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Theme 1: The search for sustained production systems in the humid and subhumid tropics

PAPER 1/7

RESEARCH AND TRAINING NEEDS IN THE TROPICS: THE NEED FOR RE-EVALUATION

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ABSTRACT

Training and research priorities for the tropics require re-evaluation because many of the existing documents on the subject are not based on comprehensive synthesis of the state of knowledge, contain numerous misconceptions, and their recommended priorities are out of focus. Examples illustrate each of these problems and their consequences. Training and research priorities for the tropics must be coupled to management and peoples needs and to the limits on resource use and organic production imposed by natural laws. Efforts should be directed to filling existing gaps in knowledge and focused at an ecosystem or global level of organization, levels where the most critical human problems are rooted. An organizational scheme for the fields of training, management, research, and planning is proposed to coordinate these activities in the tropics.

KEYWORDS

Tropical ecosystems, research priorities, training priorities, tropical forestry, tropical ecology, tropical forest management.

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COMMUNICATION 1/7

BESOINS EN MATIERE DE RECHERCHE ET DE FORMATION DANS
LES ZONES TROPICALES : NECESSITE D'UNE REEVALUATION

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RESUME

Les priorités dans les domaines de la recherche et de la formation dans les zones tropicales doivent être réévaluées car la documentation existante sur ces sujets n'est pas basée sur la synthèse compréhensive de l'état des connaissances. Elle contient beaucoup d'idées fausses et les priorités recommandées ne correspondent pas à la réalité. Ce rapport donne des exemples et leur conséquences pour chacun de ces problèmes. Les priorités pour la recherche et la formation des régions tropicales doivent être liées aux nécessités de gestion des ressources et à celles des populations locales, mais également tenir compte des limites dans l'utilisation des ressources et de la production organique imposées par les lois naturelles. Des efforts doivent donc être entrepris pour combler les lacunes dans ce domaine. Ces efforts doivent être centrés sur un écosystème, c'est-à-dire sur un niveau global d'organisation : niveaux où les problèmes humains les plus critiques sont enracinés. Un planning dans les domaines de la formation et de la gestion, de la recherche et de la planification est proposé pour coordonner ces activités dans les zones tropicales.

MOTS CLES

Ecosystèmes tropicaux, priorités dans la recherche, priorités dans la formation, sylviculture tropicale, écologie tropicale, gestion des forêts tropicales.

INTRODUCTION

The list of documents containing training and research priorities for the study and management of tropical ecosystems grows each day (Barney, 1980; Farnworth and Golley, 1974; National Research Council, 1980; World Bank, 1978). With different degrees of detail these documents already contain every conceivable training or research project that should or could be done in the diverse tropical lands. Any scientist preparing a proposal on any subject matter of ecology can use one of these documents to show that his work has priority. The work of granting agencies is facilitated because they can select any study, research site, or institution for short or long-term ecological research and point to the document that supports their decision. Are these documents fulfilling their stated objectives? Has the subject matter been exhausted? Should the MAB program follow the same procedure?

These questions cannot be answered categorically because of the complexity of the issue. In general, the documents that have been quoted are landmarks and have been extremely useful in alerting the public, the scientific field, and decision makers to the serious problems faced by humanity in the tropics. Yet, after reading the documents, one is not convinced that, if all the suggested projects were conducted, progress would be made in resolving the ecological problems in the tropics. Nor is one convinced that the proper types of professions would be trained to cope with the problems of today and those of the future. There is still considerable room for improving the way training and research priorities are developed for resolving the problems of tropical forestry.

We believe that the identification of training and research priorities must be based on a thorough scientific analysis of the state of knowledge and that scientific credibility must be maintained even if the document is

intended for a non-scientific audience. Examples of such comprehensive analyses are Farnworth and Golley (1974) and UNESCO (1978). However, not all efforts are accompanied by such analysis. Sometimes questionable "facts" are used in order to attract attention. In the United States, for example, most of the emphasis on tropical forests is powered by the belief that they will almost disappear by the end of the century and that two decades later, even remnant areas of tropical forests in the Amazon and Congo basins will also disappear (National Research Council, 1980). Simultaneously, between 500,000 and 1 million of the species will become extinct (Barney, 1980). Are the problems in the tropics less serious if the forests were to disappear in 100 rather than 40 years or if species extinctions were to be a small fraction of the predicted number? We believe the resource problems in the tropics are urgent and important enough to require priority attention without misleading the public.

