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The relationship of basic research to the development of the technologies that will sustain tropical forest resources.

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INTRODUCTION

At the outset, several definitions are in order. A forest resource as used herein is natural forested vegetation or forested vegetation derived from a natural forest; it explicitly excludes pastures cleaned of forest, croplands, and planted tree plantations (which are, in fact, nothing more than croplands with greater-than-annual harvest cycles). This is not to say that the biology of forest resources is inapplicable to the above kinds of managed vegetation, but rather to say that my focused concern is not on them; I am not a designer of agricultural lands or of tree plantations, and do not intend to become one. Throughout the remainder of this essay, a forest resource will be simply termed a 'forest'. I should note, however, that a forest may contain up to rather substantial areas of low and/or herbaceous vegetation (marshes, grasslands, early succession following landslides or land use by humans, fires and tree falls, and edaphically tree-free soil). A tropical forest is one between the Tropics of Cancer and Capricorn, and ranges from extremely deciduous scrub and desert to water-logged rainforest, from sea level to alpine dwarf cloud forest.

A sustained forest resource is one that is still present in essentially the same form after tens to hundreds of years of whatever use is planned and carried out. Cutting a natural dipterocarp forest in Malaysia and replacing it with a dipterocarp or eucalyptus plantation is explicitly not sustaining a forest resource as the term is used here. Clearing the Brazilian rainforest and replacing it with a pasture sward that is just as high quality in soil preservation and prevention of water runoff as was the original forest is not sustaining a forest resource. Practicing shelterwood timber harvest in a Nigerian forest in such a manner that 50 years later one can hardly tell that the timbering operation was ever there, is sustaining a

forest resource. True shifting cultivation is sustaining a forest resource. Harvesting agoutis, pacas, capybaras and peccaries from a northern South American rainforest under such a regime that their density approximates that of the natural situation can be sustaining a forest resource.

I am an ecologist. All of my experience dictates that if I am to understand the forces operating to produce a given pattern in nature (and keep it at that pattern), I cannot afford to restrict my understanding to any particular taxon or class of forces. Therefore the background for my essay will range from the production practices of USA furniture manufacture to the fitness of tropical colonists to seed defecation. An essay is a linear format; ecology is a network. Some things will not be clear until we have moved quite some distance.

The baseline needs for sustained forests

If you put me in charge of maintaining this or that tropical forest on a sustained basis, what basic information do I need?. It is, after all, this basic information that we all seem to be concerned is not being produced or flowing to the manager, if it is being produced. We have arrived at core question number one. What is the harvest from this sustained forest to be? I will develop my answer around two quite different classes of harvest.

Product 1. A living museum in perpetuity from which only a) information on how living systems work, b) stocks (animal and plant) for colonization outside of the forest, and c) aesthetic experience, will be harvested. The aesthetic product is not trivial, as I will develop later in this essay.

To maintain any particular living museum (once its existence has been firmly established as a geographic entity) requires little direct basic research. Living museums take care of themselves, if they are truly allowed to do so. However, if a part of the idea of a particular living museum

is the maintenance of a particular state of succession or an exceptional density of some particular animal or plant of great interest, the manager of the museum will have to get some rather direct basic information feedback from researchers working in the museum; normally, this is provided through 'applied basic research' and even with differences of opinion among researchers, is a problem of small moment. However, it should be added that such a management scheme may well throw the museum from the category of product 1 to product 2 (see below).

The management of living museums encounters a much larger problem in the question of how to maintain it while extracting information about it, while allowing full aesthetic use, and while allowing extraction of breeding or other kinds of experimental stocks, without doing long-lasting damage. In one sentence, this is an area for common sense that is fine-tuned by local knowledge of the particular organisms, behavior of tourists and classes of damage expected from researchers. It is clear that the way to maximize basic information flow from the researcher to the user (museum manager, visitor, world at large) is to aggressively take that information and put it where it belongs. Specific ways to do this will be suggested in a later section of this essay.

However, as I see it, the most critical, difficult and pressing aspect of basic information flow from the living museum to the manager for sustained yield is the most indirect. The public is manager and consumer. It is imperative that the existence of living museums become as integral a part of public consciousness as are telephones, public transportation, schools, markets, medical services, musical events, news services and all those other parts of society that in fact are not indispensible but we have come to think of as indispensible. Such a view carries a clear message.

The way to apply basic research to sustained yield of living museums is to program the society in which that living museum is imbedded as to what is in the museum. In one sentence, the society deprived of living museums is as deprived as would be a society in which absolutely no musical activity could be known or carried out. However, for virtually all tropical countries, the society-wide level of sophistication on the content of living museums is to what it could be as a 5 second TV ad jingle is to all the music that humans have created in the past 7,000 years. Lest extra-tropical societies get puffed out of proportion, they are at the level of tune 40 on the top 40 hit parade in February.

What then are the more conspicuous and high-yield avenues to the thorough implantation of living museums in the consciousness of tropical societies? I dwell on these not only for their applicability here, but because they are quite applicable to the second portion of this essay as well. I do not dwell on their practicality; while a given point may be quite impractical or inappropriate for the tropical country with which you are most familiar, it is quite applicable to some other site. They are not ordered in any particular ranking.

a) From grade 1, make guided and structured school use of the living museums as integral a part of curricula as one expects for reading, mathematics, mechanical arts, physical education, etc. Get at least a part of school biology away from the pickled frog and back into the forest litter. A living museum is an incredibly resilient organism-rich laboratory for everything from the aesthetics and physics of color to competition theory for cropland planting density and market economics. There are two essentials. i) Living museums have to be large enough and cleverly enough managed such that they

can withstand and rebound from the impact of school groups. ii) Funds must be found for 'remedial' instruction for gradeschool teachers; it is their very lack of competence in this area that has led to the production of the current generation of tropical peoples, which are without doubt substantially less sophisticated biologically than were their grandparents (the same applies to the medical knowledge of the person on the street). b) Explicitly move the knowledge already in hand and being gained every day into lay person adult education facilities. Adults of this generation are particularly susceptible. They can still remember some of the urban nature that still existed in their childhood (or that of their parents). Their generation was not entirely reared on human artifactual complexity. They are somewhat bored with the humdrum nature of day to day living. They are at least partly satiated with or have completed courtship displays. They are concerned with the education of their own children. They have learned their way into other complex art forms.

