Seeing the fruit for the trees in Borneo

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Abstract:

The recent mass fruiting of forest trees in Borneo is an urgent wakeup call: existing policy instruments, financial mechanisms, and forestry infrastructure are inadequate to take full advantage of these infrequent opportunities for forest restoration and conservation. Tropical forest restoration can provide substantial benefits for biodiversity conservation, climate change mitigation, and poverty alleviation. Yet the unpredictability of the synchronized flowering and consequent mass fruiting of many forest trees in Borneo presents a distinctive set of challenges for forest restoration. Significant financing and a considerable coordinated effort are required to prepare for future mass fruiting events if we are to capitalize on opportunities for ecological restoration. The continued high rate of forest clearance in this region and the rarity of mass fruiting events suggest that there may be few remaining opportunities to prevent widespread species extinctions. In this article we propose a facilitatory policy framework for forest restoration in Borneo to stimulate action in advance of the next mass fruiting of forest trees.

Introduction

The island of Borneo is a recognized biodiversity hotspot and its forests contribute disproportionately to the global total of Critically Endangered forest-dependent species (Brooks *et al.* 2006; Normile 2010). Lowland rain forests in Borneo are among the most diverse biomes, but are vulnerable to clearance for agriculture, as well as fire,

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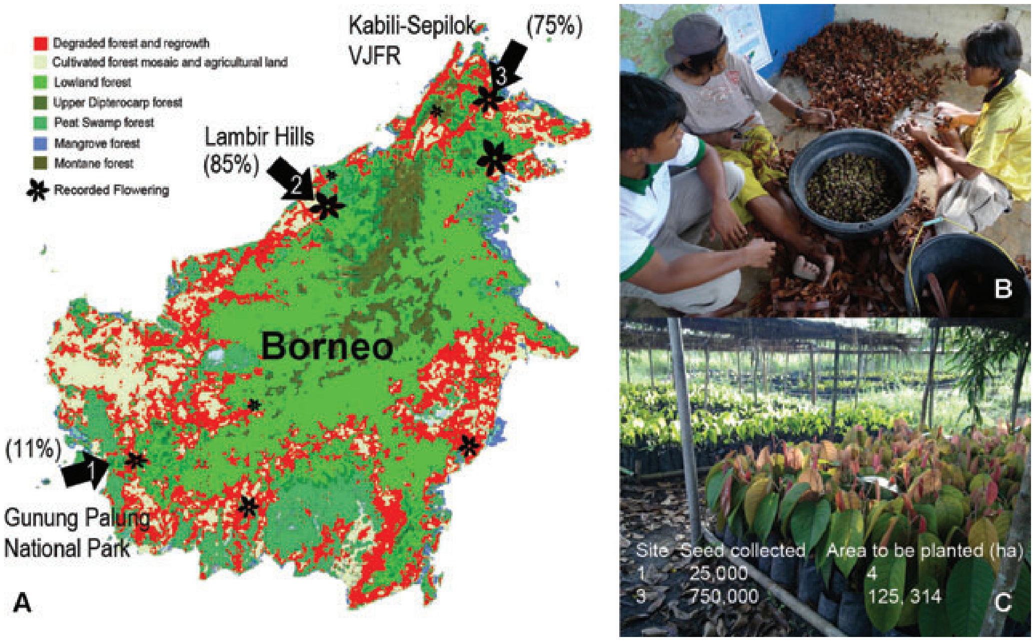

Figure 1 (A) Map of Borneo showing forest degradation, the locations of three sites where the general flowering event has been quantified and other locations where general flowering has been recorded (flower size indicates the intensity of the event). Values are percentage of trees >30 cm DBH flowering (B) Seeds of native (dipterocarp) trees being processed at the Alam Sehat Lestari nursery near Gunung Palung National Park, West Kalimantan and (C) the nursery at Gunung Palung rearing trees for restoration. The values in 1c are numbers of seeds collected from Gunung Palung and Kabili-Sepilok Virgin Jungle Reserve (sites 1 and 3, respectively) and the area of land being restored.

