Ecosystem Approaches to Forestry: The Secret is in the Canopy

Peter S. Ashton
Bullard Professor of Forestry, emeritus
Arnold Arboretum, Harvard University
22, Divinity Avenue, Cambridge, Massachusetts 02138-2020, USA.
E-mail: Peter_Ashton@ksg.harvard.edu

It is a privilege, and an enormous pleasure, to be back here among so many friends today. For this, I express deep thanks to my long-while colleague and friend Toshinori Okuda and to Japan's National Institute for Environmental Studies (NIES), whose far-sighted international research program is providing leadership in fields of ever-growing importance in today's world. I, and the Center for Tropical Forest Science of the Smithsonian Institution and Harvard University's Arnold Arboretum which I represent, have long benefited from our collaboration with NIES researchers, and offer our congratulations for this timely symposium.

It is an incontrovertible fact that the fate of forests lies in their economic value and its change over time. Their value changes with changing markets and with changing technology, and can be modified by policy. Nowhere have these changes taken place more rapidly than in Peninsular Malaysia. Here, changes in the relative economic value of the diverse products and services of the exceptionally biodiverse forests have taken place over shorter intervals than it takes a tree to grow to timber size, posing enormous difficulties for designing successful silvicultural protocols for sustaining forest values. Malaysia's forests originally had high value for the traditional products harvested by nearby rural communities, collected at low intensity requiring no silvicultural intervention for their generally successful sustainment. The development of state and national markets for durable heavy hardwoods and gutta percha (*Palaquium gutta*) in the late 19th century led to a change in the relative economic value of the products of more accessible forests, accelerated as commercial products increasingly substituted many medicinals and other traditionally harvested products. The growth of cities led to increasing demand for charcoal and fuel wood, which recovered the cost of the understorey thinning prescribed for regeneration of the hardwoods. By the second decade of the 20th century, however, kerosene started to replace charcoal for cooking in cities, and by the end of the third decade mechanization of sawmills and, soon after, introduction of pressurized wood preservatives led to replacement of heavy hardwoods by light hardwoods in economic priority, and more extensive logging concessions. Silvicultural management had to be radically changed, starting in the thirties, by introduction of shelterwood systems, which FRIM researchers had developed by the nineteen sixties into the Malayan Uniform System. Long before the 50-70 years required at that time to grow a light hardwood red meranti to merchantable size, though the economic value of commodity crops, notably oil palm, had far exceeded that of the lowland mixed dipterocarp forest (MDF) which is the main source of meranti; now, little remains outside conservation or research areas. The remaining forests, on hills too steep for continuous cultivation, have proven difficult to manage for a specific timber group.

Nevertheless, the market now accepts almost all indigenous timbers. Emphasis increases to concentrate on the fastest growing species including pioneer species with long-fibred wood, while heavy hardwoods still remaining in uncut forests, such as balau (*Shorea* section *Shorea*) and merbau (*Intsia* palembanica) have regained value in the export market.

The changing forest values experienced in Peninsular Malaysian forests have followed a similar path to those in all nations undergoing successful economic development but, whereas they have taken place over one century here, in early industrializing countries like Britain and Germany it took a more amenable three centuries, and in North America two. The trend common to all follows what economists call a Kuznets Curve (figure 1):