The avenues are evident: a daily or weekly column on nature or the National Parks in the principle (newspaper(s); a weekly or monthly photograph-rich lecture (as in Saturday evening at the concert) for a nominal fee (or free, depending on advertising psychology of the region) on the biology in one of the country's living museums (geographic location(s) of such shows depends on location of population centers); weekend government subsidized public transportation tours (or outings) from population centers to living museums; weekly prime time TV programs as a public service by the major channels here, films and programs on living museums in other countries (and their problems) are especially important; explicit development of the museum to maximize ease of use and education by visitors (coupled with appropriate controls and area size to prevent destruction by use).

Where funds and man-hours should be placed in the above is self-evident. The larger problem is personnel and getting funds for their training. In addition to the expected hiring of civil service personnel, there is a minor and major source of human resource. First, the US Peace Corps could be used much more extensively and effectively in this context. For a variety of reasons that I won't take space here to dwell on, PC volunteers are much more likely to be successful in this area than they have been in many of the more traditional slots into which they are plugged; I might add that there is here also a conspicuous place for what might be termed a 'senior citizens' living museum Peace Corps.

But the largest source of both information and man-hours can and should be the researchers themselves working in the living museums. Their country of origin is irrelevant. The core problem is time (to a perhaps trivial extent, money as well). A person cannot spend 16 hours a day for a month monitoring the fate of seeds of a tropical rainforest tree and simultaneously guide a group of adults through a forest, write a nature column for the newspaper, and give monthly nature concerts in the National Theater. Even if she wants to. This is where the big money comes in. We need a cadre of persons who embody the essential traits of a medical technician-New York Times science writer-Park Naturalist. There is no school or institute that can produce such a professional. There is, however, a very clear means for producing such people (following in the tradition of 'paramedic', 'paralegal', perhaps they could be called 'biocasters'). A person with a modicum of biological background (high school level might well be adequate) is simply assigned to a cluster of scientists working in a living museum (or set of them) and that person spends his days observing what is happening, talking to him about what is happening, reading his literature, hanging around with

his students, attending his lectures (if any be), and explaining to the scientist what he has come to understand of what he is doing and finding out. His job is explicitly not to be a research associate or assistant to the scientist. His job is to aggressively convey what is happening to the audience which by and large consists of the populace in which the living museums are imbedded. While his messages might well be aired outside the country of origin, such airing would be a goal only in exceptional circumstances. Another aspect of his job is to maximize exposure of the scientists in his harem to his audience with relatively minor, or mutually agreeable, distraction from the work itself; there may well be occasions when impact would be greatly increased by the scientist himself guiding an audience through a subject or forest (e.g., when the President of the country visits the forest).

There are two costs of such a program. First, there is the actual salary and other expenses of the person. Second, there should be a small fund easily tapped for visual aids and other similar devices produced by the system (e.g., a set of kodachrome slide duplicates of the researcher's research slides that can then be used freely for public lectures, a professional translation for public dissemination of an exceptionally valuable piece of literature about a living museum in some quite different part of the tropics, start-up money to pay for the publishing of a pamphlet that will eventually pay for itself through sales at tourist centers).

c) Explicitly move the knowledge at hand and being gained daily into the pool of available knowledge guiding actions in management of areas producing the second kind of product (see below) and into management of standard crop lands (though applicability will often be minimal here. It is obvious that the 'biocasters' described above are a potentially major pipeline of this information flow, but there are others as will be mentioned

later. I view it largely the responsibility of those gaining a market product from a wildland forest or a cropland to be aggressive seekers of information obtained from living museums.

Product 2. A relatively wildland forest from which there is a sustained yield of timber, meat, fruits and nuts, drugs or some other explicit products. While such a forest may in part provide a variety of things provided by a living museum, these things are largely byproducts rather than the prime justification for not converting the wildland to cropland.

At the outset, I have to make explicit a harsh reality of sustained yields from tropical wildlands. They are almost always, if not always, incompatible with the 10-20 year investment-return schemes view as appropriate to small scale ownership where annual returns are determined largely by the degree of activity of the owner. Stop looking for the formula that will turn base metal into gold. Whether a large operation is organized or run by a government or other form of corporation does not concern me here; what is essential to grasp is that the persons involved with harvest and other decisions will be largely if not entirely salaried and guided by a plan based on decisions of as long or longer term than the working life-span of the persons involved. Not only does the management plan have to be based on long-term processes, but the desired product must also be in demand for a long period. If you design a wildland forest for sustained yield of wild game (meat and hides) and then allow a cultural change to heavy preference for lamb and beef, the scheme will fail, no matter how good your biology.

