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Costa Rica´s INBio: Towards sustainable use of natural biodiversity

Odd Terje Sandlund

NINA

NORSK INSTITUTT FOR NATURFORSKNING

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Abstract

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This report describes the efforts of Costa Rica to save its natural biodiversity and to use it sustainably for the benefit of society. The national effort includes two major elements: 1) Relatively large national parks organized in conservation areas with extensive autonomy aimed at integration into the local communities' economic and organizational structure. 2) INBio, the National Biodiversity Institute, which aims at creating a total inventory of Costa Rica's biodiversity within a ten year period, and to offer this information to the public in various ways. INBio's enormous task is performed through: 1) The parataxonomists: local personnel, who after receiving a basic training in field biology, systematically collect biological material in the national parks. 2) The apprentice curators: personnel with 3 - 5 years university education who receive on-the-job training in curational skills while collaborating with international taxonomists visiting INBio, thus becoming qualified to manage INBio's collections. 3) Totally computerized taxonomical and ecological information concerning the specimens in the collections. This makes the information easily accessible for any public use. 4) Active dissemination of information to the public, such as local organizations, schools at all levels, governmental nature management agencies, eco-tourism, international biotechnology industry, etc. The report discusses the Costa Rican model with a view to the general applicability of the various elements for biodiversity conservation work.

Key words: National parks, Conservation areas, Parataxonomists, Natural history collections, Biochemical prospecting, Eco-tourism.

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Referat

Sandlund, O.T. 1991. INBio - for bærekraftig utnyttelse av Costa Ricas biologiske mangfold. - NINA Notat 007: 1 - 25.

Notatet beskriver arbeidet som skjer i Costa Rica med sikte på å bevare, kartlegge og ta i bruk på en bærekraftig måte landets biologiske mangfold. Den nasjonale innsatsen består av to hovedelementer: 1) Et relativt stort areal i nasjonalparker som er organisert i regionale naturvernområder med utstrakt lokalt selvstyre. Dette tar sikte på å integrere nasjonalparkene i det lokale organisasjons- og næringsliv. 2) INBio, det nasjonale biodiversitetsinstitutt, hvis målsetning er å gjennomføre en fullstendig kartlegging av Costa Ricas biologiske mangfold i løpet av en ti års periode, og å tilby denne informasjonen til alle aktuelle brukere. INBios enorme oppgave gjennomføres ved: 1) Parataksonomene; lokalt personell som etter et kort kurs i feltbiologi arbeider med systematisk innsamling av biologisk materiale i nasjonalparkene. 2) Konservator-lærlinger; personell med 3 - 5 års biologisk utdannelse fra costaricansk universitet som gjennom samarbeid med internasjonale gjesteforskere i taksonomi ved INBio blir velutdannete konservatorer som kan ta ansvaret for INBios samlinger. 3) Fullstendig edb-basert lagring av all taksonomisk og økologisk informasjon om hvert eksemplar i samlingene gjør informasjonen lett tilgjengelig for bruk. 4) Aktiv utadrettet virksomhet, der informasjon om biodiversiteten spres til publikum, som f eks lokale organsiasjoner, skoler på alle trinn, offentlig naturforvaltning, øko-turismen, og internasjonal bioteknologisk industri. I notatet diskuteres i hvilken grad den costarikanske modellen kan ha generell anvendbarhet, både i andre utviklingsland og i Norge.

Resumen

Sandlund, O.T. 1991. INBio: Para el uso sustentable de la biodiversidad de Costa Rica. - NINA Notat 007: 1 - 25.

Este informe describe los esfuerzos de Costa Rica para inventar y proteger su biodiversidad natural y para utilizarla en una manera que pueda beneficiar a la sociedad. El esfuerzo nacional incluye dos elementos principales: 1) Parques nacionales relativamente extensos organizados en areas protegidas regionales con alto grado de autonomía, con fines de intergrarlos en la estructura local organizativa y económica. 2) INBio, el Instituto Nacional de Biodiversidad de Costa Rica, cuyos fines son la creación de un inventario completo de la biodiversidad costarricense en el curso de diez años, y el ofrecimiento de esta información a los usuarios.

Esta tarea muy desafiante se realizará atraves de:

1) Los parataxónomos; colectores locales que después de un curso básico de biología de campo realizarán la recolección sistematica de especímens e información de campo.

2) Aprendices conservadores. Personas con 3-5 años de educación universitaria que mediante estrecha colaboración con especialistas internacionales visitando el INBio se califican de conservadores responsables de la colección de INBio.

3) Información ecológica y taxonómica sobre todos los especímens será asequible al usuario a traves de una base de datos computerizado.

4) Divulgar activamente la información al público, el cual será por ejemplo las escuelas, colegios y universidades, las organizaciones locales, las agencias interesadas en la promoción del turismo naturalista, la indústria biotecnológica internacional y las agenicias gubernamentales engargadas de la planificación y uso de los recursos naturales.

El informe discuta cómo se pueda aplicar el modelo costarricense a otros países, tanto tropicales como Noruega, para conseguir una protección mejor de la biodiversidad global.

Preface

Conservation and sustainable use of biodiversity is a highly important problem in today's world. It is of particular relevance to management of natural resources in developing countries and to international development cooperation, which often face the apparent conflict between economic development and conservation of biodiversity.

The Royal Norwegian Ministry of Foreign Affairs granted economic support to the Norwegian Institute for Nature Research (NINA) to study Costa Rica's efforts to sustainably employ biodiversity in their economic development. This enabled me to stay in Costa Rica from mid-February to late March, 1991. During the five weeks stay, I was able to study INBio's central facilities in Santo Domingo de Heredia (San José), and discuss INBio's activities with director Rodrigo Gámez. I was also able to study the work of several parataxonomists in Guanacaste Conservation Area, while participating in a field course headed by professor Dan Janzen for a group of doctorate students from the University and the Forestry University of Umeå, Sweden.

I will express my gratitude to Rodrigo Gámez, Dan Janzen, Winifred Hallwachs, Petrona Rios Castro, Carlos Chavez and Calixto Moraga for providing the information which forms the basis for this report. I also want to thank my travel companion Bjørn Haavind of the Norwegian Broadcasting Corporation-TV for pleasant company and rewarding discussions. The Swedish students, and their leaders, professors Kjell Danell and Christian Otto, were very enthusiastic and inspiring company in the bush in Guanacaste. Director Karl Baadsvik, NINA, commented on a draft of the report.

Mari Lise Sjong translated the abstract into Spanish.

Trondheim, May 1991

Odd Terje Sandlund

Contents

1 Introduction

Natural biodiversity is threatened by human activities in all parts of the world. Yet the long-term existence of human societies depends on natural biodiversity.

The establishment of national parks has been the single most important step to save natural habitats and their biodiversity, both in developed and developing countries. In fact, many developing countries have impressive conserved areas. However, the conserved areas in developing countries will not be able to withstand the ever increasing pressure from the surrounding poor population if the parks do not provide obvious economic benefits to the population. The benefits should at least be comparable to the benefits expected by the disruption of the natural habitats, which occurs e.g. as a result of clearing of land for agriculture, deforestation, logging operations, and industrial and infrastructural development. The pressure on natural habitats caused by economic activities aimed at increasing food production and employment to accomodate the growing human population often seem most dramatic in developing countries, due to their serious poverty problems and high rates of population increase. Governments of poor countries may in many cases feel a strong obligation to choose short-term solutions to improve the population's standard of living. In poor rural societies, conserved wildlands may be the only land not occupied. As the question at stake for the individual farmer may be the survival of his family, encroachment on the conserved area through e.g. slash and burn agriculture cannot be avoided unless alternative income opportunities are created. Thus, in a long-term perspective, the conserved wildlands must be regarded as a social and economic asset for the local and national society if they are to be conserved at all in the long run.