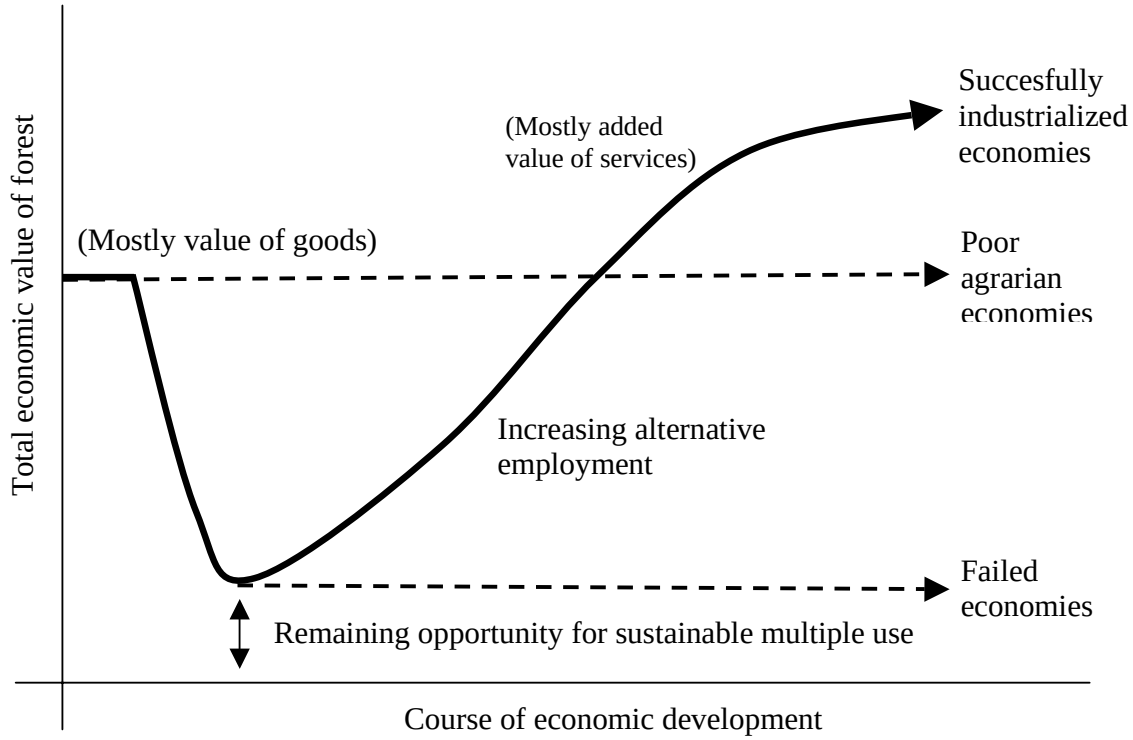

Figure 1. Changes of the economic value of forests in the course of national development.

Initially, in traditional agrarian economies communities are highly dependent on forests whose economic value is consequently high. When communications permitting entry of commercial interests arrive at the forest, the community gains access to cash

wages, albeit often for a few years only. Cash enables members to substitute traditionally harvested forest products with commercial alternatives perceived to be superior, and technologically superior harvesting tools such as chainsaws and guns which for the first time permit chronic overexploitation. The value of the forest resource plummets. Unlike temperate forests, fragile forest soils and lack of seed dormancy in the humid tropics makes permanent loss of species and of productive natural forests inevitable under unmanaged exploitation. This early stage of local economic development is therefore the danger time, when lack of foresight and weak institutions can permanently impair a tropical nation's capability of eventually availing of its substantially unique natural resources in an eventually prosperous modern economy (see figure).

However, if policies and technologies are consistently implemented which provide incentives and means to sustain the natural forest resource, its economic value returns in a modern developed economy and can be far exceeded. Although products such as timber which can be sustainably harvested economically may continue to provide value, it is now the services that forests provide to successful industrial economies that increase forest economic values up to and even beyond their former levels. These values include reliable and clean water supply for industry and the increasingly urbanized population, low soil erosion and siltation rates along lowland water courses and estuaries, local weather (diurnal temperature and rainfall intensity) amelioration, recreation and the tourism industry, education and research, carbon sequestration from the atmosphere (for which there is increasing evidence, even in mature forests in biomass equilibrium, into forest soils), amelioration of global climate change, 'existence value' which is the value of remaining aboriginal landscapes as national heritage, and, in some societies, spiritual value. Parts of Malaysia, particularly the peninsula west of the Main Range, are achieving this economic level.

These changes in value accompany a drastic change in the spatial scale of the communities that benefit. Whereas the remaining traditional products harvested, cash wages in logging operations, quality water and amelioration of weather and soil erosion continue to benefit local communities, these and siltation reduction, recreation, tourism, biodiversity, education and research values benefit a region and the nation at large, while biodiversity, carbon, and climate change amelioration are of global benefit. Incentive for conservation of these values must rest on a just apportion of its costs among all the beneficiaries. At present, the global community is a 'free rider' - gaining the benefits without payment of a just rental. This must be the greatest priority for policy reform, through international treaty.

Values such as 'existence' or biodiversity are difficult to convincingly estimate. A minimum reasonable estimate is the cost to the owner, or concessionaire, of the loss of profit incurred by retaining them.

Tropical forests therefore have a greater diversity of real economic values, whether successfully recovered or not, than ever previously realized. The central question for the economist and silvicultural manager is to what extent single forest stands can be best managed for several products and services, or would different forests within the

landscape better be managed for different outputs. Management of a tropical forest for more than a single output, such as timber and overall biodiversity, is more difficult to execute and monitor in practice than for a single product or service. Further, the optimization of their dual sustainment and economic benefit is more difficult to achieve in practice. For instance, in the most obvious case timber harvesting, for which silvicultural protocols for sustainable production are generally not difficult to devise, are rarely achieved in practice because their costs to the concessionaire substantially reduce immediate profit: Conservation of biodiversity and non-timber products in logging concessions in developing economies, where oversight is usually lax, is therefore only achieved to the extent that it does not increase logging costs, except where a private forest owner or concessionaire has his own incentive to do so.