The central point of this paper is that training and research priorities that emerge from misdirected analyses are bound to be themselves misdirected. Because we can cite numerous examples of misdirected thinking associated with tropical forestry, we reason that a re-evaluation of training and research priorities that have evolved from these erroneous points of view is needed.

The main factors that affect the development of better training and research priorities for tropical forestry are the lack of a comprehensive synthesis of the available knowledge, abundance of myths or misconceptions about the field of tropical forestry, and improper focus of programs, ideas, and solutions, which will be discussed and illustrated with examples. Then, we present our alternative approach for developing training and research priorities for the tropics.

LACK OF COMPREHENSIVE SYNTHESIS

Attempts to formulate training and research priorities for tropical environments usually emerge from group efforts. Because of time constraints and the nature of committees, topics out of the focus of collective interests are left out and this may lead to gaps in the resulting recommendations. For example, in the National Research Council's Research Priorities in Tropical Biology, the driest site recommended for study receives from 1.0-1.2 m of rain annually. The dry tropics, which represent about 46% of all tropical lands (1,887 million ha) were totally ignored. Yet, the fuel-wood crisis described by Eckholm (1975) as "the other energy crisis" has its main setting in dry forest areas. Are there biological priorities in these areas?

These gaps in summary documents result from a lack of comprehensive synthesis prior to formulating recommendations. We will use our synthesis work on organic matter production and storage in tropical forests (Brown and Lugo, 1981) to illustrate the importance of synthesis work. In the process of reviewing the literature on this subject we have discovered that of 30 tropical and subtropical life zones that support forests, less than half have been studied (Table 1). There are only a few studies on gross and net primary production of tropical forests, but many on litter production. Only 11 studies (in five life zones) report wood production in natural forests. All studies combined total less than 200 and are expected to cover 18,389 million ha of tropical forest. These statistics clearly illustrate that knowledge of the rudiments of organic matter production and storage in tropical forests is sketchy at best. If current research priorities are followed, this knowledge will not be improved greatly in the near future for natural forests.

The situation is better for plantations even though plantations comprise only 1% of the tropical forest areas. Foresters have described organic production and storage in plantations for a broader set of conditions than ecologists have for natural forests. In our survey of the literature we found 71 studies of stem wood production on 13 life zones. Many of these studies often include hundreds of plots.

There is a paradox in the current state of knowledge about primary production of tropical forests. To manage forests for yield one needs to understand the natural processes of storage and production of organic matter. The methods to measure these parameters are now standardized and considered routine. Yet, granting agencies will not fund these studies as they are no longer "in" with the scientific establishment. Few realize that at the level of the ecosystem, each study, if done in a different life zone, is analogous to a point in a graph whose abscissa covers the broad expanse of 30 forested life zones in the tropics. To date, most points have been placed in the same few life zones (those whose potential evapotranspiration to precipitation ratio is close to 1). A plant physiologist would never venture to finish a photosynthetic study without completing measurements on the whole range of light, temperature, and moisture conditions encountered by the plant under study. Similarly, understanding of primary production and other ecosystem level processes will not be complete until the data from a network of numerous individual studies are synthesized under some unifying scheme. Knowing what needs to be measured and where requires careful synthesis of current knowledge. Without synthesis some studies may be repeated.

In summary, research priorities for the tropics must emerge from comprehensive analyses of state of knowledge for the broad range of tropical

environments (dry to wet, lowland to highland, hot to cold) rather than from worn out comprehensive lists of research projects in the same moist environments.