In Costa Rica, Central America, action has been taken on local and national level to put the national parks and the biodiversity found in them to work for society in a sustainable way, i. e. to create economic opportunities and jobs based on the living resources without compromising the resources. The activities of the National Biodiversity Institute (INBio) appears to be a completely novel way of utilizing a country's biodiversity for economic development.

This report describes the activities of INBio, and analyses the various elements of this pioneer institution with a view to the applicability of the activities for biodiversity conservation work in other countries. The report is based on information and impressions gathered during the author's five-week visit to Costa Rica (San José and Guanacaste Conservation Area) in February-March 1991.

2 Costa Rica

2.1 The country

Costa Rica is a relatively small (51,000 km^2) Central American country straddling 10 °N latitude (Fig. 1). The population of approximately 3 million people are mainly of Spanish origin (97%), with some of African-/Jamaican (2.8%), and a few of Amerindian (0.2%), descent. The population density is relatively low in many parts of the country, as a large part of the population is concentrated in the central valley around the capital, San José. Population increase was very high (3.8%) in the early 1980's, but appears to be decreasing swiftly, the most recent figure given is 2.7%. However, nearly 50% of the population is below 20 years of age.

Costa Rica enjoys a stable parliamentary democracy in a region where military dictatorship and civil war is the rule. Since the late 1940's, the country has had no regular army. The average annual income is approximately equivalent to USD 2,100, and the population's literacy rate is nearly 100%.

The country's main export commodities are coffee, bananas, sugarcane, and beef. As a result of a plan to diversify the economy, the proportion of export earnings coming from coffee decreased from 42.4% in 1980 to 25% in 1989.

2.2 The natural environment

Central America bridges two continents. As a consequence of its geographic position, Costa Rica's flora and fauna contains elements from both the North and South American (Nearctic and Neotropical) biogeographic regions (Rich and Rich 1983). In addition, the climatic and topographic conditions of the country create a great variety of habitats. Costa Rica is roughly divided into a wet Atlantic and a seasonally dry Pacific side (Fig. 1). On the Atlantic side, the wet (rain) forests extend from sea level to altitudes of more than 3,000 m. On the Pacific side, high altitude humid cloud forests change gradually into a seasonally dry forest at lower altitudes (Coen 1983). The country's biogeographic position and the diversity of habitats are the main reason for the occurrence of an estimated 500,000 species of animals and plants in Costa Rica (Table 1); i.e. an extremely high biological diversity in a small area.

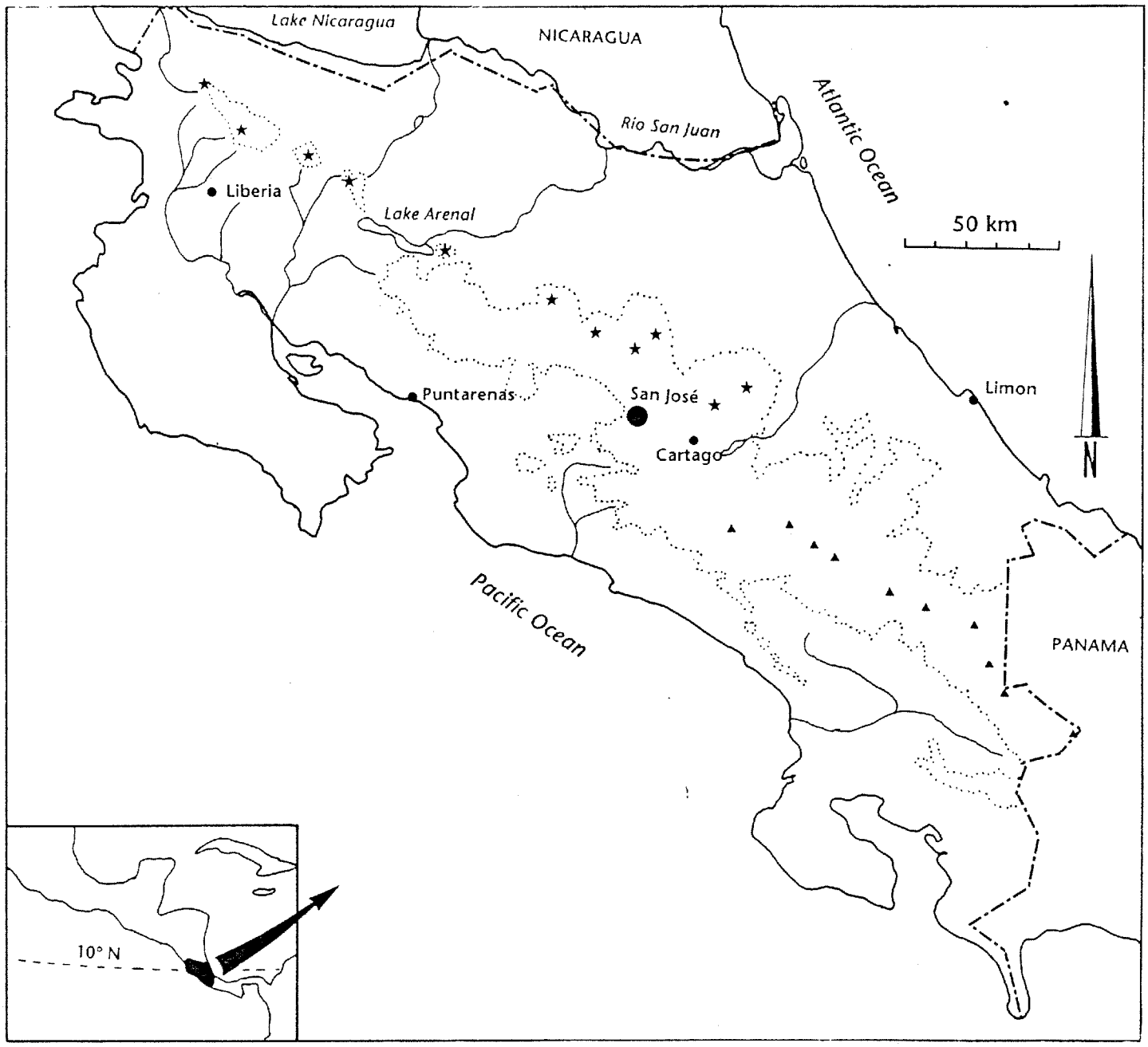

Fig. 1 Costa Rica, with major cities, volcanos (asterisks) and tectonic mountain peaks (triangles). The dotted line indicates the 1,000 m a.s.l. contour.

Table 1 Estimated number of species of organisms in Costa Rica. The figures were based on estimates from specialists in the various groups. From Janzen (1990).

Group	No. of species
Arthropods	365,000
Other invertebrates	85,000
Bacteria, viruses, etc.	35,000
Plants	10,000
Fungi	2,500
Vertebrates	1,500
Total	500,000

Biological and ecological research has been performed in Costa Rica for many years (review in Gomez and Savage 1983). Since 1963, the Organization for Tropical Studies (OTS), which is a cooperation between the University of Costa Rica and seven universities in the United States, has run courses in tropical ecology for students from the U.S. and elsewhere, and a number of Costa Rican and North American scientists have been doing research in Costa Rica. Due to this activity some parts of the fauna are fairly well known, e.g. some butterfly families (DeVries 1987), birds (Stiles et al. 1989), mammals (Eisenberg 1989, Emmons 1990), and freshwater fishes (Bussing 1987). However, less than 80% of the estimated 12,000 plant species, and 20% of the 365,000 arthropod species have been described (Janzen 1983, Lewin 1988, Janzen 1990, Tangley 1990).

2.3 Nature conservation

Costa Rica has protected approximately 27% of its area in national parks or similar conserved areas (Fig. 2). The national parks cover most of the habitat types in the country (Boza 1988). In recent years there has been some local conflicts between the conservation of land and the use of land for agriculture and forestry. It has therefore been realized that a long term conservation is dependent on the ability to create economic benefits for the local and national community from the conserved wildlands. The reorganization of the national park management and the establishment of the National Biodiversity Institute (Instituto Nacional de Biodiversidad de Costa Rica, INBio) are major elements in these efforts.