Research has yet to address the detailed costs and benefits, and the silvicultural and economic optimization of dual or multiple use management of tropical biodiverse production forest, but current experience suggests that opportunities are limited. Better, at least because more reliable, conservation of biodiversity and some other services are achieved by setting aside strict conservation 'virgin jungle reserves' and nature reserves within the production forest estate. Thereby, species such as arboreal vertebrates and epiphytes endangered by logging may be retained within refuges from which the more mobile species may reinvade as the forest regenerates, while generalists such as top predators, vertebrate browsers and successional plant species may prosper in the young regenerating forest itself. Provided breeding populations of sufficient size are retained, plant species can survive in remarkably small populations for many generations, as the specialized floras of isolated limestone karst hills attest.

The residual indigenous forests of this region are by now almost entirely restricted to land unsuitable to sustained agriculture. The lowland mixed dipterocarp forest ecosystems of this region were equal with those of the upper Amazon hylaea as the most species-rich plant communities on earth, and probably since life began. Those few pockets that yet remain are therefore priceless to humanity as libraries of genetic information. Their conservation will need not only rigorous oversight, but also active management as does production forest, in their case to sustain their exceptional levels of biodiversity. On-the-ground research in recent years has gained much understanding of how species diversity is maintained in hyperdiverse ecosystems, which can be applied to their active management. There still remains more to be learned, though.

Biodiversity is concentrated, albeit not exclusive to, the canopy. The canopy is the engine of the forest, because it is here that leaves can maintain near-maximum rates of photosynthesis during the day. It is here, therefore, that most primary production and most gas exchange takes place. The canopy is the filter for carbon dioxide emitted during decomposition which mainly takes place on and in the soil, for oxygen entering from the atmosphere. The canopy intercepts most rainfall, adds solutes to the drops which fall below, and retains some. Water vapor diffuses through it from the saturated subcanopy atmosphere and evaporates from canopy surfaces. Most competition between trees is finally resolved in the canopy, most reproduction takes place, and most herbivory and many pathogens are concentrated there.

Yet we, as tailless primates unable to brachiate, have up to now been severely restricted in our ability to do forest canopy research. For the first time in Peninsular Malaysia thanks to NIES sponsorship, the FRIM-NIES canopy walkway in mixed dipterocarp forest at Pasoh research forest, Negeri Sembilan, fully provided with electricity outlets, provides that opportunity. Its 400 m length opens the full range of the complex rain forest structure to investigation. Replication and comparison with other sites are available thanks to the canopy walkway and tower crane at Lambir Hills National Park, Sarawak, a collaboration of the Sarawak Forest Department with Osaka City and Kyoto universities, by Sabah Park's walkway in lower montane forest at Poring, Kinabalu, and by the Sabah Foundation-Royal Society of London tower at Danum forest.

Japanese and Thai researchers discovered the startling fact that the primary gross production rate of a rain forest at Narathiwat, south Peninsular Thailand, is similar to that of a mere irrigated rice paddy nearby. The explanation is not difficult: All plants involved have the same biochemical pathway for photosynthesis, while the leaf area index (area of upper leaf surface for a given area of ground beneath: LAI), is also similar. The rice maximizes LAI by extending long thin leaves close to the vertical, which still receive sufficient light to photosynthesize at maximum rates yet cast little shadow, thereby allowing many leaves to be stacked. The forest does the opposite: the canopy leaves are each of similar area to rice leaves, but broader and shorter; they are arranged densely and often closer to horizontal. They therefore cast much shadow, excluding light from leaves immediately beneath implying that they are competing for it. These observations suggest that the potential for increasing primary production, and carbon assimilation, in tropical rain forest is substantial. Experiment into the means for geometric and genetic manipulation of canopy leaf morphology, anatomy, and architecture, through ecological, silvicultural and genetic research in the forest canopy, is a necessary basis for optimizing the design of multiple species tree plantations. Some of us believe these to be the most promising future source of tropical timbers. This is just one out of countless examples of the species- and habitat-specific research which is now opened up for the first time at Pasoh.

The Forest Research Institute Malaysia is a leading regional center for forestry research. I wish to end this address by emphasizing that NIES, through its many research investments with FRIM, provides FRIM now with the opportunity to lead the next phase of regional research and education in forests and forestry: through building strong regional partnerships. During this recent postcolonial epoch emphasis has been on addressing national research priorities in isolation. This deprives researchers of the breadth of vision, so necessary in field research, that can only be gained from real field experience at regional scale. NIES and CTFS researchers have gained immeasurably from opportunities to compare results from different sites throughout the region. Both of us are increasing opportunities for intra-regional collaboration, as can be seen – in the case of NIES - by the participants at this symposium. But conferences are not equal to collaboration in field research. It is surely time now for regional centers to themselves sponsor regional partnerships in research and research training.