ABUNDANCE OF MYTHS

Myths are produced by the lack of comprehensive analysis. With adequate analysis, myths are usually dismissed. For example, comprehensive soil studies destroyed the myth that most tropical soils in the Amazon were lateritic and would harden when cleared of vegetation (Goodland and Irwin, 1975). Soils continue to draw most attention; extreme care must be taken when interpreting results from ecosystems growing in nutrient-poor soils (Herrera and colleagues, 1981; Klinge, 1965; Stark, 1978). Soil scientists argue that the nutrient-poor white sands (spodosols) comprise 2% of the Amazon and 1% of all the tropics and that not enough attention is given by ecologists to the more extensive oxisols and ultisols which do respond to management (Sanchez and Buol, 1975). Thus, if care is not taken to find out how representative the results of field studies are, limited research funds will be spent on the wrong areas of research, implications of the heterogeneity of tropical soil conditions are not properly studied, decision makers become confused and discouraged, and attention to the real problem areas may be delayed. These are the costs of myths.

We identified a number of popular myths¹ that tend to slow down progress in tropical forestry training and research by misguiding people's

¹ We recognize that professional foresters, ecologists, and other professionals with field experience in the tropics are not fooled by these myths. The myths, however, are popular in much of the literature that finds its way to the public and decision makers who determine much of what happens in the tropical lands.

conception of the tropics (Lugo and Brown, 1981a). Because our objective here is not to develop each theme in detail but only to flag issues that affect the development of training and research priorities in tropical forestry, we will only list some of the most serious ones and their consequences.

Myth: Tropical forests are moist forests.

Fact: Classifying the 41 million km² of tropical lands according to the Life Zone System (Holdridge, 1967), we find that 46% are in dry, 38% are in moist, 16% are in wet forested life zones. Thus, not all tropical forests are moist; in fact, about half are dry.

Consequence of myth: Dry tropical forests do not get the attention they deserve.

Myth: All tropical forests are highly productive.

Fact: With the best data available we found that gross primary production of forests decreases rapidly along the gradient from wet to dry forested life zones (Fig. 1) and litter production (a rough indicator of net organic matter production) peaks in the moist life zones and decreases toward the very dry and very wet ones (Fig. 2). Obviously, not all tropical forests can be expected to yield organic matter at the same rate. Management and human expectations must be tempered by the reality that the production potential of forests sites is limited by the climate.

Consequence of myth: Unrealistic proposals for food or fiber production schemes are formulated and planning is misdirected.

Myth: Natural tropical forests with their high diversity of tree species have little use as a continuous source of wood.

Fact: About 80% of the wood that is cut in natural forest lands and reported in world statistics is used by local people for charcoal and fuelwood.

Consequence of myth: Research and training in the management and culture of natural forests (including work in secondary forests) for wood production has been largely discontinued. This causes a significant void in our capacity to improve techniques for the use of vast tropical forest areas.

Myth: Deforestation is proceeding at a such a rate that by the end of the century most tropical forests will have disappeared.

Fact: Recent estimates suggest that forests are being converted at rates between 0.4-0.7%/yr (Lanly and Clement, 1979; Lugo and Brown, 1981b; Seiler and Crutzen, 1980). In some countries, such as Thailand, Nigeria, Ivory Coast, and Liberia, deforestation rates exceed 5%/yr, but these countries contain only a small fraction of the total forest area. In countries with vast areas of tropical forests, such as Brazil and other South American countries and Zaire and other African countries in the Congo Basin, deforestation rates are very small (less than 0.5%/yr). However, all these numbers are preliminary at best; we still know very little about rates of forest conversion, and the FAO project on continuous forest inventory is critically needed.

Consequence of myth: Research, training, and management strategies change completely depending upon the urgency of the problem

(next section); the wrong strategy, when it fails, leads to backlash and loss of credibility in the public eye.

Myth: Fallow or secondary forests are worthless brush.

Fact: These forests support many successional tree species whose qualities are intermediate between the early pioneers and the late climax species. Because of their rapid growth characteristics and wood qualities, many of these species could be managed for wood or biomass yield. Also, secondary forests play an important role in restoring the carbon balance of the site, protecting and restoring eroded soils, supporting wildlife, and maintaining water and site quality.