mining, and unsustainable logging. In Kalimantan (Indonesian Borneo) there is a risk that 2.1 billion tonnes of CO_2 will be released into the atmosphere over the next 30 years as a consequence of forest and peat land conversion to oil palm plantations (Venter *et al.* 2009). The rate of forest clearance (excluding forest degradation) across Borneo exceeds 1.7% per annum (circa 2002 to 2005), which is faster than for any other part of Southeast Asia and among the highest in the world (Koh 2007; Langner *et al.* 2007). The degradation of these forests also has major implications for the substantial numbers of forest dependent rural poor (Poffenberger 2009). Reversing these trends through forest restoration is attracting attention across the tropics (Braxton Little 2008; Chazdon 2008; Normile 2009), motivated by the need to mitigate greenhouse gas emissions (Drummond *et al.* 2010), restore key habitats for species of conservation concern and enhance the biodiversity value of human-modified landscapes (Gardner *et al.* 2009). For example, the restoration of logged-over forests in Sabah has resulted in more rapid recovery of insectivorous bird populations than in naturally regenerating logged forest (Edwards *et al.* 2009).

Large-scale forest restoration programs will require, among other things, adequate financing, co-ordinated action and infrastructure, especially tree nurseries that have adequate stocks of seedlings of native tree species. The latter is dependent on access to large quantities of viable and genetically diverse seeds. Many of the larger Bornean tree species (particularly among the Dipterocarpaceae) reproduce during infrequent community-wide events known as "general flowering", while seed production during intervening years only rarely leads to seedling recruitment (Ashton 1988; Brearley *et al.* 2007; Cannon *et al.* 2007). In addition, the seeds of dipterocarps, which comprise 10% of tree species and 80% of canopy species in Borneo, are recalcitrant, germinate rapidly after dispersal and cannot be stored (Adjers *et al.* 1995; Li & Pritchard 2009). These biological constraints present a serious challenge to collection of seeds and seedlings that form the basis of any forest restoration project on Borneo.

Since late 2009, we have been witnessing the largest general flowering and mast fruiting event in Borneo in over 12 years, both in its geographic extent and abundance of reproductively active trees (see Figure 1). Current infrastructure, including nursery facilities and organisational capacity, have proved inadequate to the task of seed collection on this occasion (Kettle *et al.* 2010), and large scale restoration work will have to depend on another future reproductive event. It is imperative that we meet this challenge in advance of the next mass fruiting event some years hence. But what, exactly, constitutes the forest restoration challenge in Borneo? In essence, we need to ensure that we are able to deliver the necessary biological resources, scientific knowledge, organisational capacity, infrastructural needs and supportive policy framework for any serious effort at large scale ecological restoration of Bornean tropical forests.

Biological resources

Existing restoration and enrichment planting projects in Borneo plant between 500 and 2,500 seedlings per ha, depending on the site. Assuming a conservative estimate of 500 seedlings per ha, some 7.1 billion seedlings of native tree species would be required to restore the 14.3 million ha of degraded forest (<40% canopy cover) land in Borneo (based upon figures derived from Langner *et al.* 2007). Substantially larger quantities will be required for planting abandoned and bare land. Given the unpredictable yet synchronous fruiting of many of these species, we are faced with the challenge of collecting such large numbers of seeds within a short window of opportunity (a matter of weeks), but with only a very general idea of when this might occur.

It is not only the numerical challenges that need to be met, but seed collections should ideally be sourced from a wide range of the tree diversity, including many threatened species, that occurs at any one locality in Borneo, with due attention paid to genetically diverse seed sources (Kettle 2010). Dipterocarps alone constitute 267 tree species in Borneo, and ecological restoration efforts, which go beyond the production-driven objectives of plantation forestry, would need to reflect this diversity of species.

Scientific knowledge

The knowledge-base for implementing successful forest restoration has grown over several decades of silvicultural and ecological research in tropical Asia (Adjers *et al.* 1995; Kettle 2010). For example, research has demonstrated that matching species to appropriate soil type and light regimes enhances survival (Paoli *et al.* 2006; Shono *et al.* 2007; Russo *et al.* 2008). Careful tending of planted trees for several years after planting is necessary to reduce competition from faster growing pioneer species or lianas (Romell *et al.* 2009). Many of these principles have been long embedded in forest management guidelines, such as the Indonesian Selective Cutting and line Planting System for lowland forest (TPTJ) and forest management rules in Malaysia (www.forest.sabah.gov.my/ 2010) and Brunei (www.forestry.gov.bn/dept˙policy.htm 2010), and they are conveyed to trainee foresters throughout the region.