The golden rules of wildland sustained harvest are i) be crystal clear as to the product desired, ii) have unambiguous control (ownership) over

the use of the area, iii) know the pragmatic biology/ecology of the key organisms, iv) educate your market, and v) understand that the direct yield per area per year will be low. Sustained yield tropical wildland systems are designed for humanity, not for individuals. Probably the largest single barrier to sustained yield wildland development in the tropics is that the boundaries and population sizes of must tropical countries were not determined by the natural carrying capacity and rules for resource harvest of that habitat, but rather by political/economic forces from outside the tropics dividing up an exploitable resource. For example, it is quite absurd to speak of designing much other than trivial wildland harvest schemes for individual tropical countries the size of those dotted down the Central American isthmus; a high quality tropical shelterwood timbering scheme (see below) might require as much as half the area of Costa Rica. On the other hand, were the established croplands of El Salvador, Nicaragua and dry-land Costa Rica and Panama to be organized as a produce-oriented farming system and the remaining forests of Honduras, Nicaragua, Panama and Costa Rica turned to various kinds of sustained yield forest ecosystems, there would probably be enough resource harvest to sustain the populations of El Salvador to Panama at the level to which they aspire.

Perhaps a sixth rule should be added. There can be no sacred cows. Or if there is one, then it better be the produce desired. We heard about cultural control of pests. Then there was chemical control, biological control, supervised control, etc. And then the blinding light of "integrated control" - lo and behold, all the different methods were applied in concert. What a revolutionary thought. The only thing that got left out was "psychological control" - convincing the consumer that control wasn't even necessary in some cases, because all that was being controlled was the cosmetics of the

ear of corn, apple, etc. The same applies to wildland sustained yield. If capybaras are the best kinds of cows for certain floodplain tropical swamp forests, then perhaps the most important research of all is market effort to where capybara sirloin is top cut.

To return briefly to our original question, given we are confronted with a large wildland destined perhaps for sustained yield harvest, where is the contemporary impediment to the flow of basic research to management of that wildland? There are numerous answers.

a) There is no impediment, for many products and many of the wildlands of the tropics. The impediment is the society that raises its infantile screams for more now when the more is far more than any wildland can produce. Part of the story in converting the screams to more intelligible growls is contained in my discussion above of product 1.

b) The products that can be (or must be) produced by wildland vegetation are not in high demand (compared with cash crops for purchase of guns, gasoline and gifts). Costa Rica has harvested its national crop of accessible cocobola trees (Dalbergia retusa) between 1966 and 1980; the members of that cohort were 100-300 years of age. Cocobola does not regenerate in pastures, croplands and fencerows; to grow it as a plantation tree or as a member of a sustained yield timber scheme would be very simple given i) our collective knowledge of isolated surviving seed trees, ii) our collective knowledge of its seedling and sapling requirements, and iii) 1-2 years of field trials to clear up a few minor gaps in knowledge. However, there will be no supply of cocobola 100-300+ years from now in Costa Rica for the very simple reason that there is no administrative program, governmental or private, that makes either the cash or administrative commitment to establishing either plantations or wildland yield sites for cocobola. The

extinction of cocobola from the Costa Rican countryside (90% complete at present) and the elimination of it as a timber option is not due to technical failure. The same applies to virtually every other species of widely used timber tree in Costa Rica.

c) The information is contained in libraries, researchers' heads, government reports, experiment station files, and common sense. However, it is not being tapped, pooled, collated and dispersed to the active sites of decision making. There are multiple causes of this failure.

i) There is no paid body of professional international civil servants whose explicit task it is to do as suggested for the more local 'biocasters' described under product 1.

ii) There is a general failure to appreciate that the general problems are the same the tropics (and the world) over and therefore there is a failure to work collectively on them. It is the local details that vary from site to site (though it is important to note that the difference between agriculture in lowland wet Colombia and lowland wet India is substantially less than the difference between agriculture in Montana dry land wheat farming and Georgia cotton farming). A worker in Sri Lanka has an enormous amount to gain from a visit to a Brazilian experiment station or successful productive scheme. This is probably the place to point out that we have been long hampered by the false platitude that temperate zone agricultural methods cannot be applied to the tropics, and that what is wrong with agriculture in the tropics is the attempted transfer. South Carolina agriculture doesn't work in California either; the problem is not latitudinal disjunction but rather simply human convenience and stupidity in failing to fine-tune an agriculture to the local habitat and market, irrespective of the region.

Agro information also does not flow laterally within the tropics as a special case of the general phenomenon that lateral information flow (and its pre-condition, information storage) is very poorly developed in the tropics (a moment's reflection on the history of the establishment of what are called tropical 'countries' makes it evident why this is the case).

iii) Much of this information is worthless, even as 'basic' research. It was gathered by incompetent technicians following outdated or incompetently transcribed recipes, and cannot even be re-examined because the habitats in which it was gathered have long since been destroyed. It is also often conceptually worthless because it was 'make-work' generated to satisfy an employer. It is often worthless because it was gathered about a specific circumstance which no longer exists, either here or abroad (and the specific circumstance was often one generated by the experiment station or agricultural event and bears little or no resemblance to comtemporary situations). Finally, it is often worthless because there is no one who understands enough biology of the current problem to be able to extract from it what might be of value.

iv) Many project managers or designers realize that the peculiar situation in which they find themselves can be elucidated only with information gathered now about the particular problem at hand. Information from other sites and projects gives them ideas about how to proceed, but there is no substitute for the local experiment aimed at obtaining fine tuning information. It is here, perhaps, that the tropics differs enormously from extra tropical zones (and may come to do so even more) because of the much greater diversity of crop types and products that can occur in tropical agroecosystems.

v) There is little incentive for doing a good job in designing or managing a given project; the pay is low and the rewards few. The reason for this is in great part that the produce is for a foreign market; the manager

is pushed even further from his consumer and therefore deprived of all the possible personal incentive systems. I am reminded of the situation of the Costa Rican experiment station director where all the station's efforts are going into sugar cane in a province entirely clothed with cattle ranchers because the government wants the external cash that sugar provides.

d) The information has never been generated. There is a negative feedback loop here; with little or no information about the kinds of products that sustained yield tropical wildlands can produce, there is little call for their establishment (and therefore little need for basic information to aid in establishment).

