INTENSIFICATION OF TROPICAL SILVICULTURE

FE Putz & Ruslandi

Department of Biology, University of Florida, Gainesville, FL 32611 USA; fep@ufl.edu

Maintenance, in as natural a state as possible, of many of the world's 400 million ha of officially designated tropical production forests will ironically require silvicultural intensification in selected portions of some landscapes. Hopefully these intensively managed forests will continue to support abundant biodiversity and continue to provide many other environmental services, but profitable management is key to their survival as forests. While an increasing proportion of the growing global demand for forest products will be satisfied by plantations, most natural forests will certainly not be spared from harvesting.

Even if the profitability of natural forest management can be increased through silvicultural interventions, it will remain difficult to financially justify natural forest management where there are high opportunity costs of retaining forests in lieu of other land uses (e.g. oil palm plantations, soybean fields or cattle ranches). That said, it is also important to recognise that these opportunity costs vary by orders of magnitude across the landscape. Areas of difficult access and adverse terrain yield lower profits from any landuse, with the magnitude of effect inversely proportional to the required capital investments. For this reason, natural forests mostly remain in swamps, on steep slopes and in remote areas. Unfortunately, these adverse conditions are also not conducive to environmentally-sound and profitable natural forest management.

Whereas in many temperate and boreal forests, especially on private lands, environmentally-concerned foresters are working against the trend towards increased intensity of management and the consequent forest simplification, natural forest management in the tropics is still not common. Instead, timber exploitation (log mining) is likely to continue for the foreseeable future in much of the tropics. Here we focus on one tropical forest where the transition from exploitation to management occurred in response to a combination of governmental policies and the business interests of a private concessionaire.

An important step in the transition from unnecessarily destructive timber mining to responsible forest management is employment of reduced-impact logging (RIL) techniques. Some costs of RIL are recovered by increased efficiency but loggers are not spontaneously adopting sound harvesting practices out of enlightened self-interest, at least not of the short-term financial variety. Furthermore, while low intensity, single-tree selection RIL harvests are environmentally benign, this gentle approach is neither very profitable nor sustainable where commercial timber species regenerate in canopy openings larger than those created by low intensity single tree selection. In most forests, other silvicultural interventions are needed to maintain timber yields and profits. Payments for environmental services (e.g. carbon sequestration) may cover some of the foregone costs of very low intensity timber stand management, but those payments are unlikely to be available for the vast majority of production forests in the tropics.

To sustain yields and profits, one possible option is to increase intensity of tropical silviculture. The end of the continuum of silvicultural intensification is the conversion of natural forests into plantation monocultures, which we consider deforestation and do not cover further here. Between plantation conversion and single-tree selection using RIL is a wide variety of silvicultural interventions that tropical foresters all learn about in school but seldom see applied outside of experimental plots. Approaches such as shelterwoods, group selection and liberation thinning all have received substantial attention from researchers but have generally not been adopted by forest industries. Here we focus on enrichment planting, which is at the intensive end of natural forest management. Although enrichment planting, which is more completely referred to as plantation conversion by enrichment planting, has a long history of wasted effort in tropical forests around the world, here we focus on its successful application at an industrial scale in a forest concession in Indonesia.

We base our discussion of enrichment planting on observations we made in the Sari Bumi Kusuma (SBK) concession in Central Kalimantan, Indonesia. SBK is one of four concessions of the Alas Kusuma Group, which also operates one of the few remaining plywood/lumber mills in West Kalimantan. While the scale of SBK's accomplishments is impressive in terms of planted tree survival and growth, we focus on the planned harvests of the enriched stands and consider silvicultural options to what would amount to clearcutting if all trees larger than the minimum cutting diameter of 40 cm are felled.

