Note to Chapter 6

"The ecological consequences of logging in the burned forests of East Kalimantan, Indonesia"
(With Douglas Sheil and Kuswata Kartawinata)

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The ecological consequences of logging in the burned forests of East Kalimantan, Indonesia

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Introduction

In 1997-1998 over 50,000 km² of East Kalimantan burned, and some 26,000 km² of natural forest concessions were affected. This is nearly one-quarter (24%) of the area of all natural forest concessions in the province (Hoffmann et al. 1999, Siegert et al. 2001). The biomass of the trees living at the time of the burn was little reduced by the fire which tended to be restricted to the litter and understory, and although many trees died, most stems remained standing after fire. These dead stems in the burned forest represent a significant timber resource. A government regulation was issued (Directorate of Forest Utilization 1999) indicating that in concessions where fires had occurred, "salvage felling" (harvesting of the remnant commercial dead timber by conventional methods) should precede any continuation of regular harvesting operations in unburned forest areas. The reason for this regulation was that the dead stems could still provide valuable timber if removed before serious deterioration (Ulbricht et al. 1999). It was apparently assumed that such salvage activities would have little additional effect on the already degraded forest. There are good reasons, however, to be concerned about the ecological effects of salvage felling after fire.

Forest areas can recover after fire, but remain in a very sensitive state in which additional disturbances, such as salvage felling, will cause significantly increased levels of forest deterioration and loss. The results from our 2-year study on post-fire vegetation dynamics in the unlogged dipterocarp rainforest of Sungai Wain near to Balikpapan (1°16' S and 116°54’ E; altitude 40 to 140 m.a.s.l.; average yearly rainfall 2790 mm (Vose et al. 1992), East Kalimantan, compel us to warn against the implications of salvage felling. We intend to publish a more detailed account of our study but the urgency of the situation makes it important that we disseminate our main conclusions as soon as possible.
Vegetation processes after single and repeated disturbance

The recovery capacity of forest vegetation after fire and other disturbances involves four main processes: tree survival, the resprouting of damaged trees, germination of seeds in the seed bank, and the seed rain. To study the relative contribution of these processes to vegetation development, we established permanent sample plots of 1.8 ha each in unburned forest and in forest that burned accidentally in March 1998 after several months of drought. Nine pairs of burned and unburned plots were established adjacent to each other over a human-made edge (a successful fire break that usually does not correspond to any topographical feature) between burned and unburned forest. The plots were spread over a total area of circa 20 km². Each pair of plots formed one contiguous transect of 60 x 600 m half in burned and half in unburned forest. In these plots, more than 3000 (both dead and living) stems larger than 28 cm dbh (diameter measured at 1.3 m height) were measured and labeled. In subplots of 0.4 ha, an additional 4700 trees between 8 cm and 28 cm dbh were measured and labeled. A total of 2190 (dead and living) seedlings and saplings (<8 cm dbh) and 445 living resprouts on stems smaller than 8 cm dbh were measured and labeled in 10 m² burned subplots. Living trees and sprouts and dead trees larger than 28 cm dbh belonging to 10 common species were identified by local experts.

Directly after the low intensity ground fire most of the trees remained standing, although a high proportion of the stems appeared to be dead. One year after burning < 1% of trees smaller than 8 cm dbh survived, but larger sizes generally fared better. Survival of trees larger than 30 cm dbh was circa 45%, with a range from 20 to 95% among species. Comparable levels of survival for trees larger than 10 cm dbh 1 month after fire have been found in a recently logged forest in Sabah (Woods 1988), whereas survival 6 months after fire was circa 25% higher in an unlogged forest in Kutai National Park, East Kalimantan (Leighton & Wirawan 1986) and in Sumatra (Kinnaird & O’Brien 1998). The surviving trees in the Sungai Wain forest appeared sensitive to wind. Of the 35% of the living stems that died in the second year, one-fifth had fallen. The remaining trees provided a sparse matrix, with a considerably impoverished species composition.

After the fire, some trees that were killed above ground sprouted from basal parts. This is a common phenomenon after slash and burn practices (Stocker 1981; Riswan & Kartawinata 1991 a & b; Kammesheidt 1998) and has been observed after fire in other tropical forests (Leighton & Wirawan 1986; Riswan & Yusuf 1986; Pinard et al. 1999). With a proportion of circa 17%, sprouting frequency was highest for above-ground-killed seedlings and saplings smaller than 8 cm dbh. This was enough to provide densities of 0.2 to 0.4 sprouting trees per m². Trees larger than 10 cm dbh that were killed above ground had a sprouting frequency below 10% and added little to the density of sprouting individuals.