3 The concepts in biodiversity conservation

The efforts to conserve biodiversity through sustainable use include three necessary, but not individually sufficient, overlapping steps (Janzen 1991): 1) Save it, 2) Know what it is, and 3) Use it sustainably.

3.1 "Save it"

The "save it" step in conservation is obviously the first and most important to avoid the irreversible process of extinction of populations and species. Many tropical countries have made considerable efforts to save their natural biodiversity through establishing large parts of their areas (5 - 20%) as national parks or similar. This process has been costly, involving dedicated hard work from individuals, non-governmental organizations and governments, as well as large sums of money.

One important economic value of conserved natural ecosystems is related to the role of natural vegetation in water storage and continuous water flow in rivers, and the effects of conserved wildlands in e.g. erosion control, maintenance of game populations, and climate modification. These factors may be of vital importance to agriculture in the surrounding areas, but are rarely appreciated in economic terms. However, the tax money going into national park budgets may be considered indirect payment for these services.

The selection of areas for conservation has rarely been based on thorough research. The areas were usually selected because they were particularly pristine, or they were habitats for a variety of spectacular species of mammals or birds. However, a list of a dozen species of large mammals does give much information about the biodiversity of the area. In general, national parks of the tropics are banks containing largely unknown treasures of genetic resources.

3.2 "Know what it is"

To be able to sustainably use the biodiversity and genetic resources of the national parks for the benefit of the society, an inventory of the resources is crucial.

The present inventories of species in most tropical national parks are largely based on the individual interests of the scientists who happened to be working in the areas. Thus the species in some groups of organisms may be well known, whereas other groups are virtually unknown.

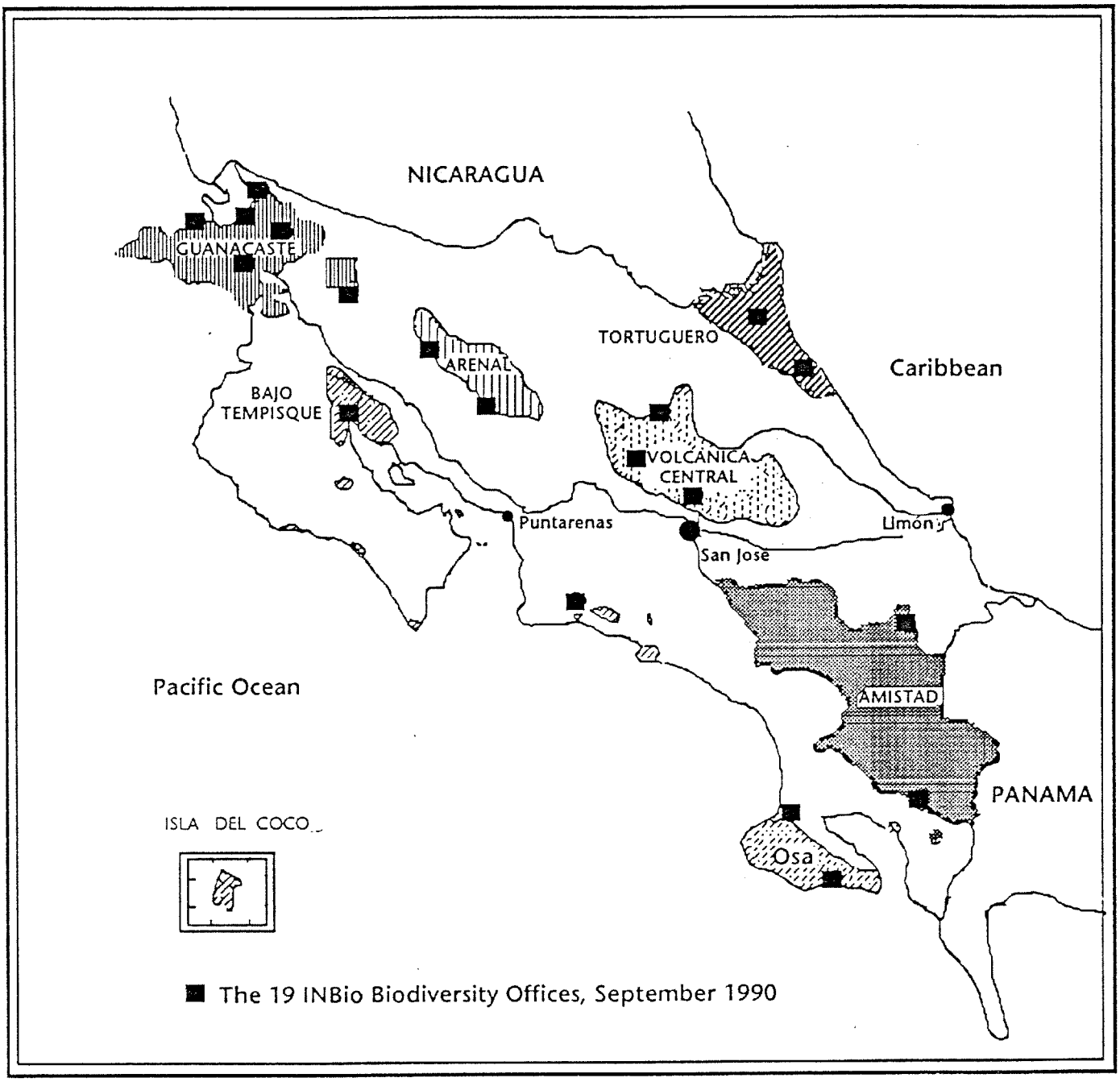

Fig. 2 Costa Rica's eight Conservation Areas (various shadings), and the 19 INBio Biodiversity Offices, September 1990. From Janzen (1991).

Traditionally, much of the collecting activities in the tropics were done by naturalists and scientists from abroad, who sent their material back to museums and collections in Europe or North America. Most tropical countries have possessed neither the institutions nor the resources to handle extensive collections of biological material. When these countries establish natural history collections, either as independent institutions or as parts of their universities, they have to look for scattered pieces of their natural history all over the industrialized world. To achieve a near complete biodiversity inventory, they also have to start an extensive collecting program.

The usual way of collecting biological material is based on the academically educated, specialized scientist going out to sample his or her group of organisms, ignoring most other parts of the ecosystem. Thus, a person working with beetles samples only beetles, perhaps broadening his view to take notes of what plants the beetles are eating. To obtain a complete inventory of the biodiversity of any tropical country in this way will be far too costly and time-consuming to be completed while we still have any wildlands left.

The model adopted by INBio to create a biodiversity inventory for Costa Rica is aimed at completing the main part of the job within a decade. In this model, the so-called "parataxonomists", plays a vital role. This is outlined in some detail in the following chapters.

3.3 "Use it sustainably"

The idea of a national park is to conserve the biodiversity of the area for the "eternal" future. This puts obvious restrictions on the potential economic use of this biodiversity. However, to secure the long-term existence of the national parks, the local population has to experience economic benefits from the conserved areas. Thus, to ensure long term conservation the national park management has to develop ways of using the natural biodiversity without destroying the natural ecosystems. For society to accept the costs of conserving wildlands, the products delivered from the national parks must be appreciated by the population.

The aim of INBio is to convey information from the biodiversity inventory to all parts of society. This includes not only information to students from kindergarten to university level, and to management employees, but also to commercial users. One condition is that the commercial users are willing to ensure that a portion of the profits returns to the management budgets for Cost Rica's conservation areas. These commercial users are many and diverse; natural products for industrial, medical and agrochemical use; genetic materials for biotechnology; natural history information for ecotourism programs; distributional information for company planners, etc.

4 The Costa Rican model for biodiversity conservation

During the last couple of years Costa Rica has taken several measures to ensure a long term existence of the ecosystems in its national parks through making their biodiversity resources useful and of economic value to local societies and the national economy. These measures include two main elements: 1) A reorganization of national parks into decentralized regional entities (Areas de Concervación, or Conservation areas) which are relatively independent and should be run in a way to ensure that the revenues created by the parks in the region benefit the local communities, by creating jobs and income opportunities. 2) The establishment of INBio addresses the task of creating a national inventory for the biodiversity of the conserved areas and establishes a framework for an organized trade with the biodiversity resources and the information hidden in this biodiversity.