Certainly basic research has a huge serendipity aspect, but there are three ways to increase the number of happy serendipitous discoveries that are of relevance to sustained yield wildlands. Increase the amount of biological research conducted overall in all kinds of tropical field circumstances, set up financial and other resource inducements to encourage researchers to focus their activities on a relatively small subset of the totally available habitat types and locations, and embark on a crash program for the production of people whose profession it is to find out what is being found out and convey that information to both other researchers and management/planners of wildland harvest systems.

Examples

At this time, it seems appropriate to turn to two examples that for me illustrate many of the more general points mentioned above. It should be clear that in both cases, basic research is needed and appropriate for fine tuning in specific cases, but lack of it is not the source of the problem(s) nor what is preventing establishment of the two systems.

Slash and burn agriculture

Native tropical peoples did our research for us; when their experiments failed, they paid with lives rather than dejected reports to the National Science Foundation. What the village discovered was that you can get away with making a large mimic of a tree fall in a tropical forest, planting it for a year or two with annual crops, and then moving on to a quite different patch for the next year's crop, and so on, as long as you don't go back to the first site for 50-100 years. It is (was) called shifting agriculture, and was characterized by both cutting and burning a patch of the forest during the dry season before the rainy season in which the planting was to be done. And it worked from the driest sites to wettest, from sea level to 2000+ meters elevation, on many soil types. It destroyed neither species nor habitats (though it surely altered the densities of many species, and added a habitat that was a newcomer on an evolutionary time scale). And it worked for a low density of people, controlling their own destiny.

What is today called 'slash and burn agriculture' is not what I described above. If you take what I have described above and add livestock, foreign markets, single family unit control and investment regimes, you have forest elimination by slash and burn agriculture. And you have sustained yield after the system has oscillated to an asymptote of about 1 head of cattle per 5-30 ha. If the question is what kind of research is needed to double the yield in cattle, I defer the question as I am uninterested. If the question is what kind of research is needed to maintain the original slash and burn agriculture as described in my first paragraph - i.e., a sustained yield forest herbaceous crop agriculture system based on a collective social system - then the following seems self-evident (who or what institutions should conduct the research is also self-evident):

1) A social adminstration must be developed that provides normal educational, social, medical, etc. opportunities for people living the kind of locally nomadic life required of true slash and burn agriculture (The Trans-Amazonian highway provides the best anti-example going).

2) A marketing administration must be developed that integrates the appropriate crops with the realities of the best forest-field rotation cycle for that site.

3) A basic research program must be established which

a) uses the ongoing farming as a giant experiment,

b) determines ways to improve the return of a field to forest,

c) determines the pattern of local heterogeneity required in fallow times (some forest types may require as little as 50 years before being returned to field, others as much as 200 years),

d) determines the kinds of crops to grow that permit optimal return to forest when the field is abandoned,

e) determines the kinds of meat-animal encouragements appropriate to integration of wild or domestic livestock with the fallow and field edges without deflecting the forest return, and

f) integrates the above with at a minimum a timber and drug plant harvest system from forest being cleared for a fields. This research program is also "applied" in emphasis, though not totally directed at products of known properties.

4) Such a system must be imbedded in a political system that allows, aids and subsidizes (at least at the beginning) such an operation on a long-term basis. Without that, forget it and go to cattle pasture (or bananas).

There are clearly places in the above recipe where information from basic

research on tropical forests is relevant, needed and lacking. Which kinds of forest tree seedlings should not be weeded out of the crops and which should be? Which forest animals should be allowed to forage in the fields and which should be excluded? Should single trees be left standing in fields to encourage seed-dispersing birds to fly across fields (and thereby defecate seeds in them)? What kinds of forest tree stumps should be left living in the field as a reservoir of mycorrhizal fungi for new forest tree seedlings? Should fields be squares, strips, circles or some other optimal shape to maximize their return to forest? What time of the dry season gives both the best burn and the least death to forest tree sapling stumps? Can forest trees be seeded in by hand? How much forest game can be removed from field edges without depleting the populations to where they are in danger of extinction through natural causes? Is the forest a reservoir of pest insects or a barrier to their movement between crops, or both? What is a reasonable linear distance between successive fields cut out of the forest? None of these questions will be answered directly through basic research in tropical forests, but all can be partly answered through such research and in all cases, the essential applied research program can be planned with many fewer errors and at lower cost by someone quite familiar with the ecology and biology of the particular kind of forest through the basic research that has been performed in it.

It is likewise clear that while sound biology is a prerequisite for the survival of such a recipe (and the people dependent on it), that is certainly not sufficient. A moment's glance at the Trans-Amazonian Highway experience, the colonization of Malaya by western agriculture and the disintegration of much of the once-successful rainforest farming of western Africa makes it clear that social processes are a far larger barrier than are the lack of biological information. However, it should also be added that once the

social system gets itself straightened out, the biological problems will become proportionately much greater. The simple lack of a correct identification of a leaf-eating beetle may turn out to be as large an albatross as is contemporary manipulation of agricultural population centers for political gain.

