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The Royal Society's South-east Asian Rain Forest Research Programme: an introduction

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SUMMARY

This symposium reports some of the major findings to date of the Royal Society's South-east Asian Rain Forest Research Programme initiated in 1985 on 'The recovery of tropical forest following disturbance: patterns and processes'. The objective is to gain an understanding of the influence of the creation of gaps of various sizes and kinds, both natural and man-made, upon the flora and fauna of closed-canopy forest, and of the processes whereby these gaps will eventually be filled. Major studies in the first six years have examined spatial dynamics of trees, regeneration dynamics, the role of colonization species and of mycorrhiza, forest hydrology and geomorphic processes, arthropods as decomposers and predators, and the effects of selective logging upon animal populations.

Research is concentrated at the Danum Valley Field Centre in Sabah in Malaysian Borneo, but associated projects have been undertaken elsewhere in Malesia. At Danum, British input in the first six years has involved ten scientists in long-term residence and 98 short-term visits. Fundamental to the programme has been collaboration between British participants from a variety of disciplines belonging to ten universities and five research institutes, and between British and overseas scientists. Also fundamental has been the provision of training in rain forest ecology; to date, this has involved 12 Doctoral and four Masters students of which six and three respectively are from South-east Asia.

Tropical rain forests are the richest ecosystems that the world has ever known. The great number of species that form them is the reason for their fascination to people, their value to the biosphere, and the complexity of their proper management. The land that they occupy, and the value of just one of their many useful products – timber – are the reasons why they are rapidly disappearing. It has been estimated that 11 million hectares (ha)† of mature tropical forests are converted each year to other uses, of which 7.5 million ha are rain forests; the great majority is changed to non-forest uses, only 600 000 ha becoming timber plantations (Gomez-Pompa & Burley 1991; Lerdau *et al.* 1991; Schmidt 1991; WRI 1985). In addition, much tropical forest is degraded every year, perhaps 4.5 million ha through selective logging, the vast majority of this receiving no subsequent active management. In total it is estimated that 20 million ha of tropical forest lands are altered annually; and yet, despite the value of timber as an export (the international trade in tropical timber realizes U.S.$7 billion a year) and the necessity of fuel wood for many poor people, forests were being cleared in the early 1980s in Africa 29 times as fast as they were being planted, and in tropical America 10.5 and in tropical Asia 4.5 times as fast. In 1989 it was estimated that just 0.1% of the remaining natural tropical forest was under active sustainable management and only 3% set aside for the conservation of biodiversity (Holmberg *et al.* 1991).

A sustainable supply of timber and other rain forest resources is obviously a desirable goal for any equatorial nation. For this, a combination of plantations, natural production forests and fully protected forests will make the most efficient use of tropical land resources. Biologists, aware both of the great values of the rain forest ecosystem and of the social, economic and political milieu in which they are found, are increasingly turning their attention from undisturbed areas to production forests, attempting to assess how these can best be managed both to provide long-term economic benefit and to serve the needs of species preservation.

The belief that rain forests have existed largely unchanged for millions of years is now seen to be a myth. At one end of a temporal spectrum forests have, throughout the Quaternary, ebbed and flowed over Asia, Africa and America; at the other, changes due to local disturbances – storms, landslides or the death of individual trees (about 1% of trees die annually) – result in the forest being an ever-changing mosaic of gaps, trees growing up in former gaps, and mature forest (see, for example, Whitmore (1991)). Furthermore, the concept that man has influenced the forest only in the last couple of centuries is flawed; it is now apparent that most forests have for millennia undergone numerous cycles of disturbance and abandonment by forest peoples (Gomez-Pompa & Burley

† 1 ha = 10^4 m^2

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1991). However, both the present rate and scale of forest disturbance are very much higher than has ever been known before, and those forests regenerating after selective logging exhibit a very much coarser mosaic than is found in unlogged forest.

Over the past 25 years, our understanding of the functioning of the rain forest ecosystem has increased enormously. Many are now convinced that managing these forests for sustainable economic benefit is feasible, and that such management will provide much greater long-term security for people than the present pattern of forest destruction. Yet only a very small proportion of the forest is managed in any real sense of the word, this failure being primarily due to political, administrative and economic causes (Schmidt 1991). So what can biologists in temperate lands do to assist?

