2 A south-north perspective on science in the management, use, and economic development of biodiversity

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ABSTRACT

The only certain way to save tropical biodiversity is to use it sustainably. To use it requires saving it as conserved wildlands and determining what is in them. Both these steps must be carried out by local human resources and a home-grown scientific and administrative system, but the development of both of these requires facilitation by the international scientific community. This facilitation requires that the international scientific community abandons its contemporary view of tropical biodiversity as largely an intellectual resource to be harvested by the extra-tropical academic community. Sustainable use of tropical biodiversity requires goal-directed search for intellectual and economic uses, realistic evaluation of impact by users, recognition that the wildland administration itself is a user, and the establishment of a mechanism by which the user community truly pays for use. Income ranges from on-site entrance and use fees to direct payment for off-site environmental services to royalties derived from the direct commercialization of biodiversity information such as phytochemicals and genes. A mechanism must be found whereby these fees come to pay the management costs for tropical wildlands. A National Biodiversity Institute is a mechanism to promote and develop all of these processes in coordination with the institutional management of the conserved wildlands themselves. Examples from Costa Rica are used to illustrate all of these problems and processes.

INTRODUCTION

The only certain way to save tropical biodiversity is to use it sustainably. The users must range from its immediate neighbors to the most global corners of society. Under this premise, the tropical conservation challenge is converted from "how to select, decree and guard what tropical national park", to "how does one manage a biodiverse wildland area in such a manner that

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its biodiversity remains relatively intact yet society's intellect and purse benefit from its presence"?

The process of biodiversity conservation through use has three overlapping steps, each of which is necessary but not sufficient for biodiversity conservation:

1. Save it.
2. Know what it is.
3. Use it sustainably.

Such a view moves the newly-labeled academic domain of "conservation biology" or "conservation science" from being a self-perpetuating process to being one of many means to achieve a goal. However, if conservation science is viewed as a means to a goal other than self-perpetuation, then its activity needs to be defined and structured with respect to that goal, rather than with respect to the traditions in which nearly all of its practitioners received their initial academic training.

If we scientists expect laymen and the commercial world to change in favor of biodiversity conservation and sane management of the environment – and surely the current demand for a 'sustained yield economy' is such a change – then we must also be willing to submit our own academic indoctrination to an intellectual and pragmatic goal-directed revision. No one said it would be easy. But all of us can see that it is necessary.

BACKGROUND

This essay touches on the interplay of systematics, conservation science, phytochemical ecology, and other kinds of biological science in the emerging area of the conservation of tropical biodiversity through sustainable use. I attempt to adopt the viewpoint of the tropical user society, the society that receives a product from its own tropical biodiverse conserved wildland – whether it is called a national park, game refuge, forest reserve or other similar legal designation. This viewpoint will appear relatively unsympathetic to many of the academic traditions in which I and many other biologists have spent, and still are spending, substantial parts of our lives. However, it is time to seek a new kind of fine-tuned and responsive contract between tropical academic science, local human problems, and local environmental processes.

Scientific research, and especially academic scientific research, is only a small – even if critically important – portion of the array of forces, processes and institutions that demand attention and fine-tuning if there is to be sustainable use and development of wildland biodiversity. The specific kinds of research required for real sustainable uses of tropical biodiversity are relatively straightforward and already practiced throughout the tropics by many people. However, if the questions and the researchers are isolated from society, the results generally only very slowly find their way into society. A yet more difficult problem is that research truly directed at the sustainable uses of biodiversity rarely involve the megaquestions and sweeping generalities that are so prized by the academic community.

I urge the reader to not confound scientific and academic traditions. The scientific way of thinking (double-checking facts, describing things as the way they are rather than as is politically convenient, posing clear questions, encouraging public discussion of hypotheses and conclusions, conducting controlled experiments, viewing as public the information used to arrive at a decision, placing a philosophy ahead of pecuniary benefit, non-acceptance of contradictions, the separation of a process or idea from the person who happened to think of it, the unwillingness to appeal to higher authority as a justification for a conclusion, etc.) is an extremely important methodology to bring to bear on the problems of the conservation of tropical biodiversity. This is particularly true in the tropics, where the distance between the scientific way of thinking and the lay processes of social life are often substantially greater than is the case in much of the developed world. However, academia and quasi-academia (museums, government research institutes, etc.) have quite reasonably developed their own more specific traditions as to how the tools of science are to be applied and to what. It is these traditions – ranging from what is viewed as an accomplishment to who is a legitimate practitioner of an activity – that require minor to major revision in an effort to put tropical biodiversity to work sustainably.

Economics also enters into the south-north contrast in an unexpected way. For at least several decades, the application of science to tropical problems will be largely funded by the developed countries, either by direct subsidy, or indirectly by the in-country tax base generated by export goods (just as it has been for past decades). In this situation it is especially hard for tropical in-country scientists to be responsive to the needs and desires of their own society. However, it is responsiveness to these needs and desires that will eventually make that society want to fund the in-country science establishment, thereby allowing major portions of the scientific community to operate with the social freedom so characteristic of science in developed countries. Funds spent on 'nationalization' of a tropical country's science community may do as much for the conservation of tropical biodiversity as funds spent on commercialization of tropical science in response to an international market. The latter produces an increase in national GNP, the former an increase in votes for biodiversity conservation.

My goal is to use thoughts provoked by current experiences in Costa Rica to broaden the contemporary discussion of conservation of tropical biodiversity.

THE BASIC FRAMEWORK

There are three co-occurring and overlapping contrasts that strongly affect any effort to conserve tropical biodiversity through use.

1. We of the developed world are accustomed to having massive resources available to apply to a particular conservation situation. We are also accustomed to a populace that rarely threatens a conserved wildland by stating that if it is not immediately turned into material production, it will lose its conservation status. By way of contrast, in most of the tropics all resources are scarce, and conserved wildlands are frequently threatened by direct economic interests. In effect, extra-tropical conservation takes place today in a relatively friendlier social milieu than does tropical conservation, not because tropical peoples are inherently more malicious but because there are fewer resources per person.
2. Scientific research, and especially research in academia, has a major ritualistic and display component; there is ample evidence that academic scientists as a group will be very human and dance to this tune if left to themselves. Most academic scientists have long ago come to the conclusion that they pay adequate dues to society by being solid citizens within their universities and research institutes. However, there is enormous potential for academic scientists to participate in the upcoming conservation of tropical biodiversity through use by society at large (e.g. phytochemical prospecting, Eisner 1990). The realization of this potential requires significant deviation from academic goals, geographic focus, partnership mores, etc.
3. A major body of scientific research applies to the act of actually managing

> and using a conserved wildland. This is where most, if not all, of conservation biology, wildland management, etc. has been directed for the past decade. Meanwhile, we lack a major body of scientific research on the use of the biodiversity that is present in a tropical conserved wildland. Research on biodiversity's non-destructive uses is essential for sustainable use of conserved wildlands by tropical societies. These two quite different areas of research overlap at many points, and conflicts over conservation research priorities are often due to failure to distinguish between them. For example, a species inventory is of paramount importance to the development of a national park as a library of phytochemical resources, but a species inventory of that park may be of very low priority to the park manager protecting the park from man-made fires (what species would be incinerated by a fire is far less important than keeping them from being incinerated in the first place).

All three of these sets of contrasts come together and underlie the realization of the following description of a specific country:

> "Costa Rica is a corporation with 50,000 km^2 of land, on which are 12,000 km^2 of greenhouses. In those greenhouses live 500,000 species. This corporation has 3,000,000 stockholders. At present, there is $1,500 worth of GNP per stockholder. Costa Ricans aspire to a standard of living that is normally associated with about $10,000-$15,000 worth of GNP."

THE FIRST STEP: SAVE IT

In the past 1–3 decades many tropical countries have set aside 5–20 % of their national territory as wildlands ostensibly conserved for their biodiversity (national parks or similar). This step has been costly and has required much energy and dedication by individuals, non-government organizations and governments. The community of academic tropical field biologists has mainly contributed by indicating where there are patches of vegetation, species or populations of particular interest. They have done this especially at the time when these units are approaching major perturbation or extinction. The more conspicuous contribution by the bulk of the overall academic community has been largely aimed at theoretical considerations of what sizes and configurations of reserves are optimal to support a maximum number of species. Most recently, the theoretical importance of inter-reserve corridors, edge effects, potential impact of climate shifts, keystone species, reintroductions, and introduction of exotics has been touched on by the same academic circles.

