to accomplish important results in their efforts at biochemical prospecting. INBio has combined the expertise of the local universities with new funding and the objective of obtaining knowledge or products that can be marketed in the short-run. In return INBio provides its university partners with collaborative research inputs, opportunities for training, and scientific feedback, as well as organization and logistical support.

The Prospecting Division also offers its research capabilities to commercial entities interested in screening biotic material - e.g. dried or processed samples of biodiversity. The selection of these species is based on information regarding available specimens of plants or insects provided by the database of knowledge developed by Inventory personnel. In consultation with the buyer, the Prospecting Division develops protocols for collection and any processing desired. The Contracts with Merck & Co. and BTG fall into this category.

Information Management and Dissemination

During the period covered by the research undertaken for this paper the information management and dissemination function at INBio consisted largely of activities surrounding the Conservation Database. The Conservation Database was originally based at the Neotropica Foundation, however, upon the creation of INBio the Foundation deemed the database of better use to INBio. As a result, the Neotropica Foundation donated all the information and equipment to INBio and INBio took over the staff working on the database.

The Conservation Database is a relational database developed by the Nature Conservancy. The Database serves as a tool for centralizing all the information regarding the legal, administrative and environmental state of Costa Rican protected areas - particularly information on threatened species - for the purpose of assisting policy-making and conservation efforts. In the past few years, efforts have concentrated on the collection of a wide variety of information related to the species found in the country. This information is obtained from all available sources, assessed and entered into the database. Ideally, the information developed by the inventory would be linked in to this database. The development of a comprehensive database is one of the objectives of a project under development at INBio in collaboration with Intergraph - a multinational information services company. Intergraph has agreed to work with INBio in the development of a Biodiversity Information Management System that will manage all the information being generated by INBio.

A range of users consult INBio for conservation information. Box 2 shows the type and number of information requests handled by INBio in 1992. Government, universities and non-governmental organizations are clearly the largest users of information supplied by INBio. The number of requests from NGOs reflects the large impact of foreign requests from this group. In addition, to the 567 requests for information in 1992, INBio received 72 and 152 information requests in 1990 and 1991 respectively (Lewin *et al.* 1992).

In sum a number of organizational structures and institutional arrangements have contributed to INBio's initial success - i.e. by giving INBio a *comparative advantage* in the activities it engages in. The early effort devoted to developing the Inventory - a *R&D start-up* phase - has been crucial to INBio's ability to attract research contracts with commercial and non-commercial entities. Establishing INBio's credentials as a scientific institution, the Inventory indicates INBio's ability to generate a variety of important information about Costa Rican species. Second, the close nature of INBio's relationship with the Conservation Areas - particularly the Guanacaste Conservation Area - and government officials have been a key factor in establishing INBio's as an officially recognized partner for research departments from foreign commercial companies or universities that are interested in assistance in the biochemical evaluation of Costa Rican biotic material. Finally, INBio's ability to act as a catalyst for existing Costa Rican university expertise has generated *economies of scale* in the field of biochemical evaluation as well as furthering the development of additional value-added prospecting activities.

3. FINANCIAL AND ECONOMIC COSTS OF INBIO'S ACTIVITIES

In this section a model for estimating the financial and economic costs of INBio's activities is presented. The model is then applied to the data available for the first couple of years of INBio's operating activities. This yields preliminary - though rough - indications of the economic costs of INBio's functional activities and the cost-effectiveness of INBio's primary activity during this period. As part of a continuing collaborative research project at INBio, the model and empirical measures of INBio's cost-effectiveness in developing taxonomic information are being improved and updated with data subsequent years.[4] Through training of INBio staff in the use of the model this continued work should enable INBio to track changes in the Institute's cost structure and effectiveness over time.

Methodology

The objectives of the cost model are:

- to develop a comprehensive database of the financial expenditures made by INBio in the years 1990-91
- to allocate financial expenditures according to INBio's functional activities (economic cost centers) during this period
- to make the necessary economic adjustments to arrive at the annual economic costs of each activity
- to provide a summary of financial and economic expenditures by activities and indicate the proportion of total costs incurred by administration activities
- where feasible, to match costs with outputs in deriving cost-effectiveness indicators for individual activities on a year by year basis

The information used in the analysis of the costs of INBio's activities was obtained from INBio's accounting records, written reports produced by the institution and through interviews with relevant personnel at INBio.

After obtaining a description of the activities undertaken by INBio and defining their major steps, a list of inputs required by each activity was produced. This list was corrected and checked by the head of the Inventory Division and used as a guide to determine the cost of each step within each activity.

In gathering data on the actual financial expenditures made by INBio, consultations were held with the administration unit regarding the accounts. Unfortunately, the actual classification of expenditures was not appropriate for the purposes of a financial, or economic, analysis. The accounts showed only details on the net amounts for each account (assets and liabilities,

---

[4]This work is funded by the Swedish International Development Authority.

or income and expenditures) arranged according to the funding institution. From the existing system of accounts there was no way to break out expenditures by the relevant functional activities. As a result, it was necessary to use the consecutive series of cheque books as the primary source of information to determine the cost of each activity undertaken by INBio.

INBio was legally established in October 1989 and has registered that it received funding as far back as March 1989. However, accounting information regarding most of the variable and fixed costs of INBio's activities during 1989 is not available. Data for 1990 and 1991 were developed by classifying each cheque written by INBio during 1990 and 1991 according to the relevant activity and input heading. INBio management has reviewed the resulting financial data set and agreed that it represents as accurate a picture of INBio's expenditures as is possible at this time.

The analysis presented below is, therefore, restricted to the information that exists for 1990 and 1991. An exception is made in the case of major fixed assets such as the land and central office building at INBio headquarters, and the cost of the first training course for parataxonomists in early 1989. These investments continue to contribute to INBio activities. These financial expenditures are entered for 1989 and an annualized economic charge developed for the purpose of allocating an appropriate charge for these fixed assets in subsequent years.

In order to properly evaluate the real resource costs of INBio's activities the financial expenditures made by INBio need to be adjusted to reflect the annual economic costs of the inputs. Adjustments made to financial data to obtain these real resource costs include:

- adding any "hidden" costs
- removing transfer payments - e.g. taxes and subsidies
- spreading the cost of fixed assets across an appropriate number of years
- adjusting for inflation

"Hidden" costs are those financial expenditures which are incurred by other institutions or individuals, but which directly fund activities at INBio. A number of inputs used by INBio in its work are donated directly to the Institute. As a result, these expenditures do not pass through INBio's accounts and were not picked up in the review of the cheque books. For example, MIRENEM pays the salary of a large number of parataxonomists. A few additional parataxonomists are paid by other research-based non-governmental organizations. The parataxonomists are, however, paid to work on the INBio inventory and can be considered as economic inputs in the collection process. Accounting for these "hidden" expenditures is important if an accurate record of the costs of INBio's activities is to be obtained.

Unfortunately, it is inevitable that the costs of some of the donated inputs used by INBio are difficult to trace. For example, some of the material used by parataxonomists in their work - tweezers, plastic used to mount insects, lights, etc. - are difficult to track down and place a value on. It is very hard to estimate how significant these items may be, especially when they are donated by different sources and no record of the expenditures are kept by INBio or donors.

An additional input into the training of parataxonomists and the curation of specimens on which it is difficult to place a cost figure is the contribution made by international experts in taxonomy. For example, interviews with personnel at the Natural History Museum (NHM) in London and the Royal Botanic Garden, Kew revealed that considerable time, effort and expense is devoted to assisting INBio in its mission. Quantifying the costs of this contribution is difficult for two reasons. First, neither the contributing institution nor INBio keep records of the time and expense incurred in rendering taxonomic support to INBio. Second, the extent to which such efforts can be considered as input costs is subject to interpretation. Most trips to Costa Rica by NHM personnel combine both capacity-building and research work. In addition, curation of Costa Rican specimens carried out in London often contributes directly to existing research programmes of NHM and Kew. As international experts benefit from their collaboration with INBio, it becomes even more difficult to specify what share of the costs of these activities should be charged to INBio.

In deriving economic costs from financial expenditures it is important to account for any transfer payments that appear as financial costs (Gittinger 1982). *Transfer payments* - such as taxes and subsidies - distort markets for goods and services causing financial prices to diverge from economic prices. For example, import duty paid on a vehicle is simply a transfer to the government treasury. Duty is paid on top of the economic price of the vehicle. In order to obtain the economic cost of goods and services that are bought and sold in distorted markets the financial expenditures must be "adjusted" by the amount of the transfer.

In the case of INBio's expenditures, few transfer payments were identified. Although INBio pays sales and import taxes it was not always possible to identify the exact amount. Where such information is available, adjustments to reflect the added burden of the sales tax are made. Adjustments to reflect tax on personal income were not made as all salary charges are already net of tax.

Annual financial data includes both variable and fixed costs. In order to properly compare performance year by year it is necessary to adjust the annual costs charged for fixed assets to reflect their *annualized economic cost*, not their full cash value. This is accomplished by calculating the annuity (annual payment) that would be payable each year based on the length of life of the asset, its initial purchase value and the opportunity cost of capital. In the case of land the length of life is effectively infinite and is represented by a sixty year length of life.

The final adjustment made in the spreadsheet is the conversion of all economic subtotals into constant terms (1990 colones). By putting all figures in 1990 prices direct comparison of economic costs across different years becomes possible. In summarizing the results a number of the figures are converted into dollar figures by applying either the 1990 dollar rate or - in the case of current expenditures - the appropriate exchange rate for that year. Adjustment of tradeable and non-tradeable inputs into either border price levels or domestic market price levels could be accommodated by the development of an appropriate conversion factor or shadow foreign exchange rate (Gittinger 1982; Ray 1990). Unfortunately, such estimates for Costa Rica were not available. Future elaborations of the model should, however, explicitly explore the issue of whether border and domestic price levels differ to a significant extent.

The derivation of economic costs requires some estimation of the outputs generated by the investment of resources in order to convey meaningful results to decision-makers. As will be discussed in Section 4, it is next to impossible to provide a comprehensive evaluation of the benefits - in monetary terms - generated by INBio as a whole. Thus, a formal cost-benefit analysis of INBio's activities is not possible.

If monetary measures of output are not available, the development of quantitative indicators of physical outputs allows the derivation of cost-effectiveness measures for particular activities. Cost-effectiveness measures have two primary uses in decision-making and program management: they can be used by an organization to monitor efficiency of production over time and they can be used to compare performance with other producers of similar goods and services.

In order to develop cost-effectiveness measures for activities at INBio it is necessary to define economic cost centers, or functional activities that produce specific outputs. As indicated earlier the functional areas at INBio can be divided into inventory, biodiversity prospecting and information components. For the purposes of this study the inventory is the functional area most amenable to the use of cost-effectiveness analysis. The inventory itself can be separated into four relatively distinct functional activities with distinct outputs:

- the collection of arthropod specimens
- the collection of botanical specimens
- the curation of arthropod specimens
- the curation of botanical specimens

During the period studied the information activities were focussed on a single objective: the development and use of the Conservation Database. As a result there is no need to disaggregate expenditures in this area - the functional activity pursued in the model is the cost of the Information Division. Potential measures of output include measures relating to the development of the database - i.e. entries or additions to the stock of information - and those indicating the actual use of the database such as the number of information requests received and handled.

In the case of Biodiversity Prospecting, expenditures are segregated according to whether they are core or project costs. Individual projects will have definable outputs such as the number of samples demonstrating bioactivity in screens (the Research Coordination project) or the number of plant and insect extracts produced (INBio - Merck & Co. contract). Indeed, if the expenses and outputs associated with particular stages of the projects can be identified, then it becomes possible to monitor cost-effectiveness for each stage in the process - e.g. the collection and extraction of biotic samples. In this paper Biodiversity Prospecting expenditures for 1990-91 are allocated to core and to the two aforementioned projects originated during this period.

No attempt is made here to specify outputs or develop cost-effectiveness measures. At the request of the Biodiversity Prospecting Division, additional research was conducted to develop output measures and cost allocations for the Research Coordination project and the INBio-Merck & Co. contract. This involves training Biodiversity Prospecting staff in the use of the spreadsheet model and the updating of data to reflect 1992 core and project data.

As this data is considered proprietary, the results will not be published, rather they are for internal use by INBio management only. Thus, for the purposes of allocating indirect costs Biodiversity Prospecting is considered as a single functional activity.

Clearly, the brevity of the period that is covered in this analysis and the difficulties encountered in obtaining information on financial expenditures, hidden costs, transfer payments and output data limits the conclusions that can be drawn from the results. However, it was realized early on that the development of such a spreadsheet model would be only the initial phase in implementing a financial and economic cost accounting framework at INBio. Thus, the costing exercise emphasized the development and pre-testing of a comprehensive framework model for estimating the annual economic costs of INBio's activities. The capabilities of this model are no doubt underutilized in its present application due to the limited nature of the data on hidden costs, transfer payments and outputs available for 1990-91. However, the development of a full model has ensured that local capacity now exists to assist INBio in training its staff to update and maintain the model. INBio is currently developing its inventory information management system and installing a new computerized accounting system. These activities should assist INBio in overcoming some of the record-keeping difficulties experienced with the current implementation of the model. Based on a technical assistance project initiated in late 1993, INBio staff should be in a position to utilize effectively the full capacity of the model in future years.

Parameters and Data

The following economic parameters (shown in Table 1) are utilized in the model:

- The *nominal interest rate* corresponds to the average interest rate paid by public or private institutions on deposit certificates for a 12 month period of time.

- The *Gross Internal Product inflation (GIP) index* calculated by the Central Bank of Costa Rica is used in converting expenditures made in different years into constant, or real, terms. The base year for the purposes of the model is 1990.

- The *real interest rate* is derived from the nominal interest rate and the rate of inflation.

- The *real opportunity cost of capital* is used in developing the annuity payments for fixed assets. In order to simplify these calculations a single opportunity cost of capital is used rather than attempting to incorporate year to year volatility as expressed in the real interest rate. The chosen opportunity cost of capital is 10 percent. This corresponds with the standard figure used by the World Bank in project appraisal in developing countries. It is also a realistic reflection of the real interest rate in Costa Rica during the 1989-91 period (see table). The sensitivity of cost-effectiveness measures to this parameter are tested by comparing results using a 5 percent and 15 percent rate.

- The colones - dollar *exchange rate* (¢/$). The rate corresponds to the average annual official rate paid by public institutions when buying dollars.

Table 1 Macroeconomic and Policy Parameters

	units	1988	1989	1990	1991	1992
Nominal interest rate a\	% change		26.3%	31.3%	35.8%	
GIP inflation index b\	1990=100	0.73	0.84	1.00	1.27	
	% change		15.2%	19.1%	27.2%	
Real interest rate c\	% change		9.6%	10.2%	6.7%	
Real opportunity cost of capital		0.10				
Exchange rate d\	Colones / $		81.58	92.07	122.10	
Sales tax e\	%		0.10	0.10	0.13	0.12

Notes: a\ yearly average passive rate from Central Bank of Costa Rica
b\ From index calibrated in 1966. Source: Central Bank of Costa Rica
c\ based on a\ and b\
d\ average official buy rate from the Central Bank of Costa Rica
e\ These percentages are established by law.

Table 2 Length of Life of Fixed Assets a\

	Length of Life (years)
Land	200.00
Buildings	
Cement Buildings	50.00
Wood Buildings	10.00
Furniture and Office Equipment	10.00
Equipment	
Biodiversity Office Equipment	10.00
Curation Equipment	5.00
Laboratory Equipment	5.00
Computer Equipment	2.00
Other Minor Equipment	1.00
Transport	
Vehicles	5.00
Alternative Means of Transport b\	5.00
Parataxonomists	5.00

Notes: a\ Length of life periods used by INBio's accounting department.
b\ includes motorcycles, boats and horses

- The figures for *sales tax* reflect the legal rate charged by the government for each year. It is used to determine the economic cost of inputs on which INBio paid out sales tax.

Table 2 lists the *length of life parameters* (in years) used in deriving annualized economic costs. These parameters are the same as those used for accounting purposes by INBio.

A number of the expenditures made at INBio are not specifically linked to the functional activities underway at INBio. These include the indirect costs of land, the central office building, general administration and the shared costs of collection. As originally purchased the land at INBio's headquarters in Santa Domingo de Heredia included several buildings. Only one of the buildings was kept. It was remodeled and is currently used as the central office building. The other buildings were demolished. The expenditure on land used in the model represents the total purchase value minus the value of the remaining building - as indicated by INBio's records. The financial cost of land is converted to an annualized economic cost based on the relevant annuity payment. The financial and economic costs of land are then distributed across all of INBio's departments based on the allocation parameters agreed upon with INBio personnel.

The costs of acquiring the central building and all subsequent refurbishment of the offices in this building also need to be pro-rated across the functional activities. The other buildings at the main complex in Santa Domingo are dedicated primarily to one or two particular activities and are covered under the fixed costs for the relevant activity. Annualized economic costs for these expenditures are allocated across the different units according to the parameters derived for the use of the central office building.

The general administration costs are adjusted for the transfer payment made by INBio to the government for employee medical services (*planilla*). In order to obtain total administrative expenditures and economic costs, the fixed and variable subtotals are added to the land and building allocations. The percentages for pro-rating administration costs provided by the [then] Biodiversity Office are then used in order to arrive at the general administration charges of each activity.

A number of collection costs are shared between the botanical and arthropod collecting functions. These include the costs of training parataxonomists and the costs of running the biodiversity field offices. Although the 1989 training course took place before INBio was created, the parataxonomists from this group are affiliated with INBio and have contributed their specimen to the inventory. As a result, the cost of their training is included in the calculations. Expenditures included as training costs are those variable costs that are inseparable from the production of the fixed asset - a trained parataxonomist. Salaries (for teachers and students), materials, living expenses, transportation costs and administrative costs are included. Fixed costs - equipment and buildings - that facilitate the training, but are principally purchased for use by parataxonomists once they are trained and employed as parataxonomists are not included here. In the future, a portion of the annualized charge for such assets could be charged to each of the training programs if appropriate.