4.1 Areas de Concervación (AC)

The national parks and reserves of Costa Rica have been reorganized into eight regional conservation areas (Fig. 2).

4.1.1 Administrative structure

The national park administration of the country used to be centralized, with one director for each park, living in San José. The park rangers had unspecified guard jobs, and they were not allowed to live with their families within the park areas. This structure lacked both local identification and motivation, and cooperation between local communities and park administrations.

Under the present structure, each AC has its own budget, and its own management structure, from director down, living within the AC. The AC-administration is responsible to a Regional Committee, which approves the annual activity plan developed by the director. The members of the regional committee are prominent persons from the region's political institutions, non-governmental organizations, and private businesses. Above the regional committees, on the national level, is a National Committee, consisting of 13 representatives from Ministries, Universities, and other institutions, like INBio. The various ACs have a high degree of autonomy.

The administration of the AC covers two main sectors: 1) education and research, and 2) physical operations. Compared to the old structure, the staff has been reorganized and have received on-the-job training, to become specialists in their jobs; they are fire guards, drivers, maintenance personnel, servicing school classes, etc. All employees live within the area, according to the principle that the employees at all levels should identify themselves with their conservation area. They should know the local neighbouring communities, and experience the region's problems.

4.1.2 Economy

The annual budget of Costa Rica's national parks has increased from 1.25 million USD to 8 million USD. The governmental contribution is still approximately 1.25 million USD, and the increase is made up by foreign aid, the donors being governments as well as non-governmental organizations (NGOs). The money has so far been used for infrastructure development (roads, houses, information signs, etc.), creation of endowment funds, planning of future income opportunities, and to purchase land to expand the parks.

The largest possible portion of the running costs of the conservation areas should be used in the AC's "area of influence" to boost economic activities. The money spent in the surrounding area of influence by tourists, researchers, and other visitors to the national parks are also of great importance for the population's attitude towards the conserved wildlands.

Among the obvious means of income for the ACs are ecotourism and scientific research. For example: all visitors entering the parks by road have to pay an admission fee, and 5% of the project budget for any research project within a park is charged as a fee to the park. To encourage national and international research, several research stations and other infrastructure are being built within the conservation areas.

In several of the established ACs, the conserved areas have been enlarged through aquisition of new lands. This process is as far as possible based on ecological knowledge. The conserved areas should be large enough and contain the habitats necessary to ensure the survival of the complete ecosystems (Janzen 1986). In many cases, the land aquired to enlarge the parks were farmlands, where the intention is to regenerate natural forest. The cultivated land usually has people living on it. With the present structure in Costa Rica, the land owners are often living in San José or other towns, while the people living on the land are employed farm workers or squatters (people with no legal right to live on that land). As far as possible, people living on the land aquired for the national parks has been offered jobs in the AC administration, but some

local conflicts will inevitably result from changes in land use.

The principle that AC staff are living within the AC also involve problems. Whereas a few months stay in the field may seem exiting to an international scientist, permanent residence for families with children may be a serious problem. This can be compensated by better salaries, housing, schools, health care, etc. Continued training of staff in the technical and philosophical aspects of their job, and intellectual opportunities for families are also important in the welfare of resident staff. The permanent residence of employees and their families involves stress on the ecosystem, in the form of e.g. collection of firewood, diversion of streams for drinking water, waste water disposal, areas cleared to raise livestock, noisy generators running, etc. The practices and behaviour of the people have to be adapted to living in a conserved area. This is best attained by teaching staff and families about the effects of various behaviour on the ecosystem (Janzen 1991).

AC Guanacaste in the northern part of Costa Rica is so far one of the best developed conservation areas (Janzen 1986, 1991). The organizational changes are, however, quite recent, and the new structure and the development of conservation areas are still subject to some discussion within Costa Rica. In particular, some doubt has been raised about the role of private donors in this development (e.g. Cheney 1991). The variation in the economy of the ACs, which is a result of the high degree of autonomy, is also discussed.

4.2 Instituto Nacional de Biodiversidad de Costa Rica (INBio)

4.2.1 Objectives

INBio is a non-profit, public-interest organization, established to understand Costa Rica's biodiversity and to help society use it in a sustainable way. According to INBio's own information pamphlet "Understanding comes about through finding out what it is and finding out what we and the world already know about these species. Use comes about by disseminating this information to the many potential kinds of users".

The INBio Planning Commission was established through a Presidential Executive Decree on 5 June 1989, and the INBio Association was legally registered on 26 October 1989. INBio is governed by an Assembly of Founders and a Board of Directors (Appendix 1). The composition of these bodies reflects the involvement of large sectors of Costa Rican society in this work (Appendix 2). There are economists, lawyers, educators and journalists, as well as chemists, botanists and ecologists, representing e.g. universities, media, ministries and banks.

4.2.2 Mapping biodiversity

The first and foremost goal of INBio is to create a relatively complete inventory of Costa Rica's biodiversity within a decade, before the year 2000 (Janzen 1990). Considering the enormous biodiversity of the country, this appears to be beyond the reach of any society, and indeed beyond the reach of a poor country like Costa Rica. The element in the INBio activities that seems to make this goal realistic is that a large part of the work is to be conducted by a small army of parataxonomists trained for the task, working in very close collaboration with national and international curators and taxonomists (Hoagland 1990).

4.2.3 The parataxonomist

The parataxonomists were selected among park employees, and through a process where village teachers and others were involved in finding the right persons among people living in the vicinity of the parks. Two groups have been receiving the basic 6 month course (in 1989 and 1990), and of the 31 persons trained so far, only two have dropped out. The people selected were between 14 and 45 years of age, and had from six years in primary school to one year at the University. The majority were between 25 and 35 years, and had finished high school. The basic training includes collection and preparation of biological samples, some basic taxonomy, and some basic park administration. The course includes approximately equal parts of theory and field work.

The parataxonomists are stationed at 19 Biodiversity Offices located in a network over the country's conserved wildlands (Fig. 2). At present some of the parataxonomists are working alone, but the goal is two persons at each Biodiversity Office. They are collecting plants, arthropods and small vertebrates. Working 24 days per month, they spend 17 days in the field, and seven days at INBio, reviewing their own material together with a taxonomist. This means continuous on-the-job training, and feedback as to which taxonomic groups to give priority. Every second month all parataxonomists meet to discuss their experiences and problems.

The parataxonomist earn approximately USD 350 per month. Staying at e.g. field stations they pay approximately USD 1.5 per day for lodging and food. This salary is well above salaries obtained by people with

similar educational levels, but the parataxonomist's working conditions are quite difficult, and quite a high level. of dedication is needed. Parataxonomists interviewed by the author expressed great satisfaction with their job, which they found interesting and important. On their own initiative, some parataxonomists have started a cooperation with the local primary schools. Classes are taken out into the field and taught some of the basic ecology of their home area. The response to this has been extremely positive among the children and in the local communities.

4.2.4 The apprentice curators

The collected specimens and accompanying field data flow to the central INBio office (Fig. 3). While concentrating on insects, a parataxonomist may collect, conserve and mount at least 200 specimens per day. Working in the field nearly 20 days per month, 30 parataxonomists will during one year produce approximately 1.3 million mounted insects for the INBio collections. When this effort is invested in a systematic way, the collections may quickly include all species, except, possibly, some extremely rare ones.

At INBio the samples are sorted to order, family and genus by apprentice curators. The apprentice curator in many ways represents a new profession. They are mainly university graduates with a 3 - 5 year degree in biology from a Costa Rican university. The apprentice curator receives on the job training in basic curational skills and uses of taxonomy, gradually developing qualifications to do the job expected of a Ph.D. taxonomist. The term apprentice curator is used because the idea is to apprentice him or her to a practicing Ph.D. taxonomist (local or international), spending time at INBio. The apprentice curator eventually becomes a well qualified curator, educated in a job environment where the main goal is not to create an academic natural history museum, but to put biodiversity to use for society. This means that elements like writing natural history handbooks and guides for ecotourists, and evaluating the potential value of plants or animals for biochemical prospecting become very important.