Sustainability, as used here, includes considerations of sustainable timber yields as well as maintenance of the biodiversity and ecosystem services characteristic of natural forests. We do not address social issues in depth but recognise that they loom large in most landscape-level analyses. In the case of SBK, for example, we admit that it is ludicrous to disregard the interests of the 5000 people who still reside in the eight villages that were present in 1978 when the government granted the 147,600 ha concession. Our justification for this oversight is that we are silviculturalists not sociologists and struggle to address even only the biophysical aspects of sustainability. We should mention, however, that SBK has 25 full-time employees who run numerous social welfare programmes that seem to provide substantial benefits to the people who live within and near the concession.

SBK's landscape-level planning reveals weakness in the land-sparing versus land-sharing debate that rages in conservation literature. That planning involves three main steps along a gradient of silvicultural intensity from protected areas to areas managed with selective logging (locally, *Tebang Pilih Tanam Indonesia*—TPTI) to areas in which seedlings of native species are planted along cleared lines in twice-logged forests (*Tebang Pilih Tanam Jalur*—TPTJ). Even within the blocks allocated for TPTI or TPTJ, some areas are completely protected. For example, consider a typical 100-ha block from which 50 m^3 ha^{-1} (4–6 trees ha^{-1}) of timber is selectively harvested following standard RIL guidelines with a tracked skidder (CAT527) with average cable winching distances of 20 m. In that 100-ha block, spatial variation in stocking and terrain would result in perhaps 5 ha remaining completely untouched by loggers and a few additional hectares through which only a few logs were skidded and few trees were felled. Does this scenario represent land-sparing or land-sharing? At a larger spatial scale, what about the areas spared from enrichment planting but not spared from logging?

For landscape-level sustainability, planning is obviously critical at a wide range of scales, from within 100-ha logging blocks up to entire concessions. In areas with steep and hence erosion-prone slopes, the first prerequisite for good planning is accurate topographic maps. Unfortunately, the air photo-based maps used in most planning operations and even digital elevation models based on passive remote sensing (e.g. Landsat or ASTER satellite data) tend to underestimate slopes by substantial margins. In a study of five logging concessions in East Kalimantan, for example, ASTER data underestimated slopes by 50% when checked against crown-penetrating LiDAR and ground-based measurements (unpublished data). SBK and most other conscientious concessionaires overcome this problem, by preparing 1:1000 scale topographic maps based on data collected by timber inventory crews.

At the concession scale, even inaccurate topographic maps can be used to demarcate areas where steep (i.e. > 20–30%) slopes predominate. In the SBK concession, a 59,000-ha area with steep slopes was identified and then allocated for the less intensive silvicultural intervention of TPTI. Given that skidders cannot safely traverse steep slopes without cutting switchbacks, which are both expensive to construct and environmentally devastating, we recommend that in such areas logs be extracted with long-line cable systems to protect the topsoil and to minimise collateral damage to the residual stand. With mobile towers that move along ridge-top roads and cable yarding distances of up to 300 m, most harvestable timber can be accessed with this method at a cost lower than with standard ground-based approaches. Despite the benefits of cable yarding, its adoption is likely to be slow without government support at least in the form of reduced import duties on the necessary equipment. It would also help if governments prohibited the cutting of switchbacks up steep slopes, which is easily detected on satellite images. We also recommend that cable-RIL be followed by liberation of future crop trees and other light stand improvement treatments.

About 60,000 ha of less steep area in the SBK concession is allocated for the more silviculturally intense TPTJ system. In this area, riparian buffer zones are neither logged nor planted; slopes > 20% are also not planted, which leaves only about 70% for timber stand management. In the planted areas, seedlings are planted at 5-m intervals in 30 cm × 30 cm × 30 cm holes excavated along 3-m wide planting lines cleared at 20-m intervals through twice-logged forest. As of late 2014, SBK had planted about 49,000 ha with an average survivorship to age 5 years of about 80%. Growth rates of planted trees are fantastic; based on 15 years of monitoring, 70% of planted trees will reach 40 cm (the minimum cutting diameter) at the end of the 25-year cutting cycle. We question the harvest of trees with mean annual increments that have not yet slowed as well as the planting of seedlings of a one to a few species where there is sufficient natural regeneration, but here focus on the upcoming harvest of the enriched stands.

While the results of SBK's multi-million dollar investment in enrichment planting look promising in terms of timber and perhaps financial yields, we are worried about the impact of harvesting these super-stocked stands. Our investigations of some of the characteristics of these planted stands are described in three articles in this volume of the *Journal of Tropical Forest Science*, but here we focus more broadly on the long-term environmental consequences of this intensive silvicultural intervention. Although we concentrate on the likely stand-level impacts of the planned harvests 25 years after enrichment planting, we try to maintain a landscape level perspective.

The crux of our concerns about SBK's very successful enrichment planting intervention is the observation that researchers in the region demonstrated that if more than 8–10 trees or 60–80 m^3 are harvested from a single hectare, the benefits of RIL are difficult to discern. In SBK's stands managed by TPTJ, the expectation is that at 25 years about 40 of the planted trees will be ready to harvest plus an additional 10 trees from the natural forest retained between the planting lines. Certainly if all of these trees are harvested at one time, the effect will be tantamount to clearcutting.

SBK successfully met the initial challenges of industrial-scale stand enrichment with their effective planting and tending systems, which essentially follow prescriptions C Dawkins described more than 50 years ago (Dawkins 1958). With their extensive super-stocked stands, the company now needs to consider ways to assure long-term sustainability and to maintain biodiversity. In particular, stand establishment practices need to be designed with future harvests in mind. For example, if the intention is to selectively log enriched stands and not clearfell them, then the densities and spatial patterns of like clearcut planting need adjustment. Instead of planting 80–100 trees ha^{-1} of one or a few species that grow at similar rates, mixtures of species could be planted that will mature at different times and yield timber of different qualities and values. For example, fast-growing species of *Shorea* (e.g. *S. leprosula* and *S. parvifolia*) that produce timber used mostly for utility-grade plywood might be mixed with slower-growing species (e.g. *S. laevis, Eusideroxylon zwageri, Palaquium* spp.) that produce more highly valued timber used for furniture, flooring and naturally rot-resistant patio furniture. To promote wildlife in enriched stands, a proportion of the planted trees may be species that produce fleshy fruits (e.g. *Garcinia* spp.), some of which also produce commercial timber (e.g. *Durio* spp.). We also recommend that more use be made of natural regeneration rather than planting. Given that planted dipterocarp trees in SBK start to reproduce when as young as 15 years, by the time of the first allowed harvest, that natural regeneration should be abundant. They might also use shelterwood harvests to favour natural regeneration and to protect the planted trees that have not quite reached the minimum cutting diameter at the time of the first harvest. The challenge will be to minimise stand damage when these broad-crowned trees are harvested, especially if heavy ground-based machines are used for log yarding.

SBK's foresters have shown that silvicultural intensification is possible at industrial scales in a tropical forest but they now need to modify the intervention to reflect their longer-term goals. Based on our participatory research experience, those foresters have the capability and initiative to adaptively manage the forest in which they have been entrusted. They should use the copious amounts of data they have collected to develop harvest models that reflect the differences in terrain, stocking and spatial arrangements in the enriched stands they helped create. Hopefully these foresters will be allowed to adapt their management in response to what they learn from earlier interventions.

ACKNOWLEDGEMENTS

This editorial is an outcome of the Future of Production Forests in the Tropics Project funded by the Department for International Development, UK and implemented by the Center for International Forestry Research and the CGIAR Research Program on Forests, Trees and Agroforestry (FTA). J Palmer provided insightful comments on an earlier draft of this editorial.

REFERENCE

Dawkins HC. 1958. *The Management of Natural Tropical High-Forest With Special Reference to Uganda*. Commonwealth Forestry Institute Paper 34. Oxford University, Oxford.

***Jack** is a Professor at the University of Florida where Ruslandi is completing his PhD. In November 2015 they ran a research workshop in Kalimantan with local scientists and foresters as well as a Japanese graduate student. Together they designed and implemented three studies on enrichment planting to gain research experience and to learn more about intensive natural forest management.*