The principal economic adjustment that could be made in the case of the training costs would be to reflect the hidden costs of international taxonomists who offer their services as trainers on a *pro bono* basis to INBio. As no official records were kept on the contribution of these taxonomists it is impossible to estimate their contribution to the training courses.

The fixed costs of training are then annualized based on an estimated "length of life" (e.g. years of service to INBio in their current capacity) for parataxonomists. Early experience indicates that there is a gradual attrition rate as parataxonomists leave to pursue other opportunities. In estimating training requirements for a ten year national inventory Janzen and Hallwachs (1991) project an annual attrition rate of 10 percent. As a result a length of life of 5 years is used in the analysis. As evidence on this trend accumulates it may be possible to revise this estimated "length of life'.

The Biodiversity Office costs include the fixed costs incurred in setting up parataxonomists' field sites, the fixed and variable costs of coordinating the parataxonomists and the variable costs of in-service training. It also includes the fixed costs of the hostel (*albergue*) in Santa Domingo which is used by parataxonomists when they visit INBio headquarters.

Having calculated the "indirect" costs attributable to each of the functional activities, these costs are merged with the "direct" costs in order to develop the total costs of each functional activity. In each case the direct - fixed and variable - financial expenditures are recorded and adjusted to annualized economic costs. The indirect cost charges are then added in to reach a total financial expenditure and economic cost. The allocation percentages used in the allocating the costs of land are loosely based on the proportion of area utilized by each functional activity. The central office building allocation is based on approximate usage of square footage. The percentages used in allocating general administration costs were estimated by INBio staff. The percentages used in allocating the shared costs of collection across the arthropod and botanical collecting activities were supplied by the Biodiversity Field Office Coordination Department All of these allocation percentages were reviewed and approved by relevant INBio personnel.

In the case of the inventory, expenditures and costs are allocated according to whether expenditures were directed towards collection or curation activities and whether they were incurred in work on botanical or arthropod specimens. In the case of collection activities the principal direct costs are parataxonomist salaries. Hidden costs that are not paid by INBio are substantial for both activities and represent the salaries of parataxonomists that are paid by MIRENEM. The major curation inputs include fixed costs - the curation facilities, equipment and vehicles - and the variable costs of wages and materials.

As the Biodiversity Prospecting Division started activities in 1991 there are no expenditures or costs allocated in 1990. Expenditures in 1991 are segregated according to whether they are "core" expenditures - i.e unallocated expenditures - or project expenditures. The main core costs including expenses associated with permanent staff of the Division, and office and travel expenses. Expenses associated with the Research Coordination project include wages, equipment, transportation and payments for external services. Note that the Research Coordination project involved a large pass-through of funds to the University of Costa Rica and the National University. These expenses are included under hidden costs. As the INBio-Merck & Co. contract began in late 1991, expenditures on this project were necessarily limited.

The final functional activity incorporated into the model - for the 1990-91 period - is the Information Directorate (Conservation Database) in 1990-91. Expenses consisted primarily of the fixed office costs and variable costs of wages, and research and information dissemination activities. In future years, the Conservation Database is likely to be one of several projects under the Information Management (or Dissemination) Division

Results: Summary of Financial and Economic Costs[5]

Total financial expenditures and economic costs recorded by the model for 1990-91 are presented in Table 3. INBio's financial expenditures in 1990 were $610,000 and in 1991 they were $1.2 million in current terms. Total economic costs for the period showed a high rate of increase over the two year period - tripling from $440,000 to more than $1.2 million. The increase in economic costs was largely due to the start-up of activities in the Biodiversity Prospecting Unit - in particular those connected with the Research Coordination project. Biodiversity Prospecting accounted for $560,000 in 1991. Nonetheless, the annual economic cost of the inventory did increase by roughly 50 percent to $580,000 in 1991. The Conservation Database almost doubled its use of economic resources to $87,000 from 1990 to 1991.

In percentage terms the Inventory was the dominant activity at INBio in 1990, accounting for almost 90 percent of total economic costs. However, in 1991 costs were largely split between the Inventory and Biodiversity Prospecting at 47 percent and 46 percent respectively. Nonetheless, in 1991 the Inventory still accounted for over 63 percent of financial expenditures. This highlights the fact that a large portion of the economic costs of the Research Coordination project are presented as "hidden" costs and did not, therefore, enter into the financial figures. The share of total economic costs attributable to the Conservation Database fell from 13 percent in 1991 to 7 percent in 1991.

Whether these trends will continue is uncertain. Yearly expenditure levels - and hence economic costs - of the Biodiversity Prospecting are likely to vary from year to year depending on the success of the Division in attracting new projects. Expenditures on the inventory might be expected to grow slowly each year as INBio strives to reach its target of 100 parataxonomists and adds to its curation capacity. The importance of the information function is also likely to grow substantially over time as the Information Management and Dissemination Division initiates additional projects beyond the Conservation Database.

A detailed examination of Inventory expenditures and costs is presented in Tables 4 and 5. Financial expenditure levels are substantially higher than economic costs in both years, indicating the presence of considerable investment in fixed assets by INBio during this period. The Arthropod Department has clearly had priority in the first few years accounting for roughly 60 percent of expenditures and costs over the two years. This allocation is expected given that the plants of Costa Rica are relatively well known (and far fewer in number) in comparison with arthropods (as shown earlier in Box 1). The scale of the

[5]All financial expenditures are in current colones or current US dollars. All economic costs cited are in 1990 US dollars or 1990 Costa Rican colones.

Table 3 INBio's Functional Activities - Summary of Costs

	1989	1990	1991	1990-91
A. Financial Expenditures				
Totals in Current US Dollars	350,584	607,478	1,172,793	
Inventory	337,101	543,622	739,971	
Biodiversity Prospecting	-	-	374,019	
Information	13,484	63,856	58,803	
Totals in Percentage Terms	100.0%	100.0%	100.0%	
Inventory	96.2%	89.5%	63.1%	
Biodiversity Prospecting	-	-	31.9%	
Information	3.8%	10.5%	5.0%	
B. Economic Costs				
Totals in 1990 US Dollars	-	438,463	1,217,782	1,656,244
Inventory		382,391	576,072	958,463
Biodiversity Prospecting		-	555,194	555,194
Information		56,072	86,516	142,587
Totals in Percentage Terms	-	100.0%	100.0%	100.0%
Inventory		87.2%	47.3%	57.9%
Biodiversity Prospecting		-	45.6%	33.5%
Information		12.8%	7.1%	8.6%

Table 4 Inventory - Summary of Financial Expenditures

	1989	1990	1991
A. Financial Totals (Current US Dollars)	337,101	543,622	739,971
Subtotal - Collection	276,435	346,503	220,985
Arthropods	204,244	258,834	131,425
Botanicals	72,191	87,669	89,560
Subtotal - Curation	60,666	197,119	518,987
Arthropods	35,863	92,097	296,138
Botanicals	24,803	105,022	222,849
B. Financial Totals (in Percentage Terms)			
Inventory	-	100%	100%
Collection		64%	30%
Curation		36%	70%
Inventory		100%	100%
Arthropod		65%	58%
Botanical		35%	42%
Subtotal - Arthropods		100%	100%
Collection		74%	31%
Curation		26%	69%
Subtotal - Botanicals		100%	100%
Collection		45%	29%
Curation		55%	71%
Subtotal - Collection		100%	100%
Arthropods		75%	59%
Botanicals		25%	41%
Subtotal - Curation		100%	100%
Arthropods		47%	57%
Botanicals		53%	43%

Table 5 Inventory - Summary of Economic Costs

	1989	1990	1991	Totals
A. Economic Costs (1990 US Dollars)	-	382,391	576,072	958,463
Subtotal - Collection		212,742	301,862	514,604
Arthropods		160,558	202,588	363,146
Botanicals		52,185	99,273	151,458
Subtotal - Curation		169,649	274,211	887,718
Arthropods		61,347	162,380	223,728
Botanicals		108,301	111,830	220,132
B. Economic Costs (in Percentage Terms)				
Inventory	-	100%	100%	100%
Collection		56%	52%	54%
Curation		44%	48%	46%
Inventory		100%	100%	100%
Arthropod		58%	63%	61%
Botanical		42%	37%	39%
Subtotal - Arthropods		100%	100%	100%
Collection		72%	56%	62%
Curation		28%	44%	38%
Subtotal - Botanicals		100%	100%	100%
Collection		33%	47%	41%
Curation		67%	53%	59%
Subtotal - Collection		100%	100%	100%
Arthropods		75%	67%	71%
Botanicals		25%	33%	29%
Subtotal - Curation		100%	100%	100%
Arthropods		36%	59%	50%
Botanicals		64%	41%	50%

Table 6 Determination of General Administration Overheads

	1989	1990	1991
A. Financial			
As percent of total financial costs		23.2%	20.0%
B. Economic			
As percent of total financial costs		26.4%	17.3%

Table 7 Cross-check of Percentages Used in Allocating Administration Costs

	1989	1990	1991
A. Financial Expenditures Before Administration Charges			
As Percentage of Total	100.0%	100.0%	100.0%
Inventory (Subtotal)	95.9%	86.7%	59.9%
Collection - Arthropods	60.2%	46.5%	10.0%
Collection - Botanicals	20.5%	12.4%	2.0%
Curation - Arthropods	9.1%	11.8%	27.1%
Curation - Botanicals	6.1%	16.0%	20.7%
Biodiversity Prospecting	-	-	34.0%
Conservation Database	4.1%	13.3%	6.1%
B. Economic Costs Before Administration Charges			
In Percentage Terms		100.0%	100.0%
Inventory (Subtotal)		86.2%	41.7%
Collection - Arthropods		40.8%	17.2%
Collection - Botanicals		9.0%	3.6%
Curation - Arthropods		10.0%	11.2%
Curation - Botanicals		26.4%	9.6%
Biodiversity Prospecting		-	51.7%
Conservation Database		13.8%	6.6%

respective tasks is revealed by progress on each front to the end of 1992. The Botanical Department had already collected and identified specimens of more than half of the expected number of plant species in Costa Rica while the Arthropod Department had catalogued just over 1 percent of arthropod species in Costa Rica (inventory outputs are illustrated in Table 8).

Within the Inventory as a whole, resources were evenly divided between collection and curation activities. In the Arthropod Department, collection activities predominate, consuming over 70 percent of resources in 1990 and 55 percent in 1991. The situation is reversed in the Botanical Department where collection commands the majority of resources - 68 percent in 1990 and 53 percent in 1991. The trend does indicate an equalization of resources devoted to these activities within each department. In the case of the Arthropod Department, this change reflects the expansion of the curation Department as they moved into their new offices in 1991.

This variation in the division of effort between collection and curation activities in the two departments may explain the difference between the two programs in terms of collection/curation efficiency. A far larger proportion of the specimens collected by the Botanical Department have been sorted to the major groups and actually named than is the case with the arthropods. Through 1992, the Arthropod Department had curated only one-fifth of collected specimens to species level. According to data for 1989-91 the Botanical Department had classified one-third of specimens collected. Given the large numbers of specimens remaining to be curated it is worth questioning whether it might not be more efficient to reduce the rate of collection and instead devote the resources currently incurred in storing specimens to curation activities.

Whether holding such large, unidentified collections is inefficient hinges on the extent of storage costs at INBio as versus storage costs in the Conservation Areas. Clearly, the latter is negligible unless the risk of degradation and extinction is high. As Costa Rica prides itself on having completed the first step in conservation - that of setting aside large areas of biodiversity - it is possible to assume that this risk is low. The costs of storage botanicals are minimal - only a few storage lockers are required. In the case of arthropods, the costs are likely to be higher due to the space requirement for holding so many specimens, the fixed and operating costs of the cooling unit, equipment, etc. The yearly annuity on the fixed costs of the reference collection equipment comes to roughly $3,000 and operating costs a portion of this amount - although it is impossible to separate out the exact amount from the Institute's total bill.

Assuming that the arthropod storage area consumes one-third of the total area in the new arthropod facilities the yearly annuity for building costs of storage would be $3,200. Assuming that the total costs of storage may be in the region of $7,000 per annum, and that the "efficiency losses" of storing backlogged specimens are as large as four-fifths of this total - i.e. assuming just-in-time delivery of additional storage capacity - the costs of excess storage would be in the realm of $6,000 per year. This represents just 3-4 percent of curation costs in 1991. As a result, the opportunity costs of collecting large numbers of arthropod specimens appear relatively insignificant in terms of the benefits that would be gained by investing a similar amount in additional curation activities.

Table 6 summarizes administration expenditures as a percent of total expenditures during the 1990-91 period. In current terms, expenditures on administration consumed 20-23 percent of total finance during the 1990-91 period. A larger variance in the administration burden between the two years is apparent in economic terms. However the swing from 26 percent in 1990 to 17 percent in 1991 is likely to reflect the large magnitude of the "hidden costs" associated with Biodiversity Prospecting's Research Coordination project.

Table 7 aggregates total expenditures across the functional areas before the addition of administration charges. This allows a cross-check of the percentages used in allocating administration costs to these activity areas. The assumption underlying this comparison is that the contribution of administration to the achievement of the objectives of each activity is in proportion to the costs of that activity in total costs. In other words, an alternative method of deriving the percentages governing the allocation of administration costs to functional activities is to pro-rate them in accordance with the percentage of total functional expenditures incurred.

The results of the cross-check indicate a potentially important discrepancy between the estimated percentages provided by INBio and those derived from each activity's relative share of total financial expenditures. For example, in the estimation of the model botanical collection activities are allocated 20 percent and 30 percent of administration costs in 1990 and 1991 respectively. However, the cross-check shows that collection of botanicals incurred only 12 percent and 2 percent of the costs before administration expenses in those two years. Considering that administration expenditures are roughly 20 percent of total expenditures such a variance has a large effect on cost figures for particular activities. In the case of botanical collections in 1991, for instance, total administration charges were almost four times as large as actual botanical collection expenses (including land and building charges). It might be more reasonable, then, to base all administration charges to functional activities on the portion of financial expenditures incurred by each activity as developed in Table 7.

Cost-Effectiveness Analysis

Table 8 lists the outputs of the inventory process divided into collection and curation, and arthropod and botanical components. In the case of collections, the output measure is simply the number of specimens collected. In the case of curation, a number of measures are available. Curation involves sorting specimens through a series of taxonomic levels of identification until the specimen is classed as a member of a previously known or unknown species. Technically, the sorting of specimens into each, increasingly narrow taxonomic group is a stage in the curation process. Unfortunately, allocation of costs to each such stage is not possible. Nonetheless, information on the number of specimens sorted to each taxonomic level was gathered to indicate the progression towards species identification.

While curation to different levels may be interpreted as an intermediate output of the curation process, the final output is the identification of specimens as species. As INBio's objective is a national inventory - and a national reference collection - the final output is best represented by the production of a "new" species. Once a specimen is matched to a known species type or is identified as a previously unknown species, it adds to the number of species that INBio "knows" and maintains in its collections. Thus, a relevant output

Table 8 Inventory Output Parameters

A. Arthropods	1989	1990	1991	1992	1990-91	1989-92
Collection a\						
Specimens Collected	43,981	263,868	320,276	414,073	584,164	1,042,218
Curation b\						
Specimens Labelled						
Specimens Sorted to Order	29,962	179,772	218,183	282,083	397,955	710,000
Specimens Sorted to Family	23,210	139,260	169,015	218,515	308,275	550,000
Specimens Sorted to Morphospecies	8,862	53,172	64,533	83,433	117,705	210,000
Number of 'New' Species d\					3,000	5,000
Average Number of Specimens Collected per 'New' Species e\					39.24	42.00

B. Botanicals e\	1989	1990	1991	1990-91	1989-91	Total to 1992
Collection						
Specimens Collected	4,846	29,077	29,077		58,154	
Curation						
Specimens Sorted to Family	4,513	27,083	27,083		54,165	
Specimens Sorted to Genus	3,012	18,074	18,074		36,147	
Specimens Sorted to Named Species	1,595	9,572	9,572		19,144	
Number of 'New' Species d\				2,667	4,000	8,000
Average Number of Specimens Collected per 'New' Species e\					4.79	
Number of new 'Global species g\				83		250

Notes: a\ Collection numbers for arthropods are recorded by INBio on a yearly basis
b\ INBio's curation department has allocated totals from 1989-92 to each year based on the proportion of specimens collected in that year.
c\ Morphospecies are specimens that are expected to be 'new' species but have not yet been assigned a name.
d\ The objective of the inventory is to build a collection at INBio, thus the number of species or morphospecies, that are 'new' to the INBio collection is the principal output of curation
e\ The number of specimens sorted o species divided by the number of 'new' species
f\ INBio's botanical department has allocated the 1990-91 totals equally across the time INBio has been in operation
g\ Species never before identified anywhere else in the world

parameter for evaluating inventory cost-effectiveness is a species that is "new" relative to INBio's existing collection. It does not necessarily have to be a new species from the perspective of a global list of species. Nonetheless, a measure of cost-effectiveness in obtaining new "global" species is also an interesting statistic in light of assessing progress towards identification of the world's biodiversity.

Given the number of specimens that INBio has identified to species level and the number of "new" species found through this process, it is possible to specify the number of curated specimens per newly identified species (see Table 8). The identification of additional specimens of the same species may add to the physical collection and the information base - i.e. by providing additional sites where the species can be found. It may, therefore, add additional value to the inventory. However, it is likely that diminishing returns will eventually occur for additional, identified specimens of a species already "known" and present in the reference collection. Given that collection costs per specimen are low (as shown below) and that it is likely to require less and less effort to match additional specimens of a species to those already identified and held in the reference collection, it is possible to suggest that - for the purposes of a cost-effectiveness analysis - the principal output of the curation process is the development of "new" species.

The source of the data for each of the output categories listed in Table 8 is as follows:

- Figures for *arthropod collections* are tracked on a yearly basis by INBio. As of May 1993 only 513,000 specimens have been entered into the Inventory database (Sittenfeld pers. comm. 1993).[6]

- The annual numbers for *arthropod sorting* outputs represent only an approximation made by the Arthropod Curation Department. As of May 1993 expected curation totals were 6,000 species well identified to species level of which 2,000 are entered in the database (Sittenfeld pers. comm. 1993). The yearly curation figures - for each of the levels of sorting - are based on estimates of curation totals for 1989-92. The outputs are pro-rated by INBio according to the rate of collection in each year. However, as it is unlikely that the curation activity follows the same cycle as the collection activity these yearly numbers are likely to be unreliable estimates of actual outputs.

- The 1989-92 estimate of *"new" species* was supplied by the Inventory Coordination Department in January 1993. The 1990-91 estimate is generated by pro-rating the total over the 3.25 years INBio was in operation during this period.[7]

- The 1989-91 totals and the yearly figures for *botanical collections and sorting outputs* were supplied by the Botanical Department. The totals are simply divided across the

[6]Remaining uncertainty regarding the accuracy of these numbers regards whether the total represents the totals received from the field or whether it represents the aggregate number of specimens processed by the labelling department. Additional estimates received from the Inventory indicate a total of 1.3 million specimens collected with 464,000 specimens unlabelled.

[7]It remains unclear whether the estimated total includes identified specimens donated to INBio at the outset.

years 1989-1991 on a pro-rata basis. Thus the yearly totals are not likely to be reliable measures of outputs. For the purposes of a year-to-year cost-effectiveness analysis, such a pro-rating of outputs implies that the resulting cost-effectiveness figure is determined completely by the level of expenditure in each year. This is not very satisfying. Thus, only 1990-91 totals are used in the cost-effectiveness analysis.[8]

- The total to year end 1992 of *"new" species* was supplied by Botanical Curation Department in January 1993. It remains unclear whether the total includes the identification of specimens accomplished as far back as 1987 when the Missouri Botanical Gardens project began. The movement of the National Herbarium collection to INBio and then back to the National Museum complicates this issue. Apparently, this necessitated the recollection of large numbers of specimens by INBio in 1992. However, prior knowledge regarding the characteristics and location of these species is likely to have eased the curation burden. As a result, an estimate for 1990-91 is generated by pro-rating the total over the 6 year period from 1987-1992. In addition, the Botanical Curation Department has suggested that 250 new species (from a global perspective) were identified from 1987-92. A total for 1990-91 is developed by pro-rating this figure over the 1987-1992 period.

Clearly, the reliability of the output parameters - particularly those for arthropods - could be improved. Efforts to update this model may provide more reliable cost-effectiveness indicators given recent improvements in the inventory database.

Table 9 illustrates the calculations of economic cost-effectiveness for both botanical and arthropod specimens. The costs of collecting a single arthropod specimen are fairly constant over 1990-91 averaging $0.62 per specimen. The cost of collecting a single botanical specimen over the 1990-91 period is estimated to be $2.60. A higher cost of collection for botanicals seems reasonable, given that parataxonomists are much more selective in gathering plants than they are in gathering insects. This is, in part, a result of the extent to which specimens of "new" species are relatively more scarce and harder to find in the case of botanicals. Nonetheless, the botanical cost may be inflated by the large administration charge taken in 1992, as indicated above.

Comparison with other figures indicate that these estimates are in the expected range. Erwin (1992) cites data from Peru on average arthropod collection costs of $0.18 per individual (average cost of $93.00 for collections averaging 514 individuals). Daly (pers. comm. 1992) cites research at the New York Botanical Garden suggesting collection costs of $1.00 per specimen. Lucas (pers. comm. 1992) indicates that the field costs incurred by the Royal Botanic Garden, Kew, on a collecting expedition with fairly specific collecting objectives may be approximately $7.50 (£5.00) per specimen. Obviously, it is difficult to make exact comparisons without knowing just what variable and fixed costs are included, how fixed costs are treated, and the methodology used in deriving the data. In addition, the costs will vary depending on how specific the objectives of a collecting exercise are in terms of searching

[8] A comparison of collection figures presented here and those in Lewin *et al.* (1992) report indicates some rather large differences. Lewin *et al.* (1992) report the number of total labelled specimens as 38,000 for 1987-92 as opposed to 58,000 for 1989-1991 listed in Table 8.

Table 9 Inventory Cost-Effectiveness (in 1990 US Dollars)

(From Tables 5 and 8)	1989	1990	1991	1990-91
A. Collection				
Arthropods - per specimen	-	0.61	0.63	0.62
Botanicals - per specimen	-	na	na	2.60
B. Curation				
Arthropods				
Per Specimen Sorted to Species	-	na	na	1.90
Per 'New' Species a\	-	na	na	74.58
Botanicals				
Per Specimen Sorted to Species	-	na	na	11.50
Per 'New' Species a\	-	na	na	82.55
Per New 'Global' Species		na	na	2,641.58
C. Total Cost-Effectiveness				
Arthropods				
Cost of Collecting Enough Specimens to Obtain one 'New' Species a\				24.39
Cost per 'New' Species				74.58
Total Costs per 'New' Species				98.97
Botanicals				
Cost of Collecting Enough Specimens to Obtain one 'New' Species a\				12.46
Cost per 'New' Species				82.55
Total Costs per 'New' Species				95.01

Notes: a\ Average number of specimens collected per 'new' species (from Table 8) multiplied by the cost of collection per specimen

n Yearly figures not calculated as output measures are not reliable for particular types of organisms. Nevertheless, a cursory examination of the evidence suggests that collection costs at INBio are at least of the right order of magnitude.

INBio curation costs per sorted specimen are quite low due to the number of specimens of each "new" species that are collected. However, costs per "new" species are $75 for arthropods and $83 for botanicals. Once again, these figures are not unreasonable. A detailed survey by the US Advisory Committee for Systematic Resources in Botany (1979) examined curation costs in US herbaria and reports costs per identified specimen as roughly $10 (in 1990 dollars). While this is much lower than the INBio figure for botanicals, the study was largely based on time and motion exercises and included routine identifications. Sohmer (pers. comm. 1992) cites all-in costs of $400 per species to conduct a flora of 2,000 species in the Hawaiian Islands. Lucas (pers. comm. 1992) suggests that depending on the degree of difficulty the cost of identifying a herbarium specimen might run as high as $150.[9] For commercial customers, the Natural History Museum in London levies a minimum charge of roughly $50 for identification specimens. While the same qualifications mentioned above in the case of collections apply, the cost of curating a "new" specimen at INBio does appear to be in line with other cost estimates for curation.

In the case of botanical curation the cost of curating a new "global" species is over $2,600 This figure is thirty times the expense incurred in curating taxonomically known species and probably overstates the cost as the objective of the curating activities at INBio are on generating a full national reference collection not merely new "global" species. Nonetheless, the sheer magnitude of the figure conveys the degree to which diminishing returns to taxonomic effort are likely to set in as the number of unidentified species (from either a *"global" or INBio perspective) grow increasingly scarce in the later stages of an inventory.*

As an overall measure of the cost-effectiveness of the inventory the costs of collection are integrated with the costs of curation in part B. of Table 9. By estimating the total cost of the number of specimens that - on average - are collected in the process of identifying a "new" species the calculation accommodates the concern voiced by many taxonomists that parataxonomists are not specific enough in their collections. If this is the case, then the total costs of collecting specimens will be inflated by the extra costs associated with collecting many duplicate specimens. As estimated in Table 8 the average number of specimens collected per "new" species is 39 for arthropods and 5 for botanicals. Again, this reflects the selective nature of botanical collecting compared with arthropod collecting.

The results indicate that the economic costs of collection associated with identifying a "new" species are $24 for arthropods and $12 for botanicals. Adding in the costs of curating a "new" species gives a total of $100 for arthropods and $95 for botanicals. Thus, the higher costs of collecting arthropods counteract the marginally lower costs of curating arthropods. Sensitivity analysis reveals that these results are not particularly sensitive to the choice of discount rate used throughout the analysis in deriving annuities for fixed costs. The use of 5 and 15 percent rates result in a swing in the results of 5 percent in either direction. The

[9]Lucas (pers. comm. 1992) also reveals that in the old days plant curators were paid one pence per plant identification - which is why many of the more difficult specimens of the 6 million held at Kew remain unnamed.

final results are, therefore, not greatly affected by the change in assumptions about the opportunity cost of capital.

Technically speaking a cost-effectiveness analysis provides the means to calculate projections for the accomplishment of work objectives. Given input-output figures it is possible to use projections of funding levels to forecast outputs. In the case of one of INBio's immediate objectives - the completion of a national inventory - the final target is deceptively obvious. Nevertheless, the data developed in the cost model can be used to provide estimates regarding the costs of completing the inventory and the time that this would take given current funding levels.

As indicated earlier, the botanical inventory is quite far along towards its goal. INBio has curated specimens of 8,000 species. The National Study of Biodiversity prepared for the United Nations Environment Programme suggests that there are just over 13,000 species in the plantae group (GOCR 1992). The World Conservation Monitoring Centre (1992) predicts that there are from 11-13,000 species of vascular plants in Costa Rica. Taking 12,000 as a mid-point of the number of expected species, INBio is 4,000 species away from its goal.

At an economic cost of roughly $100 per species it is possible to forecast a further investment of $400,000 to complete the botanical inventory. In 1991 economic costs devoted to the botanical inventory totaled $211,00 (see Table 5). A straight-line projection at current funding levels suggests that the plant inventory may be completed in a matter of a couple of years. However, diminishing returns are likely to set in as the additional species that are identified are not just new to INBio but are new "global" species. Although this may be counteracted by the cumulative effects of learning by doing on the part of curators and parataxonomists, the estimate may serve as a lower bound as the resource costs of chasing down the remaining species is likely to grow as the inventory moves to completion.

Unlike the botanical inventory, the arthropod inventory has a very long way to go. INBio has curated only 1 percent of the number of expected species. If the inventory has built a reference collection of 5,000 species by the end of 1992, roughly an additional 360,000 remain (GOCR 1992). At $100 per species the economic cost of completing such an inventory would be in the realm of $40 million. In 1991 economic resources devoted to the arthropod inventory totaled $365,000. At this level of commitment the arthropod inventory would not be finished before the end of the 21st Century. Moreover, completion of the inventory in ten years would require a commitment of social resources equal to roughly $4 million per year.

Cost-effectiveness figures averaged for two years can provide only approximate estimates of the marginal costs of collection for a particular taxonomic group over time. Thus, the projections presented above are speculative. However, they do indicate that the completion of the botanical inventory is a realistic short-term objective, while the arthropod inventory remains very much a long-term endeavor.

For the arthropod inventory a crucial issue is the supply of taxonomic expertise for completing the identification of specimens gathered by parataxonomists. Whether such expertise will come from resources developed within Costa Rica, from the supply of external expertise from the North or be provided in automated form - e.g. optical scanning equipment or expert computer systems - is still unclear. INBio suggests that it will rely on the automated route (Gámez pers. comm. 1993), but is increasing its curatorial staff by 60 percent in 1993-94 in connection with a Global Environmental Facility project (Sittenfeld pers. comm. 1993). Nevertheless, INBio also realizes that assistance - particularly *pro bono* work and training - from the major taxonomic institutions will become increasingly scarce as other countries in the biodiversity-rich developing world initiate there own national inventories.

One potential solution to the development of additional in-country taxonomic expertise would be to encourage parataxonomists to move gradually into curation activities. Part of the motivation behind the development of INBio's parataxonomist program was the feeling that a developing country could not afford the Ph.D level taxonomists necessary to collect the specimens for an inventory in the traditional manner. Yet, it is also true that for intensive curation activities a Ph.D is not of the utmost importance. The basic morphology of organisms is often a major element in their classification. Prance (pers. comm. 1993) suggests that even at the Royal Botanic Gardens, Kew it is recognized that the classification of specimens is essentially a matter of experience and recognition. For the day to day needs of an inventory in Costa Rica, INBio needs to determine whether a trained Costa Rican or a an optical scanner would be the most appropriate technology. Given that neither is currently available in a mass-marketed form the issue is academic at this point.

As discussed above, the cost-effectiveness analysis is currently being extended to cover the projects under the Biodiversity Prospecting Division. In addition, it might be interesting to pursue further the use of cost-effectiveness analysis in providing useful performance measures for the outputs of the information program.

Currently the only data on the Conservation Database consists of the number of information requests that are received and processed. In 1990 and 1991 the number of requests were 72 and 152 respectively. A very crude cost-effectiveness analysis can be conducted using the figures for economic costs of the Conservation Database. The cost per information request was $740 in 1990 and $540 in 1991. These figures are of limited use only. However, they do indicate that in terms of outreach the Conservation Database became more cost-effective in 1991. Given the large number of requests for 1992 cited in Box 3 this decline in the costs per request may be continuing.

Potential also exists to examine the cost-effectiveness of the research process. What are the costs per entry in the database might be a potential cost-effectiveness measure in this case. In a sense, the research activities build up the stock of information - which can be drawn on over and over again. Thus, the information contained in the database is a renewable resource. In this case, efforts by INBio to recoup the costs of production of such information would not really justify charging user fees in the $500-$700 range as might be inferred from the cost-effectiveness figures. Instead, INBio could cover the costs of responding to information requests from the stock of information and rely on donor funding to continue to add to the database. In future work it might be advisable to disaggregate the cost-effectiveness analysis of information activities into its component parts - the development, management and dissemination of information - and develop cost-effectiveness indicators for each area.

4. ECONOMIC BENEFITS GENERATED BY INBIO

As documented in Section 3, INBio's activities incur significant economic resource costs. In evaluating the commitment of resources to these activities it is, therefore, important to examine the potential range and magnitude of the benefits this investment is likely to provide. This section presents an analysis of the benefits generated by INBio's activities.[10] However, most of the benefits INBio provides - both now and in the future - are intangible and not traded in markets. This makes a calculation of the monetary value of these benefits difficult and time consuming. As a result this paper has emphasized initially the development of a framework for describing and analyzing the many types of benefits INBio is generating in a consistent manner. Section 5 then explores a few of these benefits in greater detail.

A number of methodological points precede a discussion of the benefits of INBio's activities. These points concern:

- the general classification of benefits
- the distribution of benefits
- the incremental nature of benefits
- the aggregation of benefits

Methodology for Evaluating Benefits

As an institution directed towards the production of information about biodiversity, INBio essentially has three types of outputs that generate economic benefits. The first, of course, is simply information. INBio is investing in the production of knowledge which is valuable to society. However, by developing information about biodiversity, INBio may also be adding value to the "raw material" of biodiversity itself. The second output generated by INBio, then, is a value-added biodiversity product comprised of biodiversity and the attached information - improved natural capital.

The third - the improvement of human capital - is essentially a spin-off benefit of undertaking information-generating activities. As a diffuse commodity, information does not adhere only to the end product, but is also appropriated by individuals and groups involved in these knowledge-building activities. Thus, in the process of investing in information generation there are many explicit and implicit ways in which the capability of the human resources involved are improved. The benefit derived from an improvement in human capital is distinct from the benefits generated by the development of "information" *per se*.

Romer (1990) refers to the use of the terms "embodied" and "disembodied" knowledge as a means of illustrating the difference between a "piece" of human capital such as the ability to add and a piece of knowledge such as a design for a new product (technology). The former is tied to a specific person, while the latter is not. Romer (1990) uses this distinction in develop a growth model incorporating capital, labor, human capital and an index of the

[10] A broader, more general evaluation of the organization is presented in Lewin *et al.*, however, economic benefits were not dealt with in detail.

level of technology.[11] The model is driven by endogenous technological change. The results indicate that the rate of economic growth is determined by the stock of human capital - not population growth as previous growth models suggest. Thus, the human capital formation generated by INBio's activities must be regarded as an important feature of INBio's economic contribution to Costa Rica's future economic welfare.

The economic benefits generated by an ecosystem - or its subcomponents - are often characterized as comprising direct and indirect use values, and option and non-use values. This classification of benefits can be extended to incorporate the three types of outputs generated by INBio. *Direct use values* are derived from goods and services that are used in consumption or production. The benefits of information, value-added natural capital, physical capital or human capital improvements are all examples of direct use values. *Indirect use values* originate from the environmental functions that support and protect economic activity. For example, the watershed protection function of forests stabilizes soil and regulates water flow. While INBio's activities may increase people's understanding and awareness regarding these ecosystem benefits, INBio does not itself generate indirect use values

In addition to direct and indirect use values environmental resources may have *option and existence values*. Two types of option values are referred to in the environmental economics literature: option and quasi-option value. Option value is associated with uncertainty regarding the future use value of a resource. Quasi-option value reflects the intertemporal aspects of irreversible decisions to develop natural resources and the role of information therein. Option value suggests a risk premium attributable to the resource, while quasi-option value conveys the premium associated with the prospect of gaining better information as time passes (Hanemann 1989).

INBio's activities in the generation of biodiversity information and biodiversity prospecting have an impact on both types of option values held for natural resources. Prospecting activities generate information about the value of biodiversity and should over time, other things equal, reduce the uncertainty over the future value of Costa Rica's biodiversity. For example, engaging in the collection and marketing of biotic samples for the purposes of biochemical screening actually reduces - to a degree - the uncertainty over the biochemical potential of the species involved. Thus, INBio transforms uncertainty regarding the value of biological resources into certainty (relatively speaking). Uncertainty over the biochemical potential of biodiversity as a whole is expressed in terms of option value; knowledge about the biochemical potential of biodiversity is simply evidence of the direct use value of a particular species. Therefore, INBio may actually reduce the option values associated with biological resources, whilst simultaneously increasing its direct use value.

At the same time, INBio may increase the quasi-option value of Costa Rican biodiversity. The development of a Costa Rican institution with a mission of developing information about biodiversity through a national inventory and biodiversity prospecting ensures that information on the consequences of irreversible development will be available in the future.

[11]Labor refers to those services derived from a healthy physical body and are, therefore, distinct from human capital or "embodied knowledge."

Therefore, policy-makers and citizens groups uncertain about the consequences of such development should, other things equal, be more willing to accept any costs associated with postponing development decisions than they would in the absence of such an institution.

Finally, there may be non-use or existence values associated with a resource. These are benefits derived by an individual from the mere knowledge that the resource continues to exist. In its role as a provider of information about biodiversity, INBio may play an important role in the existence value attributed to Costa Rican biodiversity. Unfortunately, this connection remains speculative as there is very little empirical work examining the effect of information disclosure on existence values. Samples, Dixon and McGowen (1986) found a significant positive relationship between the disclosure of information about endangered species and willingness to pay for preservation bids in one of two survey experiments conducted. Brown (pers. comm. 1993) suggests that recent research in experimental markets has shown that the disclosure of information does not actually change the magnitude of existence values, rather it simply decreases their variance.

The motivation behind INBio's activities rests largely on the argument that the sustainable use of biodiversity will lead to its conservation. Nonetheless, there is certainly a strong feeling on the part of INBio staff that in assisting Costa Rica to learn about biodiversity, INBio will increase society's willingness to pay to preserve biodiversity. Although this study can neither confirm nor reject this hypothesis, a number of the activities at INBio are at least tangentially oriented towards this type of benefit and are covered in the framework of benefits.

As indicated in Section 2, INBio is engaged in a wide variety of activities with many different sectors of Costa Rican society. Activities undertaken by INBio provide benefits not only to INBio itself, but also to many different social groups, local and international institutions, and the Costa Rican protected areas. It is, therefore, important to define clearly who receives the benefits generated by INBio.

Benefits that accrue to individual actors and segments of Costa Rican society, include the benefits that accrue directly to INBio, other institutions, communities or individuals. For example, the commercial ventures undertaken by the Biodiversity Prospecting Division generate financial returns for INBio, the Conservation Areas and local universities. In addition, the many individuals and sub-contracting institutions also receive less tangible benefits from INBio's activities such as training. Local communities may share in the benefits generated by the parataxonomists program.

National benefits include those benefits that are of a public or quasi-public nature. For example increased productivity of the labor force, training, intellectual capacity building and capital creation funded by external grants (such as new machinery and equipment received by the public universities). Economic benefits are also received at the national level by projects such as those carried out jointly with Universities.

There are also benefits which accrue to the global community. For instance, taxonomic and biochemical knowledge generated by INBio may be consumed by many interested parties outside of Costa Rica. Likewise, the development of biodiversity information may lead to increased existence values for biodiversity in general. A final global benefit reflects the value of the knowledge generated through the INBio experience. By developing such a novel institution, Costa Rica provides the global community with an example of how an institution can develop and capture the value of species information.

In this section all of these different benefits are explored. However, it is important to list one limitation and one caveat to this discussion. First, the benefits considered here are only the incremental benefits that result from the additional economic inputs deployed by INBio. Due to INBio's close relationship with the existing system of Conservation Areas it is important to distinguish between the value added by INBio and those benefits that the Conservation Areas would generate in the absence of INBio's efforts. It is likely that biodiversity and information about biodiversity are complementary goods (Aylward and Barbier 1992). If this is the case, an independent examination of INBio on the one hand, and the Conservation Areas on the other, would miss the complementarities between the two projects and understate their total value to Costa Rica.

In addition, benefits generated by INBio that accrue to different levels of society are not necessarily additive. For example, certain benefits gained by specific groups - e.g. employment and contractual income gained by INBio staff and sub-contractors - are in fact inputs in the process of producing other intermediate and final products such as the inventory reference collection and information and database.

Benefits of the National Inventory

The national inventory generates a number of different outputs which yield economic benefits including

- species information
- a species reference collection
- human capital formation
- environmental education in local communities

Information is generated throughout the collection and curation of specimens. Along with the physical specimens, parataxonomists enclose information on the collection site and conditions. This information is of value to the Biodiversity Prospecting Division and other researchers in the recollection of similar specimens for the purposes of scientific research. Curators add value to these collected specimens by sorting them into taxonomic groups and in many cases identifying the specimens to species level. This classification is very important to those interested in areas of scientific research such as ecology, genetics or pharmaceutical investigation. Accompanying these information outputs is the physical reference collection itself. While this collection (or library) is of little value without the information (or catalogue) the existence of a physical collection is also an important factor in drawing researchers to INBio and Costa Rica.

The benefits derived from these two outputs are likely to accrue to both INBio and the country as a whole. INBio uses the collections and information generated by the inventory in its own prospecting activities. Thus, these inventory outputs serve as inputs to commercial activities carried out by INBio. In addition, the national economy benefits, for example, from the increased likelihood that foreign scientists will choose Costa Rica as a research site. Foreign scientists may come to Costa Rica expressly to study the specimens that are kept in the collections, or they may be attracted by the availability of a well-catalogued resource that precludes the need for them to carry out their own taxonomic research.

A study by Laarman and Perdue (1989) measured the benefits to the Costa Rican economy that result from the Organization for Tropical Studies' (OTS) "scientific tourism" activities in Costa Rica. The authors found that net annual receipts to the Costa Rican economy directly attributable to OTS are between $1.9 and $3.4 million with a total of $10 million in receipts likely as a result of the multiplier effect of tourism expenditures.

Classified specimens may also generate benefits for other organizations. Natural history museums and visitors centers at tourist destinations may also exhibit specimens collected and curated by INBio staff. INBio might itself one day exhibit some of its specimens in a commercial manner, bringing tourists from hotels in San José and giving them a tour of INBio's collections.

The parataxonomist program provides a number of human capital formation benefits to Costa Rica. Employment as a parataxonomist represents a non-traditional job opportunity for people who might otherwise be presently under-employed were it not for INBio. The gain to the individual parataxonomist that is occasioned by the presence of INBio is the difference between what the individuals were likely to have accomplished without INBio and what they are achieving with the opportunity generated by INBio. The benefits of human capital formation are, therefore, revealed by changes in the productivity of labor. If parataxonomists are compared with their counterparts working in cattle ranches or in low-paying jobs in hotels and restaurants, they appear better-off in terms of their salaries, their future expectations and self determination.

These labor productivity benefits may be broken down into formal training, learning by doing and post-INBio spin-off benefits. The benefits of increased labour productivity generated by formal training and by on the job learning are captured by INBio in the form of the collections that the parataxonomists provide. These benefits are, then, intermediate inputs in the process of producing species information and the reference collection. Once the parataxonomist leaves INBio, any continuing labor productivity benefits are captured not by INBio, but by society at large - e.g. by future employers of parataxonomists. Nevertheless, as with all benefits generated by investments in employment and human capital improvements, the net benefits to the country will depend on a comparison of returns from alternative investments in human capital. A detailed examination of the human capital formation generated by the investment in parataxonomists is provided in Section 5. Benefits of improvements in labor productivity are not the exclusive of parataxonomists. Curators also receive training and learn-by-doing

The parataxonomists and the biodiversity offices also play a very important role in educating people about the benefits and the importance of preserving natural environments. Parataxonomists are drawn from communities in and around the Conservation Areas. As a result it is easy for them to interact with local people and to share both their knowledge about biodiversity and their enthusiasm for their work. For example, in Sarapiquí, there are five school kids now working with the local parataxonomist based in the Cordillera Volcánica

Central Conservation Area. At the Palo Verde National Park a parataxonomist is collaborating with the Park's environmental education program, giving lessons and providing schools with boxes full of insects. This has lead to growing interest on the part of school children in fields such as biology and ecology.[12]

In theory, the interaction of the parataxonomists with members of their community will lead to the spread of information about wild areas. Tosi (pers. comm. 1992) suggests that this effort raises the public consciousness about the issues that affect the environment and the importance of wild areas. If people's attitudes towards protected areas change - that is if they place a higher value on these areas - the result may be a change in behavior. Reduction of fires and poaching are potential visible effects of these behavioral changes. The nature or magnitude of this impact is as of yet unknown. However, a number of indicators described in Section 5 suggest that parataxonomists are already having an important educational impact on their communities. In addition, parataxonomists are also learning about biodiversity from their communities and may serve as a useful local focal point for ethnobiological information.

Benefits of Biodiversity Prospecting

Once knowledge about species is developed by the Inventory it can be put to use by INBio - or other organizations in the public or private sector - in research programs designed to find non-traditional or new uses for biodiversity. Financial returns from such arrangements can then be used by INBio to support the Conservation Areas and the Inventory. This is the objective of the Biodiversity Prospecting Division. By finding new and sustainable uses for biodiversity INBio expects that resource conservation in Costa Rica will be strengthened. Besides the financial returns derived from research contracts, prospecting activities also generate human capital formation benefits.

To date, INBio's efforts to pursue commercial prospecting arrangements have focussed largely on collaborative research agreements for the development and use of biotic samples in screening programs designed to isolate useful pharmaceutical or agrochemical applications. In conducting research - for Merck & Co. for example - the Biodiversity Prospecting Division draws on the species information developed by the inventory. However, additional effort is expended in the recollection, classification and processing of biodiversity specimens - this is value that is added to the raw biotic material by the Prospecting Division.

Payments for research leading to the development of biotic samples are the principal tangible benefits of prospecting arrangements. In the case of the Merck & Co. arrangement the payment for the two-year contract came to $1 million. However, $100,000 of this amount was allocated for donation to the national parks system. In addition, INBio is using an additional share of the proceeds to fund the work of the parataxonomists and the curators. The direct payment simply for the collection and processing of the samples is, therefore, substantially less than the full $1 million. In 1992 INBio entered into its second research contract with a commercial company - delivering samples of a natural product with potential

[12] The educational role of the parataxonomist is examined further in Section 5.

nematocidal properties to the British Technology Group (BTG) in exchange for a cash payment.

In addition to fees for research services, INBio also endeavors to negotiate access to the commercial returns that screening programs might generate in the form of future marketable products. In the case of the INBio - Merck & Co. agreement INBio has negotiated a share of royalties on any successful products resulting from the collaboration. The INBio - Merck & Co. contract is explored further in Section 5 of this paper.[13]

In its negotiations with the British Technology Group, INBio obtained an exclusive license for the sale of the final product in Costa Rica. Thus, INBio will also receive intellectual property benefits from this arrangement as well. INBio is likely to sub-license an industrial concern to carry out the actual production and marketing of any such products in return for royalties on actual production. In the case of production for the Costa Rican market, the country will gain the benefits of producing the final product, not just the benefits of producing the active ingredient. However, the full extent to which the Costa Rican economy will actually gain from this transaction will depend on the efficiency of the eventual local producer as versus an external producer. If the domestic resource costs of local production are excessive, Costa Rican consumers of the product will be made worse off than if a foreign company had retained the rights to the Costa Rican market.

Another source of commercial benefits - both for INBio and local communities - stems from the possibility of actually harvesting or cultivating the plant or insect used in a product developed from biotic samples originally generated by INBio. As part of the arrangement with BTG, INBio negotiated a contract specifying that third party licensees producing the nematocide for sale in other markets would give consideration to purchasing supplies of the active ingredient from Costa Rica.[14] In this fashion, INBio's prospecting activities may provide Costa Ricans with the potential opportunity to benefit from a new production crop. Additional spin-off benefits will also be generated if - as is the case with the nematocide - the biological product is put to use in Costa Rica leading to a reduction in the use of more environmentally damaging agricultural chemicals. The BTG arrangement is analyzed in more detail in Section 5.

Physical capital formation refers to the acquisition of new equipment and technology and similar productive assets that have a cash value. INBio through its work with foreign companies, universities, governments and organizations is in a position to assist in transferring new technology to Costa Rica. For example, as a result of the Merck agreement, INBio has acquired equipment and proprietary knowledge from abroad in the area of chemical extraction of both plant and insect samples.

The non-commercial benefits generated by prospecting activities are also very important. Both the Merck & Co. and Research Coordination projects have involved a considerable amount of structured and on the job training - i.e. the improvement of human capital. In

---

[13] *See* Aylward (1993) for more on the potential commercial returns of supply contracts for biotic samples.

[14]BTG simply assists in the development of new technologies it does not engage in production and marketing activities.

some instances, Costa Rican scientists have travelled abroad to receive training and to work with counterpart organizations. In others, scientists from these organizations have come to Costa Rica to assist staff at INBio and the local universities in learning new skills and techniques. For example, prior to the Research Coordination project bioassay-directed fractionation had never before been conducted in Costa Rica. In addition, the projects sponsored under the Research Coordination project have provided funding for Costa Rican scientists to further explore areas in which local expertise already exists. These benefits are captured both by INBio and Costa Rican society as a whole.

Benefits of Information Management and Dissemination

At present there is little that can be said about the economic benefits generated by the Information Management and Dissemination Divisions as INBio is still in the process of developing these programs. During the 1989-1992 period the Conservation Database was the primary activity in the information management and dissemination area. While INBio continues to support the development of this Database it was up and running before INBio was created. In a sense, then the information contained in the Database - and consequently any flows of this information to users - is not strictly attributable to INBio.

Drawing on this experience with the Database it is possible to suggest the types of benefits and users that a full-fledged Information Management and Dissemination Program would generate. The information management function performs the task of integrating and managing all the various types of primary information generated by INBio's programs. The information dissemination function generates publications and other reports from the Database to suit the needs of information users. This information has economic value inasmuch as potential users are willing to pay for the use of INBio's services in this regard. In addition, the information may generate spin-off benefits if its application leads to the realization of economic benefits - such as improved policy-making - that would not otherwise have occurred. There are several markets to which such information may be targeted:

Ecotourism. The attraction of Costa Rica as an international tourist destination may be enhanced by INBio's efforts to develop and disseminate information about the country's biodiversity. Tourist guides to particular areas and taxonomic groups may not only lead tourists to choose Costa Rica as a destination, but may add to their enjoyment while in the country. This argument also applies to local tourism.

Formal Education. INBio produces information that could be packaged for formal education programs. This includes text books, computer based biodiversity information systems and other materials that can be used in Costa Rican schools and universities.

Scientific Users. Once a formal information management system is available with a proper user interface, prospective scientific users will no longer need to sort through raw inventory data. Instead, sophisticated searching techniques and report generating functions are likely to substantially improve the ease and convenience of access to this information. In the absence of INBio, many scientific users would need to carry out the basic taxonomic research on their own - or hire another to do it. Thus, INBio's information activities are likely to provide a valuable service to the scientific community.

Policy makers. INBio's information outputs may also be used in the determination of public policy regarding natural resources. By generating and disseminating biodiversity information INBio may assist Costa Rica in developing public policies that maximize future rents to society from the nation's biotic resources. This may occur either through direct interaction with government officials or through providing information to non-governmental organizations for use in policy campaigns.

General Public. General information dissemination - through newspapers, public address, etc. - may provide economic benefits to Costa Rica by improving peoples attitudes towards, and interest in, biodiversity.

A final economic benefit generated through information activities is the development of new technologies. INBio has reached agreement with Intergraph - a major multinational supplier of computer services - to collaborate in the development of a biodiversity information management system. Intergraph is contributing about $750,000 to this venture which will provide a variety of benefits to INBio and Costa Rica. In addition, INBio will obtain a share of the proceeds of any marketable information technologies that result from the collaboration. In this regard, the Intergraph agreement is not unlike the arrangement with Merck & Co. It is worth stressing again that these projects have come to Costa Rica - not so much because *it is rich in biodiversity, but because INBio has made a commitment to develop information* about biodiversity.

Currently INBio does not charge for access to information contained in the Conservation or Inventory Databases. Discussions with the Inventory Division suggest that information from the Inventory Databases is available to the public at no charge and will continue to be so when the new information management system is developed. Discussions with INBio's Director reveal that INBio may yet develop a "gatekeeper" function to limit access to information sensitive to INBio's efforts in the area of prospecting.

Sensitive information in this case is likely to refer to information used by the Biodiversity Prospecting in the development of biotic samples for screening programs. The fundamental problem posed by leaving the Inventory open to access by all interested parties is that other commercial collectors would be in a position to access - for free - the same information as the Prospecting Division. The innovative aspect of INBio's structure is that its prospecting activities provide a direct financial return to the continued development of taxonomic knowledge.[15] The Prospecting Division is committed to sharing any receipts from sales or royalties with the Inventory in recognition of its input into the prospecting process. This raises the price at which the Prospecting Division can offer its services to potential customers. There exists the danger, therefore, that a collector who does not have to pay for access to the same information will have a cost advantage in supply. This could drive INBio's prospecting activities out of the business of supplying samples of Costa Rican biodiversity to screening programs.

---

[15]*See* Aylward (1993) for a discussion of different approaches to capturing the value of taxonomic information.

Thus, allowing access to the reference collection and the Database of information regarding the collection site, conditions and name of the parataxonomist collecting a particular specimen may endanger the system of sharing benefits that INBio has developed.[16] There are, however, a number of difficulties with solving this problem through a "gatekeeper" function. Ideally, only potential competitors would be excluded from full access. However, it may be extremely difficult in practice to identify commercial collectors. The alternative is limiting information flows to all prospective users. This would fall afoul of the convention of researchers sharing scientific information and limit the benefits that are generated by investing in information production.

In any case, from an economic perspective, restricting access to commercial collectors is a blunt and inefficient solution to the problem. The result is to effectively exclude other commercial collectors from operating within Costa Rica - with the exception of plant collectors who choose to use the collection at the National Museum. A lack of competition in the market for biotic samples within Costa Rica is likely to lead to inefficient outcomes and the waste of valuable resources. An alternative solution is to equalize the costs of obtaining access to species information and reference collections across all commercial users of this information. By charging commercial collectors for information services these collectors would not, then, have an "unfair" cost advantage. They would also contribute to the generation of species information and biodiversity protection, just as does the Biodiversity Prospecting Division. A charging system does not solve the problem of identifying commercial collectors. However, the incentive to cheat is far less than if there is an effective ban on participation.

The subject of benefits arising out of information management and dissemination activities is not pursued further in the current study. However, the increasing number of information requests received by the Conservation Database and the recent development of formal Divisions for management and dissemination may provide the opportunity to examine more closely the willingness-to-pay for information services and develop a user fee system for more than just commercial users. A proposal for an investigation of the willingness to pay for taxonomic information is provided in Appendix A. Such a survey would assist INBio to evaluate the potential for instituting user fees for information services.

Benefit Evaluation

In Box 3 the benefits described above are combined into a framework of benefits provided by INBio. In order to generate a short list of benefits that would be amenable to further investigation this framework was reviewed and assessed with INBio's Executive Director, Dr. Rodrigo Gámez and the Director of Biodiversity Prospecting, Msc. Ana Sittenfeld. They were asked to classify each benefit category according to its importance to INBio and the likely magnitude of its economic value to Costa Rica. In both cases a low-medium-high scale was used.

[16]Note also, that driving the Prospecting Division out of business would also put an end to the return of benefits to the Conservation Areas.

Box 3 Economic Benefits Framework for INBio

	Importance of Benefits	Priority
The National Inventory		
1. Species Information	high	high
2. Reference Collections	high	high
3. Human Capital Formation	med	med/high
4. Educational Role of the Parataxonomists	hi	*
Biodiversity Prospecting		
1. Payments for Biotic Samples	high	high
2. Intellectual Property Benefits	high	high
3. Production Benefits	high	high
4. Human Capital Formation	high	high
5. Physical Capital Formation	high	high
Biodiversity Information Management (by type of user)		
1. Ecotourism	medium	medium
2. Formal Education	high	medium
3. Scientific Users	medium/high	low
4. Policy-Makers	high	high
5. General Public	high	high

Notes: All ratings are as supplied by INBio
*A spin-off benefit and, therefore, not really a priority.

As illustrated by Box 3, INBio expects that most of the benefit categories are of high importance and likely to be of large economic importance. A few points emerging from the discussion of these benefits are worth highlighting. The educational role of the parataxonomists is seen very much as a spin-off benefit of the program. Thus, it is difficult to assert that it has any particular level of priority in the scheme of INBio planning or objectives. Nonetheless, the feeling is that the interaction of parataxonomists with their community may play an important part in increasing the "bioliteracy" of rural peoples.

INBio considers the human capital formation benefits to be of comparable if not larger value than the financial benefits of prospecting arrangements. However, the political necessity of demonstrating that biodiversity "pays" is such that a large emphasis must be placed on these financial benefits. Otherwise, it is felt that society will not be interested in supporting the costs of preserving biodiversity.

Although INBio acknowledges that the probabilities of deriving a successful pharmaceutical product from the contract with Merck & Co may be small, the magnitude of such benefits were felt to be of considerable importance to INBio. Likewise, the possibility of deriving production benefits from successful products may be small, but was considered to be of considerable importance due to the need to bring the benefits of biodiversity to the local level.

Compared to the tasks of developing the national inventory and demonstrating the economic value of biodiversity and species information, INBio places relatively less priority on the information dissemination activities. For example, in the case of benefits derived by scientific users it was deemed that these benefits "come by themselves." Nevertheless, there is one major exception. INBio and its staff invest significant amounts of time advising government and helping to create and implement conservation policy.

5. BENEFITS STUDIES

Based on the benefits framework developed in the previous section and discussions with INBio staff, a number of benefit areas were selected for additional research:

- benefits of investing in human capital - the case of the parataxonomists

- benefits of disseminating species information - the case of the parataxonomists

- production benefits of prospecting - the BTG case

The results of the research into these areas is presented in this section along with a brief discussion of the INBio - Merck & Co. contract.

Benefits of Investing in Human Capital - the Case of the Parataxonomists

This study investigates the benefits generated by INBio's investment in the parataxonomist program. The initial investment made by INBio is in a formal training course which provides parataxonomists with the basic skills and knowledge necessary to begin their collecting duties. Parataxonomists are then fully occupied in collecting, however, through various means including their field experience, in-service training and feedback sessions with curators the parataxonomists learn-by-doing. They acquire additional skills and knowledge that make them more productive at the task of collecting biodiversity specimens. When parataxonomists leave their position at INBio to take up another job these skills may continue to contribute to their productivity. Thus, there are three kinds of benefits produced by INBio's investment in training and employment of parataxonomists:

- benefits of formal training
- benefits of learning by doing
- spin-off benefits in future occupations

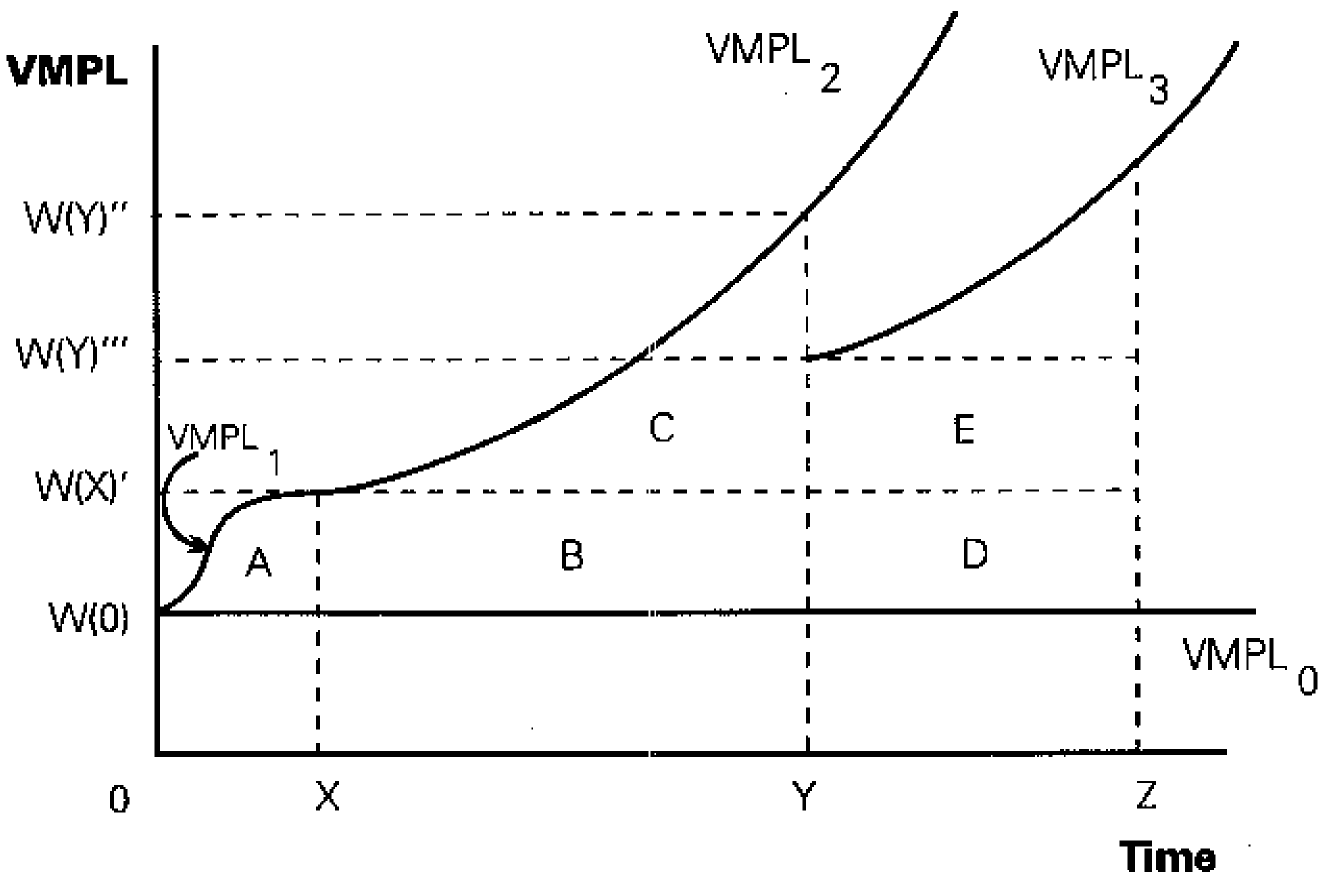
The first two categories of benefits accrue directly to INBio in the form of improved efficiency of collection. The latter category of benefits are captured by other organizations and Costa Rica as a whole.

Improvement in human capital leads to changes in labour productivity. The benefit generated by the employment of a productive asset is expressed as its value marginal product - in this case the value marginal product of labour (VMPL). Evaluation of changes in VMPL enable an analysis of the three types of human capital formation benefits listed above.

Figure 2 summarizes the theoretical presentation that follows. In the diagram four set time periods are used in the analysis:

- $t=0$ - the point at which the training course starts;
- $t=X$ - the end of the training course, normally six months
- $t=Y$ - the end of the parataxonomists working life at INBio
- $t=Z$ - the point of retirement at 60 years of age.

Figure 2 Value Marginal Product of Labor - Parataxonomists



Parataxonomists, before enrolling in the training course, that is at time 0, have an initial productivity level, $VMPL_0$, and initial wage level, W(0). Through time their VMPL in their pre-INBio occupation may increase, decrease or remain constant. For the sake of simplicity, it is assumed that the average rural occupation does not provide much opportunity for learning by doing and that improvement of a worker's productivity is limited. Thus, as productivity is assumed constant over Z years the $VMPL_0$ curve is pictured as flat in Figure 2.

When parataxonomists start the formal training course their productivity starts to rise, although with decreasing returns (as shown by $VMPL_1$). Nevertheless it raises their productivity at time X to wage level, W(X)'. After finishing their training they start to learn-by-doing which leads to a gradual rise in their productivity along $VMPL_2$. At time period Y, they stop working at INBio at a VMPL equal to wage W(Y)''.

If the parataxonomists' next occupation utilizes skills developed at INBio, some portion of their productivity is likely to be attributable to their work at INBio. In Figure 2, it is observed that their initial productivity in the next job, $VMPL_3$, is likely to be less than that of their final productivity at INBio. As a consequence, wages in the new job are lower, i.e. W(Y)''' < W(Y)''. This is not necessarily the case as parataxonomists may in fact be hired to work at a higher wage level that effectively captures their productivity developed at INBio. In Figure 2 it is further assumed that in their next occupation their productivity continues to grow - $VMPL_3$ increases over time as additional learning by doing occurs. Thus, it can be argued that a share of their productivity post-INBio is a result of training and learning by doing generated by INBio's investment in the parataxonomists. While INBio cannot capture this benefit it is a spin-off benefit to the national economy for which INBio may take credit.

The productivity benefits generated by INBio must reflect the incremental gains generated by the investment in training and learning by doing as compared to the productivity that would have been experienced in the absence of INBio. Thus, the net benefits attributable to INBio's efforts in developing the labour productivity of the parataxonomists are represented in Figure 2 as those areas that lie above the initial $VMPL_0$ curve.

The benefits of formal training that are captured by INBio are made up of the area above $VMPL_0$, but below $VMPL_1$ from t=0 to t=Y, or areas A and B. The benefits of learning by doing are the area above W(X)' and below $VMPL_2$ from X to Y, or area C. The spin-off benefits to the national economy is the area above $VMPL_0$ but below W(Y)'' and from t=Y until the worker retires, t=Z. These benefits include both areas D and E on the diagram. D represents the continuation of training benefits and E the continuation of learning by doing benefits.

In order to estimate the training, learning by doing and spin-off benefits the salary history of the parataxonomists was reconstructed by means of a survey and reference to INBio's records. The survey questioned parataxonomists on their previous occupations, current salaries, future career expectations and other matters. The survey was sent to all 38 parataxonomists and 31 responses were received. Wage levels are used as a surrogate variable for VMPL. Other indicators of a parataxonomists productivity were explored but were not suitable to the tasks. For example, specimens collected could not be used because,

because as parataxonomists become more experienced they may collect fewer species in absolute terms.

Parataxonomists were separated in three groups according to which training course they attended. There have been three such courses:

1 January-June 1989
2 April-September 1990
3 January-June 1992

At the time of the survey in January 1993, the groups were respectively, 4 years, 3, years and 1 year into their career at INBio.

The survey allowed a partial and approximate analysis of the hypothesis that the parataxonomists' productivity in their previous jobs would have been constant in real terms over their working life (i.e. a flat $VMPL_0$). The first step was to estimate W(0). This was achieved by asking for the parataxonomists' monthly salaries at their previous occupation. The parataxonomists were then asked what they thought their salary would have currently been in their previous occupations had they not taken up employment with INBio. Their $VMPL_0$ curve was then obtained by joining these two salary points.

Real monthly wages in previous jobs (before INBio) are different for each group. Individuals in both groups 1 and 2 were mainly park guards working at the Guanacaste Conservation Area and were making an average of ¢20,771 and ¢18,677, respectively.[17] Group 3, on the other hand, is comprised mainly of women, most of whom were working in their households at the time they started to work for INBio. The Costa Rican legal minimum wage is used in deriving the opportunity cost of their labour. As a result, the average monthly salary for this group before entering the training program was estimated at ¢12,287. The weighted average for W(0) for the three groups is then ¢17,241.

Asked about what their income would be if they never had participated in the parataxonomist program the three groups mention average monthly wages of ¢21,990, ¢21,033 and ¢13,711, respectively. The $VMPL_0$ curve, that is at the situation without INBio, is fairly flat for all groups. Furthermore, most people indicated that they would be doing basically the same thing they were doing before enrolling in the course. For example in group 3 which consisted almost exclusively of women working in the home, a high percentage said that their occupation would not have changed had it not been for INBio. Thus, in the calculations that follow it is reasonable to assume that $VMPL_0$ is flat for all groups.

Estimates of the productivity benefits generated by the training courses could be obtained only for group 3. This was the only group for which salaries at t=0 and t=X were available. For groups 1 and 2 the training and the learning by doing could not be separated. According to Janzen (pers. comm. 1993), who conducted the first three training course, the situation with the first two groups was somewhat atypical in any case. Janzen adds that

[17]All figures from this point on are in 1990 constant colones. Adjustments are made using the low to middle income consumer price index.

Group 3 better reflects INBio's policy regarding the training courses and the compensation of workers' productivity.

Individuals from Group 3 had an implicit, average wage of ¢12,287 in their previous occupations. Upon selection for the training course they were immediately upgraded to a monthly salary of ¢18,378, as recognition for having been selected (only 16 were selected out of a total 165 applicants). Six months later, after successfully finishing the course they received another raise to ¢22,461 (W(0)'). Although their salary was increased at the outset it is unlikely that their productivity would have increased so abruptly, it was therefore assumed that $VMPL_1$ rose gradually from ¢12,287 to ¢22,461 at the end of the course.

Current average wages (W(Y)'') are ¢29,251, ¢28,312 and ¢22,880 for groups 1, 2 and 3, respectively. As can be seen, real wages have increased with time. If our assumption that the real wage reflects the worker's productivity is true, then it is possible to say they get more productive with time, that is, they learn-by-doing.

There is little empirical evidence regarding the exact magnitude of potential post-INBio spin-off benefits after the parataxonomists leave INBio - e.g. data on initial wages at new jobs, W(Y)'''. However, INBio was able to provide information about the new jobs taken up by parataxonomists that have left their positions. In addition, some speculative information on future plans was captured through the questionnaire.

Although the majority of parataxonomists express a desire to continue working as parataxonomists, results to date suggest that there is a significant attrition rate. Of the 51 parataxonomists trained by INBio, 14 (or 27 percent) are now working at different occupations for different employers. Of the 14 that have left their posts as parataxonomists one has become a curator of the National Inventory Program; one is a drawing assistant at INBio; six are working at different Conservation Areas on environmental education and scientific research; three are pursuing further studies and the rest are working in the private sector.

Regarding the parataxonomists' expectations the survey showed that after INBio 46 percent suggested they would continue working. Of those planning to continue working 29 percent mentioned biology as their future field of work, 21 percent tourism, 14 percent research, 14 percent protected area management and 14 percent environmental education. Interestingly, none mentioned curation as their future expected work - of course biology includes curation, but nobody referred to it specifically. This may be due to the fact that parataxonomists enjoy working outdoors, curation usually involves more time "inside" which may not be attractive to them. On the other hand, they may not feel qualified enough for the position of curator or may not be interested in moving to Santa Domingo. This result sheds doubt on the potential for developing local curating expertise out of the parataxonomist program. In any case, INBio has designed the parataxonomists program to train rural people how to earn a decent and ecologically sustainable livelihood in their home communities.

Taking on board both the actual occupations of former parataxonomists and the expectations of current parataxonomists it is likely that the parataxonomist program is generating an important spin-off benefit in terms of labour productivity. Most parataxonomists have taken new jobs in fields that draw upon skills developed at INBio. Individuals working now in scientific research, environmental education and other activities are enjoying now better wages thanks to skills they developed working as parataxonomists. Furthermore, 90 percent considered that the training they have received would be important in their future job or academic studies, and 87 percent said it would help them to obtain a better salary.

As a result it is safe to assume that the average starting wage on their next job, W(Y)''', would be at least equal to their salary when they leave INBio. As indicated in Section 3, Janzen and Hallwachs (1991) suggest an attrition rate of 10 percent per year for parataxonomists engaged in the national inventory. On average, then, the length of life of parataxonomists in their current position would be 5 years (assumed to be 60 months post-training). Given that on average the parataxonomists surveyed are 27 years old, and have worked with INBio for two years, it is possible to estimate the duration during which post-INBio spin-off benefits are likely to be generated. A retirement age of 60 means that parataxonomists will generate spin-off benefits for 29.5 years after leaving INBio.

With the information generated above it is possible to create an aggregate time profile for a "typical" parataxonomist. The $VMPL_0$ curve is assumed to be flat and the initial wage, W(0), is set at ¢17,241, the average for the three groups. The information from Group 3 for the wages before and immediately after training is assumed to be representative of all groups and provides the $VMPL_1$ curve. For the benefits of learning by doing, three data points exist for the $VMPL_2$ curve, each corresponding to the actual wage level of each group, at t=12, 36 and 48 months. The projection from t=48 to t=66 in order to complete the $VMPL_2$ curve and obtain W(Y)''is assumed to have the same slope as $VMPL_2$ from t=36 to t=48. The "typical" parataxonomist is assumed to move into a related occupation and continue working until t=420, or 60 years of age.

Figure 3 shows the resulting time profile of the VMPL curve for a "typical" parataxonomists. Comparing this profile with that first presented in Figure 2 indicates that the slope of $VMPL_2$ exhibits not exponential growth, but logistic growth. The implication is that productivity increases rapidly initially, then levels off and towards the third year of the parataxonomists stay in this position demonstrates diminishing returns. While the data are limited, this profile is probably an accurate description of the real situation, i.e. with time productivity continues to increase but at a lower rate.

Box 4 reveals the labour productivity benefits generated by INBio in the case of a "typical' parataxonomist. The totals for each area are presented in net present value terms. Benefits accrued during the formal training course, or area A, are ¢14,000. Total benefits from the training, accrued by INBio while parataxonomists are employed (Area B), are ¢227,000. Thus, total benefits appropriable by INBio of the formal training course (areas A + B) are ¢241,000. Extending these benefits over the life time of a parataxonomist (area D) gives an additional ¢349,000 for a grand total of ¢590,000 in total economic benefits from training. Total benefits from learning by doing while at INBio, or area C, are ¢195,000. Spin-off benefits, or area D, society would receive once the parataxonomist moves on to another related occupation, are ¢548,000. Total benefits from learning by doing gained by Costa Rica are ¢743,000. The training and learning by doing benefits are illustrated in Figure 4.

The results indicate that spin-off benefits are a significant proportion (67 percent) of the total training and learning by doing benefits. INBio manages to capture only 33 percent of the

Box 4 Training and Learning by Doing Benefits of the Parataxonomist Program

		Training			Learning by Doing		Total Benefits
		To INBio		To Society	To INBio	To Society	
		A	B	D	C	E	
Total Value	1990 colones	14,236	226,661	348,976	178,068	548,133	1,316,075
	1990 dollars	155	2,462	3,790	1,934	5,953	14,294
% of Total		1%	17%	27%	14%	42%	100%

Figure 3 Wage Profile of a "Typical" Parataxonomist

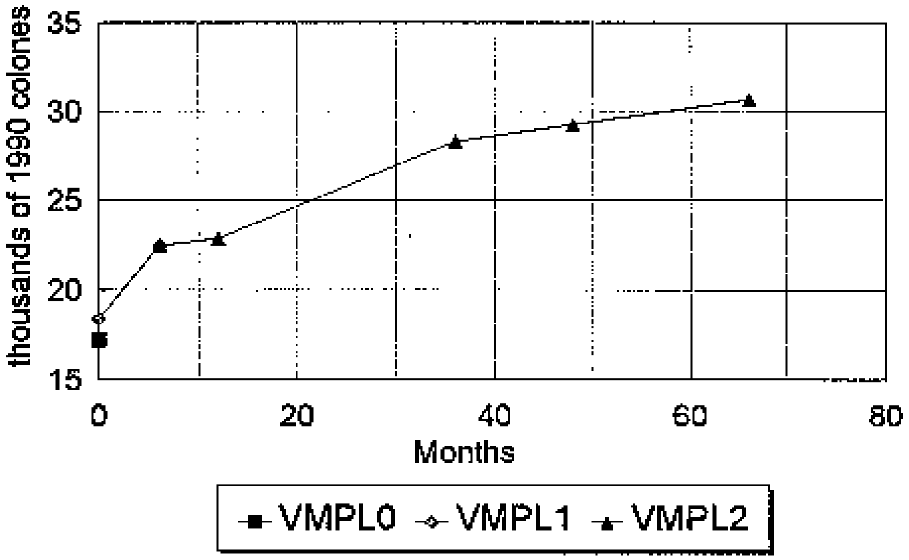
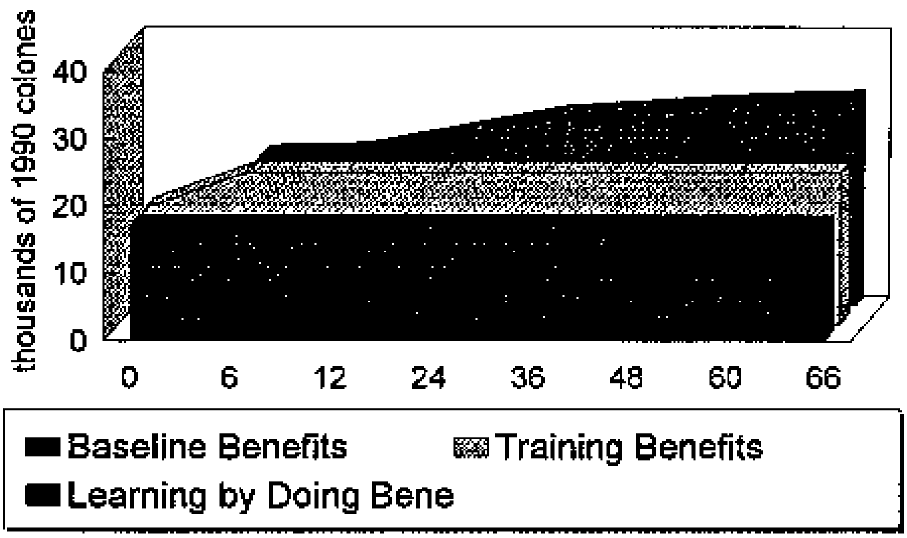


Figure 4 Labour Productivity Benefits Generated by INBio's Parataxonomists



benefits of its investment in the parataxonomists under this scenario. However, INBio does manage to capture a larger share of the training benefits than of the learning by doing benefits. The analysis also shows that the total economic benefits of learning by doing (56 percent of the total) are marginally larger than the training benefits.

The total value of the productivity benefits is ¢1.3 million or just over $14,000. In comparison the costs of training a single parataxonomist - based on the first two courses - is almost ¢900,000 or $10,000 (*See* Table 10). While the data and methods used are only a first approximation, this analysis suggests that a modest level of economic benefits are generated by INBio's investment in the parataxonomist program.

Local Benefits of Disseminating Species Information

The educational role of the parataxonomists in disseminating information about biodiversity within their communities is often cited as an example of how INBio is improving Costa Rica's biological literacy, or bioliteracy, and changing attitudes towards Conservation Areas. As noted in Section 5, the educational function of parataxonomists is not an explicit objective in their work. However, this spin-off benefits is one way in which the INBio approach differs from the more traditional "expedition-based" approach to taxonomic research. In the "expedition-based" approach collection of samples is typically carried out by foreigners and local staff who are usually well-educated and live in metropolitan areas. This approach is likely to have far less of a positive impact on local people's attitudes towards protected area than an approach based on parataxonomists who - in addition to having an interesting and well-paying job working in the protected area - are also likely to share information gleaned from their experiences with people in their communities.

Before concluding on these grounds that the INBio approach is preferable to an "expedition-based" approach it is important to assess if parataxonomists actually do play an important educational role in their communities. Do they educate people in these communities about biodiversity and does this lead to changes in attitudes and concurrent changes in behavior? If so, society as a whole may gain through this dissemination function by way of people preventing forest fires and giving, in general, more importance to the protection of wild areas, relative to other economic activities.

It was also hypothesized that parataxonomists may increase the use values of wild areas by showing locals new uses of wild plants and animals. However, this premise was discarded quickly as it became clear that this flow of information operates the other way around. It turns out that locals have more knowledge about using wild plants and animals than do parataxonomists, and often teach them about these uses. This leads to the possibility that parataxonomists may develop a second role within their community as the repository of information about the local economic uses of biodiversity.

Following consultations with a sociologist it was decided to conduct two visits to local communities where parataxonomists live and work. This was done in a rather informal manner: chatting with people in the community, asking them if they knew about INBio, the Inventory and the parataxonomists work. Also, an effort was made to try and determine if parataxonomists had changed peoples' attitudes towards natural systems and protected areas

Table 10 Cost of Training Parataxonomists

	1989	1990	1991	Total
A. Effective Number of Parataxonomists Trained				
Number trained	15	15		30
Number dropping out	2	2		
Effective Number Trained	13	13		26
B. Financial Expenditures				
Total Cost				
Current Colones	6,356,328	15,791,754		
Cost per Trained Parataxonomist				
Current Colones	488,948	1,214,750		
Current US Dollars	5,993	13,194		
C. Economic Costs				
Annualized Economic Cost				
1989-90 Training Courses		6,163,661	6,163,661	
Present Value of Training Costs (given 5 year annuity)				
1989-90 Training Courses				23,365,123
Cost per Trained Parataxonomist				
1989-90 Training Courses				
1990 Colones				898,659
1990 US Dollars				9,761

Notes: The present value calculations assumes the annuity is paid at the end of the period

Box 5 Educational Activities of Parataxonomists

Activity	Percentage of Total Respondents Answering in the Affirmative
1. Talked to family about their work	90 percent
2. Talked to friends about their work	90 percent
3. Talked to tourists about their work	76 percent
4. Gave talks to their community	26 percent
5. Gave classes in school	26 percent

as a result of interacting with parataxonomists. The information generated was used to estimate qualitatively the economic benefits derived from the parataxonomists affecting behavior towards national parks and natural areas. This in no way constitutes a scientific survey. It is an attempt to take a first look at how parataxonomists and their work are viewed by the people in their communities and to examine the extent of the educational impact the parataxonomists are having on their communities.

Prior to carrying out the field visits, several questions were included in the parataxonomists' survey (referred to in the analysis of productivity benefits above) to obtain the parataxonomists own opinion about the manner in which they interact and educate people in their communities. Most parataxonomists have carried out at least informal education activities. Box 5 shows the percentage of the total parataxonomists interviewed (n=30) which said they had done the different activities. We can see that nearly all of them have talked to their family and friends about their work. Also, a significant percentage of them have interacted with tourists. Approximately a quarter of them have given talks to their communities and the same percentage to schools.

The effects of the informal interaction were not measured in the written survey, however, it is possible to intuitively suppose that it has a multiplier effect. Individuals would then talk to their friends and peers about conservation issues, the importance of protected areas and taxonomy.

When asked if there was interest about their jobs in the community 83 percent of the parataxonomists responded in the affirmative. Most respondents mentioned that people in general seem very interested about their job. Parataxonomists are often asked about their work and people have even joined them while they go out to collect specimens. Other examples of locals showing interest include farmers providing them with lodging and food, people visiting the biodiversity offices, requests for talks and presentations to schools and boy-scout groups and basing the biodiversity office in the town school. According to one respondent, people see their job as a way to provide income for locals and at the same time preserve forests.

Concerning changes in the communities" attitude towards protected areas resulting from the parataxonomist's work, 66 percent of parataxonomists indicated that they had observed such changes. For example, the parataxonomist working in Tortuguero mentions that since his community is dependent upon tourism they have learned to appreciate the enormous richness being preserved by forests and wild protected areas. Others make reference to all kinds of short stories and anecdotes regarding changes in their communities. Several of those stories talk about how people now respect and appreciate wildlife species that before were considered enemies, such as snakes, caterpillars and spiders. Having learned their ecological role and the benefits they provide to humans, the parataxonomists suggest that local people do not eliminate these species any more. Also, some respondents mentioned a reduction in hunting activities.

Regarding changes in the parataxonomist's own behavior toward protected areas, 70 percent of respondents mentioned that their own attitudes have changed as a result of their work as parataxonomists. However, many of those who said they did not change their attitudes were already interested in nature and biological issues (e.g. the first group of parataxonomists was made up of national park rangers).

The survey was kept very simple given time and money constraints. It was carried out in two different Conservation Areas, Arenal and Tempisque. After discussing possible sites for the interviews with INBio officials they suggested places where parataxonomist live and work in the community. Possible sites were Barra Honda, Tierras Morenas, La Vírgen and Rancho Quemado. Barra Honda and Tierras Morenas were selected. Tierras Morenas is a small town located near the northwestern shore of the Arenal Lake. Barra Honda is located in the southeastern section of the Nicoya Peninsula. Both towns have one parataxonomist.

Tierras Morenas was visited first. A very small town, of perhaps 750 people, its economy is based on agriculture, tourism and electricity generation. Tourism is starting to grow in importance to the other two activities and several hotels are being built or expanded. The area is starting to be known in other countries as a prime spot for windsurfing.

The first stop was at the grocery store. There the store owner and a customer were interviewed. Both of them knew about the local parataxonomist and her work as a parataxonomist. They knew details about her work, such as that she was collecting at night. Although they said the area would benefit from nature-related projects, such as those being developed by the Arenal Conservation Area, they did not think the parataxonomists work was very important. On the other hand the Director of the Education Center,[18] indicated that she thought the parataxonomist's work was very important and interesting from an educational perspective. She also mentioned that they had planned to build a small insect collection for the Center, and that she had been motivated by the parataxonomist's work to better appreciate natural areas. The Director and the janitor (who was also present during the interview) seem to be aware of the details of the work engaged in by the parataxonomist.

After visiting the Education Center, an informal interview was held with the husband of the school's principal and three other individuals. They were all aware of the work of the parataxonomist, in fact someone mentioned she had given a talk with videos to the community, and someone else said that everybody wanted to have a job like hers. They also knew details of her work, for example, that she was working at night.

[18]A nursery school for pre-school children run by the Ministry of Health.

Barra Honda, the second site, is a very small town with little in the way of economic activities except for some sugar cane, cattle and forestry. Even tourism did not seem to be important at all here. Only a very few people and businesses were found in this town.

The first visit was to a public "administered" phone[19]. The two persons who were there, the phone's administrator and a customer, both knew the parataxonomist and thought her work was important. They also said it helped them to better appreciate protected areas (specifically the Barra Honda National Park). Also, they said there is a change in attitudes towards hunters since she has made people familiar with, and aware of, the benefits provided by protected areas. However, they acknowledged that even if her work would change attitudes towards hunters, it was almost impossible to change a hunter's attitudes, because hunting was embedded in their culture.

The survey was continued at Barrio Cubillo, located at the entrance of Barra Honda National Park. In Barrio Cubillo a small restaurant and ecotourism project was visited. There a member of the local development association and the woman in charge of the restaurant at that time were interviewed. Both knew details about the work of the parataxonomist and thought it was very important. The man suggested that he would be interested in working as a parataxonomist. He considered her work to be very important and an example of how protected areas can be "used" sustainably.

Summarizing the visits to both sites, parataxonomists and their work are very well known in the communities in which they live. It was very surprising that every single person randomly interviewed knew about the existence of a parataxonomist in the community and the kind of work they were carrying out. Parataxonomists are considered by their peers as a tangible example of a sustainable use for protected wild areas. Their research activities makes local people realize that there are ways to benefit from protected areas without destroying them. As a result, the costs of damage to protected areas avoided by educating local people should be considered a spin-off economic benefit of this program.

During both visits no evidence was found of increased use of wild plants and animals as a result of parataxonomists working in those communities. None of the people interviewed seemed to think that the parataxonomist played a significant role in this fashion. This confirmed the observation made by the Biodiversity Office Coordinator that it is the other way around. Generally locals teach parataxonomists about the uses of wild plants and animals. This was not totally unexpected, since the parataxonomist's work does not actually involve learning about medicinal or other uses of biodiversity; they just collect and to some extent classify specimens.

This preliminary work indicates that over the longer term, the continued presence of parataxonomists is likely to have a significant impact on local people's attitudes towards biodiversity. These are benefits that are unlikely to be generated through an "expedition-based" approach to taxonomic work.

---

[19]This a non-automatic public phones administered by locals from their house or business.

The educational role of the parataxonomists is a topic worth pursuing in greater detail as a better understanding of the interactions between people and protected areas would greatly assist ongoing efforts in protected area planning. A proposal to this effect is included in Appendix B

Production Benefits of Generating Species Information.

As mentioned throughout this report, INBio's policy of finding sustainable and economic uses for biodiversity has led to the active pursuit of such novel uses for biodiversity by the Biodiversity Prospecting Division. The contract established by INBio with the British Technology Group (BTG) is an interesting example of the potential of such efforts to yield production benefits for local communities in and around protected areas. In addition, the contract illustrates the difficulties faced by developing countries over intellectual property issues.

DMDP is a demonstrated phloem mobile nematicide which can be derived from a plant that grows in Costa Rica.[20] BTG has filed to obtain a patent on the use of DMDP as a nematicide in the United States, Britain and other countries. Although DMDP can be synthesized artificially, the cost is very high, which has raised BTG's interest in finding a natural source of supply for the active ingredient. INBio was therefore a natural partner for BTG.

The partnership with BTG includes three main components: INBio's sale of an unspecified amount of pure active ingredient to BTG, BTG's granting of exclusive production and distribution rights within Costa Rica to INBio for the final product and a clause stipulating that licensees in other countries will seek to source the raw material for this product from Costa Rica.[21]

Only one small remaining population of Plant A exists in Costa Rica which raises concern about the danger of depleting the resource. This situation has encouraged INBio to explore the means of cultivating this species. This is the only option as the remaining population is too small to support continued exploitation.

If BTG is successful in getting licensees to produce and market the nematicide, there is a good chance that INBio will have the opportunity to engage in the actual production of the aforementioned species. In this regard it is not yet known how production would be developed - i.e. will it be produced by INBio, by local farmers, or private companies? INBio's may choose to work with local farmers living around protected areas. If this were the case, the potential exists for generating economic benefits for local communities that engage in production of the species. At this time no research into the economic feasibility

---

[20]At INBio's request the name of such plant is not mentioned in this report. It will be referred to as Plant A.

[21]For the raw material BTG paid INBio an initial fee of which 30 percent went to the National Park Service. INBio negotiated exclusive production and commercial development rights of the new product within Costa Rica as a substitute for a royalty arrangement.

of commercially producing Plant A has been carried out so it is not possible to speculate on the magnitude of these potential production benefits.

Nevertheless, the BTG agreement demonstrates that the existence of INBio may generate spin-off production benefits for Costa Rica. Whether or not these benefits accrue to small farmers or large firms is as of yet unclear. However, as with its other arrangements it might be advisable for INBio to set forth its own policy on how such matters will be handled in light of the objectives of the institution.

It is also worth mentioning that there are additional benefits derived from the development of a plant-based nematicide such as DMDP. In Costa Rica, for example, ecological damages from the use and abuse of agrochemicals, and especially nematicides are known to be quite high. DMDP has shown in tests to have a very low mammalian toxicity and no phytotoxicity. Therefore, its widespread commercial use may mean lower contamination levels and a healthier ecosystem.

One difficulty faced by INBio in its efforts to capture the value of this prospecting activity concerns the existing patent system in Costa Rica. Patent rights on agrochemicals are granted in Costa Rica for a duration of only a single year. Furthermore, patents on uses are not granted in Costa Rica. As a result INBio must be assured that it can produce at an absolute minimum cost, otherwise, competitors would quickly undermine the value of their exclusive right obtained from BTG. Thus, patent protection policy in Costa Rica will affect the Biodiversity Prospecting Division's decisions regarding the extent of its investment in developing new products. R&D expenditures are often difficult to recoup in a marketplace where the end product is easily copied and is not protected by intellectual property protection.

As with many other developing countries, Costa Rica is now under external pressure in international fora such as the GATT to adopt patent laws that are compatible with the standards set by OECD countries. Patent protection in OECD countries range from 16 to 20 years. The argument typically employed by developing countries to justify minimal intellectual property protection is that the country cannot afford to pay the high prices charged by companies (mostly OECD in origin) selling on-patent drugs, agrochemicals and other patented products. A country such as Costa Rica gains from the lack of patent protection, as generic products may be manufactured and sold without the need to cover the full costs of the intellectual property involved.

Subramanian (1991) formalizes the welfare effects of this argument by suggesting that low levels of intellectual property protection are a superior policy option when a developing country imports technology, protection in the country has no effect on global R&D levels and inventions developed abroad can be costlessly or cheaply imitated. In this case, the lack of protection allows the importing country cheap access to technology without affecting overall levels of R&D.

Moreover, Subramanian (1991) asserts that because there is already a wide discrepancy in the levels of protection offered by different countries it is not possible to level the criticism that if all countries behaved this way there would be no production of R&D. Considerable investment in R&D is already expended by companies in OECD countries. It would appear that the lack of patent protection in developing countries does not deter, for example, OECD-based pharmaceutical companies from investing in R&D.

However, this view takes a very narrow interpretation of the subject. Another viewpoint comes from examining the options open to developing countries seeking continued economic growth and a (more) favorable balance of payments. Runnals and Cosbey (1992) point out that in the new knowledge-based global economy, only those countries capable of generating knowledge-based value-added products will face improving terms of trade. Countries choosing to rely on exports of raw materials and commodities will be left with declining terms of trade. In addition, Hobbelink (1991) raises the specter of a future in which improved biotechnological applications developed by companies in the developed world will substitute for many of the cash crops currently grown by developing countries.

Clearly, countries such as Costa Rica face a difficult choice on the question of patent harmonization. One possibility is to enact enhanced levels of patent protection and accept the accompanying higher costs of patented technology in the hope of developing knowledge-based industries over the longer run. The other choice is to maintain the status quo. This involves remaining dependent on raw material and commodities exports or finding alternative means of encouraging the development of a local R&D sector.

From the perspective of a novel institution - such as INBio - that is actively attempting to develop a local R&D sector based on technologies that utilize biological materials - the former choice might seem preferable.

Prospecting for Biotic Samples: INBio - Merck & Co. Contract

The Biodiversity Prospecting Division's first agreement with a commercial organization - Merck & Co. was signed in September 1991. Over two years INBio is to receive $1,000,000 in exchange for an unspecified number of plant, insect and environmental samples. In addition, INBio will receive an unspecified royalty (percentage of net sales) on any marketable product that is produced from the Costa Rican samples. As part of the arrangement, Merck is also providing approximately $183,000 to be used for purchasing equipment to be used in developing processing facilities in Costa Rica (Sittenfeld pers. comm. 1993). Merck & Co. is providing INBio with the protocol for milling and extraction of samples. The milling is conducted at a laboratory based at INBio. The chemical extraction process is subcontracted to laboratories at the University of Costa Rica. Following termination of the contract, INBio and the University will be free to use the milling and extraction laboratories for their own purposes. The contract also specifies that INBio staff will receive training at Merck facilities in the US or any other research center selected by INBio.

Thus, the contract with Merck & Co. provides INBio with for four distinct benefits:

- payments for samples
- royalties
- physical capital formation or technology transfer
- human capital formation or training

It is important to recognize that the INBio - Merck & Co. contract involves not only financial benefits - the first two items - but the transfer of know-how both in the form of technology transfer and training. Based on collection and processing rates at other collecting institutions it is possible to suggest that it is likely that INBio will be supplying Merck with somewhere between 1,000-3,000 samples during the two years of the agreement. Using results from Aylward (1993) - and an estimate of 2,000 samples the expected present value of the contract royalties would be only $350,000. If the samples contribute to the development of a drug with sales in the top decile of all drugs the expected present value rises to $1.5 million. Thus, it is possible to argue that the benefits derived from the payment for samples and the physical and human capital benefits are just as important - if not more so due to their certainty - as any royalty payments that may be received.

Much public attention has centered on the INBio "experiment" in the area of chemical prospecting. This led to initial praise and criticism of the INBio experiment. While many conservationist laud INBio as a "pioneering institution in biodiversity management" (WRI 1992) some commentators have accused INBio of selling off the national patrimony to a multinational - Merck & Co. (Kloppenburg and Rodriguez 1992, Gershon 1992). Unfortunately, the latter claims were based on an initial misunderstanding of the INBio-Merck & Co. contract terms and an ideological objection to collaboration with multinationals. The key issues in this debate are the extent to which INBio has *exclusive access* to Costa Rican biodiversity and the extent to which its activities will contribute to conservation.

In large part, the exclusivity issue is a result of public confusion over the details of the INBio-Merck & Co. contract. The contract guarantees Merck & Co. two years of exclusive access to a limited number of samples provided to Merck by INBio. This stipulation merely implies that INBio will not circulate samples of the same species to other buyers of INBio's services. It does not mean that other collectors are excluded from collecting their own samples from Costa Rican wildlands. It would be incorrect, therefore, to insist that INBio has ever had a "monopoly" over collections from these Conservation Areas.

In a recent update of laws governing Costa Rican wildlife, the Costa Rican legislature reaffirmed the conditions under which interested parties may use collected biological material for scientific purposes (Asamblea Legislativa 1992).. Both foreigners and Costa Rican residents may apply for collection permits. A small fee for the permit in local currency is charged. The equivalent of $3 buys residents an annual permit, while non-resident foreigners pay $30 for a permit of six months in duration. A number of additional requirements are specified in the document:

- Collectors must present a plan indicating their plans for collection and research to the Wildlife Department.

- Copies of any publications generated by the research must be sent to the National Library or the Wildlife Department.

- Collectors must present certification of their institutional affiliation upon application for a permit. Foreigners are required to have such authorizations from their home country corroborated by officials of the local Costa Rican Consular Service.

- Collection from official protected areas requires a written permit from the institution administering the area, collection from private lands require the permission of those legally authorized to grant it.

- Export of specimens requires written permission from the Wildlife Department

- Collectors exporting specimens to foreign institutions must leave an identical sample with the relevant national collections.

The law confirms the fact that the Wildlife Department has administrative and legal control over access to Costa Rican biodiversity for scientific purposes. It also provides an indication of the types of information, requirements and procedures that are necessary for a country to maintain effective "control" over its biodiversity.

From a conservation standpoint, the "overhead" payment directly to the national parks is the "pioneering" element of the INBio-Merck & Co. deal from a conservation standpoint. Other suppliers of plant material do not ensure that a portion of the up-front payment for the plant samples is returned to conservation purposes. Laird (1993) observes that scientists in developing countries do receive initial benefits from the collaborative work they carry out *with their Northern counterparts. The benefits are, however, limited to funding for scientific* research and associated infrastructure. It is difficult, however, to sort out which of the benefits a Southern institution receives from a Northern partner are a direct result of a contract for collecting plant samples for chemical prospecting and which are benefits that would have occurred anyway as a result of purely "scientific" collaboration.

The INBio-Merck & Co. contract benefits Costa Rica conservation efforts in a number of ways. As part of the payment received by INBio in exchange for samples, the national parks of Costa Rica receive a 10 percent cut, $100,000 as an "overhead" payment towards the upkeep and maintenance of the Conservation Areas. Roughly, another 40 percent of the payment goes to support the inventory program. Of this 40 percent, approximately one-quarter is allocated towards funding INBio's parataxonomists - local inhabitants of the Conservation Areas who are trained in basic biology and collect biodiversity specimens for the national inventory. In this fashion, the chemical prospecting effort at Merck & Co. pays for access to biodiversity samples provided by the Conservation Areas and the information about biodiversity that is generated by INBio's inventory effort.

On 5 November 1992, INBio entered into a five year, legally-binding agreement with the Costa Rican Ministry of Natural Resources, Minerals and Energy (MIRENEM) which sets forth not only the general terms of MIRENEM - INBio cooperation, but the terms for the collection of specimens for scientific research (including chemical prospecting). The agreement formalizes a number of the practices regarding the transfer of benefits from INBio to the national parks that were first applied in the case of the INBio-Merck & Co. arrangement:

- INBio collectors will receive collection permits from MIRENEM. INBio will have to communicate its annual research program to the National Park system and the relevant protected areas.

- Sample collection will be carried out so as not to cause damage or alteration to local biodiversity.

- In the case of projects financed by commercial organizations, INBio is required to give a donation of no less than 10 percent of the total budget of the project to the national parks. INBio agrees to try and include a similar donation of 10 percent in its publicly funded research projects.

- INBio will donate 50 percent of any economic benefits gathered by INBio as a result of its research activities

In sum, the INBio-Merck & Co. arrangement provides a number of financial and economic benefits to Costa Rica. In addition, it provides an innovative example of how biodiversity prospecting can compensate the development of species information and biodiversity protection.[22] From the perspective of INBio and Costa Rica the arrangement is very rewarding. The interesting question that has yet to be addressed is what does Merck obtain in return? While the "goodwill" returns the arrangement has generated in terms of its positive impact on Merck's public relations should not be discounted - the contract with INBio was one of the motivating factors leading the US National Wildlife Federation to present its annual award to Merck in 1993 - it is unlikely that this was the motivating factor behind the collaboration.

Conversations with INBio and Merck employees as well as other industry sources suggest that Merck has a number of substantial reasons for undertaking this *scientific collaboration*. INBio and Costa Rica offer Merck a range of services:

- access to a national inventory - i.e. the ability to provide a diverse range of samples including insects

- reputable collecting and identification infrastructure

- ability to provide fresh samples - i.e. samples are refrigerated immediately upon collection

- ability to provide extracts

- ability to provide information on the status of species - i.e INBio would not supply threatened species which would prove difficult to resupply

- guaranteed access to protected areas due to the nature of INBio-MIRENEM relations - i.e. the ability to re-sample when needed

- political, economic and legal stability in Costa Rica

---

[22] *See* Aylward (1993) for a more detailed treatment of these issues.

- availability of a local Merck affiliate that could coordinate shipments and other logistics

Certainly some of these characteristics are more important than others. The question is why INBio and not another collector of biotic samples? And why would Merck be willing to pay far more than the natural products department budgets of other companies to obtain these services? Perhaps the most convincing answer is that Merck takes the exploration of the chemical potential of biodiversity seriously. Merck is probably more aware of the potential of biodiversity than most companies. Mevacor, a drug derived by Merck scientists from a microorganism sold over $1 billion in 1992. Success in the pharmaceutical industry increasingly depends on generating blockbuster drugs that revolutionize treatment in a particular therapeutic area - and biodiversity is a source of novel chemical compounds.

Ideally a company truly interested in prospecting for drugs using natural products would want access to as full a range of biodiversity as possible. They would want absolute confidence in the taxonomic classification of samples and the ability to return for additional material. In addition, they would want to preserve as much bioactivity as possible from the moment of collection by preserving, processing and transporting the sample with the utmost of care and the latest techniques. The company would also want to have as high a degree of confidence as possible that they would not be subject to any administrative, legal or political blockage to supply. They would also wish to avoid any recrimination of any kind from the country of collection. They would also want to be able to trust their collaborators to put it all together and deliver a superior product. Although many collectors can meet a number of these conditions it is quite likely that INBio is the only collecting institution that can *supply all of these.*

6. CONCLUSIONS

This paper has demonstrated the application of the tools of economic analysis to the activities underway at Costa Rica's National Biodiversity Institute. Like any other activity, INBio can be understood as an economic process involving value-added inputs and outputs. In this analysis of INBio a conventional environmental economics framework of costs and benefits is expanded to incorporate an analysis of activities directed towards the development of biodiversity information. The objective was to assist INBio in understanding the economic trade-offs involved in its operations and to assist donors and other developing countries to better understand the fundamental economic components that make INBio such an innovative institution.

Given the long-term nature of INBio's mission, it would be premature to pass judgement based on the results of an analysis of only the first few, formative years of INBio's experience. Nevertheless a number of important points emerge from this study:

- By the end of the 1990-91 period, the overall level of support given to the Inventory and Biodiversity Prospecting activities indicates that these two activities are well underway. The information management and dissemination function, has received tertiary priority after the Inventory and Biodiversity Prospecting, respectively.

- A detailed analysis of the cost-effectiveness of the collection and curation functions indicates that they are within a reasonable range of efficiency for such activities.

- Completion of the botanical inventory is a feasible short-run goal, while completion of the arthropod inventory within the ten-year estimate initially suggested by INBio is extremely unlikely.

- INBio provides a wide range of important benefits to Costa Rica from its efforts in developing species information, value-added biodiversity products, and human capital.

- The parataxonomist program makes an important contribution to the development of Costa Rican human capital and may also generate spin-off benefits in local communities through the diffusion of information about biodiversity.

- Prospecting activities may provide the opportunity for local communities to capitalize on production benefits from the development of new, sustainable uses of biodiversity.

- INBio's contract with Merck & Co. provides a pioneering example of how the use of biodiversity in prospecting can generate financial flows in support of biodiversity protection and the development of taxonomic knowledge.

Based on the analysis a number of recommendations regarding INBio policy can be made:

- Administration overheads should be revised to reflect actual overheads costs which are in the region of 20 percent.

- Further consideration needs to be given to the development of human or technological capital to assist in the classification of arthropod specimens.

- The development of a policy covering access by external users to information should consider the use of a charging system instead of a "gatekeeper" function.

The paper has also pointed to the dilemma faced by developing countries that wish to encourage institutions - such as INBio - to invest in knowledge-based research and development of biological resources yet maintain only minimal intellectual property protection

Finally, a number of actions can be taken by INBio to improve the accessibility and quality of the data required for economic analysis:

- improve day-to-day record-keeping regarding expenditures

- document funding flows between departments

- develop a link between the new accounting system and an economic cost model as developed in this report

- clearly establish the functional activities of each Division and specify the physical or monetary outputs of each activities

- develop record-keeping systems for tracking outputs over time

In this paper a cost model and a benefits framework are developed that could be re-deployed in the future to provide a more comprehensive economic evaluation of INBio. Improving the data needed for such an analysis would be an important component of such a future assessment. In the meantime, there are a number of specific research tasks that could be undertaken that would contribute to INBio's development and an understanding of the benefits that INBio is generating. Short proposals for these tasks are listed in the Appendices.

REFERENCES

Advisory Committee for Systematic Resources in Botany. 1979. "Systematic Botany Resources in America: Part II, the Costs of Services'. A Report to the Public and to the Botanical Systematics Community. NY: The New York Botanical Garden, Cary Arboretum Millbrook.

Asamblea Legislativa. 1992. "Ley de Conservacion de la Vida Silvestre: Informe Sobre la Redaccion Final del Texto Aprobado en Primer Debate." 14 October, San José, Costa Rica.

Aylward, B.A. 1993. *The Economic Value of Pharmaceutical Prospecting and its Role in Biodiversity Conservation.* LEEC Discussion Paper DP 93-05. London: International Institute for Environment and Development.

Aylward, B.A., Echeverria, J., Fendt, L and Barbier, E.B. 1993. 'The Economic Value of Species Information and its Role in Biodiversity Conservation: Case Studies of Costa Rica's National Biodiversity Institute and Pharmaceutical Prospecting,' A Report to the Swedish International Development Authority by the London Environmental Economics Centre and the Tropical Science Center in collaboration with the National Biodiversity Institute of Costa Rica, London, U.K.

Brown, G. 1993. Department of Economics, University of Washington. Personal Communication.

Daly, D. 1992. B.A. Krukoff Curator of Amazonian Botany, the New York Botanical Garden. Personal communication.

Erwin, T.L. 1992. "Stratification and distribution of Neotropical Forest Microhabitats and Associated Arthropod faunules: A Methodology Report." Abstract from Paper presented at the ATB Symposium, 10 August 1992, Honolulu.

Gamez, R. 1991. "Biodiversity Conservation Through Facilitation of its Sustainable Use: Costa Rica's National Bodiversity Institute." *TREE* 6(12): 377-8.

Gamez, R. 1993. Executive Director, INBio. Personal Communication.

Gershon, D. 1992. "If Biological Diversity has a Price, Who Sets it and Who Should Benefit?" *Nature* 359(15 October): 565.

Gittinger, J. 1982. *Economic Analysis of Agricultural Projects.* The Economic Development Institute of the World Bank, The John Hopkins University Press.

Hamel, B. 1993. Director of Botany, INBio. Personal communication.

Hanemann, W.M. 1989. "Information and the Concept of Option Value'. *Journal of Environmental Economics and Management*: 23-37.

Harlan, J. 1975. "Our Vanishing Genetic Resources'. *Science* 188 (9 May): 681-621.

Harvard Business School (HBS). 1992. *INBio/Merck Agreement: Pioneers in Sustainable Development.* NI-593-015. Boston: HBS.

Hobbelink, H. 1991. *Biotechnology and the Future of World Agriculture.* London: Zed Books Ltd.

Janzen, D.H. 1991. "Costa Rica's National Inventory: the Role of the Parataxonomist." Paper prepared for INBio-WRI Technical Workshop "Information for Decision Making: How Tropical Countries can Mobilise their Biotic Wealth', 20-22 June, San Jose, Costa Rica.

Janzen, D.H. 1993. Department of Biology, University of Pennsylvania. Personal communication.

Janzen, D.H. and Hallwachs, W. 1991. *Costa Rica's National Biodiversity Inventory: The Role of the Parataxonomists and the Experiences of the First Two Parataxonomist Training Courses, 1989 and 1990.* Report to USAID. San José: Instituto Nacional de Biodiversidad.

Kloppenburg, J. and Rodriguez, S. 1992. "Conservationists or Corsairs." *Seedling* 9 (2&3): 12-17.

Laarman, J.G. and Perdue, R. R. 1989. *Tropical Science and Tourism: The Case of OTS in Costa Rica.* Tourism Management.

Laird, S. 1993. "Contracts for Biodiversity Prospecting'. In W.V. Reid *et al.* (eds), *Biodiversity Prospecting*, Chapter IV, 99-130. Washington: WRI Publications.

Lewin, A., van Door, J., Flint, M. and Solórzano, R. 1992. *Biodiversity Conservation in Costa Rica.* An evaluation of the Guanacaste and INBio projects prepared for SIDA and MIRENEM.

Lucas, G 1992. Director, The Herbarium, Royal Botanical Gardens, Kew. Personal Communication.

Prance, G.T. 1993. Director, Royal Botanic Gardens, Kew. Personal communication.

Ray, A. 1990. *Cost-Benefit Analysis: Issues and Methodologies.* MD: The Johns Hopkins University Press.

Romer, P.M. 1990. "Endogenous Technological Change'. *Journal of Political Economy* 98(5): S71-102.

Runnalls, D. and Cosbey, A. 1992. *Trade and Sustainable Development: A Survey of the Issues and A New Research Agenda.* Manitoba: International Institute for Sustainable Development (IISD).

Samples, K.C., Dixon, J.A. and McGowen, M.M. 1986. "Information Disclosure and Endangered Species Valuation'. *Land Economics* 62(3): 306-312.

Sandlund, O. 1991. *Costa Rica's INBio: Towards Sustainable Use of Natural Biodiversity*. The Norwegian Institute for Nature Research.

Sittenfeld, A. 1992. "Tropical Medicinal Plant Conservation and Development Projects: The Case of the Costa Rican National Institute of Biodiversity'. Draft Paper prepared for Tropical Forest Medical Resources and The Conservation of Biodiversity, 24-25 January 1992, New York.

Sittenfeld, A. 1993. Director of Biodiversity Prospecting Division, INBio, Costa Rica. Personal communication.

Sohmer, S.H. 1992. Senior Biodiversity Advisor, Office of Forestry, Environment and Natural Resources, USAID. Personal communication.

Subramanian, A. 1991. "The International Economics of Intellectual Property Right Protection: A Welfare-Theoretic Trade Policy Analysis. *World Development* 19(8):945-956.

Tosi, J. 1993. President, Tropical Science Center, Costa Rica. Personal communication.

Umaña, A. and Brandon, K. 1992. "Inventing Institutions for Conservation: Lessons from Costa Rica'. In A. Sheldon *et al.* (contributors). *Poverty, Natural Resources and Public Policy in Central America*: 85-107. Washington DC: Overseas Development Council.

World Resource Institute (WRI). 1992. *Global Biodiversity Strategy*. Washington DC: WRI.

Appendix A Research Proposal - the Willingness to Pay for Biodiversity Information Services in Developing Countries: The Case of the National Biodiversity Institute of Costa Rica

This research project would examine the value of the information that is being generated by INBio. The argument is that by making information available to researchers, policy-makers, ecotourists and other potential users, INBio provides a valuable service to society. Potential users are not required to expend their own effort, resources and time generating or collect the data themselves.

Two approaches could be used to determine the value of the information. The first approach would be to determine how much the information is worth to the end user. This could be achieved by means of a contingent valuation survey of the willingness to pay for information. This would provide a direct measure of the economic value of this information. A second approach would rely on the use of the travel cost method to indirectly derive the demand for information services. This research would explore the use of these two approaches from both theoretical and practical standpoints and - in consultation with relevant INBio staff - choose and implement one of the methods.

This research would assist INBio in determining the likely level of user fees and their practicability. It would also demonstrate the economic value of the information services INBio is providing.

For further details contact Jaime Echeverría at the Tropical Science Center, Apdo. 8-3870, CP 1000, San José, Costa Rica. Tel (506) 34 25 39, fax (506) 53 49 63.

Appendix B Research Proposal - the Socio-Economics of Environmental Education: The Educational Role of INBIo's Parataxonomists in Local Communities

Although the educational role that parataxonomists play in their communities is explored in this paper, the analysis is necessarily superficial due to time and budget constraints. However, a detailed sociological and economic investigation of the parataxonomist's experience presents a very interesting opportunity to learn how local individuals working in research-related activities can modify attitudes towards protected areas. Sonia Cervantes, a sociologist and Research Associate at the Tropical Science Center (TSC), hypothesizes that in educating people about biodiversity parataxonomists are causing a chain effect in changing local communities attitudes and behavior vis-a-vis protected areas. Unfortunately, this effect could not be analyzed and quantified during the current study.

This proposal requests $29,500 to carry out a comprehensive survey in order to investigate and quantify the effect parataxonomists are having in their communities. This research will provide guidelines for policy makers interested in supporting and promoting scientific and environmental educational activities in developing countries.

For further details contact Jaime Echeverría at the Tropical Science Center, Apdo. 8-3870, CP 1000, San José, Costa Rica. Tel (506) 34 25 39, fax (506) 53 49 63.

DISCUSSION PAPERS

LEEC Discussion Papers examine a wide range of issues in environmental economics, including theoretical questions as well as applications, case studies and policy analysis. They are directed mainly at academics and researchers. Discussion Papers may be purchased for £3.50 each unless otherwise stated.

DP 88-01
September 1988
David W Pearce, Edward B Barbier and Anil Markandya
Environmental Economics and Decision Making in Sub-Saharan Africa

DP 88-02
October 1988
Edward B Barbier
Sustainable Agriculture and the Resource Poor: Policy Issues and Options

DP 88-03
November 1988
David W Pearce, Edward B Barbier and Anil Markandya
Sustainable Development and Cost Benefit Analysis

DP 89-01
January 1989
Edward B Barbier and Anil Markandya
The Conditions for Achieving Environmentally Sustainable Development

DP 89-02
February 1989
Nicholas Michael and David W Pearce
Cost Benefit Analysis and Land Reclamation: A Case Study

DP 89-03
March 1989
Douglas Southgate
Efficient Management of Biologically Diverse Tropical Forests

DP 89-04
May 1989
Timothy Swanson
International Regulation of the Ivory Trade (£4.00)

DP 89-05
June 1989
Edward B Barbier and Joanne C Burgess
Analysis of the Demand For Raw Ivory: Case Studies of Japan and Hong Kong

DP 89-06
June 1989
Scott Barrett
Deforestation, Biological Conservation, and the Optimal Provision of Wildlife Reserves

DP 89-07
July 1989
Scott Barrett
On The Overgrazing Problem

DP 89-08
July 1989
Scott Barrett
Optimal Soil Conservation and the Reform of Agricultural Pricing Policies

DP 89-09
October 1989
Douglas Southgate, Rodrigo Sierra and Lawrence Brown
The Causes of Tropical Deforestation in Ecuador: A Statistical Analysis

DP 89-11
November 1989
Charles Perrings, Alison Gilbert, David W Pearce and Anne Harrison
Natural Resource Accounts for Botswana: Environmental Accounting for a Natural Resource-Based Economy

DP 89-12
November 1989
Gardner Brown Jr. and Wes Henry
The Economic Value of Elephants

DP 89-13
December 1989
Charles Perrings
Industrial Growth, Rural Income and the Sustainability of Agriculture in the Dual Economy

DP 90-01 March 1990	R Kerry Turner and David W Pearce **The Ethical Foundations of Sustainable Economic Development**
DP 90-02 May 1990	Anil Markandya **Environmental Costs and Power Systems Planning**
DP 90-03 June 1990	Edward B Barbier **The Economics of Controlling Degradation: Rehabilitating Gum Arabic Systems in Sudan**
DP 90-04 October 1990	Charles Perrings **Stress, Shock and the Sustainability of Optimal Resource Utilization in a Stochastic Environment**
DP 90-05 October 1990	Edward B Barbier, Joanne C Burgess and David W Pearce **Slowing Global Warming: Options for Greenhouse Gas Substitution**
DP 90-06 November 1990	David W. Pearce **An Economic Approach to Saving the Tropical Forests**
DP 91-01 January 1991	Douglas Southgate **Tropical Deforestation and Agricultural Development in Latin America**
DP 91-02 April 1991	Edward B Barbier, William M Adams and Kevin Kimmage **Economic Valuation of Wetland Benefits: The Hadejia-Jama'are Floodplain, Nigeria**
DP 91-03 May 1991	Timothy Swanson **Wildlife Utilisation as an Instrument for Natural Habitat Conservation: A Survey of the Literature and of the Issues**
DP 91-04 June 1991	Gregor Büchner, Joanne C Burgess, Victoria C Drake, Tom Gameson and David Hanrahan **Gender, Environmental Degradation and Development: The Extent of the Problem**
DP 91-05 July 1991	Edward B Barbier **The Role of Smallholder Producer Prices in Land Degradation: The Case of Malawi**
DP 91-06 November 1991	Anil Markandya and Charles Perrings **Resource Accounting for Sustainable Development: A Review of Basic Concepts, Recent Debate and Future Needs**
DP 91-07 November 1991	Edward B Barbier **Environmental Management and Development in the South: Prerequisites for Sustainable Development**
DP 92 -01 June 1991	Edward B Barbier, Joanne C Burgess, Bruce A Aylward and Joshua Bishop **Timber Trade, Trade Policies and Environmental Degradation**
DP 92-02 June 1992	Joanne C Burgess **Impact of Wildlife Trade on Endangered Species**
DP 92-03 June 1992	Joanne C Burgess **Economic Analysis of the Causes of Tropical Deforestation**
DP 92-04 October 1992	Edward B Barbier **Valuing Environmental Functions: Tropical Wetlands**

DP 92-05 November 1992	Bruce A Aylward and Edward B Barbier **What is Biodiversity Worth to a Developing Country? Capturing the Pharmaceutical Value of Species Information**
DP 93-01 April 1993	Edward B Barbier, Joanne C Burgess, Nancy Bockstael and Ivar Strand **The Timber Trade and Tropical Deforestation in Indonesia**
DP 93-02 June 1993	Edward B Barbier **Policy Issues and Options Concerning Linkages Between the Tropical Timber Trade and Sustainable Forest Management**
DP 93-03 June 1993	John M Perez-Garcia and Bruce Lippke **Measuring the Impacts of Tropical Timber Supply Constraints, Tropical Timber Trade Constraints and Global Trade Liberalization**
DP 93-04 June 1993	David Brooks **Market Conditions for Tropical Timber**
DP 93-05 December 1993	Bruce A Aylward **The Economic Value of Pharmaceutical Prospecting and its Role in Biodiversity Conservation**
DP 93-06 December 1993	Bruce A Aylward, Jaime Echeverría, Liza Fendt and Edward B Barbier **The Economic Value of Species Information and its Role in Biodiversity Conservation: Costa Rica's National Biodiversity Institute**

GATEKEEPER SERIES

The LEEC Gatekeeper Series highlights key topics in the field of environmental and resource economics. Each paper reviews a selected issue of contemporary importance and draws preliminary conclusions of relevance to development activities. References are provided to important sources and background materials. The Swedish International Development Authority (SIDA) funds the series, which is aimed especially at the field staff, researchers and decision-makers of SIDA and other development agencies. All Gatekeepers are priced £2.50 unless otherwise stated.

GK 89-01 June 1989	David W Pearce **Sustainable Development: an Economic Perspective**
GK 89-02 August 1989	Edward B Barbier **The Economic Value of Ecosystems: 1 - Tropical Wetlands**
GK 89-03 October 1989	David W Pearce **The Polluter Pays Principle**
GK 89-04 November 1989	Joanne C Burgess **Economics of Controlling the Trade in Endangered Species: The African Elephant**
GK 90-01 March 1990	Edward B Barbier **Natural Resource Degradation Policy, Economics and Management**
GK 91-01 January 1991	Edward B Barbier **The Economic Value of Ecosystems: 2 - Tropical Forests**
GK 91-02 May 1991	Joshua Bishop, Bruce A Aylward and Edward B Barbier, **Guidelines for Applying Environmental Economics in Developing Countries**
GK 91-03 June 1991	Bruce A Aylward **The Economic Value of Ecosystems: 3 - Biological Diversity**
GK 91-04 May 1991	David W Pearce **Afforestation and the Greenhouse Effect: The Economics of Fixing Carbon by Growing Trees**
GK 92-01 March 1992	Joshua Bishop **Economic Analysis of Soil Degradation**
GK 92-02 September 1992	Edward B Barbier **The Nature of Economic Instruments: A Brief Overview**
GK 92-03 October 1992	James P G Spurgeon and Bruce A Aylward **The Economic Value of Ecosystems: 4 - Coral Reefs**
GK 92-04 December 1992	Douglas Southgate **The Rationality of Land Degradation in Latin America: Some Lessons from the Ecuadorian Andes**
GK 93-01 June 1993	Bruce A Aylward, Joshua Bishop and Edward B Barbier **Economic Efficiency, Rent Capture and Market Failure in Tropical Forest Management**

BOOKS

Edward B. Barbier
Economics, Natural-Resource Scarcity and Development: Conventional and Alternative Views, Earthscan, London, 1989 (paperback £17.50)

The history of environmental and resource economics is reviewed; then using insights from environmentalism, ecology and thermodynamics, Barbier begins the construction of a new economic approach to the use of natural resources, particularly to the problem of environmental degradation. With examples from the global greenhouse effect, Amazonian deforestation and upland degradation on Java, Barbier develops a major theoretical advance and shows how it can be applied. This book breaks new ground in the search for an economics of sustainable development.

David W. Pearce, Anil Markandya and Edward B. Barbier
Blueprint for a Green Economy, Earthscan, London, 1989 (paperback £8.95)

This book was initially prepared as a report to the Department of Environment, as part of the response by the government of the United Kingdom to the Brundtland Report, *Our Common Future*. The government stated that: '...the UK fully intends to continue building *on this approach (environmental improvement) and further to develop policies consistent with* the concept of sustainable development.' The book attempts to assist that process.

Edward B. Barbier, Joanne C. Burgess, Timothy M. Swanson and David W. Pearce
Elephants, Economics and Ivory, Earthscan, London, 1990 (paperback £10.95)

The dramatic decline in elephant numbers in most of Africa has been largely attributed to the illegal harvesting of ivory. The recent decision to ban all trade in ivory is intended to save the elephant. This book examines the ivory trade, its regulation and its implications for elephant management from an economic perspective. The authors' preferred option is for a very limited trade in ivory, designed to maintain the incentive for sustainable management in the southern African countries and to encourage other countries to follow suit.

Gordon R. Conway and Edward B. Barbier
After the Green Revolution: Sustainable Agriculture for Development, Earthscan Pub. Ltd., London, 1990 (paperback £10.95)

The Green Revolution has successfully improved agricultural productivity in many parts of the developing world. But these successes may be limited to specific favourable agro-ecological and economic conditions. This book discusses how more sustainable and equitable forms of agricultural development need to be promoted. The key is developing appropriate techniques and participatory approaches at the local level, advocating complementary policy reforms at the national level and working within the constraints imposed by the international economic system.

David W. Pearce, Edward B. Barbier and Anil Markandya
Sustainable Development: Economics and Environment in the Third World, London and Earthscan Pub. Ltd., London, 1990 (paperback £11.95)

The authors elaborate on the concept of sustainable development and illustrate how environmental economics can be applied to the developing world. Beginning with an overview of the concept of sustainable development, the authors indicate its implications for discounting and economic appraisal. Case studies on natural resource economics and management issues are drawn from Indonesia, Sudan, Botswana, Nepal and the Amazon.

David W. Pearce, Edward B. Barbier, Anil Markandya, Scott Barrett, R. Kerry Turner and Timothy M. Swanson
Blueprint 2: Greening the World Economy, Earthscan Pub. Ltd., London, 1991 (paperback £8.95)

Following the success of *Blueprint for a Green Economy*, LEEC has turned its attention to global environmental threats. The book reviews the role of economics in analyzing global resources such as climate, ozone and biodiversity, and considers economic policy options to address such problems as global climate change, ozone depletion and tropical deforestation.

E.B. Barbier and T.M Swanson (eds.)
Economics for the Wilds: Wildlife Wildlands, Diversity and Development, Earthscan Pub. Ltd., London, 1992 (paperback £12.95).

This collection of essays addresses the key issues of the economic role of natural habitat and wildlife utilization in development. The book argues that this role is significant, and composes such benefits as wildlife and wildland products, ecotourism, community-based wildlife development, environmental services and the conservation of biodiversity.

Copies of publications listed above may be obtained from the bookshop at IIED. Please use the order form below, and send to:

Marilyn John
Publications Department
IIED
3 Endsleigh Street
London WC1H 0DD, UK
Tel: 071-388 2117
Fax: 071-388 2826
Telex: 261681 EASCAN G

Please add £1.00 post and packing per publication. Orders over £20.00 in value will be sent post free **(UK only)**.

Overseas customers: please do **not** send payment with your order; you will receive a *pro forma* invoice once the cost of dispatching your order has been calculated.

Publications Department
IIED, 3 Endsleigh Street
London WC1H 0DD

PUBLICATIONS ORDER FORM

Name: ______________________________

Address: ______________________________

____

____

Reference/Title	**Price**	**Quantity**

Payment enclosed: £ ____________

The London Environmental Economics Centre (LEEC) is now known as the Environmental Economics Programme, at the International Institute for Environment and Development. The former name dates from 1987 when the Centre was established by IIED and the Economics Department of University College, London.

Today, all environmental economics staff and research projects are based at IIED where the Programme has become a core area of Institute activity.

The Environmental Economic Programme conducts economic research and policy analysis for improved management of natural resources and sustainable economic growth in the developing world.

iied

International Institute of Environment and Development
3 Endsleigh Street, London WC1H 0DD
Tel: 0171-388 2117 Fax: 0171-388 2826