However, there has been little serious effort at hands-on integration of conservation science findings and understandings with the remainder of the process of selecting, establishing, and managing actual specific conserved wildlands. Almost all of these decisions have been made in isolation by professional conservationists, (usually) well-meaning legislators, wildlife managers, and enthusiastic amateurs, with minimal participation by the academic biological science community. The academic community has yet to provide high quality human resources, time and energy for on-site participation in serious planning and designation of tropical conserved wildlands – the "save it" part of the process.

It costs approximately four months of serious full-time mental investment to generate a quality manuscript for Annual Review of Ecology and Systematics, for example. The outcome is a widely read paper, a "scientific advancement", and a healthy jump in the value of the author's CV on the academic job market. Those same four months dedicated to the "save it" stage of a 50,000 ha national park may result in tens of thousands of saved species and subsequent tens of thousands of pages of science about their biology over upcoming decades. However, the academic scientist who engages in the latter career choice for a tropical national park is almost certain to go unheralded, receive no credit from peers, receive no financial approval from his or her department chairperson or research institute head, and jeopardize an "academic" career.

The blame for this sorry state of affairs is due to characteristics of both conservation projects and academia. Very few tropical conservation systems reach out eagerly for quantity and quality input from academia. This is partly because the academic offerings that appear haphazardly on the managers' doorsteps have often been ephemeral, insensitive, self-centered, fickle and mediocre. However, it is also because the management administrations are often defensive, petty, unreceptive, resentful and quite unclear as to overall goals. This conflict is not restricted to tropical regions. Two recent cases are the on-going struggle to determine the best system of management and goals for Yellowstone National Park (e.g. Chase 1987, 1989), and the recent exemplary revision of the US Government management plans for Luquillo National Forest in Puerto Rico following scientific and public protest (e.g. Alcock 1990).

Unfortunately, the first steps of the "save it" stage often create a major obstacle to conservation-through-use. Tropical conserved wildlands are often created when they are under immediate threat from direct harvest. The traditional method for confronting a physical threat is physical guarding backed up by laws. This method attracts a certain kind of person as administrator and guard (ranger, guardaparque), and leads to legislation and institutional attitudes to support this person in his role as guard. The park or reserve effectively becomes a "castle", with the "enemy" out there and the "good guys" inside. By definition, a state of siege is generated. And castles virtually never survive a siege. The longer the state of siege lasts, the more firmly it becomes institutionalized in salaries and jobs, budgets, regulations, legislation and neighborhood traditions. Moving from this state to the "use it sustainably" part of tropical conservation becomes difficult because such a change conflicts very strongly with a mindset and social institution that is sometimes necessary in the first step of conservation. The situation is not unlike the transition from a frontier to a stable rural agroecosystem.

The amount of conflict generated by the exact location of a park's boundaries is a major determinant of future siege intensity. This conflict in turn affects the later evolution of the park into a more civilized state of integration with the surrounding society. The academic biologist, with his or her fascination with reserve size, location of corridors, attempts at saving absolutely every species, etc. has proven to be a particularly difficult member of the conservation team at this point in the evolution of a given conserved wildland. It is appalling to hear an academic tropical biologist state flatly that he does not know anything about sociology and therefore will only consider biological factors. It is as though a doctor were to state that seat belts are an engineering problem unrelated to medicine.

The principle of "paying 5 % of biodiversity to save the other 95 %" is as important in the early "save it" stages as it is when later determining the intensity of permissible park use by visitors, yet this principle is commonly ignored in the discussions between academic biologists and park planners/administrators. For example, a chronic complaint of rural societies is that people are relocated to establish a national park. While some of this relocation or expropriation is in fact necessary, much of it may not be if the park establishment is viewed as (by necessity) a negotiation with society rather than a regal imperative. Just as the establishment of a new highway system is negotiated with land owners, traditional land uses, and other social barriers, so must be national parks.

Consider Costa Rica. The country has set aside approximately 25 % of its land area (Figure 1) for conservation of biodiversity and/or wildlands that are conserved for sustainable direct production with minimal loss of biodiversity. This "save it" stage was carried out over the past two decades, which means that an entire generation of employees and regulations have grown up with it. Fortunately, Costa Rica is only now reaching an intensity of land use where a siege mentality is a severe threat to park

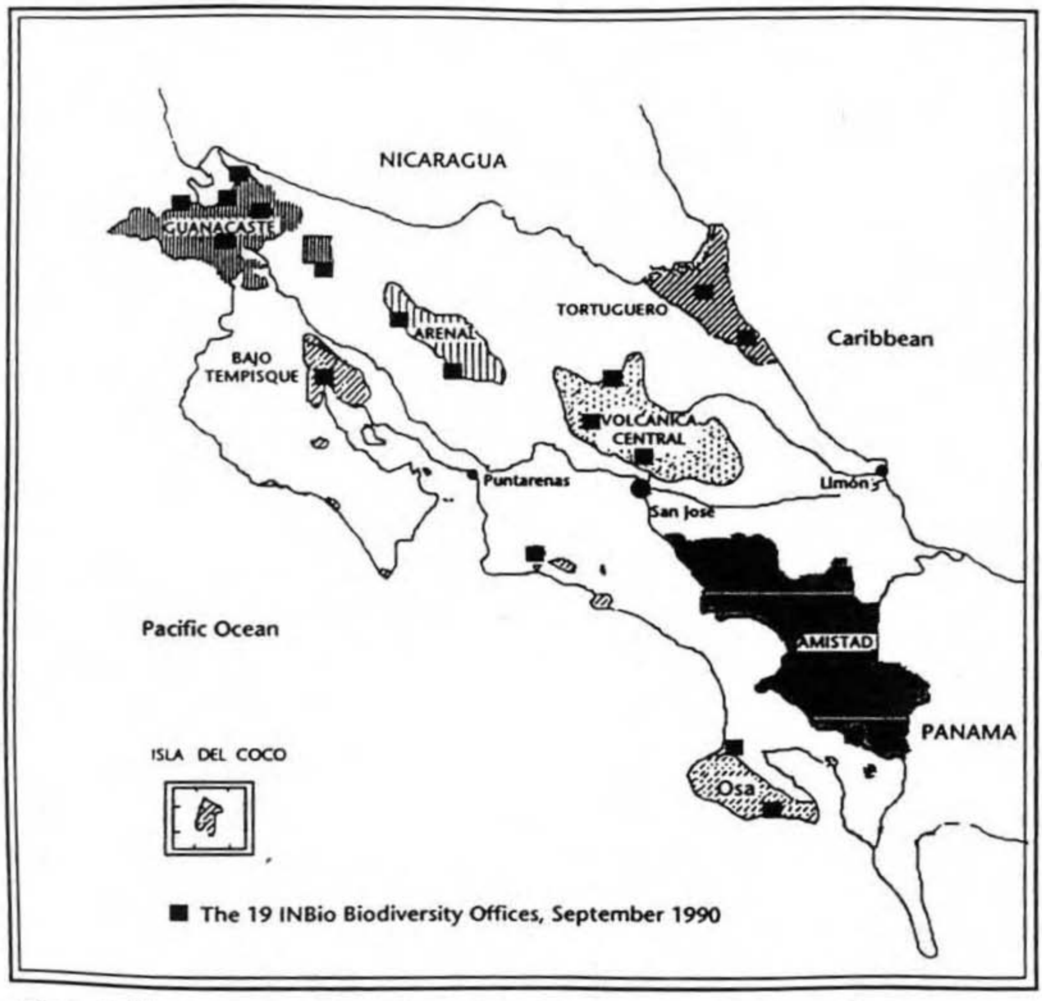

Figure 1. The location of Costa Rica's eight Conservation Areas (Areas de Concervacion) (various shadings) and 19 INBio Biodiversity Offices, September 1990.

existence. Equally fortunately, the wave of interest in moving into the "use it sustainably" stage has appeared simultaneously (and partly driven by the impending crush).

It is striking that academic professional biologists, and what is commonly viewed as academic conservation biology, have played virtually no role in the choice, siting, size or boundary details of Costa Rica's national parks. Rather, the decisions were based on: (1) a strong appreciation of seemingly undisturbed nature by select Costa Ricans, (2) accidents of donation or land ownership, (3) absence of occupants and land viewed as of low agricultural value, (4) timber reserves and water source conservation, and (5) the advice of some internationals with little to some academic exposure to professional biology.

A single example will underline this view. Costa Rica has a very fine conservation system, yet not one of the Conservation Areas (Figure 1) is established on rich agricultural soils. Academic consideration of Costa Rica's conservation planning would have avoided this error, an error that has occurred throughout the tropics.

