Logging has depleted timber resources across a considerable portion of the world’s tropical forests, leaving them vulnerable to conversion to other land-use types. This raises the question of whether management for restoration represents an economically viable alternative. We reviewed restoration concessions (areas of degraded state forest land leased to enterprises on long-term [≥60-year] licenses for restoration-compatible business development) in Indonesia since their introduction in 2004 and found that, although many opportunities and actions are being explored, business models remain largely aspirational. Costs – including those associated with taxes and reporting, forest protection, community development, and restoration interventions – are high, while developing revenues at sufficient scale from carbon markets, non-timber forest products, and ecosystem services is challenging. Potential solutions include the development of restoration-compatible revenue streams and value-added processing to generate income, investment in communities to bring them in as partners in restoration enterprises, and creation of a supportive regulatory environment by reducing statutory costs and eliminating perverse regulations. Restoration concessions are a scalable policy option for promoting private investment in restoration that could be replicated internationally to help meet ambitious global restoration targets.

In a nutshell:

• In the tropics, selectively logged forests (that is, forests from which timber trees of harvestable size/value have been removed but the residual forest remains) represent an important restoration opportunity but are vulnerable to deforestation, raising the question of whether restoration through private enterprise is economically viable.
• We examined the business environment for restoration concessions in Indonesia.
• Business models remain largely aspirational because of high costs and the difficulties in realizing sufficient income from carbon markets, non-timber forest products, and ecosystem services.
• To achieve restoration goals, restoration managers must consider diverse means to generate income within a multiuse forest management plan.
• Restoration concessions are a scalable policy instrument to stimulate private investment in restoration, but a favorable regulatory environment – one that minimizes costs and enhances business opportunities – is essential.

© 2020 The Authors. Frontiers in Ecology and the Environment published by Wiley Periodicals LLC on behalf of the Ecological Society of America.
in a forum led by Indonesia’s Forest Research and Development Agency. Having considered the situation in Indonesia, we conclude with a broader discussion on the pros and cons of restoration concessions as a policy tool for achieving global restoration targets.

### Restoration concessions in Indonesia

Ecosystem restoration concession (ERC) licenses, which are awarded by the government of Indonesia for periods of 60–100 years, provide for a shift in forest management from timber harvesting to restoration through multiuse forest management. Three types of forest resource use are recognized: “area use” covers activities such as ecotourism and conservation, “ecosystem service use” includes C sequestration schemes and water services, and “management for non-timber forest products (NTFP)” covers the production and sale of harvestable non-timber forest elements (e.g., forest foods including honey, medicinal plants, or fiber/biomass production, such as bamboo). Once “ecosystem balance” has been attained, which is expected to take several decades, ERC license holders may then opt to harvest timber. “Ecosystem balance” has been defined as the point at which legally harvestable timber volumes have been reached and there is compliance with forest management safeguards on biodiversity and the environment, such as rehabilitation of riparian buffer zones.

In total, 16 licenses have been awarded in Indonesia since 2004, covering an area of 623,075 ha (Figure 1; WebTable 1; MOEF 2018). Within the broader picture of forest management in Indonesia these figures may appear small, but ERCs have attained a high policy profile as a result of their potential to contribute to Indonesia’s international commitments on atmospheric greenhouse-gas emissions (MOEF 2018). Moreover, at the global scale, they represent the largest initiative to restore tropical forests through private investment.

#### Business models for ERCs

**Current ERC business plans**

The business plans of current ERC license holders encompass a broad spectrum of revenue sources (Table 1). All of the ERC license holders have stated their intention to develop some form of revenue stream, with the exception of ERCs held by April Group, which are supported by the parent company’s pulp and paper business. Although the conservation