In 1984 the Council of the Royal Society formed a new committee to stimulate further research by British workers on the rain forests of South-east Asia. The origins of this action date back to early 1979 when the Society's Southern Zone Research Committee (SZRC) approached a number of researchers to gauge interest in collaborative programmes in the tropics. At that time a group of scientists at British institutions were discussing ways to participate usefully in rain forest research. Their aims were not precisely defined, but there was a general desire to advance our knowledge of the rain forest ecosystem, to assist in the preservation of undisturbed forest, to obtain data useful to those charged with the management of production forests, and to provide training for the next generation of rain forest ecologists and managers. After much consultation both in the U.K. and overseas, the SZRC decided in November 1982 to recommend to the Council that the Society should support a programme on 'The recovery of tropical forest following disturbance: patterns and processes', concentrating the studies particularly, but not exclusively, at the proposed Danum Valley Field Centre in Sabah in Malaysian Borneo. In late 1984 the Royal Society's South-east Asian Rain Forest Research Committee was formed, and a Memorandum of Understanding signed between the Society and the Danum Valley Management Committee in Malaysia. The Field Centre, no more than a wooden hut at the end of a logging road, opened its doors to the first researchers in January 1985. Six years later, the Centre, with 19 full-time staff and enviable research facilities and accommodation, is one of the world's foremost rain forest research stations (Marsh & Greer, paper 2, this symposium).

Malaysia has perhaps the finest record of forest management of any equatorial nation, and is the only one undertaking significant programmes of silvicultural treatment (Collins *et al.* 1991, Schmidt 1991). Dipterocarps, which dominate the forests of South-east Asia, have a number of characteristics that allow foresters to manage these forests comparatively easily to yield economic returns: gregarious fruiting, dense seedling populations, rapid response of seedlings to light gaps, relatively fast growth, gregarious stands, convenient shape etc. (Appanah & Salleh 1991). None the less, it is likely that timber exports will cease from Peninsular Malaysia by the end of this decade; on the island of Borneo, it is estimated that Sabah will be logged out by 1995, Sarawak by 2002 and Kalimantan by 2010 (Chin 1990; Dobson & Absher 1991). In Sabah, it was estimated that 6.4 million ha (88%) of the land area of 7.4 million ha was forested in 1974 whereas by 1985 only 4.5 million ha remained, a reduction of 30% in 11 years. Of this, 3.3 million ha were forest reserves, 1.0 million ha state forests and 0.2 million ha parks and other forests; much of this had already been selectively logged. By 1989, less than 8% was still covered in undisturbed lowland forest. Within this undisturbed forest, the Danum Valley Conservation Area, covering 43 800 ha, forms a highly significant component. It lies within the timber concessions of the Sabah Foundation, and it is the Foundation that set it aside in 1981. The foresight involved in this decision is emphasized by the fact that in 1987 average timber extraction intensities in Sabah were 70 m^3 ha^{-1} with an average price of £90 m^{-3} (£55–£110), giving a potential timber value for the Conservation Area of over £200 million (C. W. Marsh, personal communication).

The Danum site is unusually suitable for a study of the influence of the creation of gaps of various sizes and kinds upon the flora and fauna of closed canopy forest, and of the processes whereby these gaps will eventually be filled. The Centre lies on the eastern boundary of the Conservation Area which provides an excellent site for base-line studies. To the east lies a large Sabah Foundation timber concession, the Ulu Segama forest, which is divided into sections (coupes) for logging between 1973 and 1996. Thus currently, the researcher can on a single day enter undisturbed forest or forest which has been selectively logged from one to 18 years previously. The first research task was to inventory the plants in the region, work largely undertaken by staff from the Royal Botanic Gardens at Kew and Edinburgh. At the same time work started on a study of the composition of two 4 ha plots of primary forest in the Conservation Area, data on 18 000 trees being recorded and providing a baseline for the long-term study of the dynamics of undisturbed forest (Newbery *et al.*, paper 3, this symposium).

One explanation that has been proposed for the high tree-species diversity of rain forest is that different species of trees grow preferentially in gaps of different sizes. A variety of different gap sizes would therefore favour the regeneration of a range of species. To test this, gaps of various sizes were artificially created and the resultant regrowth monitored; this indicated that pre-gap seedling size, rather than species, was the critical factor affecting survival and growth (Brown & Whitmore, paper 5). Using the same artificial gaps, another study (Kennedy & Swaine, paper 4) examined the influence of gap size, soil-surface conditions and competition from advanced regeneration upon the germination and growth of colonizing species. The results indicate that gap size apparently does not control the composition of the colonizing vegetation by influencing seed germination. Mycorrhizal infection may influence the growth of many trees in South-east Asian forests and two studies have examined this

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effect and the role of disturbance upon the inoculum potential of the soil (Alexander *et al.*, paper 6).