In Costa Rica, the traditional conservation biologist's concern for such things as reserve size, reserve configuration, corridors, endangered species, species reintroductions, etc. has appeared almost as an afterthought. Ironically, these discussions can be quite disruptive in Costa Rica at this stage, through disrupting emergent activities of integration of a conserved wildland with its neighbors. Expansions of established reserves are particularly disruptive in a siege situation. Even a castle-like reserve can come to an uneasy peace with its neighbors over the years. However, if the boundary then changes (commonly in response to a well-meaning academic biologist suggesting that "if it were bigger it would protect more species") – thereby threatening immediately adjacent agroindustry investments, family farm plans, rural development schemes, etc. – there is an immediate conflict. The social reaction is "hey, if we have to cut off a finger, lets do it and get on with living with the consequences. Don't keep threatening, or worrying at the wound."

This situation has proven to be especially difficult when administrators and legislative decision-makers cannot make up their minds about park expansion proposals, or when their plans are influenced by vague possibilities of raising more funds for later land purchase. It is far better to rapidly come to a peaceful settlement with society. Determine the site and shape needed for conservation of biodiversity, negotiate its boundaries once and for all, and get on with making it the best possible park on the one hand, and the surrounding area the best possible agroscape on the other. Conserved wildlands are not sandboxes for academic conservation biologists to pursue their personal research agendas, irrespective of how regal, elegant and "important" the research is deemed to be by academia or by those who borrow its "respectability" to add to their tool box.

Academic considerations of reserve size have one easily identifiable negative effect. The nature of the discussion is oriented towards "what is best", with size being the independent variable. Obviously bigger is better in the biological sense. However, this automatically converts small into "worse". Quite understandably, the strong arguments from academics result in the logical conclusion that small areas are going to gradually decompose, and therefore are not "worth conserving". This can be like discarding a unique 14th Century painting because it has a large hole burned in its lower left corner. Equally, it would be like failing to conserve an island wildland because islands are generally poor in species as compared with adjacent mainland areas of equal size. It is evident that a small and damaged habitat will retain a very large number of species of organisms in a stable manner, as is the case throughout much of the tropics sprinkled with semi-wildland habitats that have been under heavy human use for millenia. From the viewpoint of the neighborhood user, such a small imperfect area is much better than no conserved wildland at all. Yes, we need a Library of Congress, but it would be ridiculous for a country with a Library of Congress to discard the concept of public libraries in small towns (Janzen 1986a, 1988a).

Large reserves can also cause problems. A bigger castle may well contain more species than a small castle. However, if the bigger the castle the greater the social disruption and resentment, then large size is a cost to balance against the gain in social approval derived from being less demanding. A large reserve may maintain everything except a few species of very large raptors, which may be only two out of the 200,000 species in the reserve. Increasing the size of the reserve by a half again on behalf of those raptors may easily create so much antagonism that the entire reserve is assaulted by a populace that would have been willing to accept it at a smaller size.

THE SECOND STEP: KNOW WHAT IT IS

Traditionally, the decision to establish a conserved tropical wildland has been based in part on some very general understanding of what biodiversity occurs at a site, rather than specific information. Specific information is often presented as lists of species and habitats, with some maps of habitat types as well. However, such lists and maps, while attractive in annual reports and on posters, are generally of little use to the within-park manager or to the neighborhood society. As implied earlier, most tropical wildlands have been conserved for their general appearance and the pristineness of the site, rather than because of specific knowledge of what is there. If viewed as a "castle", almost all tropical conserved wildlands can be fully protected and managed with virtually no knowledge of the biodiversity that they contain (see the fire example in the introduction). In this context, a list of the five species of megamammals in a national park containing 100,000 species of organisms does not count as a "biodiversity inventory".

The academic community has sometimes participated enthusiastically in preparing lists of what biodiversity is present in a national park. However, such activity is rarely driven by actual needs of the administration of the conservation unit. Instead, it is almost always done to further a personal or academic institutional agenda. Worse, most tropical conservation area administrators/managers (guards) understand so little of wildland management that they do not know what to request from the academic biologist when assistance is volunteered. Administrators generally respond to such queries with requests for what they see the academic world doing, if for no other reason than to receive approval or credibility from the academic world.

Esoteric scientists and commercial collectors have a long history of neotropical biodiversity inventory. In the 19th Century, numerous European and North American biologists came to neotropical (huge and unconserved) wildlands and sent home specimens of tens of thousands of species. For example, of the Costa Rican macromoths that are currently being inventoried by the Instituto Nacional de Biodiversidad (INBio, see below), better than 50 % of the 7,000-plus species were described from specimens collected somewhere in the Neotropics, decades before Costa Rica even thought about having a national park system or a national inventory.

Following the adventuresome explorer-scientists, there have been several recent decades of academic biologists – such as myself and many others in Costa Rica – pursuing taxonomic research as it suited their own specific interests, cavorting in the forest quite unconcerned with whether it would still be present decades hence. For example, when I came to Costa Rica in 1963, the forest was viewed as essentially a large and diverse supermarket where one collected according to inclination. While many of these researchers were internationals, a significant number were also citizens of the countries in which they studied. Finally, only in the past decade, this effort is beginning to shift toward having a major component of in-country participation. However, the agendas that they follow with respect to conserved wildlands are still largely an extension of the academic agendas set by the (usually international) institutions where they received their academic training. The recently formed Costa Rican Instituto Nacional de Biodiversidad (INBio) is attempting to depart from this behavior (see below).

The gathering of biodiversity information from conserved wildlands in order to further sustainable use of that wildland is an infant science (e.g. Eisner 1990). A major hurdle to be overcome is that of determining the future uses of the information, a determination that will guide which items of information to focus on gathering. A guiding principle for a general-purpose biodiversity inventory is to view the effort as making a huge library functional. The inventory puts call numbers on the new books, confirms existing call numbers and their synonyms, develops a card catalogue, establishes a data base about the general content of the books, sets up a retrieval and loan system for the books, advertises the library's content to potential users, and helps to determine how much to charge the user public for services.

In Costa Rica, INBio has embarked on this exercise (Lewin 1988; Tangley 1990). The INBio has set the ten-year goal of inventorying the half million species of organisms conserved in Costa Rica's 12,000 km^2 of conserved wildlands, and getting that information into a usable format (Janzen in press; Janzen and Hallwachs in press). In the initiation of this activity, the INBio has encountered several conflicts with the world of academic taxonomy and systematics. Here, I mention a few of these conflicts, so as to give the reader the flavor of the situation.

The parataxonomist

The international taxonomic community will not mobilize sufficient human and economic resources to inventory Costa Rica's biodiversity within a decade. This short time frame is necessary if the inventory is to be the precursor to a sustainable use that will in turn facilitate and cause Costa Rican society to preserve her biodiversity. The obvious solution to this impasse is to train a large number of Costa Rican adult working-class rural residents in the technology and philosophy necessary such that they can conduct much of the inventory process, and get on with the task. Such persons are termed "parataxonomists" by the INBio, a term borrowed from the "paramedic" of the medical community. At the time of this writing, the INBio has trained 31 parataxonomists (with funding by USAID, National Science Foundation and USDA, The Natural History Museum (UK), the Pew Charitable Trust and the J. D. and C. T. MacArthur Foundation) and they are taking the first steps for the national inventory. They are generating hundreds of thousands of properly prepared specimens per year, rapidly gaining natural history information and experience, and spreading biodiversity information to the neighbors of the 19 Biodiversity Offices scattered through Costa Rica's conserved wildlands (Figure 1; Janzen in press).

Such a highly pragmatic step, which removes much of the basic work of a national inventory from the domain of the university-educated academic taxonomist, appears on first glance to be ideal. It involves the national community in its own biodiversity management, it increases the human resources that are experienced in biodiversity matters, it expands employment opportunities based on brain rather than brawn, it relieves the academic taxonomist of much time-consuming field work, it is cheap in dollars and time per specimen prepared, and it can be easily and cheaply expanded until the desired inventory intensity is attained.