Consequence of the myth: An important area of research and resource management is not given the attention it deserves.

Myth: Economic growth typically and justifiably involves the sacrifice of the natural environment.

Fact: When resources are wasted in an attempt to promote economic welfare, short-term and local economic growth is encouraged. If proper precautions are not taken, humans must eventually replace the free services and values that are lost when resources are consumed irreversibly. When that time comes, economies may collapse if the restoration costs are greater than the benefits derived from short-term growth policies (Hyams, 1976).

Consequence of myth: Development and training programs are misdirected; training and research opportunities are lost; important areas of inquiry are not explored.

In summary, the formulation of training and research priorities for the tropics demands a clear understanding of the tropics, of their conditions, and of the accuracy of knowledge about them. Short cuts in the formulation of state of knowledge documents should be avoided because these may lead to the creation or use of myths. In temperate and boreal latitudes vast expanses of land are sufficiently similar to permit generalizations over broad regions. In the tropics one deals with many more life zones, each with a small area, and thus, application of findings from one place to another may be misleading. The responsibility for the use of the myth lies with the proponents of the training or research priority and not with those who are victims of the induced misdirection.

IMPROPER FOCUS

If too many myths creep into decision making, decisions and priorities will be out of focus. For example, should taxonomic descriptions be the first priority of tropical biology? This priority emerges from the urgency created by the belief that tropical forests are about to disappear in the next 2-4 decades. Would the same focus emerge if more time was available? Unquestionably science cannot make progress without basic descriptions of the objects of study. But should the description drive research or should the description be driven instead by research questions? At what level of organization are descriptions most urgently needed? At what level should we seek the unit of ecological study? Populations? Ecosystems? Species? The same questions apply to training. To implement any large-scale scientific program in the tropics implies that the manpower must be developed through intensive training because such scientific manpower does not now exist in the tropics (Yantko and Golley, 1977).

One may argue that the salient human problems in the biosphere are global or ecosystem level problems. Examples of these are the problems of increasing atmospheric CO₂ and possible climate changes, determining the carrying capacity of tropical lands, determining alternate energy supply systems, managing limited or fragile resources, and so on. If so, training and research should be practiced at an ecosystem level or higher, but certainly not at lower levels. It is significant that while tropical biology in Latin America is dominated by evolution and population level work, these fields have, by tradition, not contributed much to the public debate on how to manage its ecosystem or resolve its ecological problems. Shouldn't research priorities then be set at the level of the problems we are trying to resolve?

Two examples of improper focus will serve to illustrate our points. There is considerable interest in finding plant species that would yield economic value or potential energy to solve the energy problems in the tropics. Extensive and useful searches (National Academy of Sciences, 1975, 1980) for the proper species have resulted in identifying species most suitable for a given purpose. However, these searches do not help resolved the basic problem of organic production in extreme environments where the energy supply problems are more critical. Regardless of the species, the production of organic matter per unit area of land is dictated by environmental conditions (Figs. 1-3). The research priority in this field should center around the understanding of systems or productions, their costs, and yields. Finding the right species is part of the effort but not the central thrust.

Gains from species or site manipulations are possible but, before they can be adopted, one must perform an analysis of net energy yield. These analyses require knowledge of all the energy costs associated with increasing yield and these costs are then subtracted from the energy yield to determine if the manipulation is worth the effort. Economic cost-benefit analyses do not satisfy this requirement because the economic analysis can be manipulated almost at will and these analyses are not constrained by the laws of energy which dictate the long-term effectiveness of energy procuring systems. When people focus only on the oil-like sap of a given plant or the fine properties of hardwoods without understanding or considering the environmental energies involved in producing these materials in large quantities, the research is misdirected.

Another example of the effects of improper focus is the situation created by the belief that human population growth is at the root of all the problems faced by humanity in the tropics and elsewhere. No one questions this fact. Yet, this ignores that it takes energy² to support any kind of growth, human population growth not excepted. The roots of the population growth question should be attributed instead to the energy supply conditions of the country. As the natural limits imposed by local energy resources are replaced with energy subsidies from outside, many countries are driven into periods of population growth. This growth taxes resources as well as social and cultural systems, creating all the problems that are blamed on population growth.