International taxonomists are invited to stay at INBio for several months per year to work on their particular taxonomic group of interest, together with the apprentice curator. Several U.S. and British institutions have funded such work during recent years.

4.2.5 The biodiversity collections

At the INBio depot, the collected samples are registered in the National Biodiversity Collections and the National Biodiversity Database. Each sample is given an INBio registation number and labelled with a bar code for quick and easy reference to the database information. Eventually, all information on the identities, geographic distribution, natural history, and uses of Costa Rica's organisms will accumulate in the database (see Appendix 3 for an example). INBio's collections may in fact be one of the first natural history collections in the world to be fully computerized.

From the database, the information is available for the National Dissemination and Extension Service, which will distribute information to users in appropriate formats (Appendix 4). INBio staff will also take part in evaluation of research and exploitation permit requests, commenting on commercial development of biodiversity, and guiding workshops etc. in biodiversity management.

4.2.6 Sustainable use of biodiversity

INBio is working along several lines towards the aim of putting biodiversity to use for society. Among the economically valuable "products" from the national parks are on-site use of the natural ecosystem, in terms of e.g. eco-tourism, biology education for all school levels, field research, and harvest of berries, fruits, and nuts. These activities may involve light to heavy human impact, and due consideration must be given to the stress on the ecosystem.

Eco-tourism is a quickly growing business in Costa Rica as well as other tropical countries. The business earns foreign currency, and in addition to the service jobs necessary in all tourist businesses, eco-tourism depends on guides well versed in the natural history of the area. In fact, INBio harbours some fear that, eventually, some of their parataxonomists will learn English and be "bought up" as guides by the eco-tourism industry. One precondition for marketing eco-tourism in any particular area is the inventory of the local biodiversity which forms the basis for printed information (handbooks etc.) as well as the knowledge of the guides.

Biochemical prospecting. The biodiversity itself is probably the economically most valuable asset of conserved tropical wildlands (Oldfield 1989). For example, the genes of the very high number of species produce innumerable chemical compounds, antibiotics, poisons, enzymes etc., which may solve many of humanity's health problems. In this context any

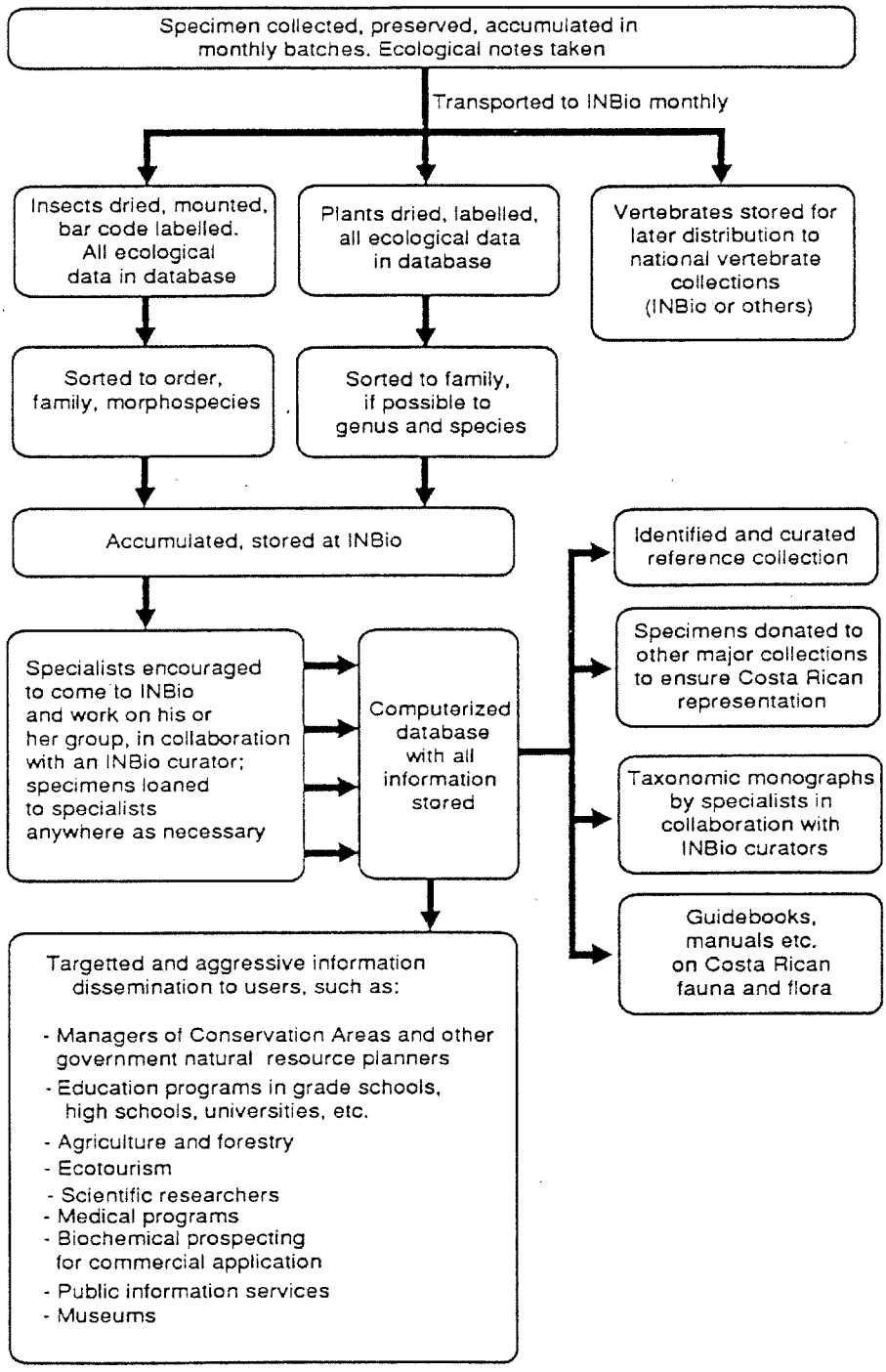

Fig. 3 The flow of collected biodiversity material from field to public use. Redrawn and somewhat simplified from Janzen (1991).

biological species, no matter how inconspicuous, may provide the substances we are looking for. The wild relatives of domesticated plants are indispensable elements in the further development of crop plants. Among the unknown plants of tropical forests may benew plants suited for domestication. Thus, the natural ecosystems are the raw material stores of the pharmaceutical, gene technology, and the agroindustrial companies of the world.

Trading with biodiversity. To provide the economy to conserve this wild gene store, the rich part of the world must accept that the biological resources in any national park belongs to the country in question, and cannot be freely used by anyone. This principle is accepted when it comes to mineral resources; the oil on the Norwegian continental shelf belongs to Norway, the copper in Zambian mines belongs to Zambia. However, most tropical countries lack the infrastructure and the know-how to manage the biological resources in a systematic way.

INBio has posed itself as a competent counterpart for international industry (Table 2), and is currently about to sign the first agreement with a multinational company to furnish biological samples for biochemical screening. This activity will be based on collaboration with university and other research institutes in Costa Rica and abroad (see Appendix 5). First of all, the industrial companies in question will have to pay for INBio's services, and eventually share the profits from any marketed product with INBio. Thus the industrial exploitation of the biodiversity information found in Costa Rican wildlands will help pay for the conservation of these wildlands. The long term objective is also to transfer as much as possible of the product development and production to Costa Rica. The multinational companies may reduce their expenses substantially by moving these activities to low cost countries.

Table 2. INBio's assets as a collaborator for industry.