![Map of ecosystem restoration concession (ERC) licenses in Sumatra and Kalimantan, Indonesia. Since 2004, when ERC licenses were first introduced, 16 licenses have been awarded to ten license holders, encompassing 623,075 ha (WebTable 1; MOEF 2018). Six of the 16 ERCs include communities with populations ranging from 150–2500 households within the concession boundary. Deforestation through encroachment is ongoing in six of the ERCs, illegal logging was reported in 12, and hunting was reported in eight. Among the problems facing the ten license holders, nine mentioned the need for improved boundary enforcement and conflict resolution; nine also requested access to carbon markets, which is currently inhibited by Indonesia’s REDD+ policy; seven requested lower taxes and a simplified, less costly permitting process; and five requested simplification of the reporting process. Nonetheless, license holders expressed a high degree of confidence of success, with all ten stating they expect to still be in business in 50 years time. AGB (t ha⁻¹) = aboveground biomass (metric tons per hectare).](image-url)
value of ERCs is well recognized (Sitompul et al. 2011), conservation payments are unlikely to comprise a substantial source of income. An economic evaluation of PT Restorasi Habitat Orangutan Indonesia (Rahmawati 2013) – which, as the name suggests, focuses on orangutan (Pongo spp) conservation, perhaps the most marketable conservation objective in Indonesia – found that biodiversity contributed to only 0.05% of the ERCs net present value (NPV). NTFPs were the most commonly stated business interest, but only four ERCs plan to add value through processing (eg packaging or manufacturing products for sale direct to end users) and only two propose to use managed plantations to augment production. Six ERCs expressed an intention to sell C credits. However, only two concessions stated an interest to develop native timber businesses, even though restoring timber stocks is the stated objective of ERCs according to Indonesia’s forest department (Walsh et al. 2012).

Finance for ERCs

Three main categories of finance are available to ERCs: donor or charitable funding, private capital, and generation of income from the land. Currently, donor or charitable funds cover the bulk of operating costs for most ERCs. Donor funding can be useful for covering immediate start-up costs, but dependency on such funds is a risky financial strategy. First, most grants are short term, and it is often difficult to persuade donors to fund beyond two or three funding cycles. Second, donors often impose their own objectives on a project, which may not align with the need to implement a business plan or to respond to unanticipated threats, such as encroachment. Finally, donors are more likely to be interested in the conservation or social outcomes of “their project” than in the long-term financial security of the ERC. This means that it will often be necessary to raise other, more flexible forms of capital. However, it may also be difficult to raise private capital because, as an unproven business model, investment in ERCs may be perceived as risky. Therefore, to reduce dependence on donor funds and make restoration a more attractive investment, restoration managers will often need to develop short-term income streams from the lands they are managing.

ERC operating costs

The operating costs of an ERC are substantial, with approximately $1 million per year (all monetary values are expressed in US dollars) needed to run a concession 40,000 ha in size (Figure 2). License holders are required to pay license fees and land taxes. Reporting demands are high and, although harvests will not be realized for decades, license holders are required to conduct costly ground-based surveys of timber stocks. Furthermore, there is a transfer of state obligations to the license holder, who has to pay for forest protection and provide social welfare to communities in and around the concession. The high cost of operating a restoration concession places a considerable burden on license holders.

Potential income streams for ERCs

Timber

Timber is and has always been by far the most valuable marketable resource for tropical forests, yet by definition ERCs have limited timber resources. Detailed studies on the recovery of selectively logged forests in Borneo suggest it will take 60–100 years for timber stocks to recover to pre-logging levels without intervention (Ruslandi et al. 2017a,b; Philipson et al. 2020). It has been argued that forests could be sustainably harvested at around 60% of pre-logging timber stocks (Putz and Romero 2015), but even at this level it may be more than 60 years before forests are harvestable without intervention. Enrichment planting can greatly increase the rate of recovery, such that timber volumes recover to primary forest levels in as little as 40 years (Ruslandi et al. 2017a; Philipson et al. 2020), but the costs of such projects are typically very high (mean $1596 ha−1, 95% CI: $1338 to $1854 ha−1; Philipson et al. 2020; for planting and subsequent control of competing vegetation for tropical rainforests, not including Australia). Assisted natural regeneration is less expensive ($100 ha−1) but up to 40 years will still be required for forests to recover to harvestable levels. Unsurprisingly, economic analysis (WebPanel 1) suggests that management for timber alone is not economical unless no-interest or very low-interest credit is available. Nonetheless, ERCs could still include timber as a component of a multifaceted business plan, with other revenue streams covering operating costs in the short term (Table 2).

Carbon

For peat swamp forests, which include nine out of the 16 Indonesian ERCs, C is potentially profitable. The economic analysis for PT Restorasi Habitat Orangutan Indonesia estimated that C contributed 98.7% of NPV and generated a
570  CONCEPTS AND QUESTIONS

RD Harrison et al.  