Shelterwood logging

Confronted with large expanses of species-rich west African tropical forests and a large European market for tropical hardwoods, British foresters between about 1910 and 1970 made liars out of the people who would like to maintain that tropical species-rich forests cannot be lumbered and simultaneously maintained. The process is simple and based on an understanding of forest dynamics. Over an area of several hundred square miles a number of small areas were logged on any one year. Logging activities at any one area lasted five years and consisted of the following steps. Year 1: a square mile was mapped with respect to the trees approximating merchantable size; each tree was identified and given a unique identification number; the list of trees was submitted to the forestry department and its foresters designated which individuals were to be cut (and billed to the lumber company); decisions were based on attempts to a) upgrade the species composition of the forest, b) remove large trees before they senesced, and c) remove trees at wide enough intervals in the forest such that their combined loss did not amount to more than a series of widely spaced 'natural' tree falls. Year 2: specific trees were cut in such a manner as to not topple other trees, and snaked out on cables or very narrow roads; each log retained its identification number; logs were trucked to a riverside depot and mixed with hundreds of logs of about 90 species from other such sites. Year 3 and 5: the site of logging was returned to and early succession species of trees and large vines manually

removed by poisoning, cutting or barking. The site was returned to for a repeat performance after 50 years. At the riverside log yard, rafts of one or a few species of logs were put together, and these were floated down stream to the mill, where they were stored underwater to prevent insect damage. On a given day, the saws were set to a particular wood property, and logs of that species were fished out of the pond for that mill run. This mill (African Timber and Plywood Company, at Sapele, coastal Nigeria) ran entirely on steam generated from burning wood waste, and its other products came from the same source (e.g., glue for plywood); its dependency was on the outside world for market and machinery. It supplied something on the order of 1/3 to 1/2 of the tropical hardwood consumption of Europe when in full operation. The cutting system dated to about 1920-1930. It was on its second cutting cycle when Nigeria shifted to wholesale clear-cutting of its rainforest to obtain ready cash for arms purchase on foreign markets.

Such a system generated a steady supply of high quality timber and plywood from a rainforest that was, to my eye, essentially intact after 20-40 years of regeneration. The art was to eliminate much of the early secondary succession in the artificial tree falls. The requirement was absolute forest use control, technically proficient labor (dropping a 10 ton rainforest tree exactly where you want it requires more than a chainsaw), and a market that has the versatility to absorb a species-rich timber line. None of these traits apply to neotropical rainforest timbering and North American markets.

There are many ways a system such as this would have to be adjusted to match the circumstances of a particular tropical habitat in Costa Rica, Brazil, Cameroon or Indonesia. However, it is evident that the largest adjustments would be in the social sphere, not the biological. On the other

hand

the basic biological thread running through such a system is understanding the natural history and ecology of the tree species involved; without this, the system will founder just as fast as was brought on by a change in Nigerian cash flow. It might well be that clearing patches of a monospecific lowland rainforest (e.g., as occur in many swampy lowland sites) would work as well as the more select method in shelterwood logging. Likewise, when integrating a system such as shelterwood logging with true rotational shifting agriculture, the profit from a small harvest of logs from a new field might well pay for a) the access road that would later get the crop out and b) the fertilizer loss when these logs were not burned, if the crop patches were small enough that they readily reseeded from adjacent standing trees and if a market infrastructure existed to dispose of the variety of log species that would be produced when the logs from many different fields were pooled.

Administrative assignment

Why are improvements in basic research a necessary prerequisite for adequate development of technologies to sustain tropical forest resources? This is the style of question posed by systems-planners and has been put to us.

Answers

1) Without basic research on tropical forests, you don't even know what they contain, and therefore can hardly even plan, much less carry out, a program for their sustained use. "What they contain" applies not only to the names of the beasts which are (just identification tags giving access to information on them gathered at other sites) but their biological properties as well. That is to say, you cannot develop sustained drug plant harvest for piece of forest without knowing what drug plants occur in

the forest, or which of the forest plants are potential drug plants.

2) Without basic research on tropical forests, you cannot know what forces exist that should be subjects of applied research for fine-tuning the anticipated system of sustained yield. It is a basic research project on forest seed biology that will tell the applied planner such things as

a) leave trees in open fields as a way of maximizing bird and bat dispersed seed rain into the field,

b) if fields are cut out of primary rainforest near old fallow fields rich in second growth species, there is likely to be a heavy soil seed bank of second growth species, whereas if there is not such an old field nearby, the opposite is likely to be true,

c) large apparently healthy trees left in fencerows and shelterbelts will both die of exposure and fail to reproduce because their seeds will either lack appropriate dispersal agents or because their seedlings will have to germinate in habitats too exposed to desiccation, fire, wind, etc.,

d) many species of canopy-member rainforest trees start out in the hole left by a tree fall, rather than in the shade and gradually grow into the canopy,

e) the value of a vertebrate as a seed dispersal agent is dependent on exactly where it puts the seeds, not just how mnay seeds it kills by consumption or by how many seeds it removes from the parent tree,

f) while one species of dispersal agent may retain a seed for 2-10 days internally, another species may hold the seed for as long as two months, etc.

I could go on indefinitely with such examples, but the main point is that researchers already know enough to rough out the outlines of sustained use. Furthermore, it is quite evident that traditional "basic research" becomes

philosophically and pragmatically synonymous with "applied research"; the questions both areas are interested in become almost identical in such activities. I want to know what is the fate of the seeds found by agoutis you want to know if shooting agoutis will depress seed dispersal or seeding survival of major timber trees.