Organization	Absolute reliability and dependable re-supply for blind sampling or ecology-driven search of novel and otherwise inaccessible tropical biological sources.
Ecology-driven search	Easily available, computerized ecological information. Direction of search guided by commercial partner interests.
Fully legal, private and politically autonomous	With the blessing of the government in a stable country. Tax-free and non-profit.
Strong links to the biological chemistry academic research community	Training, screening and isolation can occur in Costa Rica and internationally through the INBio-SIDR-Cornell consortium and other links.
Major visibility and respectability in the environmental movement	National and international.

Ecological screening. As information on biodiversity and the ecology of the organisms accumulates at INBio, ecologically directed screening for biologically active substances will be feasible. This may be illustrated by the following hypothetical example: in a medical or industrial process an enzyme is needed to degrade a particular type of substance X. The same type of substance has been found in the leaves of a plant species A collected by INBio. These leaves are poisonous to most animals, but INBio's data entry on the plant species A says that an insect larvae of species B feeds on these leaves. Thus INBio collect insect larvae B and their guts are analyzed for enzymes that may be able to degrade substance X. Once the correct type of enzyme is isolated from biological material, it may easily be produced in biological cultures or synthezised. However, the first step in identification has been made much simpler through taxonomic and ecological information.

Economy. The costs of the INBio project's two first years (1989 and 1990) have amounted to a total of USD 5.8 million. Among the contributors were various US sources, the Swedish government (SIDA), and Costa Rica's National Bank through an international debt swap operation (cf. Repetto and van Bolhuis 1989, Page 1990, Janzen 1990). Annual operation costs from 1991 onwards will be approximately USD 3 million, whereas an additional USD 2 million will be used to create an endowment fund.

Thus, the total cost for the ten years needed to create a complete inventory of Costa Rican biodiversity, will be approximately USD 50 million (Janzen 1991).

As of February 1991, 22 full time and 11 adjunct, staff members were working at INBio's central office (collections, database, and administration), in addition to 29 parataxonomists located at 19 biodiversity offices around the country (Fig. 2).

5 The applicability of the Costa Rican biodiversity conservation model

The Costa Rican approach to biodiversity conservation must be considered a pioneer effort. To my knowledge, no similar integrated national effort to ensure a long-term conservation of natural biodiversity through sustainable use has been tried anywhere in the world. The concept is highly evocative, and has already caught the interest of many countries such as Mexico, Chile, Taiwan, etc., who consider establishing institutions similar to INBio. The Costa Rican model for biodiversity conservation is composed of several elements which together or separately may be relevant for biodiversity conservation work in other parts of the world. Below, the main elements of the Costa Rican model are discussed.

5.1 The "autonomous" conservation area concept

There are several aspects of the conservation area/national park as an economically and administratively autonomous unit. The aspect which implies a close collaboration with local communities, e.g. so that the local population will benefit from the economic activities related to the park, appears to be a general precondition for the long-term conservation of conserved wildlands in any poor country (NINA 1990). Without this collaboration to ensure that the local communities consider the national park an asset, the conserved areas will sooner or later be turned into pastures or cultivated land.

The model for ensuring this collaboration, however, will probably have to vary from country to country, and even from case to case. What is the best solution will depend on factors like the relations between central and local communities, the political structures, the legislation, the national economy, the potential of the park in relation to tourists and other sources of income, etc.

5.2 The national biodiversity inventory concept

Creating a complete national biodiversity inventory is an ambitious aim under all circumstances, and the fact that such a project has been started by a poor country like Costa Rica is really astounding. It may well be said that creating such an inventory should be given first priority in any nation's policy for environmental conservation. The national biodiversity inventory is the only means of knowing what we have and what various policies, concerning e.g. land use, may cause us to lose. The present day debate about the effects of various models for forest conservation in Norway is one good example to demonstrate how we miss a national biodiversity inventory. Another important point is that any serious long-term marketing of biodiversity for biochemical screening depends on steadily increasing knowledge on the biodiversity and the ecological relationships in the natural ecosystems.

5.3 The parataxonomist

One important part of the Costa Rican model is the parataxonomists. After less than two years at work, this new profession has proven to be indispensable if biodiversity inventories are to be completed within the foreseeable future.

Among the reasons for success which also may apply under different conditions are:

- The students attending the parataxonomist courses were selected among local people familiar with their future working areas, and the selection was based on merit and interest, not on family ties or economy.
- The parataxonomists get a concentrated and targetted education within the country, and within their future working areas. This means a relatively cheap education, and the candidates are not pulled away socially or emotionally from their home areas.

Ordinary education in biology at almost any level includes a stay of several years in the capital or some other large city, or even abroad. In addition to being expensive, this often alienate the students from their rural background, and they often prefer living in the capital or even abroad after graduation. This is probably an even greater problem in developing than in industrialized countries, where the trend, at least among some educated groups, is in favour of living in the countryside. It may also be said that studying in an industrialized country in the temperate zone does not teach the student from a poor tropical country the kind of ecology he or she needs to do a good job at home.

- The continued training in the form of more specialized courses, monthly review of the parataxonomists' collected material, and the bimonthly parataxonomist meetings, provide a good opportunity for professional improvement and personal development for the parataxonomists. Their relatively frequent contact with Costa Rican

- and international scientists also probably contributes to their personal satisfaction in the job.
- The parataxonomists get a relatively good salary according to their level of education (measured in years at school). This is partly a compensation for their relatively uncomfortable working conditions, and acknowledges the fact that professionals in a developing country normally would prefer an urban life.

In relation to other developing countries, Costa Rica's population is well educated, with a literacy rate at nearly 100%. Consequently, all national park employees and most people in the communities close to the national parks will be potentially able to join a parataxonomist course. Thus, a reasonably large group of people will be available for selection based on merit, motivation and interest. In countries with high illiteracy rates, this will reduce the number of people available for the selection of candidates.

The rural populations of many developing countries are, on the other hand, living in cultures with a more profound knowledge about the nature around them than is the case in Costa Rica. A near-perfect solution would be a locally adapted parataxonomist education combining the traditional biodiversity knowledge of the local culture with a scientific approach to systematic collection of biological material.

5.4 The apprentice curator

The model for on-the-job training of the apprentice curator does not differ much from the training received by many post-graduates working on e.g. scholarships in natural history collections in the industrialized countries. For this model to work in Costa Rica, however, a steady supply of international taxonomists staying at INBio for longer periods of time is needed. Considering Costa Rica's tradition as a country of education and research for US ecologists, this will probably not pose any major problem. In other developing countries, however, the lack of similar traditions and a reputation for difficult working conditions may make a similar model less feasible, as fewer expert taxonomists may be willing to come.

5.5 The eco-tourism

Some form of eco-tourism is probably the main justification for maintaining the conserved wildlands in many developing countries, as e.g. the "safari"-tourists of East Africa have provided substantial amounts of foreign currency to their host countries. The programmes and facilities for eco-tourists may certainly be further developed in many tropical countries, to attract wider audiences. The combination of conservation and tourism will always be a delicate balance. The economy (and consequently the political viability) of a park demands more visitors spending more money, whereas the ecosystems the park was set up to protect may be seriously disturbed or even destroyed by the flow of people.

Proper planning and control of tourist activities may reduce the negative ecological effects of a steady flow of visitors. However, the most important point about eco-tourism in this context is how to create schemes which allow the local communities to benefit directly from the tourist industry. This point is realized in the national park administrations in many countries, and the models chosen must be adapted to local conditions (e.g. Kiss 1990, p. 41 - 114).

5.6 The marketing of biotechnology opportunities

This is an extremely important aspect in the process of giving natural biodiversity an economical value, which is necessary to ensure long-term conservation in poor countries. To be able to market wildland biodiversity for e.g. biochemical screening in a serious way, a proper organization must exist in the developing country. This field of exploitation of the poor countries' resources still seems to lack proper rules of conduct, cf. the debate over who "owns" biodiversity (Fowler 1991), and in a world of potential quick profits the poor country will nearly always be the loser. The experiences made by INBio in this field will pave the road for others, and hopefully make it simpler for other developing countries to utilize their biodiversity resources in a beneficial way.