In an experiment in the unburned forest we assessed the sprouting vigor of young trees of six primary forest species (Dipterocarpus confertus Sloot, Durio auctifolius [Mast.] Kosterm., Gironniera nervosa Planch., Macaranga lowii King ex Hook.f., Madhuca kingiana [Brace] H.J.Lam, Shorea laevis Ridl.), after clipping the main stem. Two hundred individuals from each species were checked monthly over 6 months for the number of sprouts produced, sprout length, and number of leaves. Sprouting occurred fast, with more than 90% of the individuals sprouted after 3 months in four of the six species. Several species were affected negatively by repeated disturbance. Plants that were clipped for a second time 2 months after the initial clipping showed a reduction in sprouting frequency ranging from 0 to 40% when the top of the remaining stem was removed to 64 to 100% reduction when clipped at ground level. Thus, where the heavy machinery used for salvage felling damages resprouts, their survival is reduced.
Sprouts of primary tree species competed with ferns and secondary seedlings of pioneer trees and shrubs in the young vegetation and were often overgrown by these within 1 year. Most of the sprouts nevertheless survived for the first 2 years. After 2 years, 25% of the sprouts had outgrown the layers of ferns and shrubs. Therefore, they appeared to play an important role in the persistence of many primary forest species.

Stratified soil samples, taken in six replicates from unburned and burned areas in the Sungai Wain forest were placed in the nursery under high light conditions, which triggered abundant germination of seeds. The experiment revealed that the fire killed 85% of the seeds lying dormant in the litter layer and more than 60% of the seeds in the upper 1.5 cm of the soil. No reduced seed density was found in deeper soil layers. In the burned forest, the gap-like environmental circumstances induced the frequent germination of seeds from the seed bank (Vázquez-Yanes & Orozco-Segovia 1993). Notwithstanding the high seed mortality in the upper soil layers, a dense carpet of pioneer seedlings had established 4 months after the fire in those places where high densities of pioneer trees had been present prior to the burning. Because of the high mortality and the high germination incidence soon after the fire, the density of viable seeds remaining in the soil is greatly reduced (Hopkins & Graham 1984; Young & Brown 1987; Saulei & Swaine 1988). Under these circumstances the local seed bank has little potential for further regrowth. These areas, if further damaged, risk invasion by wind-dispersed species, including Imperata cylindrica [L.] Beauv. (Alang-alang, grass), Pteridium caudatum [L.] Maxon (Bracken fern), and Dinochloa sp. (Bamboo). It has previously been shown in East Kalimantan that complete conversion of a primary forest to Imperata grassland can take place rapidly after clearfelling and repeated burning (Kartawinata 1993). For the local seed production of woody species to become substantial takes 1 year or more for rapidly maturing shrubby species (e.g., Homalanthus populneus [Geiseler] Pax, Macaranga trichocarpa [Reichb.f. & Zoll.] Müll.Arg., some Ficus spp.) and at least 4 years for the larger secondary tree species (e.g., Dillenia sp., Mallotus paniculatus [Lam.] Müll.Arg.) (Saulei & Swaine 1988).

Seed production by trees that survive either as individuals in the burned area or in pockets of unburned forest will ultimately be the main source of regeneration of many primary forest tree species. Initially the density and diversity of the seed rain will be impoverished due to the low availability of seed sources. Because the seed dispersal distance of many tree species is limited (Howe & Smallwood 1982; Whitmore 1984), the proximity and composition of relic unburned patches is anticipated to have a large effect on the persistence of fire-sensitive species in the burned forest.

Many species in the Sungai Wain forest fruited in 1997 during the long pre-fire drought and did not seed again during the first 2 years after the fire. As we described above, the burned forest was densely covered by ferns, pioneer seedlings, sprouts, and grasses by that time. Seedling establishment from the post-fire seed rain under these circumstances remains to be assessed, but it is evident that it will take a long time before seedlings of primary species will have established from the seed rain in numbers comparable to the post-fire density of resprouts. For that reason the presence and performance of resprouts is a more important factor in the initial restoration of the forest than is the density of tree seed sources.

Conclusions and recommendations

Fire does not in itself cause complete loss of forest cover. The survival and sprouting capacity of primary forest trees and the seedling establishment of pioneer trees and shrubs suppress the establishment of nonforest species. However, post-fire vegetation is certainly less resilient than might be assumed by anyone witnessing the vigorous post-fire regrowth. The post-fire undergrowth cannot withstand repeated disturbance: previously
sprouted individuals show reduced sprouting potential and survival after being damaged a second time, the seed-bank is largely reduced after the initial post-fire burst of germination, and the density of vital seed trees is low. The open areas created in the understory by the conventional heavy logging machinery used for salvage felling encourage the rapid development of nonforest vegetation, and seriously reduce the potential for recovery.

The genuine regenerative potential of burned tropical rain forest and the potential consequences of further disturbance caused by salvage felling need recognition. Our evidence implies that the maintenance of a productive permanent forest estate is likely to be served best by avoiding logging activities in burned areas. Further studies should be made in areas already harvested to further clarify the effects of salvage felling, but until such information is available caution is the only environmentally defensible option.

We have presented only ecological concerns so far, but there are other reasons to review current practices of salvage harvesting. In Indonesia concession holders cannot normally recut harvested forest areas without waiting the statutory period (a 20-year cutting cycle is the norm). However, if fire occurs in a concession, this restriction is lifted and further cutting is allowed. Such incentives must be avoided.

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