Dissemination of the existing knowledge via internet based virtual networks of restoration projects would enhance knowledge transfer and technical capacity. For example, a Borneo-wide online information resource base might usefully include information on all existing restoration projects, tree species used, seed source sites, ecological and genetic information, nursery techniques on maintenance and propagation, funding opportunities, as well as opportunities for sharing resources and expertise. This would require an effective and coordinated organizational structure, with governmental support.

Knowledge is of little value unless it is put to use. A recent survey of forest rehabilitation projects in Indonesia indicates that the poor success is often due to inadequate implementation of basic principles such as adequate post planting maintenance (Nawir *et al.* 2007). Demonstration projects illustrating best practices might provide the basis for knowledge transfer and capacity building. For example, projects might build upon the existing expertise of the Forest Restoration Research Unit (FORRU) of Chiang Mai University, Thailand (www.forru.org) which provides one successful model of capacity building that could be applied to other regions and institutions. A network of demonstration programs will also provide opportunities to transfer much of the currently institutionalised knowledge to local communities, through which restoration activities might be adapted to local needs and conditions.

Organizational capacity

The distinctive reproductive phenology of many Bornean forest trees requires preparedness of organisational and technical capacities and their financing. Even assuming that well-planned and co-ordinated seed collection can be achieved, the subsequent rearing of seedling stocks, preparing sites, planting seedlings and post planting maintenance will all require specific expertise, and supporting infrastructure, long-term financing and, thus, political support and commitment to the concept of forest restoration.

Development of trans boundary phenology monitoring programmes will be necessary to ensure that future flowering and mast fruiting events are capitalized to their full advantage. This will require improved cross border collaborations between forest institutes, which may in part be through the above-mentioned virtual network, but should also be encouraged through workshops and meetings. Restoration projects require access to skilled nurserymen and forest botanists able to identify the

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appropriate species for seed collection. This is particularly so because most established seed collections focus on a narrow range of common and economically significant species, while rare species of greater conservation priority are largely neglected. Thus forest institutions and universities should collaborate to provide the necessary courses and training required to establish a sufficient cadre of foresters, botanists, and nurserymen. Similarly, an expansion of restoration activities will inevitably increase the need for skilled personnel, and the organization of an appropriate education system should be developed to meet this expected future need.

Infrastructural needs

In Indonesia, a growing number of NGOs such as Yayasan Konservasi Ekosistem Hutan Indonesia (KEHI) and Borneo Orangutan Survival have obtained large-scale forest concessions to undertake restoration work. However, such projects often lack the nursery capacity as well as technical knowledge to support large scale planting. In Indonesia less than 25% of projects had even basic nursery facilities and only 14% possessed adequate maps of species distributions and soil types to make accurate site-species selections (Nawir *et al.* 2007).

The existing networks of botanical gardens and Forest Research Institutes should play a substantial role in capacity building at the local and regional scales. Many include arboreta and nursery facilities that offer a foundation for new ex situ seed orchards to help safeguard the genetic diversity of highly threatened tree species. These existing facilities also provide a vital training resource for new forest botanists and nurserymen, who are essential to increase capacity to respond to mass flowering events. Without adequate nursery infrastructure restoration projects may even have detrimental effects on natural forest. For example, recent efforts to restore degraded forest within National Parks in Indonesia such as Gunung Halimun and Gunung Salak in West Java, and Gunung Leuser in Sumatra, as well as in Sabah have all relied heavily on exploitation of wild seedlings from adjacent primary forests. This activity has the potential to affect natural regeneration processes and thereby disrupt natural forest dynamics where wild seedlings are sourced.

If forest restoration in Borneo is to contribute significantly to reversing the trend in loss of lowland forest, a major policy overhaul is required. Policies need to link existing institutional infrastructure and knowledge with the increasing number of stakeholders interested in planting native trees. These stakeholder groups include not only government agencies, private forestry companies and special interest groups, but also the large population of highly forest-dependent rural poor. Ensuring that forest-dependent rural poor are integrated into polices will be an important step toward incentivising large scale restoration (Agrawal *et al.* 2008; Angelsen *et al.* 2009; Dargusch *et al.* 2010). Below we outline the facilitatory policy framework necessary to overcome the challenges to restoring the dwindling forests of Borneo.