6 Conclusions

Costa Rica's national plan for long-term biodiversity conservation has several unique pioneer aspects, which after only two years' activity have proven to be worth adopting by other countries.

The bold plan of creating a national biodiversity inventory as a necessary basis for sustainable use of the biodiversity information should in principle be repeated by all countries. If the goals of the "Brundtland report" about saving natural biodiversity (WCED 1987, pp. 147 - 167) are taken seriously, planning for this should start immediately, on national or regional levels. The only economically possible way to get the job done in most countries is probably to adapt the parataxonomist profession to the local cultural and educational levels.

The various ways of selling biodiversity information are necessary alternatives to deforestation and other forms of degradation of the natural ecosystems in the name of economical development. The models adopted by Costa Rica appear promising, but additional ideas will certainly appear once the information has been collected and stored in accessible databases.

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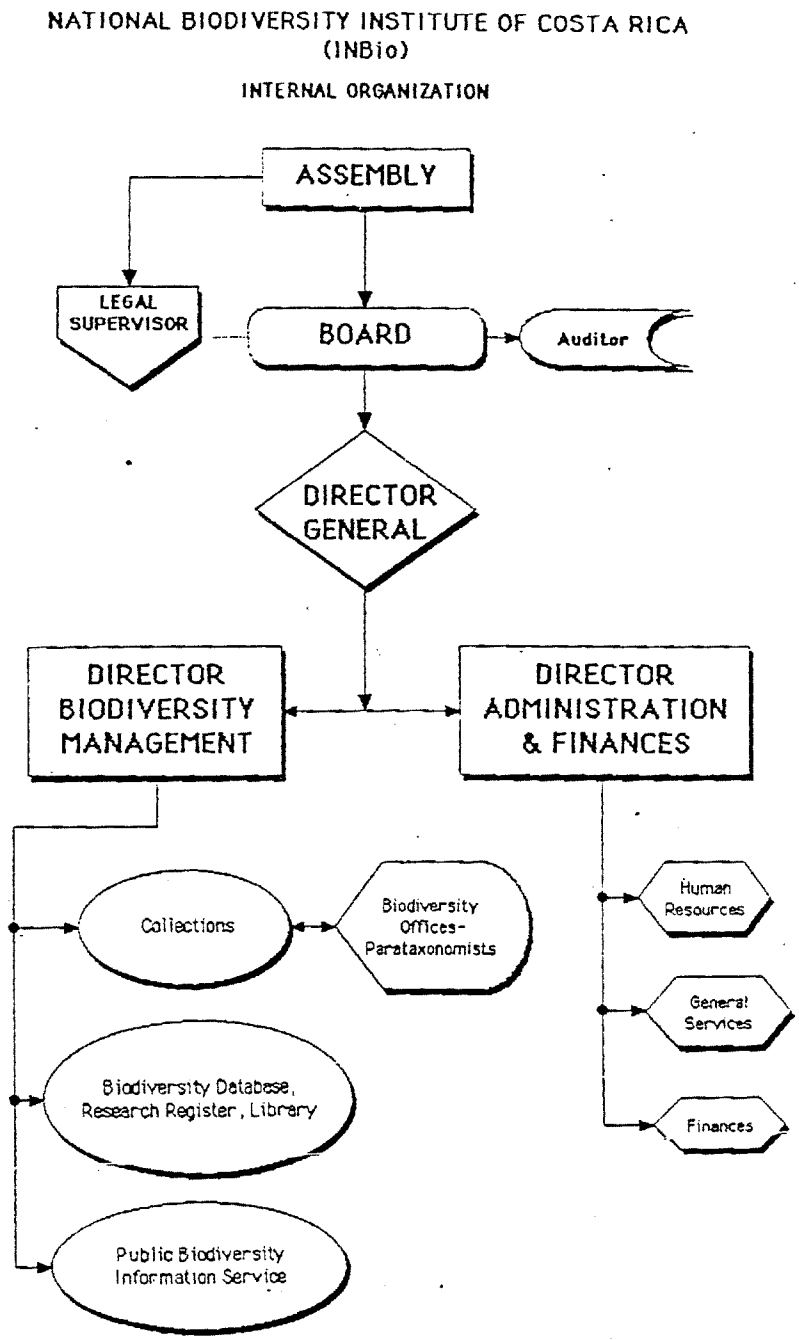
Appendix 1

INBio's organizational structure



Appendix 2

INBio's Assembly of Founders and Board of Directors

Assembly of founders:

Oscar Castro Castillo	Organic Chemist. Specialist in Natural Products Chemistry. Director of the Natural Products Research Center, Universidad de Costa Rica
Danilo Elizondo Cerdas	Lawyer. Specialist in Institutional Law. Former Director of Legal Department of the Contraloria General de la República de Costa Rica
Rodrigo Gámez Lobo	Plan Virologist. Director of INBio. Former Professor and Director of the Cellular and Molecular Biology Research Center, Universidad de Costa Rica.
Luis Diego Gómez Pignataro	Biologist. Director of the Catherine and Robert Wilson Botanical Garden, OTS, San Vito, Coto Brus, Costa Rica.
Luko Hilje Quirós	Ecologist. Entomologist. Specialist in Insect Pest Control. Associated Professor of the School of Environmental Sciences, Universidad Nacional, Heredia, Costa Rica.
Jorge León Arguedas	Botanist. Specialist in Etnobotany and Plant Genetic Resources. Former member of FAO, IICA and CATIE, Costa Rica.
Sergio Salas Durán	Biologist. Associated Professor of Ecology, School of Architecture, Universidad de Costa Rica.
Ricardo Soto Soto	Marine Ecologist. Associated Professor of the School of Biology and Limnology and Marine Sciences Research Center of the Universidad de Costa Rica.
Carlos Valerio Cutiérrez	Ecologist. Professor of the School of Biology and Dean of the Faculty of Sciences, Universidad de Costa Rica.
Ma. Eugenia Dengo Obregón	Educator and Consultant. Former Dean of the Faculty of Education and former Vice -Rector of Extension of the Universidad de Costa Rica. Former Ministry of Education, former member of UNESCO.
Rodrigo Fournier Guevara	Lawyer and Journalist. Director of the Univision News, Channel 2, Costa Rica. Former Director of the Caja Costaricense de Seguro Social.
Daniel Janzen Foster	Tropical Ecologist. Professor, University of Pennsylvania, USA and Guanacaste Conservation Area, Costa Rica.
Eduardo Lizano Fait	Economist, Consultant and University Professor. Former Manager of the Banco Central de Costa Rica.

Board of directors

Rodrigo Gámez Lobo	President
Jorge León Arguedas	Vice-President
Óscar Castro Castro	Secretary
Álvaro Sancho Castro	Treasurer
Daniel Janzen Foster	Vocal
Danilo Elizondo Cerdas	Fiscal