² Energy is used in the broad meaning of the term (ie. chemical, electric, magnetic, mechanical, etc.) including technological and monetary transfers because they also involve energy exchange (Jansson and Zucchetto, 1978).

We believe that human population growth is not the fundamental cause of problems in the tropics, but a result of the energy and resource use policies that drive growth. The fundamental cause of problems in the tropics is more likely to be the energy and resource use policies of individual countries. Notice that our view does not mean that we dismiss numbers of people as a problem. What we do is shift the emphasis to another driving force. By doing so we gain a new perspective for attacking the problem. If the myth is true, our hands are tied, as it is difficult to deal with the problem of individual human reproduction at a scale sufficient to make a global impact. Research and training would over-emphasize small scale social solutions. An alternate solution is to deal with resource allocations as a more fundamental causal factor. A completely different array of research and training priorities emerge. These would deal with ecosystem carrying capacity, resource partitioning, and coupling of human and natural ecosystems.

SUGGESTION OF AN APPROACH FOR DEVELOPING TRAINING

AND RESEARCH PRIORITIES IN TROPICAL FORESTRY

All we can do in the space given is to suggest ways to avoid the pitfalls. There are a number of imperatives that should permeate any effort of this nature:

- ° Training, management, and research in the tropics must go hand in hand. They cannot be separated and compromise on this is not possible.
- ° Any plan must be tightly coupled to peoples needs, not to academic imperatives.
- ° Suggestions have to be realistic and well within the limits of natural laws. Clearly, energy intensive proposals must be analyzed in the

context of low energy futures and must have positive net energy yields.

- ° Participants of these efforts should rotate between activities to enrich their experience and improve their effectiveness.
- ° Efforts should be directed to filling gaps in understanding. Such gaps should be formulated only after performing concerted synthesis efforts in major topics of research. Studies, results, and ideas must be tested for scale applicability to avoid erroneous extrapolations.
- ° Personal interest must be sacrificed for common goals.

To accomplish these goals, the scientific and technical manpower must be organized into an effective training, management, and research force. The scheme in Fig. 4 is given as a way to organize this effort. Four main activities are suggested: field research and synthesis of research results, application of results for better management, research and training support, and information exchange. Projects are given for some of these major activities. The driving forces are the natural phenomena and peoples needs. The lines identify the complex web of interaction that is needed to make such a scheme work.

The idea of the box diagram is to promote a system of research, training, management, and policy-making that is well integrated, responsive to public needs, aware of the earth's limits to growth, and with each component interdependent on the others. Holism is the rule that guides the function of each component of this system of tropical forestry research and training. Priorities emerge from careful analysis of knowledge and the consensus of those directly involved in the various activities in the model, e.g. those obtaining, using, or disseminating results. Because of the

constraints that we have imposed on this system (described in the goals listed above) we are sure this system will yield training and research priorities that are different in scope from those that are prevalent today. The main differences will be in the focus, emphasis, and credibility of the analysis. In training, for example, it is clear that to resolve the ecological problems of the tropics a vast array of specialists and generalists are needed to work in the diverse array of technical problems that need solution. To be effective specialists cannot work alone. They must be complemented with generalists. Similarly, without specialists, generalists cannot be effective. Training programs must be technically strong and also diverse in scope. Because the ecological problems in the tropics are urgent, we think that re-evaluating current approaches is a worthwhile effort.

Table 1. Numbers of studies on organic matter production and storage in tropical forests (Brown and Lugo, 1981).

Research category	Number of studies ¹	Number of life zones represented ²
Gross primary production	6	4
Net primary production	11	4
Litter production	73	13
Aboveground biomass	37	10
Soil organic matter	72	16

¹Individual data points.

²Of a total of 30.