A facilitatory policy framework: linking Biodiversity conservation, climate mitigation and rural livelihoods

If ecological restoration is to succeed, it needs a strong commitment from national governments. Such a commitment can be best articulated through the announcement of a set of ambitious but realistic targets on the area of degraded forest land to be restored by a particular date. Currently, roughly 14.3 million ha of Borneo's forest area is degraded to some degree (equivalent to 33% of forest), and we advocate a clear commitment to instigate the restoration of a core set of degraded areas that are strategically located to enhance the conservation of biodiversity and the delivery of ecosystem services. This in turn will require the commitment of investment in building the required capacity and for enforcing the existing policies relating to forest use.

Biodiversity conservation

If forest restoration is to meet the needs of biodiversity conservation, then policies must ensure better allocation of funds to planting native trees. The Indonesian government's Reforestation Fund, *Dana Reboisasi* (DR) is the largest source of revenue from the commercial forestry sector (valued at approximately 5.8 billion US$ over the last 20 years). The DR has been criticised for providing few benefits to forest conservation and restoration (Barr *et al.* 2010) despite its mandate to support reforestation and the rehabilitation of degraded land and forests. Corruption, misappropriation of funds to a political elite and discounted loans to commercial plantation companies have increased forest degradation rather than stimulated restoration of forest lands (Barr *et al.* 2010). Policies for better financial monitoring, verification through independent auditing, greater transparency and improved accountability are urgently needed to ensure these funds and new financial mechanisms are used to their full potential to reverse forest degradation (Barr *et al.* 2010).

The majority of the trees planted across Borneo are fast-growing exotics such as *Acacia mangium*. These trees have different silvicultural requirements to Bornean native trees, and consequently the development of silvicultural expertise for native trees has been slower than might have been the case under a policy regime that

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favored native species. Beyond the potential to restore infertile soils (Norisada *et al.* 2005) such mono-cultures provide few ecosystem services. Studies from the neo-tropics (Barlow *et al.* 2007; Gardner *et al.* 2008) and Southeast Asia (Fitzherbert *et al.* 2008) have demonstrated the negative consequences for biodiversity of forest conversion to plantations of non-native species (but see Meijaard *et al.* 2010). Up to 2007 over 1 million hectares of land had been planted with industrial timber or pulp wood plantations (HTI) in Indonesian Borneo alone, which accounts for over 57% of the total reforestation projects financed through the DR (Barr *et al.* 2010). This often leads to additional clearance of 'degraded forest' and costs to biodiversity (Nawir *et al.* 2007; Butchart *et al.* 2010; Edwards *et al.* 2010). Further expansion of such plantations is encouraged by current policies that seek to increase existing industrial plantation in Indonesia to nine million hectares by 2016 (Barr *et al.* 2010). A large proportion of these plantations are slated for Kalimantan where combined with conversion to agricultural uses, (oil palm) and production forest will result in the conversion of more than 80% of remaining lowland rain forest on mineral soils in Indonesian Borneo (Paoli *et al.* 2010). Polices need to recognize the wider benefits of multiple species plantations with native trees. Enhancing the diversity of native trees in degraded landscapes is likely to enhance function, resilience and biodiversity. Providing positive bottom-up effects on multitrophic interaction networks will support a greater diversity of interactions among species (Novotny *et al.* 2006, 2007; Scherber *et al.* 2010). Ecological restoration of natural forest within a landscape mosaic will also enhance habitat connectivity with benefits for many forest dependent species (Brockerhoff *et al.* 2008; Nasi *et al.* 2008).

Policies that aim to promote restoration for biodiversity conservation should build upon existing initiatives such as the Global Strategy for Plant Conservation (www.cbd.int/gspc/2010) and the recent Busan agreement of the UNEP which made progress towards establishing an inter-governmental platform for biodiversity and ecosystem services. Conservation certification schemes such as the Malua Biobank that is pioneering Biodiversity Conservation Certificates in Borneo (www.maluabank.com/2010), can also provide financial support for forest restoration. Such policies must ensure that financial resources designated for reforestation are only allocated to scientifically informed and sustainable restoration and planting of native forests. But, these restoration efforts should not be used as a compensatory mechanism for further degradation of existing forest (Bekessy & Wintle 2008). International policies on timber procurement and voluntary certification, such as the Forest Stewardship Council can provide powerful leverage for increasing the use of native tree species in planting on logged-over forest (Dennis *et al.* 2008).