However, such a scheme has met significant resistance from the Latin American academic sector (and some similar resistance among some older members of the North American taxonomic community). It is viewed as demeaning to the PhD taxonomist to publicly demonstrate that much of what was considered to be his or her professional domain can be carried out by a person with enthusiasm, grade-school education and six months of training. It deprives the same academic of the opportunity to state that the slow pace of his taxonomic research is caused by the difficulty of getting to the field and a shortage of funds. It likewise eviscerates the comment that we must have more (very expensive) resources and the time to train more PhDs before we can get on with an expansion of taxonomic services and activities to encompass such a task as large as a national inventory. Finally, it is the first step in popularizing an activity that, like the white lab coat, has maintained the academic at a socially prestigious level, with residence in a university or government research laboratory setting in or near a capital city at a comfortable salary. Ironically, a field task of a scientific nature is viewed as a step upward by the rural resident while a scientific task in the field is viewed as a step downward by the urban resident (who may well have spent several generations struggling to move from a rural to an urban background).

There is also an interaction between international universities, in-country tropical academics, and parataxonomists. If serious science can be done by the relatively uneducated in the field, then perhaps there is less justification for extended periods of postgraduate study on comfortable fellowships in the universities of developed countries. It is quite amazing to hear an academic lament the "shortage of taxonomists" and then criticize a parataxonomist because "he could not possibly learn or know the detailed specialized collecting methods used by a specialist in his or her group of organisms".

The parataxonomists also do not mesh well with the natural desire, or at least the fashionable feelings, of developed country academia to offer advanced degree programs to international students as their contribution to the development of human resources in undeveloped countries. A parataxonomist neither has the other academic preparation nor language skills to enter into a graduate program, nor is interested in leaving family and friends behind for years while "studying" something in Wisconsin that will be at best of marginal use to his or her daily work as a parataxonomist.

The apprentice curator

Now that the parataxonomist program is generating a very large amount of high-quality biological material, a large bulk of mounted and labeled specimens is accumulating in a central depot. In the case of Costa Rica, this depot is the buildings of the INBio, housing the National Insect Collection, National Plant Collection (National Herbarium), etc. Traditionally, in such a circumstance, various international taxonomists would then be deluged with boxes of specimens to identify and study. This would simply add to their already unbearable backlog of specimens. This would create yet more resentment amongst taxonomists that "society" is not willing to pay the maintenance costs of the taxonomic community in the developed countries (to say nothing of the undeveloped countries).

Enter the apprentice curator. Many Latin American countries generate a moderate number of university graduates with a 4- or 5-year degree in biology. Sending them off to international centers for a PhD in systematics is costly in dollars and time, and generates people with some specialization in a group or a method, but no practical experience as to how to make taxonomy a functional activity within a society (since that is not a part of academic training anywhere). For example, there is not a single advanced degree curriculum in systematics in the US that emphasizes the skills and abilities necessary to, for example, develop a layman's field guide to the identification of a major and common group of organisms. One conspicuous solution is to give tropical university graduates on-the-job training in basic curational skills and uses of taxonomy, thereby gradually training them up to a level where they are, according to their individual abilities, actually conducting the same processes expected of a PhD taxonomist when curating a major collection.

The name apprentice curator is applied to such a person because a major way to speed and facilitate the on-the-job training process is to apprentice him or her to a practicing PhD taxonomist (local or international). However, such a collaborating specialist requires two distinctive traits. These traits are rare within the systematics community but examples do exist (e.g. Janzen in press). The specialist needs to be willing to spend a serious block of time (generally several months per year at a minimum) working in the field and INBio with the apprentice curator in Costa Rica. Second, some serious part of that time has to be dedicated to the process of teaching the apprentice curator as much as is possible about the group of organisms (as well as benefiting from the apprentice curator's labors). On a short time scale, this is not the most efficient use of the PhD specialist's time, as measured in production of traditional products (monographs and/or specialized collections of focal groups). However, on a slightly longer time scale, the rewards can be huge in terms of specialized collections, companionship in productivity, and eventual production of taxonomic works by the tutor and apprentice. Fortunately, within the past several years the National Science Foundation of the US, the USDA, the Smithsonian Institution, and The Natural History Museum (UK), have come to view such a time investment by a master taxonomist as legitimate investment of time (e.g. Janzen in press).

Apprentice curators have, to date, seemed to be less depreciated by the Latin American and North American science community than have been parataxonomists. The apprentice curator is, after all, just a close subspecies of the tutor taxonomist, and many tutor taxonomists began their professional careers as informal apprentices in their youth.

However, there is still one major barrier. The funds that are generally available for a Latin American recent university graduate to go to the US and study for an extended period so as to obtain a higher degree are not generally available to support an apprentice curator in his or her on-the-job training within the developing country. One of the major reasons, though generally unspoken, is that the "student" studying and curating beetles in INBio, for example, does not conform to the traditions and reward systems of that same student studying and curating beetles in a US university. The US university funds to "produce degrees", not to accomplish a conservation objective.

There has been a second reason given as to why US university funds are not available for on-the-job in-country training. It has been noted that the apprentice curator is actually working, thereby allowing the excuse that "he or she should be supported by the INBio". Unfortunately, the INBio is not able to provide a salary that is comparable to that in the developed world for the ability and responsibility that he or she is expressing as an apprentice curator. This is not because there is particular discrimination against taxonomists or curators in Costa Rica, but because salaries are generally very low (the Minister of Natural Resources receives about the same salary as my secretary/assistant at the University of Pennsylvania). Low salaries are commonly compensated for by having several jobs and by putting substantially less than eight hours of work into a "full time" job (in Costa Rica there are even two kinds of "full time" jobs: "full time" and "exclusive dedication"). However, the INBio apprentice curator is held to standards of performance of the developed world, and therefore should be compensated accordingly.

As with the parataxonomist, the invention of the job category "apprentice curator" allows a redefinition of curatorial and systematic responsibilities in accordance with the needs of the social system of biodiversity use in Costa Rica, as opposed to the social needs of the US academic system. For example, from the beginning, the INBio curational task requires an ability to both identify specimens for various public sectors, and generate field guides, natural history synopses, and other informational services. An apprentice curator is also encouraged to invest some time in evaluating environmental impacts, teaching parataxonomists, assisting master systematists, advising the government on biodiversity questions, fund-raising, etc. In the traditional academic world, analogous activities are seen as an imposition rather than as an integral and legitimate use of a staff-member's time. Even though INBio started from bare ground in early 1989, in fact it incorporated various staff members from other more traditional institutions, staff members already somewhat steeped in traditions brought from academia both within and without the tropics. The readjustment of a mindset for these people has not always been smooth.

The inventory

An inventory of the biodiversity of a country or region has traditionally been expressed as a list of species. Many taxonomists feel that this is the end point for their participation in conservation and environmental management. However, an "inventory" as conducted by the lay community normally contains information of value about the species as well as a list of the species themselves. For example, a warehouse inventory may discuss what kinds of bolts are in the warehouse, how many there are of each kind, what they cost, how long for a backorder, where they were obtained, etc. In other words, the inventory is not an end but rather a means to the end of efficient use of a repository of diverse objects too complex to be censused at a glance.

When the INBio speaks of an inventory of the biodiversity of the half million species of organisms occurring in Costa Rica, it is not speaking of just a species list. True, the species list can be generated at any moment by the flick of a computer key, and is something that will grow continually toward an asymptote for the next decade. However, while such a list may often be cited on the international scene when comparing Costa Rica with this or that other area, it alone is virtually useless within Costa Rica. What really matters is the information stacked up in the computer base behind each of the entries in the species list.

The parataxonomist activity is initially focused on collecting samples of the species present, so as to generate the raw material that the apprentice curators and their international connections can use to put the Costa Rican species' nomenclature in (relatively) stable order. At this point, a species' presence in the inventory changes from a number to a Latin binomial (and higher categories) that allows access to the rest of the world literature about that organism (if any be), and allows taxonomic inference to play its powerful role in the perpetual guessing game about natural histories as yet unknown. But in getting the first specimens, the parataxonomist also generates the first data about the geographic and temporal location of the species within the country. As further collection occurs at the nodes in the widespread net of Biodiversity Offices (Figure 1), a better understanding of the ecological distribution of species will appear.

Some groups of species reach taxonomic stability and eco-geographic understanding quite rapidly. Virtually all vertebrates (except for a few small snakes, salamanders and obscure frogs), and about 70 % of the plant species attained this stage before the INBio was even a dream (e.g. Burger 1977; Janzen 1983). The same may be said for butterflies (DeVries 1987), saturniid and sphingid moths (D. H. Janzen and W. Hallwachs, unpublished), ophiine ichneumonid wasps (Gauld 1988), scarab beetles (A. Solis, unpublished), and dragonflies (C. Esquivel and S. Brooks, unpublished). Many other groups are still very much at their beginning, but being steadily accumulated by the parataxonomists and organized by apprentice curators and international taxonomists.