3) Basic research occurs throughout the tropics on a nearly infinite variety of habitats and from a nearly infinite variety of viewpoints. However, the total amount is still at such a low level that there is virtually no overlap and there are many areas going untouched. Basic research in tropical biology is so short of people that you can start virtually any study that comes to mind without the fear or hope that someone else is already working on it. If work were being done in all possible areas and an effective information-flow infra-structure existed, the applied planner/manager would have an enormous variety of options and examples from which to draw inspiration and plans for use in the particular habitat with which he is entrusted. Certainly the applied research under his own control will answer some of his problems, but it is not reasonable to expect him to have the resources at hand represented by the body of basic researchers at large.

4) Basic research has a tendency to be long-term in overall scope. It develops potential answers on things that the applied manager must make decisions on but cannot afford to wait 20 years for an applied study to dictate. If he wants to know how many years before a grazed cattle pasture will become forest if the fire and cattle are removed, he cannot afford the 10-20 year study to find out. However, if a basic researcher has already done it as spin-off from a succession study, the answer is already in hand when the manager needs it.

But the most appropriate answer of all is that tropical forest resources are no different than any other industry. How far would any of our major

industries be without the wedding of basic and applied research that we take for granted? There is no answer to the question that is peculiar to the tropics, except that most of the tropics is a museum or library with no card catalogue, no call numbers, no labels and no chart of atomic weights. It is simply silly to try to develop an industry on a resource when you don't even know what it is. And in a very certain real sense, what is being termed "basic research" in this essay is not; it is applied. It is applied toward figuring out how to use tropical forests before all of them are turned into newsprint, ash and babies.

But it should also be emphasized that improvements in basic research are not a prerequisite for adequate development of technologies to sustain tropical forest resources. They do and can go side by side. We know quite enough already to design high quality sustained yield systems in tropical forests, from wild game ranching in eastern Africa to shelterwood forestry in the wet lowland tropics to integration of slash and burn agriculture with forest preservations (send the God damned cows back to managed grasslands). It's not for want of basic research that the living museums of the world are not being used.

Why has the present quantity and quality of basic research been inadequate to support the pace and scale of technology development needed to sustain tropical forest and woodland resources? This question has been put to me. It is a stupid question. "Needed" by whom? What "pace" and "scale"? Forest resources in the tropics are not being sustained because it is to the advantage of their owners to cut them down, to convert them to liquid assets. You can do all the basic and applied research that you chose on a Malaysian dipterocarp forest, but on the short term it will still be vastly more profitable to cut it down and sell the logs than any kind of use

that will leave it, or a fragment of it, standing. This question brings to mind the classic misunderstanding so widespread in the developed world. The developed world still continues to maintain the childlike and highly self-serving faith that the tropics cuts down its forests because 1) "it doesn't know any better" and 2) "it hasn't done enough research to know how to use them on a long term basis". It cuts down its forests because we buy the timber standing on them and the cattle that are grown on the fallow fields, and it does not use them on a long term basis because we have done everything within our power to keep their economies on a short-term basis for the very simple reason that this produces the kinds of market and raw materials which is most advantageous to us on the world market.

Now, were the world climate to change toward one of fostering social systems that could comfortably house tropical forest and woodland sustained-yield resources, would basic research as we now know it be adequate in scale and pace? Most decidedly not. If Panama decided to put 10% of its land surface into material goods sustained yield forest output, how could we possibly advise her on the best options? We hardly even know what is in her forests, much less what biological properties they have that might be of direct use. Why is this? Here is the place for a litany of reasons why so little basic field research is done in the tropics, reasons that are obvious to all and so I will only very briefly list them as memory cues.

1) Tropical social systems do not reward basic biological (and related) studies in the field; most of the culture is copied or imported and that which glitters most gets copied most.

2) Tropical applied biologists, who might do basic research as a hobby or on the side (as is commonplace in developed countries), are generally

sufficiently poorly trained (when indigenous) or poor achievers (when expatriots) that they do not informally contribute to this pool of knowledge.

3) The educated class in most tropical countries is only one to a few generations removed from rural life that lacks the comforts of the urban habitat of the well trained. For such people, field work is hardship duty, and certainly not the area to which they turn naturally for inspiration and new areas of endeavor. This results in a disproportionately small number of biologists in tropical countries being interested in field work.

4) Associated with 3) above, medium-educated persons in tropical countries virtually never become proficient amateurs in some area of field biology; even if they had a personal proclivity for it, social pressures and lack of any formal reinforcements kill it dead.

5) Persons from a tropical country who obtain higher degrees outside and then return, are either baited out of productivity by a social system that does not reward it, or are drained off into administrative posts in a futile effort to bolster the system.

6) Outsiders that come to a tropical country to do research generally stay only a short time, conduct fragmentary studies, publish in journals and languages that foster their own fitness, are often academic dropouts or other kinds of intellectual failures, do a sloppy job because they are just beginning (dissertation studies especially), and are treated as a financial or prestige resource rather than an academic or factual resource by the members of the host country. Alternatively, if they truly intellectually or physically immigrate to the host country, they cut themselves off from research funds, peer pressure to do a good job, society pressure to do any job, stable resources for preservation and manipulation of data and specimens, relatives, familiar

social terrain, etc.

7) For the outsider going to a tropical country to do field research, it is generally more expensive in cash and mental energy than working in the vicinity of one's own university or in one's own country. For nationals doing field research, funds are usually in short supply for basic research (and salaries so low) that even a short field trip quickly becomes prohibitively expensive. It is relatively much cheaper for me to work for a month in a Costa Rican National Park than for a Costa Rican to do so, even if he lives only a few hours drive from the park.

8) Developing countries are so busy developing that they put little value on activities that do not appear to generate direct results; the outcome is that bright young people that might well end up in basic research in a developed country end up in applied activities in a tropical country.