Figure 2. The relationship between combined concession area and annual operating costs per hectare, demonstrating the reduced marginal costs of larger concessions (linear regression: degrees of freedom = 4, t = –3.19, P < 0.05; the solid blue line and shaded area depict the simple linear regression line and 95% confidence interval, respectively; black circles represent the individual data points). Operating costs ranged from $16.14 ha⁻¹ yr⁻¹ for a 100,000 ha concession to $25.38 ha⁻¹ yr⁻¹ for a 40,000 ha concession. Average total operating costs were $1 million per year for a 40,000 ha concession. Although these costs may seem high, they are comparable to previous estimates of the cost of protecting reserves (Balmford et al. 2003; Fisher et al. 2011a). We estimated that − by removing taxes, reducing reporting demands, and lowering protection costs through improvements in the governance environment – costs could be reduced by about 40% ($10 ha⁻¹ yr⁻¹ for concessions larger than 100,000 ha).

Plantations and NTFP processing

Under ERC regulations, concessionaires may develop native timber or NTFP plantations on a portion of their land. While this approach may seem counterintuitive to forest restoration, using agroforestry and multispecies silvicultural approaches to integrate NTFP production or fast-growing timber species with restoration can be an efficient means of generating short-term income and achieving restoration goals (Ashton et al. 2014; Brancalion et al. 2017; Maier Ferreira et al. 2018). Indeed, our economic analysis showed that combining commodity crops, such as rubber or bamboo, with native trees that have a commercial timber value was the best-performing business model for ERCs (Table 2). Moreover, in our model, sufficient income to make an ERC profitable could be generated from just 5% of the area, freeing up the remaining 95% for (assisted) natural regeneration and conservation. Value-added processing can also offer substantial economic returns.

In addition, NTFP plantations and processing create employment opportunities and thereby potentially reduce protection costs. Commercial agricultural extension activities, such as investment from oil-palm mills to expand feedstock, represent an important transformative force within the landscape, guiding land-use decisions and driving deforestation (Euler et al. 2016). Therefore, it is essential that ERCs are capable of influencing these decisions through their own investments. Employment and out-grower contracts, through which farmers receive high-quality germplasm and often capital loans from processors, can also provide a framework for enforcing regulations; for example, farmers may be held responsible for protecting adjacent forests or abiding by certain land management standards (eg prohibitions on open burning).

cost–benefit ratio of 1-to-337 over the 60-year license (based on a C price of $4 per metric ton; Rahmawati 2013). Unfortunately, although C resources have been shown to recover more quickly than timber (Rutishauser et al. 2015), the low demand associated with voluntary C markets has depressed its price (WebPanel 1). In addition, in 2010 Indonesia signed a bilateral REDD+ agreement with Norway, which, because it is being implemented countrywide, currently prevents site-level REDD+ projects from being developed in Indonesia.

Biomass energy

Selective thinning is widely used to improve timber stocks in tropical forests because the growth and quality of high-value stems can be enhanced through the removal of competing vegetation (Peña-Claros et al. 2008; Swinfield et al. 2016). In many degraded tropical forests, high densities of pioneer tree species, bamboos, or climber species inhibit natural regeneration, delaying forest recovery by decades. Thinning and other forms of assisted natural regeneration are relatively inexpensive interventions ($100 ha⁻¹ in Indonesia; Peña-Claros et al. 2008; Swinfield et al. 2016), but still incur costs that are typically not recouped until timber is harvested (or, in the case of ecological restoration, not at all). However, the sale of thinnings would generate funds to offset restoration costs. In Indonesia, production of fuel wood pellets is an attractive option because the Indonesian government currently buys energy from renewable resources at double the price of energy derived from fossil fuels. However, a comprehensive ban on timber harvesting in ERCs prevents restoration managers from using thinnings, even though biomass derived from early successional or invasive species might legitimately be considered an NTFP.
Tourism

The appetite for ecotourism among ERC license holders (Table 1) is perhaps derived from the analogy to national parks. However, the core costs of national parks are covered by national budgets, which makes ecotourism a profitable addition. Restoration concessions, on the other hand, must generate their own core funds. Moreover, most ERCs are inaccessible, and the cost of developing high-quality tourist infrastructure in remote locations reduces their profitability. Catering to a small number of high-paying guests may be a profitable option for ERCs with highly marketable natural attractions, such as reliable viewing of rare species, but most ERCs will struggle to compete with existing ecotourist destinations.

Ecosystem services

Several potentially valuable income streams deriving from ecosystem services, including those related to clean water and “haze offsets” (see below), are not currently being exploited by ERC license holders. A large proportion of Indonesia’s production forests are located in the watersheds of urban water suppliers. As has been demonstrated repeatedly around the world, protection of these forests is likely to be far more cost-efficient than installing expensive water treatment facilities should they be lost (Postel and Thompson 2005). However, under current regulations, ERCs are not permitted to receive government payments for ecosystem services. This stipulation may arise from concerns about the transfer of public funds into private hands, but perhaps a public–private partnership in restoration investment might serve as an alternative.