But, the INBio biodiversity database very quickly becomes a repository for Costa Rican natural history and ecological information as well as a source of locations, taxonomic certainty, literature connections, and taxonomic inference for future users.

As the taxonomic status of a group moves beyond the early "inventory" stage, the parataxonomist and even to some degree the (no longer apprentice) curator have the option of concentrating more heavily on as-yet uninventoried groups (such as a parataxonomist with years of experience with insects turning to diatoms or fungi), or focusing his or her efforts on the accumulation of information on natural history, physiology, behavior, morphology, etc. Thus the "paraecologist" is born. As the years pass, the INBio and similar organizations elsewhere will be continually confronted with the question of how best to divide their human and support resources among the activities of parataxonomists, paraecologists, curators, and unforeseen categories of specialists. This allocation will be heavily influenced by the societal involvement with biodiversity, just as the agricultural research of a major land-grant university in the US is in part guided by the crops and society of the region.

This view of an inventory meets with mixed responses by the academic (and museum) science community. In a variety of subtle ways, it departs from well-established – but recent – traditions. It is very easy to forget that the first major inventories of the neotropics by European society during the past century were, for example, largely driven by commercial drug, food and ornamental interests rather than esoteric academia. First, and perhaps foremost, such an INBio-type inventory casts the taxonomist and his or her actions as integral partners in a larger effort, rather than controllers of a self-contained and self-responsible body of endeavor (largely beholden to a dimly remembered academic exposure in a developed country). Taxonomists are, as a group, among the most independent of all kinds of biologists (witness the paucity of coauthored papers in taxonomy). However, the person who is content to spend major blocks of his or her life cloistered in a small room thinking individually about long-dead organisms tends to be at the more introverted end of the social spectrum. The inventory workplace postulated here is substantially extroverted.

Second, the products of an inventory are considered substantially less elegant, in an academic context, than are massive monographs that at least in theory "clean up" a major taxonomic group. However, traditional monographs may require decades of preparatory work, are not organized for lay readers, and are often impenetrable except to other specialized taxonomists.

Third, such an inventory is regional or even more local in scope and solutions. However, many if not most tropical organisms have geographic ranges, phylogenetic relationships, and scientific paper trails that extend far beyond this area (e.g. Janzen 1986b). To focus on putting a regional flora or fauna into a user-friendly format robs the taxonomist of the time and energy needed to ferret out these additional extra-regional connections, some of which will be important in the taxonomic designations that are assigned within the region. It cannot be forgotten that for many taxonomists, much of the original attraction to the endeavor was the great puzzle of understanding how things are related to each other. However, the clues to a taxonomic puzzle often lie geographically far outside of the region of pragmatic interest.

Fourth, an academic taxonomist commonly receives a salary appropriate to his or her level of academic training rather than to the level of productivity as measured in products that can be directly used by others. Associated with this, many taxonomists work for extremely low salaries, if their annual salaries are divided by the very large number of hours they put into their profession. In return, they are generally not asked to account for their efforts in anything but the most general manner. In the "inventory environment" discussed here, salaries and other rewards are unavoidably tied more directly to the amount and nature of directly usable output. The taxonomist is at risk of feeling much more like a cipher in the marketplace.

Finally, in an inventory such as that described here, a taxonomist's output is in fact used, and used within a short time. Taxonomists have long suffered, or enjoyed – depending on your view – nearly complete freedom from feedback from disgruntled or euphoric users. Keys, species descriptions, curated specimens in museums, monographic descriptions of ranges and morphologies, etc. commonly languish for many decades before being glanced at by, perhaps, one or two other specialists. Such specialists are adept at wending their way among the errors, oversights, lack of technology, etc. characteristic of someone working decades to centuries before them. On the other hand, in the more heavily funded areas of biology it is commonplace for quality control to be promoted by repetition or use of any significant discovery within a few days to years. This is the kind of double-checking that is simultaneously nervewracking and exhilarating for the scientist. It also throws the taxonomist into the turmoil of the marketplace, taking away a freedom that has always been one of the pleasures of most taxonomic research.

THE THIRD STEP: USE IT OR LOSE IT

Once the "save it" and "know it" steps are in motion, the "use it sustainably" stage can be entered into with vigor. In effect, the save it and know it steps are a giant production process ending in information dissemination to a major group of users (Figure 2).

However, the products from the sustainable use of a wildland conserved for its biodiversity are much more than just information. The products fall into three large and somewhat overlapping areas:

1. Physical production for the area outside of the conserved wildland (light or no human presence required): carbon storage, water generation, water flow control, erosion control, wind and temper-

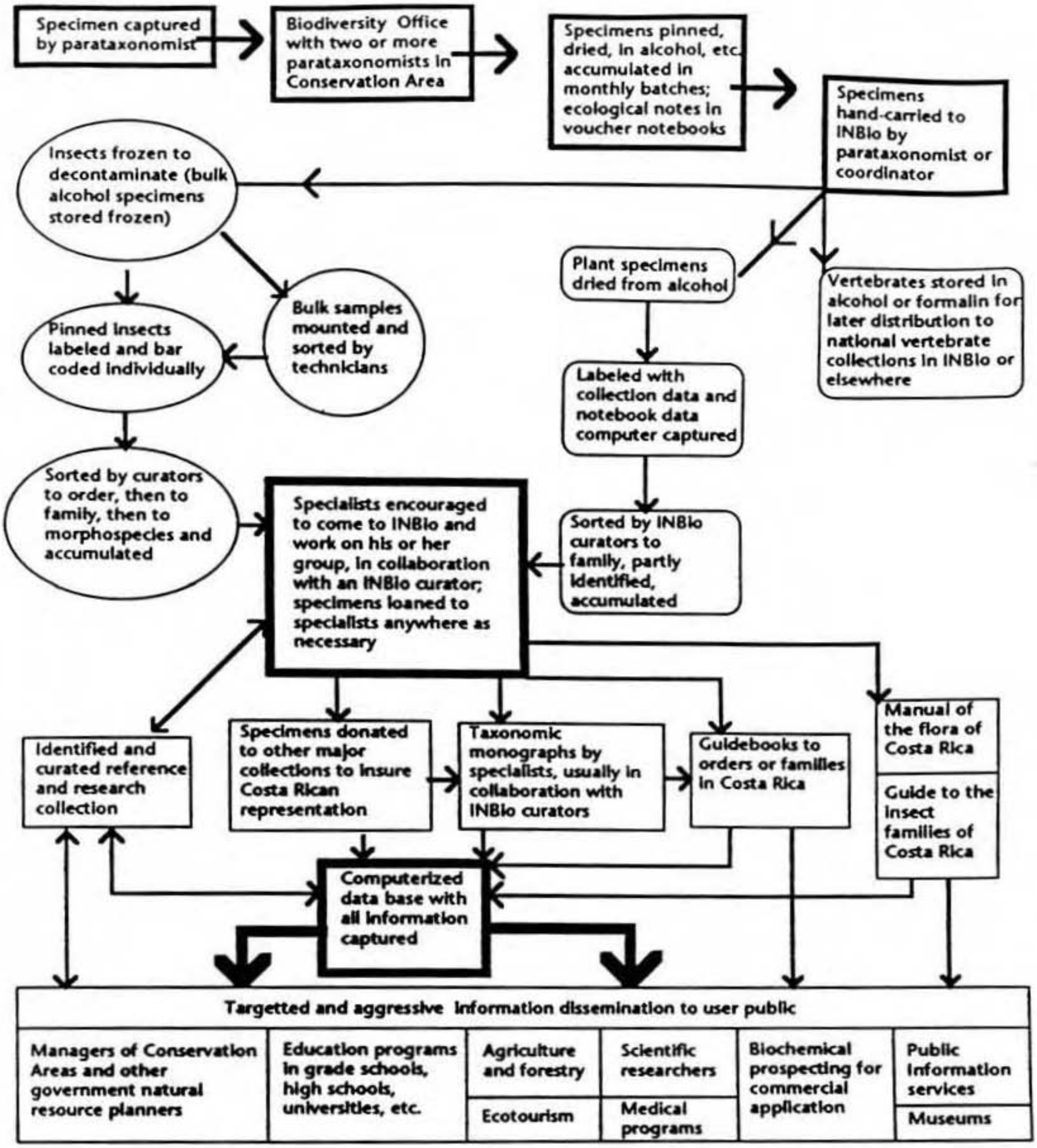

Figure 2. National Biodiversity Institute of Costa Rica (INBio): the inventory flow from field to public use.

ature modification, game refuging, fish nurseries, visual recreation (landscape beauty), gene and species banking, etc.
2. Information extraction for the outside world (very light human use): gene capture, intellectual information, research results, organisms for reintroduction elsewhere, consultation on environmental management, etc., and
3. On-site consumption (light to heavy human use): biology education programs for all ages from gradeschools to adult ecotourists, hands-on research, recreation from hiking to populous sporting events, living centers for administrative personnel and visitors, roads and trails, etc.