9) In most tropical countries, the forested terrain in which one can do basic research with any hope of long term stability of site, study plots, etc. is often maximally inaccessible; it is this way because its inaccessibility is a prime reason why it is still available to be studied.

10) In many tropical countries there is no system of national parks, biological field stations, or other similar field research facilities available for a person wishing to do basic field research (to say nothing of the absence of the basic facilities found at any U.S. university to support basic research).

11) There is no established tradition of basic biological studies and working (living) examples onto which one can add new material and after which a beginner can model. It is one thing to do a 2 year study of the moth species in a tropical forest; it is another to not only have to do the study but build and maintain a museum if you want the specimens to last more than a few years.

Just how much and of what kind of funding increase would be required to mildly alleviate the above problems is not simply determined because the contemporary level of basic biology research is so low in tropical countries that there are no starting points from which to extrapolate.

Finally, I am asked for a set of objectives to alleviate the above problem, and a statement as to how these could be achieved by reallocation of resources and by new resources. To get at these questions, I will briefly examine the above numbered litany of problems, without repeating each.

1) Put money into providing the reward (finance university faculty positions, finance museum, park service, fish and wildlife service, forestry technician positions, provide fellowships and grants that can be applied for in support of basic research, support grade school and high school programs in field biology, support national-level symposia and field courses in field biology).

2) Put money into fellowship programs allowing free post-graduate study at centers of basic field biology activity inside and outside of the target tropical country, with emphasis on support of return to target country for thesis research. Make funds available to foreign universities for salaries or research support that will make the position more attractive to higher quality personnel from countries outside of the target countries, and will make the positions more competitive with private opportunities within the target country.

3) Put funds into preservation of forested regions or temporary delay of their thorough exploitation as a way of buying time, such that there is something for the children of the current generation to work with 20-40 years down the road.

4) When home-grown amateur activities begin to coalesce in target countries, make funds available for which they can compete for local meetings, field trips, access to formal museum facilities, etc.

5) Fund symposia in basic biology within target countries, as well as field courses. Emphasize movement of scientists within the tropics (between tropical countries) for these symposia; make funds for travel freely available for citizens of tropical countries.

6) For extra-tropical workers that initiate studies in tropical countries, apply the equivalent of affirmative action towards their budget requests. For scientists that move to tropical countries to set up long term research projects, allow them to retain their full eligibility for grants from the National Science Foundation and other U.S. granting agencies irrespective of the foreign institution with which they are affiliated. For U.S., Canadian, British and European institutions that handle, or can potentially handle, large volumes of tropical reference material, strongly subsidize their taxonomic, curating and cataloguing work dealing with tropical specimens. Likewise strongly support their efforts to cooperate with tropical institutions and aid tropical institutions to establish their own stable museum and library facilities.

7) Make block grants to tropical university and other institutions specifically earmarked to be dispersed for tropical basic field studies and the laboratory work to back them up.

8) Make universities and other formal institutes that house basic biologists more competitive with private life for salaries and other resources.

9) Put funding into obtaining forested areas for basic research (and later conversion to sustained material goods yield?) near enough to population

centers that researchers can work at them and still have access to private things (family, home) and laboratory facilities.

10) Put funding into the development, and maintenance of tropical field facilities that will support basic field research, and will especially provide basic laboratory facilities adjacent to study sites.

11) Subsumed in the above 10 points.

Is it realistic to expect existing tropical institutions to perform any of the things mentioned in this report with a mere reallocation of funds? Well, are we then to assume that the fund sinks that will therefore be deprived of funding were unimportant to tropical countries? The deprivable fund sinks that come to mind are graft, excess civil servant payrolls, military expenditures, large private bank accounts, corporation profits, advertising, and ostentatious public works. Of a more biological nature, the only one that comes to mind is the depression of funding of agricultural experiment stations aimed at export cash crops. I wish you luck.

As for where to put the funds into existing institutions and develop new ones, that has to be tailor-made for the particular country. When someone shows serious interest in actually committing such an act, then I (and I am sure many others) will be quite ready to make numerous suggestions about the particular tropical country that is most familiar to me. What is realistic new funding is likewise a matter to be determined country by country. As a ball park estimate and example, 20 million a year carefully placed for twenty years in Costa Rica could really turn the system around.

Then you ask about the reasonable time lag and what changes might occur. I think 20 to 40 years is a reasonable period before basic research in Costa Rica will be at the level to fully support and have running a forest sustained

use program for the entire country. But I should add that much of that research will be as much applied as basic. The changes that might reasonably be expected to occur would be that the long term use of most of the surface of the country would be determined on an essentially permanent basis: hydroelectric power watershed, croplands, timber plantations, sustained yield forest sifting agriculture, pasture, national parks, drug plantations (relax - coffee, pepper, cacao), sustained yield forest products reserves, etc.

Would could the U. S. Congress do to attempt to cause such an event to come about through existing institutions? In one sentence, make the money available. However, I think some more detailed answers are possible. I would suggest the following as specific steps which both illustrate what is possible right now and where I feel the really critical links lie between basic research and sustained yield of tropical forested ecosystems.

1) Cause the IRS to put a small box at the beginning of each U.S. income tax form, which when checked authorizes a $10 (or more) tax-deductible contribution to be used for capital expenditures and non-development maintenance to acquire portions of the forested (as yet) tropics to be then later available for anything from living museums to sustained yield forest systems by the country of concern. This is in essence a holding action, designed to give better-educated later generations substantially more options in tropical forest use than they will have if things continue as they are. Presumably, each income tax return would be accompanied by a written brief explanation, and hopefully the idea would be sufficiently dramatic to receive attention by the news media during the several months before most Americans fill out their tax forms. Such a process would generate a reliable source of income that could be dispersed by a small multi-national agency (equivalent of a minute

hybrid of IUCN-WWF-World Bank) in response to applications made by interested parties of all sorts. Evaluating applications could be done through something similar to the NSF peer review system for research grants (or something more streamlined if people would trust it).