Climate mitigation

Linking reforestation projects to climate mitigation is increasingly possible through initiatives such as the UNFCCC Clean Development Mechanism (CDM) and United Nations programme on Reducing Emissions from Deforestation and Forest Degradation, (REDD+) (Angelsen *et al.* 2009), and other carbon credit schemes (Miles & Kapos 2008; Paquette *et al.* 2009). If forest restoration is to benefit from these initiatives the carbon benefits of restoring natural forest over industrial plantations need to be recognized (Lang 2010; Liao *et al.* 2010). Existing policy instruments require modification to make them more amenable to forest restoration. Afforestation and reforestation account for only a tiny fraction (0.52%) of UNFCCC CDM registered projects (UNFCCC 2010). Simplifying the rules and reducing the transaction costs would make these more accessible to small-scale forest restoration projects (Dargusch *et al.* 2010; Lasco *et al.* 2010). Making enrichment planting of degraded forest eligible for financing under the UNFCCC CDM, (currently only sites that have been devoid of forests since 1989 are eligible) could provide great ecological returns for the economic investment (Paquette *et al.* 2009; Edwards *et al.* 2010).

Community involvement

Establishing policies that facilitate local community involvement in restoration is desirable. Apart from providing employment opportunities, restoration could be embedded in a system of incentives, as subsidies or by providing seedlings of locally useful tree species. This might encourage local restoration initiatives alongside larger government sponsored action. Local restoration initiatives established by the local community might, for example, include a greater focus on economic species including trees that provide fruit (e.g., *Nephelium* spp, *Mangifera*, spp., *Durio*, spp.,), illipe nuts (*Shorea macrophylla* and *S. stenoptera*), incense (*Aquilaria malaccensis*), and timbers (*Agathis borneensis*, *Eusideroxylon zwageri*, *Tetramerista glabra*). These products could support local incomes in the long term. In this way ecological restoration could be embedded within existing complex agroforestry landscapes. Incentives for the development of community restoration projects might be through direct financial support with funds secured through REDD-type programmes, or through the promise of granting land tenure or long term land leases to reforested areas under a scheme that allows sustainable use of such areas (Nawir

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et al. 2007). Such approaches are likely to be more beneficial to rural livelihoods than industrial plantations where the economic benefits are often not equitably distributed, and have limited employment opportunities for the rural poor (Lamb 2011).

Both governmental and nongovernmental organizations could facilitate community-based action by helping to secure long-term financing, to educate communities and help with access to seedlings and emerging markets, such as the voluntary carbon market or other environmental certification schemes (Mangabat *et al.* 2009; Dargusch *et al.* 2010; Lasco *et al.* 2010).

Conclusions

Forest restoration has the capacity to deliver multiple benefits but it also requires investment and planning. As well as helping to conserve a substantial fraction of the Earth's remaining biodiversity, restoration and enrichment planting of Borneo's rainforests can contribute towards global efforts to mitigate climate change and could be economically beneficial to local communities and to national and state governments. The revenue generated from the unprocessed logs of legally harvested high value native timber species between 2006 and 2007 was US$1.05 billion for Malaysia, which is the largest exporter of legally harvested tropical round wood (ITTO 2008). The economic costs of climate change, degradation of natural resource base and loss of ecosystem services from Bornean forests is likely to far exceed this sum (Stern 2007; Eliasch 2008; Ring *et al.* 2010). Restoration initiatives require substantial infrastructure, as well as policies that provide long-term financial support, at national and local levels. The vast potential for forest renewal and restoration embodied by the recent general flowering event will not be realized, because the necessary coordinated response, adequate funds and nursery infrastructure were not in place. This missed opportunity serves as a wake-up call to policy makers and local stakeholders: the infrequent reproduction of Bornean forest trees, coupled with the current high rates of forest conversion, may mean that we have few remaining opportunities to initiate large-scale restoration planting of forests across lowland Borneo. Future opportunities should not be missed.

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