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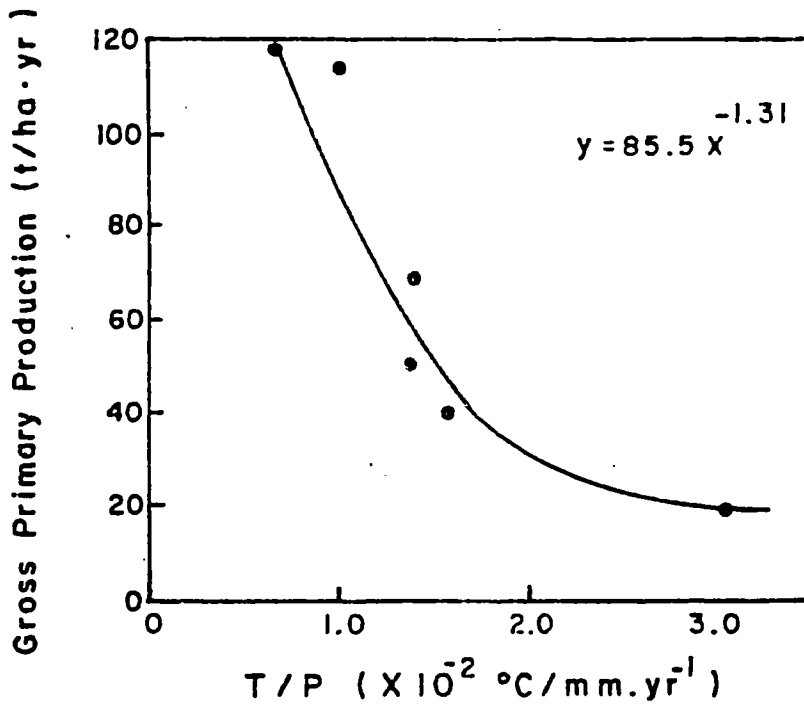


Figure 1

Relationship between gross primary production in tropical forests and temperature (T °C) to precipitation (P mm/yr) ratio (significant at $p = 0.05$, $r^2 = 0.91$; Brown and Lugo, 1981)

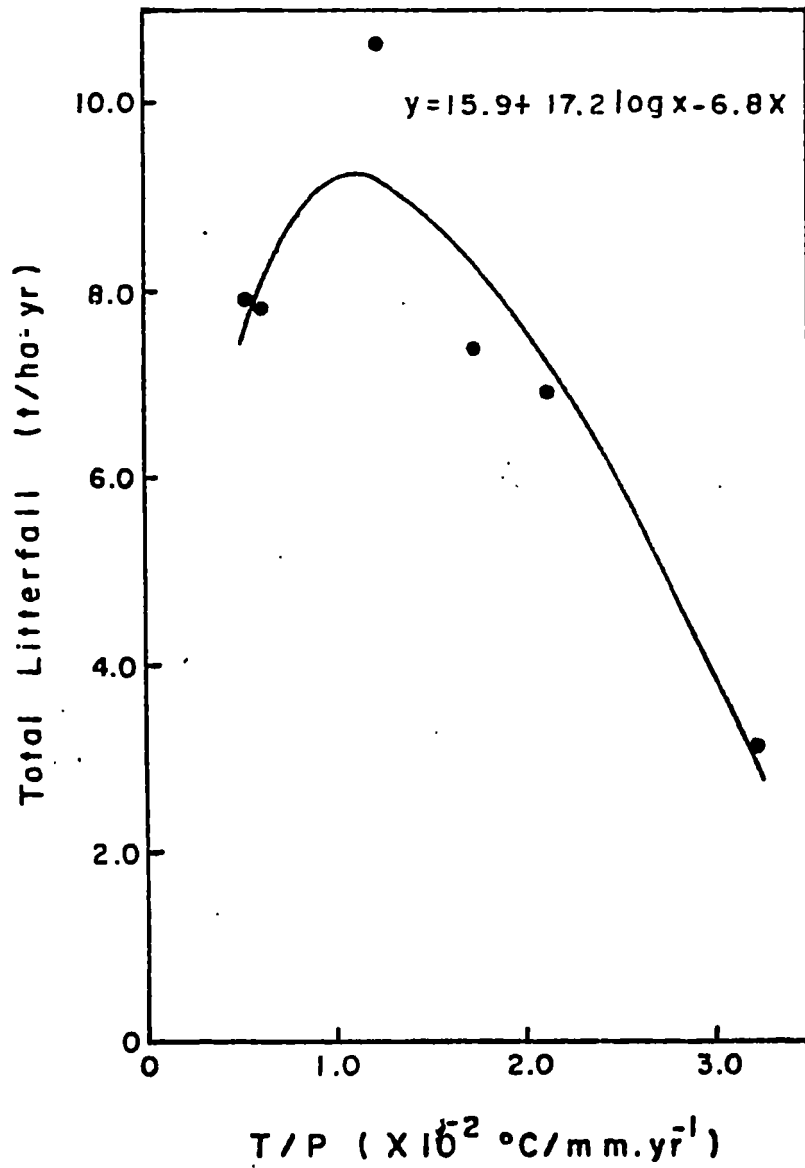


Figure 2

Relationship between total litterfall combined into six life zone groups and the temperature (T °C) to precipitation (P mm/yr) ratio (significant at $p = 0.05$, $r^2 = 0.87$; Brown and Lugo, 1981).

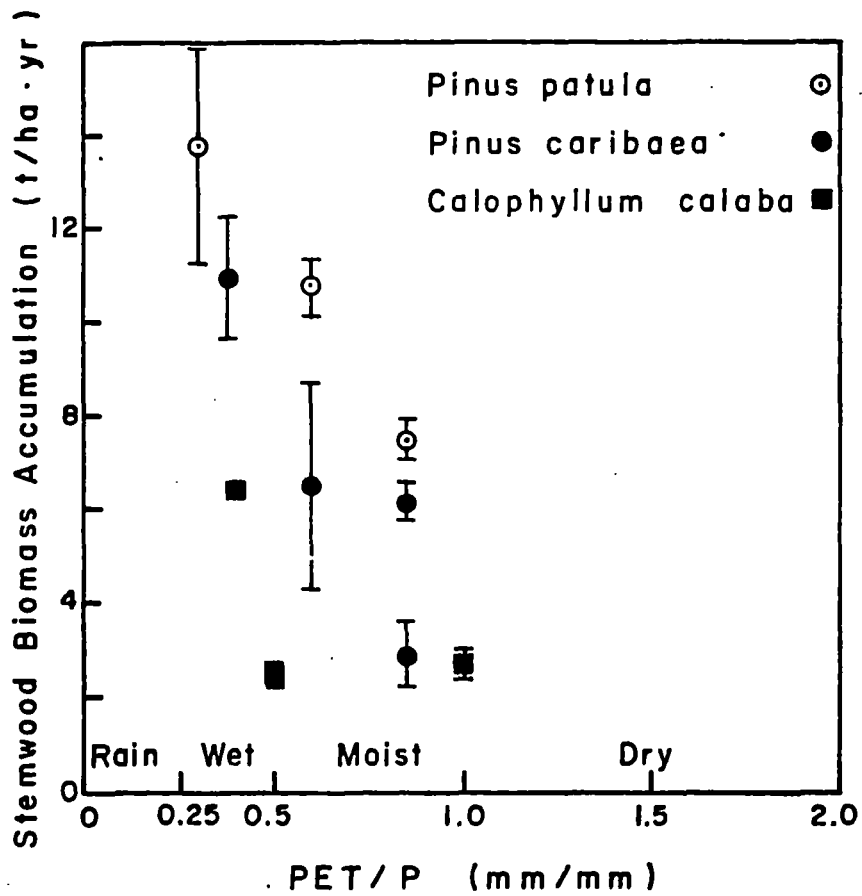


Figure 3

Relationship between species performance in plantations and potential evapotranspiration to precipitation ratio (PET/P; used as an index for life zones). Notice that a species may exhibit high yields in one life zone but lower yield in a different life zone where conditions may not be favorable for net production (Lugo and Brown, 1981a)