The phenomenon of direct use: history and background

The direct human use of the conserved wildland (items 2 and 3 above) will cause some loss of biodiversity if the naturally occurring (i.e., non-human affected) patterns of species interactions and demographies are viewed (correctly) as part of an area's biodiversity. However, this "loss" is qualitatively different from the loss of biodiversity associated with the extinction of species or populations, since naturally occurring interactions and demographies generally reappear when the perturbing influence is removed. Massive habitat restoration in some tropical national parks is based on this concept (Janzen 1988b), and the process permits tolerance of many kinds of wear and tear. For example, rotating the impact of tourists among different parts of a park over the years depends entirely on the ability of animal and plant arrays to reconstitute themselves.

When we speak of paying a few percent of the biodiversity in order to generate the products that will insure conservation of the area into perpetuity, it matters whether we are speaking of irretrievable biodiversity loss (local extinction) or restorable biodiversity loss (biotic restoration following wear and tear). It is of interest that virtually all sustained-yield agroecosystems are the latter type. It is also of interest that restoration processes are temperature-dependent. For example, the effects of fine-scale forest clearing may require millenia to disappear in Canada but disappear within decades in the hot lowland tropics, yet be extremely slow to disappear from the top of a tropical mountain (e.g. Janzen 1973).

Any consideration of use of a wildland conserved for its biodiversity products quickly encounters the question of what is "natural". In the New World tropics, about 10,000 years ago a hunting society extinguished a major set of widespread new world large vertebrates, with subsequent dramatic changes in vegetation (Janzen and Martin 1982). This means that there is no vegetation in the neotropics that is undisturbed by man. To think otherwise is to label Amboseli National Park "undisturbed" after someone has shot all the large mammals and many others (small bovids, vultures, mongooses, civets, canids, cats) have consequently starved to death. It clarifies one's vision to recall that the horse evolved in the New World, went to the Old World on its own, was subsequently extinguished in the New World by humans, and then given back to us by the Spanish. The horse is a native member of the neotropical megafauna and it certainly belongs in some conserved wildlands – though to replace it requires simultaneous replacement of some predation in the form of selective castration and the occasional rifle shot. In the Old World, humans have obviously been part and parcel of natural biodiversity for millions of years.

Overall, one is forced to the subjective and arbitrary conclusion that we should attempt to save at least the amount of biodiversity that persists when human interference is roughly that characteristic of hunter/gatherer humans (or less). To be satisfied with less is simply to accept the omnipresence of the agricultural landscape that humans have become so adept at producing as their special way of surviving (Janzen 1984, 1990) and depriving society of most biodiversity products.

These considerations invariably lead to considering the conservation of tropical wildlands as an act of conserving the garden of genetic evolution and the basket of forces thought to keep a species what it is. However, this view does not match well with what we understand of evolutionary biology.

First, all indications are that, at least for large continental areas, the species present in a given conserved wildland arrived by migration and then underwent little genetic differentiation in response to their new environment. In effect, they arrived and they "ecologically fit" (Janzen 1985, 1986b), just as we have recently witnessed in the case of the African honey bee population introduced into Brazil. This unconventional view is demonstrated by the enormous number of species that retain their characteristic life forms, colors, behaviors, morphologies, etc. over a very wide variety of habitats and selection regimes throughout many degrees of latitude in the tropics. Evolutionary biology has quite understandably long been fascinated with genetic change and its causes, and has left us rather unprepared to deal with the obvious fact that there is an enormous amount of genetic stasis in nature, tropical and otherwise.

Second, the quickest way to promote speciation – otherwise known as the generation of biodiversity – is to produce small populations, each subject to a different set of directional selective forces. It is no accident that practically all the textbook examples of observable natural selection are on real or man-made islands. If we really wanted to promote neotropical tree biodiversity, for example, we would take a tree that is distributed from south Mexican semi-desert to Brazilian rainforest and chop the distribution up into many little bits, otherwise known as national parks, and let natural selection go to work. Examples such as this force us to consider which kinds and how much of biodiversity we really want. And that depends on the user community.

Consideration of what kind of biodiversity to save leads to yet more harrowing considerations. Yes, we simply have to live with whatever kind of species and selective regimes we generate by saving a patch here and a patch there of the once-expansive areas of tropical vegetation, and then subjecting these patches to global climate changes. However, there is another kind of biodiversity conservation over which we have more control. To return for a moment to the neotropical extinct megafauna, it is no secret that neotropical vertebrate biodiversity could be substantially raised by the introduction of a large array of species of wild vertebrates from the Old World tropics. The same undoubtedly applies to trees, insects, snakes, etc.

There is absolutely no *a priori* reason to assume that any given neotropical habitat is "full". What a given park contains today is in great part the result of which species have migrated there. While there are ecological processes that set the upper limits to species richness in any given habitat, immigration rate is one of the major parameters in these processes. The fact that a southeast Asian forest has ten species of squirrels and its ecological analogue in Costa Rica has three is not determined by some magically different ceiling to squirrel species diversity in each of the two geographic areas. The paucity of plant and parrot species in African rainforest as compared with species-rich neotropical rainforests is clearly historical rather than directly ecological.

Artificially elevating an immigration rate does not automatically result in the adjustment of other processes to where the total species richness stays constant. It is an easy prediction that the introduction of the neotropical agouti (*Dasyprocta punctata*, large seed-dispersing and seed-killing rodent; Hallwachs 1986) to Ugandan rainforest would probably not result in the extinction of other animals (or plants), just as there is no evidence or *a priori* reason to suspect that the introduction of free-living *Apis melifera* automatically removed a species of insect from each of the multitude of neotropical habitats it now occupies. But both introductions would increase biodiversity. In fact, it is easy to predict from solid ecological theory that the recent introduction of the screwworm fly into North Africa (Palca 1990) from the neotropics could substantially increase both plant and vertebrate biodiversity per habitat. On the other hand, the current widespread and wholesale introduction of neotropical trees into Africa for firewood, erosion control, timber, etc. has enormous potential for decreasing plant biodiversity in conserved wildlands.

Society has to decide very rapidly for what products its biodiversity is being conserved, because that in turn determines the actual on-site management decisions. Such a decision by society requires serious effort by the science sector as well as other sectors to identify, develop and publicize those potential products, production costs, feedback mechanisms from consumer to producer, etc.

The direct impact of users

The managers of tropical conserved wildlands desperately need field biology studies of the true impact, and associated resiliency processes, of various kinds of use of those wildlands. The information available today is mostly a serendipitous byproduct of esoteric research that was conducted by academics in search of behavioral, ecological, physiological, etc. understanding for its own sake. Explicit tropical management research such as what kinds of rat poison to use to protect Galapagos birds (Cruz and Cruz 1987), how to save Sri Lanka wild fish by translocation (Wikramanayake 1990) and what are the patterns of invasion of tropical abandoned pastures (Janzen 1988c), is poorly funded and scarce.

However, the byproducts of esoteric research do tell us that certain aspects of, for example, animal behavior can be extremely sensitive to humans. For example, ordinary footpaths used as rarely as one time per day may dramatically alter movement patterns and social behavior of medium-sized terrestrial mammals living within tens of meters of the paths (W. Hallwachs, personal communication). On the other hand, a large and healthy jaguar population may co-occur with stable and intense cattle ranching and many people, if the jaguars are not hunted or chased. Such species-specific idiosyncracies are commonplace. All of the adult mahogany trees may be logged out of a tropical forest, yet a century later there be a large and robust population of juveniles and new adults. On the other hand, the removal of a single species of inconspicuous seed-dispersing large rodent from a habitat may lead to the rapid extinction of a tree species that was dependent on the rodent for its seed dispersal (e.g. Hallwachs 1986; Putz et al. 1990) or for suppressing the density of its primary competitors through seed predation (Janzen 1970).

If a wildland manager is to rotate users through different habitats, so as to allow maximum human visitation yet minimal permanent or long-term damage to biodiversity, then much understanding of restoration and reconstitution of plant and animal arrays is needed. It may well be that controlled harvest of deer from a large area of a tropical national park that is undergoing restoration might be best for both conservation of biodiversity and for the neighboring society. The studies associated with such management decisions are long-term and iterative by nature, and are thus best built into the normal research program of the wildland's administration, and/or conducted by local research expertise. This is yet one more reason why the development of local science capacity is so critical for sustainable use of tropical wildlands. On the other hand, such management decisions are also often aided by the natural history and ecology studies of shorter-term duration conducted by academic researchers using the park as a large biological station.

The impact of use has two major components. First, there is the actual impact on organisms, as demonstrated by their reactions. Second, there is the impact on society's image of what is to be conserved. A beer can on the bottom of a pristine stream is far more offensive to the visitor than is the gallon of kerosene dumped out by the same visitor, but the impact on aquatic biodiversity is the opposite. A well designed cement or asphalt trail through a muddy rainforest may both lower the impact of herds of visitors on biodiversity, and yield visitors who are more willing to support that rainforest by payments and voting; however, such a man-made trail is anathema to some kinds of ecotourists. A carefully managed five-story hotel in the middle of a conserved wildland can be a horrendous eyesore, but have no more real impact on biodiversity than a carefully landscaped and inconspicuous parking lot. In fact, if the right kind of people come to enjoy the hotel, the park may suffer far less fire damage, boundary conflict, poaching, and pesticide drift than if the hotel had never been built in the first place. The art, of course, is to plan the location of the hotel so that the use benefits acrue to the park **and** there is no eyesore. Once again, we find ourself stressing that a conserved wildland must be designed as a whole organism, not as a collection of structures and concepts, each reflecting a battle lost or won with a given social threat over the past several decades. However, in order to avoid inventing a giraffe with an elephant's trunk, we have to have a clear vision of the ecological role of any given conserved wildland vis à vis its community of users.

Social conflict among the direct users of a conserved wildland is a very complex area of management. Researchers fight over who gets to do what to this or that plot; it is striking how the politeness and reserve necessary for survival in their home university departments are abandoned when they get to the frontier of the conserved wildland. Researchers disagree with ecotourists as to who gets to enjoy what; researchers have the habit of forgetting that they are just a subspecies of ecotourist. Ecotourists go to a conserved wildland to see wild biodiversity, not other ecotourists (sometimes). Administrators can easily forget that a transportation system designed around the desires and incomes of the park's neighbors can be easily used by the international tourist, but not vice versa. Children in a biology course may not even notice the (adult) ecotourists but be horrified if they see a researcher kill an experimental animal. A Costa Rican gold miner standing in the middle of a flowing stream of mud, that he had made from a once crystal clear river, remarked to me that he much preferred the national park over noisy and congested San Jose, and that he had been certain to never cut a tree or hunt a single animal. One is reminded of the president's staff making certain that the ambassadors of two warring countries never get invited to the same dinner party. I am left with the feeling that the most fertile ground for the recruitment of park administrators should be industrial psychologists.

The park administration as a user

The administration of a conserved wildland is in a contradictory situation. Almost by definition, the staff live in those parts of the nation that are most distant from "civilization" and often viewed as the least threatened by humans. But the staff collect firewood, divert streams for drinking water, wash in streams, clear areas to maintain livestock, run noisy generators, clear roads and trails for access, have dogs and cats, etc. These things are all done with the sense of abandon that is characteristic of frontiers – where wild biodiversity is a threat, not a sustainable resource. Furthermore, the miniature police state so characteristic of most parks during their early years adds to the impression that any impact by outsiders and anything done "in here" is justified by making life more pleasant for the guards in their backwoods situation.

It takes a gentle breed of highly political scientist to point out these things to an administration and gradually bring it around to abandoning what seemed to be such reasonable behavior. What has been, in my experience, most successful is to inform about the kinds of natural history that are disrupted by collecting firewood, dumping soap into streams, etc.

As a park administration gradually evolves into maintaining the wildland for its biodiversity products, it enters into the odd situation of doing many things that seem illogical for the protection of nature. It is critical that the staff have a good scientific understanding of why they do these things, or else they will get caught in a credibility gap between their own tasks and the users' view of biodiversity conservation. The public does not take lightly to the park administration arresting and penalizing the setter of a fire that burns into the park, while at the same time the park burns large areas to maintain a particular vegetation type or create large "blackline" fire breaks. It takes a special effort to educate the neighboring ranching public that cattle can be used as biotic mowing machines and seed dispersers (under certain circumstances) as part of the forest restoration process, while that very land was expropriated from a rancher for its conservation.

A conservation area should be quite capable of harvesting certain kinds of biodiversity products (seeds, animal parts, water, animals for reintroduction elsewhere, etc.). However, this harvest can easily create national and international conflicts when the same products are being protected elsewhere by absolute bans on their sale, transport, use, purchase, etc. Repeatedly the difficulties in wildland management are not the technology of the science and biology within the conserved area, but the complexity of interactions betweens the wildland and the surrounding society. There are many occasions when the only successful park will be one that spends more of the budget outside than inside the park (K. Miller, personal communication).

The payment for use

Humans pay for their use of an object in many kinds of currency. In the tropics, as elsewhere, the currency of concern ranges from a simple park-neighbor agreement not to use those pesticides that will later be washed into the park by rain, to direct payment to the park management budget for use of the water that flows from the park, to royalties paid to the nationwide park system by an international corporation in return for phytochemical information from park plants. The corporation called Costa Rica is paying its greenhouse maintenance bill with input from all levels of society. Simultaneously, society often asks what contribution the park makes to the overall health and development of the corporation.

I earlier suggested a list of products that are a conserved wildland's contribution. My concern here is to focus on the role of the scientist in improving the quality of these products to the user, with commentary on how this may be reflected in the willingness of the user to compensate the conserved wildland for its products.

The introduction of the conserved wildland into the marketplace implies the right on the part of the consumer to have a say in the nature of the products. Automobile-users do not passively receive Detroit's products, but rather generate an ocean of regulations about the behavior of these products. What does this imply for the community of scientists and administrators of conserved wildlands? Consider that a tropical mountain reclothed with ten species of trees, all introduced, may be just as effective in modulating a watershed as was that mountain with its original 300 species of biodiverse native trees. If that does not make one pensive, then perhaps this can be achieved by the realization that agricultural inviability is the best friend that tropical conservation has ever had (Janzen 1987). If there was a corn plant that grew well on tropical rainforest soils, we would not have any tropical rainforest to argue about today. And modern science is working overtime to produce such crop plants. We had better very soon come to recognize a conserved tropical wildland as simply another kind of crop, albeit with certain special needs for its cultivation.

Fees paid by on-site users

Many uses of a conserved wildland involve the direct and frequent presence of human visitors. They, like any visitor, arrive in search of something – photographs, peace, intellectual stretching, escape, exploration, novelty, self, companionship, etc. Almost all of these activities are enhanced by an increase in the accuracy, timeliness, appropriateness, etc. of on-site information flow. This requires more and better signs, trails, guidebooks, public lectures, teaching experiments, field trials, etc. For example, an enormous contribution to tropical conservation would be made by the invention of a method to make an indestructable field sign, quickly and cheaply with formal letters of many different sizes (and options for hand-drawn patterns). Even better would be if it was made from materials that can be purchased in a local hardware store.

The source of the park's information offered to visitors is the background of the scientist, the literature, on-site research, local knowledge, and the knowledge base that field scientists carry in their heads. For example, if a national park is going to offer a major program in biological literacy to neighborhood schoolchildren, and thus be paid back by the votes of those children in later life, the park has to have access to serious biological content to teach. Slogans and platitudes will not suffice. For many tropical national parks, providing detailed biological information to be packaged and offered to the voting visitor is a much more important function of in-park research than is "management" or "contribution to the world".

As a conserved wildland becomes part of the market economy, its users do become willing to pay the opportunity costs, legislation and direct cash for a conserved wildland. However, willingness to pay is quite directly related to the quality of the product that is encountered during a visit. However, a conserved wildland differs from the commercial world in one major respect. Traditionally, the salaries (and other rewards) for a park's staff are not linked in any direct way to the quality of the products that are generated by the park. A basic human motivation for quality performance has been removed. It is imperative that each conserved wildland, in the context of its own society's mores, find a way that individual quality initiative is rewarded, just as it is in the business world. There are diverse methods for direct and indirect financial compensation (merit pay, preferential access to houses and vehicles, help with dependents' schooling, allowing the profits to return to the park endowment and be used for improvement of that park's staff, etc.) but the responsibilities associated are also diverse. The price of merit pay is eternal evaluation.

A scientist can play a major role in the non-financial compensation process. The staff of a conserved wildland is constantly being trained upward in technical and philosophical ability. In most tropical rural societies, such training is associated with translocation to progressively more urbanized ("civilized") parts of society. However, the conserved wildland asks its well-trained employees to stay "out in the bush". Such a fate may be pleasant to the jaded international scientist in search of a few months tranquility in a national park, but it can be rural hell to the park staff. One solution is to bring civilization to the park. A major part of this is accomplished by better housing, better schools, better health, etc. provided by the overall administrative system. However, the scientist can also be a major contributor by participating in continuous adult education. Many scientists are walking universities. In a tropical national park these persons are surrounded by a populace not yet jaded by thousands of hours of TV specials, school science laboratories, music summer camps, language jubilees, etc. The scientist pays in time, energy and the effort required to become multilingual. The scientist is repaid through the conservation of the biodiversity on which his or her scientific career is based, through the conservation of the raw materials of biological science.

This is not the place to discuss the complexity of how to determine a fee scale for different users – the school child, the adult ecotourist, the researcher – or how those fees are best guided back into the park's maintenance costs. What should be stressed, however, is that field research by the international scientist can easily be big business. Costa Rica's system of conserved wildlands is, for example, really a network of enormous biological research stations. Today they have minimal logistic facilties, but they are growing fast. When an international researcher obtains an NSF grant for a half million dollars of field research over three years in those parks, that is a half million dollars worth of incoming foreign currency. Furthermore, a very substantial portion of that income will be spent in the neighborhood of the park. The overall park system of Costa Rica could easily accommodate $100 million/year worth of basic biology field research with no damage to its biodiversity. I am not capable of determining here what Costa Rica would actually have to pay in additional goods and services to bring in that amount of foreign currency, but much of the infrastructure is largely in place except for more within-park living and working buildings, some slight modification of existing legislation, and some time-consuming thought by INBio and the Sistema Nacional de Areas de Conservación (SINAC) as to how to best facilitate the process.

Payment for off-site environmental services

Throughout the tropics, environmental services provided deliberately or serendipitously by conserved wildlands are not explicitly charged to the consumer. Yes, some tiny fraction of a rice-grower's taxes may be used to help finance the montane national park that generates his irrigation water, but such a contribution to the park maintenance budget does not begin to approximate the market value of that water. The same applies to erosion control, local climate modification, wind protection, etc. The tropical conserved wildland would be well-advised to formalize its position in the market economy by moving as fast as possible into a social position whereby its environmental services are paid for in one form or another.

However, my focus here is not direct

environmental economics but rather to underline that the scientist can play a very central role in this marketplace. The scientists doing research within conserved wildlands are capable of being a large body of local experts on the potential impact of this or that management action on this or that environmental service that emanates from the park. Most, if not all, tropical national parks and their zone of influence are not serviced by a large university, government research branch, consulting firm, etc. that can be counted on to provide evaluations, be expert witness, draft management plans, etc. for the area neighboring the park. If the situation is correctly structured administratively, the scientist working within the park can even make a serious contribution with a minimum loss of time.

At this point an interesting conflict between the scientist, and especially the academic scientist, and the park administration appears. The administration that figures out how to resolve this apparent conflict will tap a major source of resources for the park administration and for the neighboring society. For a very large number of academic scientists, time is substantially more valuable than money, and success is measured by results rather than a paycheck. For many members of park staffs, time spent is money earned and success is measured by the size of the paycheck. For a scientist, a day in court is a day lost, while for park staff a day in court is a good meal in a good restaurant and perhaps a break in the monotony of park tasks. Somehow, scientists have to learn how to be less contemptuous of the park administration's need for basic needs, and the park administration less contemptuous of the scientist's tight time budget.

Payment for biodiversity information

Nearing the end of this essay, we open the largest can of worms. Without doubt the actual information in biodiverse tropical wildlands has the highest market value of any of its products, and the parataxonomist – apprentice curator – scientist – INBio chain is a major mechanism in putting it on the market (e.g. Eisner 1990). If every cup of coffee in the world had a two cent (US) tax on it, the income would pay all the world's basic tropical wildland conservation management bills forever. As it is, the only income for tropical conservation from that hot soup made from the ground-up seeds of an African rainforest understory shrub is that which is allocated to parks from national budgets of countries that grow coffee. Let me put it in a different format.

I know a tropical forest tree fruit that is extremely rich in antibiotics. However, this information cannot move into the processing system of a pharmaceutical company until Costa Rica's INBio has been able to arrange a royalty arrangement guaranteeing a signficant financial return to the greenhouse maintenance bill. The days of tropical green oil exploration and exploitation without payment of royalties to the host country are over.

The academic scientist, with associated collaborators, is both the solution and the problem. For nearly a century, the academic scientist has been supported in developed country universities on the premise that basic and applied research eventually repays the investment. The academic scientist in today's tropical universities are cut from the same cloth. The academic gains approval, benefits, salary, prestige, awards, etc. for the free, rapid and open flow of information into the greater social community – be it academic or business – through conversation and publication. Note that privately financed research institutes and laboratories have long increased a researcher's financial incentives while reducing the freedom to build personal prestige/value through free dissemination of research results. The files of major drug companies are replete with private information on plant analyses that academic researchers are unknowingly struggling to replicate. For two decades of my academic life, I never thought about the potential commercial use of any tropical biodiversity finding, and published as rapidly and as freely as possible. But discovering that the same receiving society had to be cajoled, wheedled, browbeaten and courted to extract even a tiny financial resource to save a large block of tropical biodiversity led to a quite rapid rethinking of the situation.

We could discuss whether the academic in the developed world is adequately reimbursed for the labor and love of science, but that is not where I feel redress is in order. There is a much greater imbalance. The developed world is just beginning to contribute to the budget for the maintenance of the enormous pools of tropical biodiversity information from which it has extracted information for centuries, and to which it is today turning even more strongly. Academic scientists are very much a key part of the extraction process. A developed-world scientist quite innocently submits a research proposal to the administration of a large tropical national park to study the location and species composition of nickel-accumulating plants throughout the park, with the stated intent of publication of the results in scientific journals. Quite innocently a conservation-minded ethnobotanist describes with glee how he "fooled" a rainforest shaman into divulging which plants are used to treat which ailments, with subsequent immediate glowing free distribution to the developed world's medical research community. Would the same enthusiasm greet a non-US electrical engineer describing to a US customs agent how he fooled a Silicon Valley technician into revealing the design of a new computer chip for free distribution to his country's computer industry? Do those who argue that the developed world's botanical gardens should be major facilitators of tropical phytochemical prospecting devote as much resource and mental energy to insuring that the source country and its wildlands receive a truly significant fraction of the profits from the development of the chemicals that are located?

Often, the academic researcher and backers respond to such questions by noting that the source country "was not doing anything with the biodiversity information" and therefore the finder can reasonably harvest at will. Well, let's see how far someone gets with that principle when he discovers oil in your backyard, oil that you neither knew was there nor were doing anything with. It is no secret that hundreds of thousands of valuable organisms are growing in a tropical country's greenhouses. The fact that we cannot (yet) read the books in these libraries does not lessen their value. Tropical biodiversity information indisputably has commercial value, but there is no system in place for the payment and fair distribution of the royalties. INBio is a pilot project with the intent to facilitate such a system, but there is much yet to be done.

How much does one charge for biodiversity information?

Biodiversity information is no different from all the other kinds of information in the marketplace – there is some that is very cheap and some that is very expensive. The answers center on "what the market will pay". Opportunity costs, research and development costs, inter-institutional espionage, company takeovers, price wars, stockholder pressure, interest income, risk evaluation on invested information, and all the other market processes apply. In other social sectors, information management and pricing is becoming every day a larger part of life. The pricing of tropical biodiversity information will undoubtedly borrow ideas and methodologies from other sectors, and offer some insights of its own. Pricing (and/or patenting) country-specific biodiversity information about a particular plant perfume from a particular rainforest will be quite different from the equitable distribution of new orange tree genes, a decision that will affect the health of literally billions of tropical rural residents.

But however biodiversity information is priced, the tropical academic scientist studying biodiversity walks a fine line between being, on the one hand, unexpectedly and unconsciously an industrial spy and on the other hand, being the source of life-giving economic and social support for the conservation of tropical wildland biodiversity.

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