Rainfall in rain forest regions is high, and much falls in storms of high intensity. A team has been examining exactly what happens to this precipitation in mature forest; how much reaches the ground and in what form, how much is intercepted by the canopy and lost, the influence of the magnitude of storms upon this, and the effect of the removal of ground and understorey vegetation upon runoff and soil loss (Sinun *et al.*, paper 7). This study has provided baseline data for another in which the effects of disturbance upon the output of water and sediment have been monitored during the selective logging of a small catchment. Data indicate a great increase in sediment load during and immediately after logging, but loads had significantly diminished again a year after the cessation of disturbance, indicating a degree of recovery (Douglas *et al.*, paper 8).

Studies on rain forest regeneration have, for obvious reasons, tended to concentrate on the flora. In a recent book on this topic (Gomez-Pompa *et al.* 1991), only one out of 32 chapters considers the fauna. Yet clearly, animals play a vital part in this most complex of ecosystems, and an assessment of recovery from disturbance must equally concern both animal and plant communities (see Anon 1991). An examination of leaf litter decomposition and litter arthropods in both primary and logged forest showed that annual leaf litterfall, leaf litter standing crop and leaf litter decomposition were not significantly different between the two sites, but arthropod density was higher in the primary plot (Burghouts *et al.*, paper 9). Few data are available on the effects of disturbance upon the major component of tropical biodiversity: the insect fauna. Pilot studies on this have recently started at Danum, and preliminary results, contrasted with similar studies elsewhere in the Asian tropics, are presented by Holloway *et al.* (paper 11). The roles of animals as pollinators, seed predators and seed dispersers are obviously critical to the form that recovery takes, yet these roles are little understood. The rain forests of South-east Asia are unique in that many species of trees from a wide diversity of taxa exhibit mass flowering and subsequently mass fruiting at uneven intervals of years. This poses unusual problems for those animals that feed upon flowers or fruit. Toy *et al.* (paper 10) examined the role of weevils as pre-dispersal seed predators of dipterocarps in a Peninsular Malaysian forest, not specifically to examine their role as causes of seed mortality, which was difficult to ascertain, but to assess how they survived periods without flowering and seed production.

In 1988 a study commenced of the effect of logging upon forest vertebrates at Danum. Preliminary assessments showed that although logging had considerable initial effects on the primate community, the resilience shown was surprisingly high; but such resilience was greatly affected by the intensity of logging, particularly by the pattern of areas left unlogged (Johns, paper 12). Concerning birds, the great majority of species present in primary forest were also present in forest selectively logged eight years previously; however, the species mix was altered. Clearly, the extreme heterogeneity of logged-over forest suits many birds, but again the scale and pattern of logging is critical (Lambert, paper 13). Studies currently underway are assessing the influence of selective logging upon ungulates and freshwater fishes.

The above studies have been done either directly by or under the supervision of scientists from the U.K. (affiliated to ten universities and five research institutions) working in collaboration with those from South-east Asia. Much of the field work has been done by students undertaking postgraduate degrees; to date, this has involved 12 Doctoral and four Masters studies, of which six and three respectively are by South-east Asians. The work has involved ten British scientists in long-term residence overseas, 98 short-time visits from the U.K. to South-east Asia and 21 visits by South-east Asian collaborators to U.K. institutions. The record of the Programme for successful interdisciplinary and international scientific collaboration and the provision of valid training for young scientists is, I believe, a good one. From the following pages the reader will be able to judge whether we have as yet managed to fulfil our other initial aims; to advance significantly our knowledge of the functioning of rain forest ecosystems and to provide data useful to those charged with their management.

A programme such as this relies upon the goodwill and cooperation of a great many people. Tengku D. Z. Adlin (Sabah Foundation), Mr Lee Ying Fah (Sabah Forest Department) and Dr Ghazally Ismail (Universiti Kebangsaan Malaysia, Sabah Campus) have, as chairmen of the Danum Valley Management Committee and in numerous other ways, been of great support throughout. Dr Clive Marsh, as secretary of the DVMC and guiding light of the Field Centre, has played a vital part linking British and Malaysian workers. Dato Dr Salleh Mohd Nor (Forest Research Institute Malaysia) and his staff have provided much assistance. The Socio-economic Research Unit of the Prime Minister's Department has kindly given permission for participants to conduct research in Malaysia. I have also much appreciated the good advice and friendly help provided by Mr Len Mole and other officers of the Royal Society. This paper is Number A/040 of the Royal Society's South-east Asian Rain Forest Research Programme.

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