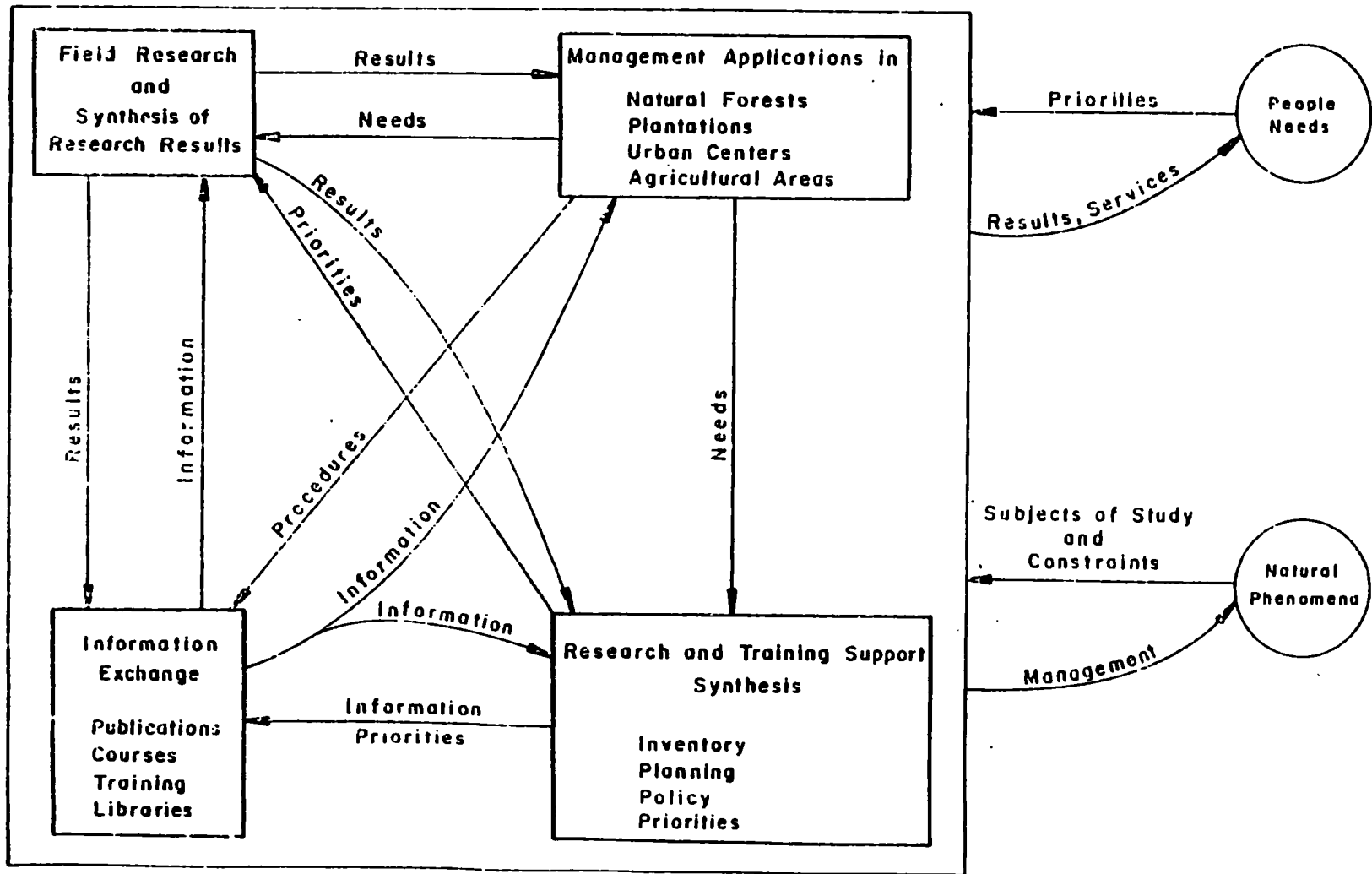


Figure 4

Components of a tropical forestry training, management, research and training program.