In addition, peat swamp ERCs could potentially earn haze offsets. During the El Niño-induced drought in 2015, haze caused by fires largely burning in Indonesia’s peat swamps cost billions to regional economies, and led to vocal political and public outcry from urban communities and neighboring countries (Chisholm et al. 2016). Establishment of ERCs on peat domes, with government funding provided to restore hydrological functions, would be a relatively straightforward way to reduce haze. Several ERCs are already protecting and restoring peat domes, but do not currently receive payments.

Financial assessment of restoration business models

We conducted a feasibility study for different restoration businesses at one ERC (Hutan Harapan; WebPanel 1). Of the business options we examined, only commodity plantations provided sufficient revenue to cover the costs of managing the concession (Table 2). Income from collecting wild NTFPs and C credits at the current voluntary price ($3.5 per metric ton, in 2019) was paltry. Although C credits could be more lucrative for peat swamp forests, according to the analysis for PT Restorasi Habitat Orangutan Indonesia (Rahmawati 2013), it still would not raise sufficient income to cover costs. In our simulations, harvest of natural NTFPs, C credits (at the current voluntary price) and ecotourism components only became economically viable when ERC operating costs were reduced by 98%, 61%, and 44%, respectively. However, all of the business models, with the exception of enrichment planting for timber, provided a positive return on investment. Thus, different businesses could be bundled within a multiuse forest management plan (Table 2). In addition, if C credit prices were to rise to $40 per metric ton, as proposed by the World Bank (CPLC 2017), then C storage would become a highly profitable option for ERCs (see also Philipson et al. 2020).

As mentioned above, enrichment planting for timber is unprofitable (WebPanel 1), due to a combination of high upfront costs (associated with planting and maintaining seedlings) and returns only being realized after ~45 years. Therefore, at sites where natural regeneration is poor, managers face an uphill struggle to restore forests profitably. The only viable
option is to combine planting with other, shorter term revenue streams that offset establishment costs, such as thinnings of faster growing species or agroforestry plantations (Figure 3).

**Multiuse sustainable forest management for restoration**

Restoration business models should be considered within the context of multiuse sustainable forest management, which has both spatial and temporal dimensions. For instance, a management plan might include areas for future timber production and for strict conservation. Both zones might also have business plans based on selling C credits, although where timber is being cut C stocks would be discounted according to the C half-life of the harvested wood. Interventions in these areas would probably be restricted to protection and monitoring, perhaps with some thinning or cutting of lianas to accelerate succession of more degraded sites. Under the same plan, NTFP plantations could be developed over small portions of the concession (eg 5%; Table 2) where intensive management is needed (eg to control invasive species). These areas would provide both critical short-term revenue for the concession opportunity and livelihood opportunities for neighboring communities, and could transition to timber or conservation management after a single plantation cycle. Harvesting and processing of wild NTFPs might be promoted for livelihood development among forest-dependent communities, with the goal of being cost-neutral to the concessionaire. Purely conservation-focused investors might opt to forgo timber harvesting, whereas fund managers might opt for a higher return on investment (Table 2). Regardless, a multiuse forest management approach could generate revenues sufficient to cover short- and long-term management and protection costs and create livelihood opportunities for local communities, while at the same time ensure that restoration and conservation goals are met.

### Agroforestry and silviculture options for restoring natural forests

Agroforestry and silviculture programs can contribute to meeting restoration targets where the desired future condition is a natural forest managed primarily for conservation benefits. Regeneration of natural forest is a multidecadal process involving transitions through a series of successional stages and, particularly during early phases, is vulnerable to reversals from threats like fire and encroachment. Agroforestry and silviculture can be used to simulate natural successional processes and, by intensifying management and deriving products from the forest over the early phases, help protect restoration and cover costs, as well as provide benefits to local people. For example, management for rubber can be combined with the planting of late successional species (Figure 3a); after 25–30 years, the rubber trees are harvested, leaving the (by then) well-established native climax tree species. Other crops, especially those that perform well in shade (eg certain bamboos and palms, cardamom, cocoa, tea, coffee), can be combined with the regeneration of native tree species in a similar way. Multispecies silvicultural approaches can involve the planting of rows of fast-growing species between rows of native climax tree species. The fast-growing species ameliorate habitat conditions and thereby enhance the survival of climax species and, at a later stage, are themselves harvested in a manner analogous to the thinning of monospecific species (Figure 3b). Alternatively, a plantation of fast-growing species may be established, thinned, and then managed for natural regeneration in the understory (Figure 3c) or underplanted with native tree species (Figure 4). The suitability
of specific options and the scale at which they are practiced will depend on economic factors, including the required capital and income level, as well as the preferred restoration trajectory. However, such approaches enable managers to contemplate the restoration of much larger areas because short-term revenue is generated to cover costs.

■ Conservation benefits of different restoration business models

In the absence of active management, selectively logged forests are vulnerable to conversion to alternative land uses, such as oil-palm or pulp-and-paper plantations (Burivalova et al. 2020). Therefore, the primary conservation benefit of restoration concessions is that they provide a means of retaining degraded tropical forests. Moreover, protected areas throughout the tropics are grossly underfunded and threatened by encroachment and hunting (Laurance et al. 2012). Active management of forests by private enterprises that have resources and an interest in protecting investments could compare favorably to state-managed protected areas in many cases. Regardless of the business model, the critical determinant of conservation benefits will be the investment in forest protection.

The conservation payoffs of different restoration options depend on the area involved and time frame of observation, as well as on the impacts of land management. For instance, protecting natural regeneration for timber, C credits, or harvest of wild NTFPs is likely to enhance conservation gains in the short term. However, in the absence of intervention, heavily disturbed forests may require more than 100 years to recover. Consequently, even relatively intensive management, by accelerating forest recovery, may generate a higher time-averaged conservation benefit over a 50- or 100-year window. Likewise, if income generated from a relatively small area of intensely managed plantations can pay for protection and restoration over a much larger area, then the area-averaged conservation benefits are likely to be high. Nonetheless, improved understanding of the conservation payoffs for different multiuse forest management plans would benefit restoration planning.

■ Can restoration concessions stimulate private investment for restoration?

The concession model for restoration is unusual. Although there have been conservation concessions in Latin America for many years and, in addition, Peru recently changed its forest code to enable agroforestry concessions, each of these examples has a somewhat different focus. The purpose of conservation concessions is to extend the protected area estate managed by the national government and usually involves payments from conservation organizations to cover opportunity costs (e.g. avoided logging; Wolman 2004), whereas agroforestry concessions were introduced to reduce farmer-driven deforestation in the Peruvian Amazon and work more like a system of conservation easements. Farmers receive tenure recognition in return for agreeing to zero deforestation and other constraints on land use (Robiglio and Reyes 2016). In contrast, the purpose of restoration concessions is to enable private management for restoration of degraded forests. While in principle they could operate as private conservation concessions, the costs of forest protection and restoration interventions essentially force license holders to develop revenue streams from the land. Furthermore, even where profit is not an objective, generating income to cover protection and management costs may enable license holders to restore larger areas than would otherwise be possible.

Logging concessions currently encompass an estimated 400 million ha globally (Cerullo and Edwards 2019) and selectively logged tropical forests retain high levels of biodiversity (Berry et al. 2010; Fisher et al. 2011b; Chazdon 2014) and C (Gilroy et al. 2014). Restoration concessions offer an alternative future for these forests, which would otherwise often be cleared for industrial plantations or by illegal encroachment (Sloan et al. 2012; Burivalova et al. 2020). One advantage of concessions is their simplicity as a policy device; because many countries already use a concession licensing system for logging, establishing restoration concessions would be a relatively simple and straightforward process. However, one potential disadvantage of the concession approach is that it may be perceived in association with a state’s historical usurpation of forest assets from local people (Barr and Sayer 2012). Consequently, legitimizing restoration concessions in the eyes of local stakeholders would
be essential. Spatial planning and delineation of boundaries must be conducted through a rights-based stakeholder engagement process. Moreover, where possible, local communities should be afforded opportunities to participate in restoration enterprises, which not only reduces conflicts but also promotes a more equitable sharing of benefits.

To encourage private investment for restoration, the business environment must be conducive to private-investment interests. Because restoration is a multidecadal process, high operating costs greatly increase both the capital required (Table 2; compare full and reduced cost models under the “Strict conservation” option) and the financial risk to the investor. Governments can help reduce costs by lowering both taxes and reporting demands, focusing on what is strictly required for quality restoration management, as well as by providing not only tax breaks on restoration investments but also a supportive governance environment that lowers protection costs. In addition, they can create business opportunities by facilitating markets for ecosystem services, for example through the development of public–private partnerships, eliminating perverse regulations (eg removal of the prohibition on selling biomass from thinnings in Indonesia), and investing in restoration-compatible value chains. Finally, states can help generate private capital for restoration by requiring that corporations involved in large-scale agriculture, plantations, and extractive activities (eg logging and mining) establish trust funds to set aside funds for restoration from pre-tax profits that are invested in restoration offsets and a more equitable sharing of benefits.

To encourage private investment for restoration, the business environment must be conducive to private-investment interests. Because restoration is a multidecadal process, high operating costs greatly increase both the capital required (Table 2; compare full and reduced cost models under the “Strict conservation” option) and the financial risk to the investor. Governments can help reduce costs by lowering both taxes and reporting demands, focusing on what is strictly required for quality restoration management, as well as by providing not only tax breaks on restoration investments but also a supportive governance environment that lowers protection costs. In addition, they can create business opportunities by facilitating markets for ecosystem services, for example through the development of public–private partnerships, eliminating perverse regulations (eg removal of the prohibition on selling biomass from thinnings in Indonesia), and investing in restoration-compatible value chains. Finally, states can help generate private capital for restoration by requiring that corporations involved in large-scale agriculture, plantations, and extractive activities (eg logging and mining) establish trust funds to set aside funds for restoration from pre-tax profits that are invested in restoration offsets and a more equitable sharing of benefits.

We believe restoration concessions are a scalable policy instrument that could be replicated globally to stimulate private investment in environmental restoration. Critical to attracting investment, however, is a robust business plan. Overemphasis on, for example, short-term conservation outcomes only serves to undermine long-term restoration and conservation goals. Financial, restoration, and conservation goals can be simultaneously met through a well-considered multiuse forest management plan. In this respect, we emphasize the value of bundling business models, both to cater to short- and long-term revenue generation and as a contingency against low market prices (eg for C) and changing regulatory environments. It is unrealistic to expect that global restoration targets can be met without substantial private investment.

## Conclusions

Even though restoration licenses were first introduced to Indonesia in 2004, to date restoration business plans remain largely aspirational, and most concessions have made only limited progress toward realizing revenue streams. High operating costs and overregulation impede the development of viable restoration business models. However, relatively small changes, such as the elimination of perverse regulations and reductions in taxes and reporting costs, could greatly improve the business environment. Recent changes to ERC regulations have begun to address these issues and, despite numerous remaining challenges, concessionaires have expressed a high degree of confidence in the ultimate success of these reforms.

We believe restoration concessions are a scalable policy instrument that could be replicated globally to stimulate private investment in environmental restoration. Critical to attracting investment, however, is a robust business plan. Overemphasis on, for example, short-term conservation outcomes only serves to undermine long-term restoration and conservation goals. Financial, restoration, and conservation goals can be simultaneously met through a well-considered multiuse forest management plan. In this respect, we emphasize the value of bundling business models, both to cater to short- and long-term revenue generation and as a contingency against low market prices (eg for C) and changing regulatory environments. It is unrealistic to expect that global restoration targets can be met without substantial private investment.

## Acknowledgements

We thank the staff at Hutan Harapan and the team at Burung Indonesia for their support and for many interesting discussions, the ERC license holders for responding to our questionnaire, FORDA for convening the ERC workshop, and the participants who attended the workshop for their contributions. Support for this research was provided by The Darwin Initiative (Award #23-029). TS received additional support from the Frank Jackson Trust through a grant to Wolfson College.

## References

Ashton MS, Gunatilleke CVS, Gunatilleke IAUN, et al. 2014. Restoration of rain forest beneath pine plantations: a relay floristic model with special application to tropical South Asia. *Forest Ecol Manag* **329**: 351–59.

Balmford A, Gaston KJ, Blyth S, et al. 2003. Global variation in terrestrial conservation costs, conservation benefits, and unmet conservation needs. *PNAS* **100**: 1046–50.

Barr CM and Sayer JA. 2012. The political economy of reforestation and forest restoration in Asia-Pacific: critical issues for REDD+. *Bioll Conserv* **154**: 9–19.

Berry NJ, Phillips OL, Lewis SL, et al. 2010. The high value of logged tropical forests: lessons from northern Borneo. *Bioll Conserv* **19**: 985–97.

Brancalion PHS, Lamb D, Cecon E, et al. 2017. Using markets to leverage investment in forest and landscape restoration in the tropics. *Forest Policy Econ* **85**: 103–13.

Búrivalova Z, Game ET, Wahyudi B, et al. 2020. