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Ecological And Biological Considerations
In The Management Of The Tropical Rainforest Ecosystem

By

Tho Yow Pong
Ecological and biological considerations in the management of the tropical rainforest ecosystem

By Tho Yow Pong, Forest Research Institute, Peninsular Malaysia

The tropical rainforest is more than just a crop of trees; it is a dynamic system with many built-in control circuits. The ecosystem is shown as a most efficient system, being in many ways self-sustaining. There has been an increasing amount of studies in the tropical forest; some of these results are discussed to show the ecological energetics of the system. An attempt is also made to relate these to present forestry management practices. A suggestion is made that ecological energetics may be a good guide to efficient management practices. Thus, the considerations should be given to the manipulation of the natural systems within the forest as a management tool.

The tropical rainforest, such as what we are endowed with in Malaysia, is in the eyes of many only a rich crop of timber trees to be exploited without the slightest thought about what such a forest really represents or stands for. Very few realize that the tropical rainforest is a striking example of how a matrix of ecological units can be intermeshed to form what can be best termed as the most efficient ecological system and complex biocenosis to be found in our globe today. Living within this system is a rich diversity of plants and animals, the inter...
dependence of which must surely be a very complicated and yet delicate relationship.

It is important that the forest should not be viewed as merely a collection of, or refuge for individual organisms, or even a mixture of populations brought together by chance. Instead, it should be looked upon as a dynamic and pulsating system with many ecological units knit together to form a high order of organisation.

With the increasing number of studies being carried out on this system, ecologists today are beginning to fathom some of the mysteries of the tropical rainforest, and to piece the information together to provide some form of rational scientific explanation. Such studies have revealed the existence of many intricate networks and specialisations operating within the forest ecosystem that are unique. Although these systems have yet to be fully understood, there is enough evidence to point to the fact that the tropical forest ecosystem has a very high degree of complexity and efficiency yet unparalleled by any other ecological system.

In fact, the tropical rainforest ecosystem might provide the examples which man might have to turn to in the future for clues in the designing of ecological systems for the survival of nature and man himself. This will be absolutely true for tropical forestry practices. However, it is ironic to note that forestry practices in this country (Malaysia) and in many tropical areas have yet to incorporate the vast amount of ecological and biological information into the proper management of the forests. The management of the tropical forest system is still by and large a very new science. In the past, very little such information was available to foresters about these forests. However, at present, in the wake of the increasing tide of valuable studies on the biological aspects and ecological energetics, it is inexcusable for forest managers and practitioners not to consider the implications of new findings in the proper management of so vital a natural resource.

It would be impossible within this paper to try to review the tremendous amount of information that has accumulated, say, during the past 10 years in Puerto Rico (Odum 1970), Thailand (Ogawa et al. 1973), Africa (Longman & Jenik 1974) and here in Malaysia (Soepadmo & Kira 1977). However, this paper will attempt to discuss some of the major findings of ecologists and biologists, especially in the field of ecological energetics, and relate these to present forestry practices of the country.

The biomass of the tropical forest

One of the most striking features of the tropical forest is its rich and luxuriant vegetation. It has now been shown in terms of the total organic matter of the vegetation or the total biomass, which is expressed as the total dry weight of plant material per unit area, that the tropical rainforest has the highest biomass of all vegetation types. An average of 450 dry tons per hectare is given as being representative of the biomass of a tropical forest (Longman and Jenik 1974). Estimate shows that, on a worldwide basis, the total biomass that is tied up in the tropical forests is equivalent to half that of all living matter put together. In Malaysia, the total standing plant biomass estimated for a piece of lowland forest is 500 to 550 dry tons per hectare (Kato et al. 1974). No figures are available for the total animal biomass such a forest supports.

Productivity

Another interesting fact about the tropical forest is the high primary pro-
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ductivity that it achieves. This is not surprising, for it is in the tropics that radiant energy is available throughout the year. It can be said that the tropical forest systems are designed to utilise this energy available to the fullest. In other words, a tropical forest is a highly efficient energy trap, converting radiant energy into potential energy which is tied up in the organic matter or biomass. The primary productivity figure obtained from the lowland forest in Malaysia is around 84.6 dry tons per hectare per year (Soepadmo & Kira 1977). This extremely high figure is testimony to the efficiency of the system.

However, in such a system which supports this immense amount of biomass, a lot of the energy taken as primary productivity will have to be necessarily channelled towards respiratory processes. Further losses will be accounted for by herbivores and decomposers of wood and leaves. In other words, a lot of the energy will be rechannelled to support the many life forms that exist in the forest. Hence the net productivity or energy tied up will be considerably less than the gross productivity. In this respect, the net productivity estimated for our lowland forest is 37.6 tons/ha/year.

Nutrient status and nutrient cycling

It is also known that in the tropical forest, especially in Malaysia, the amount of available nutrients in the soil is very low. This is not a new discovery at all, for shifting cultivators such as the Orang Asli have shown this for ages. At most, a piece of cleared forest land can support only two crops without any fertilizer input. This might seem contradictory to the high productivity of the forest but actually this is not so, for although the nutrients are not in the soil, they are stored in the trees. Table 1 gives the net primary production estimated for different vegetation types.

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<thead>
<tr>
<th>Vegetation type</th>
<th>Net primary production (dry tons/ha/yr)</th>
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<tr>
<td>Tropical forest</td>
<td>20 (10-30)</td>
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<tr>
<td>Saranna</td>
<td>15 (1-30)</td>
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<tr>
<td>Temperate forest</td>
<td>18 (5-30)</td>
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<tr>
<td>Boreal coniferous forest</td>
<td>12 (5-15)</td>
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<tr>
<td>Tundra and alpine grassland</td>
<td>14 (0-15)</td>
</tr>
<tr>
<td>Steppe and other grassland</td>
<td>9 (1-15)</td>
</tr>
<tr>
<td>Agricultural land</td>
<td>6.5 (1-140)</td>
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**Table 1. Net primary production estimated for different types of vegetation.**

On a world basis, it can be seen that forests provide more than half the primary productivity estimated for our lowland forest is 37.6 tons/ha/year.
A series of ecological units, responsible for the processes of decomposition and nutrient recycling, involving these various groups is still largely unknown. Enough evidence shows that these processes play very important roles. Termites, for example may account for the disappearance of up to 32% of the leaf litter (Matsumoto 1974) and between 14.5 to 81% of the woody litter on the forest floor in the lowland forests of Pasoh (Abe 1974). My own studies have shown that up to 40 species of termites can occur in a small area of 20 x 20 square meters in a good lowland forest, and Matsumoto (1976) has estimated the biomass of only 4 species of termites to be 361 grams/square meter.

A comparison of the biomass of termites with that of mammalian herbivores as given in Table 2, will show that they compare favourably with their mammalian counterparts in other vegetation types and hence their importance will be appreciated. Termites being much better worked on, have been singled out to illustrate just how important the role of decomposers in the forest is. It is no doubt, therefore, as more information is available on the other groups, that these units or ecological loops are an integral part of the tropical forest ecosystem. It may be relevant to point out that the rate of disappearance of freshly
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be able to manipulate some of the natural systems to their advantage, thereby minimising the energy input.

Harvesting of timber from the natural forest system is in effect the removal of a large part of the total biomass. This would also mean that the nutrients tied up in the wood are removed. The little nutrients that are available in the soil are subjected to leaching and washing away if too much of the forest cover is removed. Also the soil fauna, especially the termites, are particularly sensitive to changes in the physical environment in terms of temperature and humidity. There is evidence also to suggest that in some regenerated areas, a slowing down of growth rates occurs due to the depletion of nutrients in the site (Consens 1965). Tang (1976) recorded similar declines in growth rates in 16 out of 18 regeneration plots in Trengganu and, although he has attributed this mainly to the increased basal competition, nutrient depletion is not ruled out. It would therefore be relevant here to suggest that forest managers should not limit logging damage studies to seedlings and the standing regenerating crop alone, but should consider the damage to the 'biotic factors' and the environment as a whole.

The whole essence of the natural regeneration management hinges on the availability of seedlings and, pole-sized trees on the ground after logging. This is the regenerating factor in the choice of silvicultural treatment. It is now known and has been shown that in most dipterocarp forests, flowering and seed production is, not a regular yearly event, instead, dipterocarps tend towards gregarious flowering and mass seeding (Ng 1977). This phenomenon has been postulated by Krueger (1974) as being a mechanism for predator satiation. However, it is also known that even in a heavy seeding year, with most of the seedlings escaping possible predation, the majority of the seedling crop will still in subsequent years succumb to the physiological restraints of heavy shade prevalent on the forest floor (Burgess 1975). Those that succeed are those that are fortunate enough to find openings in the canopy. If logging is carried out after a good seed year, then there would be ample seedlings on the ground. However, if logging is carried out a few years after the good seed year the seedling crop would not be there. It would be therefore not surprising to find different areas needing different silvicultural treatments after logging.

Enrichment planting is the current practice in areas that are poor in seedlings. With this comes the collection of seeds and wildlings, the setting up of nurseries and the subsequent line-planting in the field. All this involves the expenditure of energy. Can we therefore minimise this input by encouraging the operation of natural systems within the forest?

From a purely ecological standpoint, a possible solution to some of these problems may be to take silvicultural treatments to areas scheduled for logging in subsequent years as suggested by Burgess (1973). The principle is to create openings in the forest canopy and to generally improve the light regime of the forest floor. This could be achieved by the careful killing off of uneconomic species and overmature trees. Such trees should be left in the forest to provide the "fodder" for the decomposers. Given the rapid rate of turnover as has been shown earlier, it will mean that the nutrients tied up will be released and the plants will benefit from this in addition to increased energy availability due to the improved light conditions. As a bonus, the forest manager can expect a better yield from the forest at the time of harvest (Laursen 1976). Moreover, with the expected better girth classes, cutting girth limits could be raised and less damage expected during logging.
However, the most important advantage of this method of silvicultural treatment is that it provides the much needed release factors for the seedlings on the ground. If this treatment is timed at an insurance period of 6 or more years before logging, it should effectively cover any gregarious flowering year. This sort of treatment will also ensure that we make use of the trees to provide seeds and seedlings for the area before they are logged.

In this method of forest management, we are employing and harnessing the natural systems operating within the forest to function for us. It will also retain the diversity and the genetic variability and in the meanwhile, allowing natural selection to take place. However, the most important point here is that by manipulating the forest, we reduce the necessary input of energy while enhancing the efficiency of the system.

c) Plantation forestry

With the trend towards the fuller utilisation of the forest and the popularisation of the lesser-known timber species, the overall effect on the forest will be a far greater damage and the removal of an even greater biomass. This will increase the problems of rehabilitation of the forest. A far greater input of energy will be required. In such cases where the energy input will necessarily be high, it might be much better for the forest manager to opt for plantation forestry.

However, in many ways, plantation forestry is not an efficient system, especially in the tropics. In addition to the great amount of energy input required, it is also not utilising in full the large supply of radiant energy that is available. Most of this energy will be lost as heat while some will go to the growth of weeds which demands further energy requirements to get rid of. However, in terms of net productivity, plantation forestry may be rewarding. This can be understood as the energy inputs being channelled into the standing crop. Moreover it is much easier to manage a plantation than a natural forest.

One possible way to maximise the net gain of radiant energy is by having one tree crop planted under another tree crop. It may be argued that there are already so many problems facing the forest manager in trying to establish one crop, let alone two. However, if the forester could look to the rubber industry and consider the planting of rubber, which nowadays can be considered as a timber crop as well, then some of the problems of plantation establishment would be overcome.

If, therefore, an indigenous tree crop could be planted under rubber, it would ecologically be a good move. From the physiological aspects, if the seedlings of the tree crop were to be planted after the first year of establishment of the rubber, there would be enough light for the seedlings to establish themselves and compete for the light. They would be encouraged to establish the clear bole height that foresters need from a timber crop. The many, problems of the management of a plantation would therefore also be minimised; and the economic returns will justify the intensive management practices.

Conclusion

It should be appreciated that the management of the tropical forest ecosystem has more far-reaching implications than the production of timber. The forest cannot be viewed as a mere timber crop but should be considered as a dynamic system with many built-in control circuits. Knowledge and understanding of these will help towards the eventual harnessing of such control loops for the management of the forest using relatively small energies. Forest plantations will have a continued role to play in tropical
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forestry but they should be limited in area to cater to specific requirements. Their
continued spread indicates and reflects
our failure to understand and manage
our natural forests for their full range
of values.

In this paper an attempt has been
made to relate some of the recent studies
on the tropical forest system to current
deforestry practices and management. It is
hoped that forest managers themselves
will see through the wealth of accumu-
lated data on the tropical forests, espe-
cially in ecological energetics, for clues
to devise new management systems. For-
cest management cannot be limited only
to cutting limits, cutting cycles and poi-
sioning of trees, but, should also consider
ecological principles and the proper mani-
pulation of the natural systems.

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