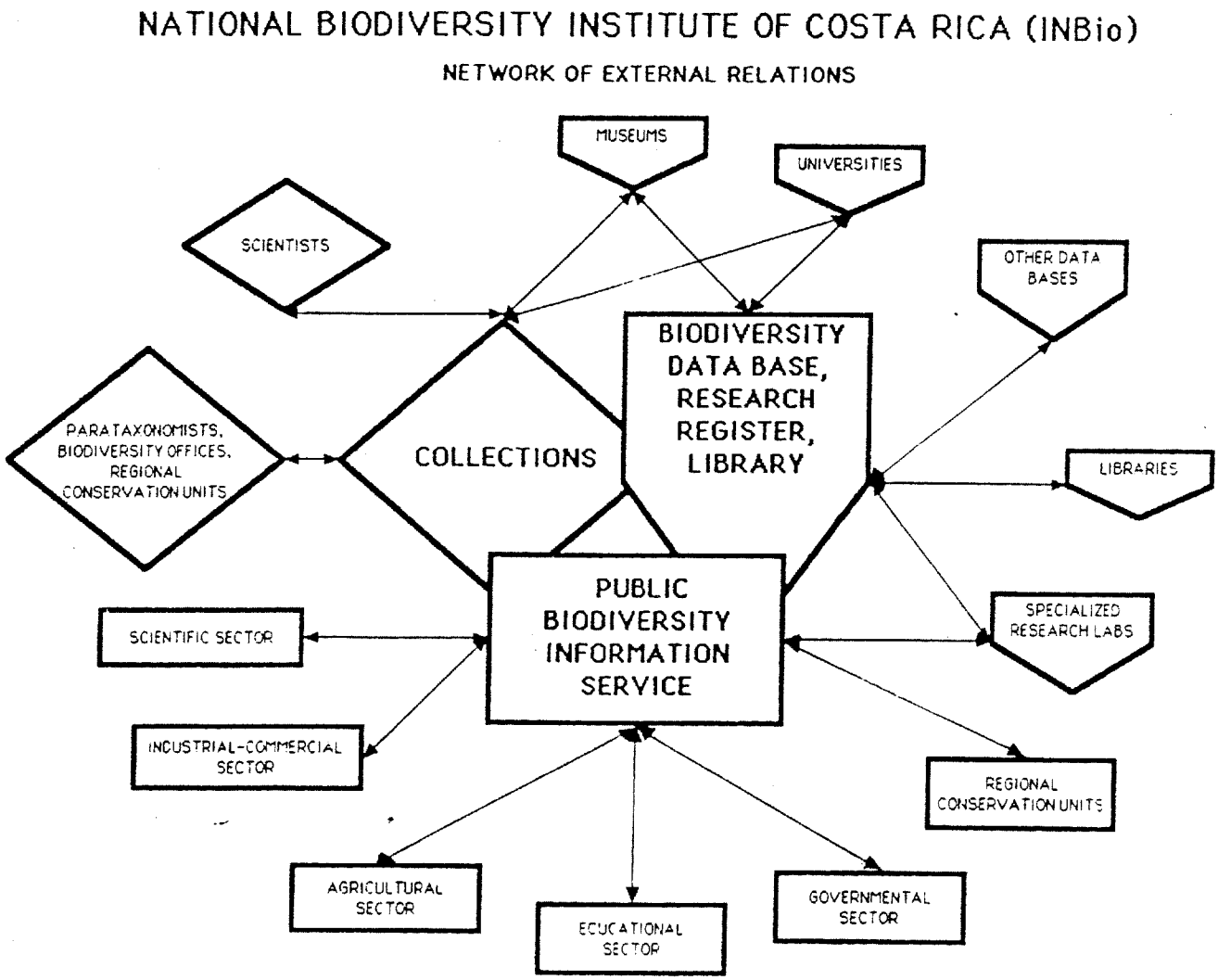
Appendix 3

Sample data entry for an arthropod specimen in INBio's data base

INBio registry number	INBio1000000973
Country	Costa Rica **Province** San Jose
Other Standard Unit	Braulio Carrillo National Park
Detail Location Desc.	Estacion Carrillo
UTM north	236700 **UTM east** 541800
Elevation in m	700 **Date of collection** Feb 1985
Collector	I.& A. Chacon
Class	Insecta **Order** Lepidoptera
Family	Saturniidae **Subfamily** Ceratocampinae
Genus	Citheronia **Tribe**
species	collaris **Life stage** adult
Det. source & date	Janzen, checked by C. Lemaire, Oct 1986;
Preservation method	pinned and oven-dried in the field
Collector Voucher No.	1916 **Coll. Voucher Code** D.H. Janzen
Specimen location	Janzen, Philadelphia;
Collection method	came to light
Observations	specimen used in DHJ moth weight study 1989;
Sex	m **Dry weight g** 0.780
Forewing length mm	50
Hindwing length mm	30
Label Collect Site	Estacion Carrillo, Pk. Nac. Braulio Carrillo
Label Elevation	700 **LabelCode**
Label Collector	I. & A. Chacon
Label Date	Feb 1985

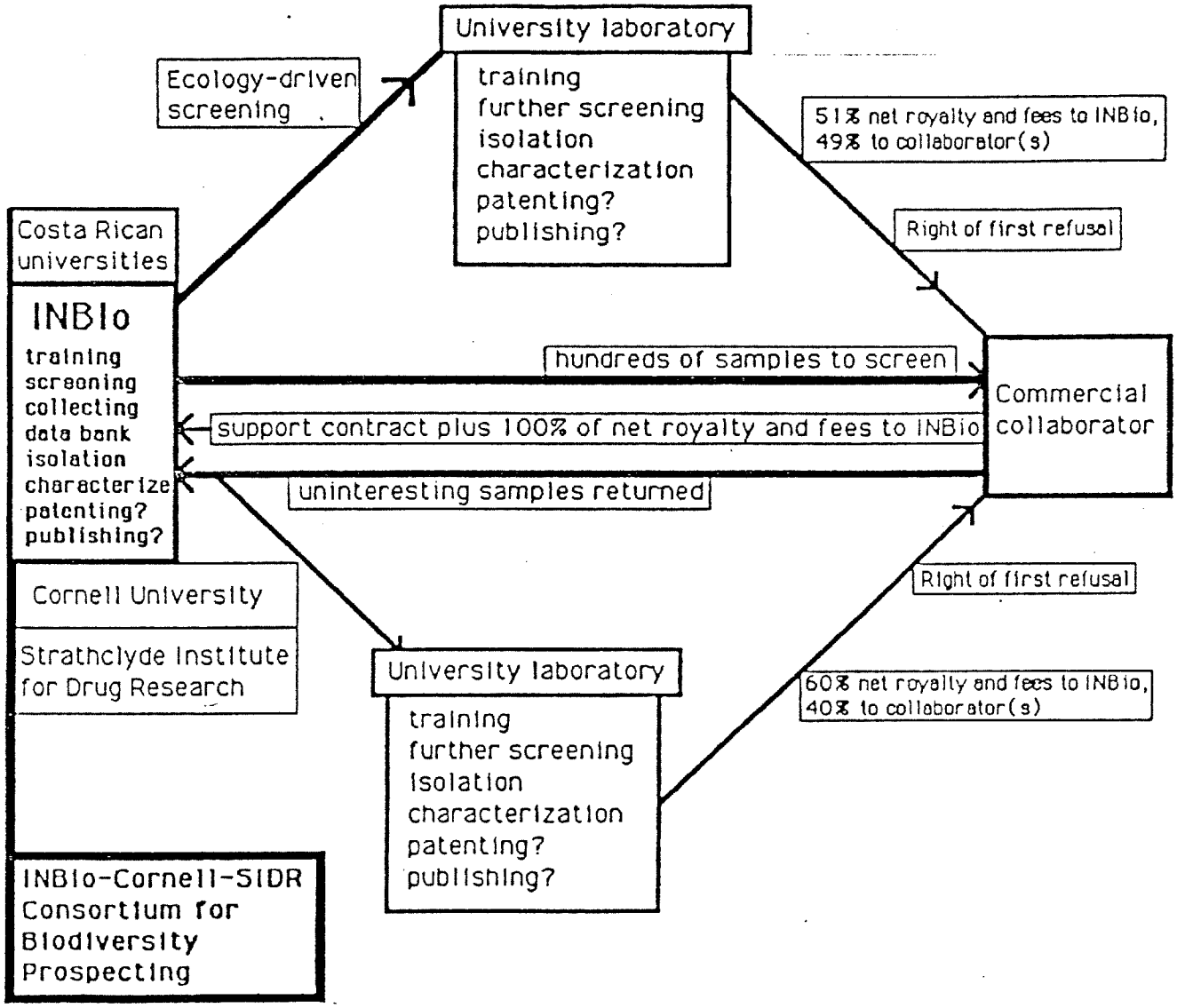
Appendix 4

INBio's network of external relations



Appendix 5

Schematic chart of the process and relations of biochemical prospecting



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