2) Set aside approximately 1 million ($) per year for the next 5 years to fund 2 conferences each year (at six month intervals). Each conference would be held in a quite different part of the tropics. Its funded attendees would be about 200 persons who are at present in charge of forest areas of the tropical world (right down to individual plantations and park managers). Each would produce a standard format paper of 5-60 typewritten pages as a condition of travel funds, and the papers would be immediately produced by offset for publication within weeks as a several volume book. The paper each would write would be explicitly what each of them sees as the primary goals of his area, the impediments to attaining those goals, and what he sees as solutions. That is to say, very many case histories. Simultaneously a small team of science writers would be hired to not only attend the conference, but to read all the papers, and produce a digest volume within a month or two (at most) of the points that should be of greatest concern to decision makers. The participants in the conference would each give a maximum of 20 minute verbal presentation, but could opt out of this if desired, and be only a listener. Verbal sessions would occur simultaneously so one person could not attend all talks. The pace would be hard and fast, with the emphasis on information exchange both during verbal presentations, and in informal poster sessions, quiet bars, etc. Invitation lists would stress geographic diversity and allowing people to speak from all levels - Presidents to game wardens.

3) Create a division within NSF that invited <u>international</u> proposals for 5 year grants to support and develop ecosystem-level working model systems

of forest sustained yield use. The funds might be matching funds for programs by tropical countries, but not necessarily so. The emphasis would be on providing the capital and start-up costs for actual systems that could be maintained with their own produce or national subsidy once rolling. Principle investigators for such systems would not have to be attached to U.S. institutions or U. S. citizens. These monies would not be taken from current NSF budgets but rather added to their budgets. I suspect that the program would have to involve 5 million a year for the first 5 years (25 projects at an average of 1 million each) to have a real effect.

4) Allow NSF to remove its requirement that Principle Investigators doing field studies (or studies in tropical countries) need to be either U.S. citizens or attached to a U.S. institution. This change would allow very imaginative and competent researchers in basic forest biology in the tropics to seek funding to the level of their ability, rather than have to creep along on the funds currently available in most tropical countries.

5) Inject a massive infusion of dollars for systematics in plant and arthropod biology on tropical organisms. This could be done with existing institutions by allowing funding of general programs, but should also be very sensitive to the development of systematics work in the tropical countries themselves. This might take the form of anything from matching funds for the entomological collections of the Instituto de Biología of the Universidad Nacional Autonomo de Mexico to fellowships for Kenyans to get training in parasitic wasp systematics at the British Museum of Natural History.

6) Do something exactly parallel to 5) above, except for the chemical and morphological traits of the organisms in tropical forests. A national museum of secondary compounds, if you like. This would be impossible

without 5) above. Also, this could be profitably aided by some kind of pressure on the large chemical companies to divulge the results of the 100's of thousands of screening tests that they have already done on tropical plants.

7) Bring really serious pressure on the multinationals involved in much of the current tropical exploitation to induce them to take an active, and not whitewash, role in the development of sustained yield systems.

8) Provide the political approval (stamp of O.K. from the State Department) for a serious statement to various tropical countries of the following sort (example only):

"Brazil's challenge to the world should be, O.K. you don't like what has happened at Jari? We don't either. Let's make a trade. For every square mile of Brazil that biologists design as a sustained yield forested agroecosystem with a dollar return over a twenty year period equal to that which would have been obtained through clearcutting the land and growing cattle or pulpwood, we (Brazilian government) will put into permanently undisturbed forest (except for indigens, true shifting cultivation, or other truly non-destructive uses). The U.S.A. provides the start-up funding and covers the losses if there are any. Products are to be sold on the open market, world-wide, to the highest bidders. Profits to the Brazilian government after the occupiers have received their wages, rewards, etc."

In closing

I have not focused on any specific products to be obtained from tropical forests in this essay. Most are obvious and vary from culture to culture, forest to forest. However, there is one that deserves special mention, if for

no other reason that we all know about it but no one seems to be able to do more than vaguely mention it. The product is aesthetics. Let me illustrate its value with a story. If I told you that I was going to magically introduce a gene into the human population that would make all your grandchildren and all their descendents color blind, you would be less than pleased. The same is true of a gene that would eliminate all awareness of music. But what are color vision and music awareness? Traits that you would never know you had if the world was not colored and the air not filled with complex sonorous sounds. I maintain that you are animals rich in mental and physical receptors for the complexity of nature, and by destroying that nature, you condemn your offspring to the sleep of never even knowing those receptors exist. And by destroying tropical nature, you destroy easily the majority of the signals those receptors are designed to receive. Of course humans are good at generating mild complexity in their workings, but the level of complexity generated by humanity is to the complexity of a tropical forest as a mouse's squeak is to all of human music. The center-city dweller who feels no cultural and biological deprivation is simply unaware of what he is missing. If your response is, well, what he doesn't know won't hurt him, then I suppose that you won't mind if I eliminate color vision from your children at birth, and all their children after them. Humans have spent rather many millions of years inventing the ability to be very aware of what is around them. How ironic that just about the time they get themselves to where they can sit back and gawk rather than fear all of that, their quintessimal human trait is removing the very thing that made them what they are. A human without senses is not even an animal; to sense, you have to have both receptors and transmitters. Keep a piece of the latter around for your offspring.

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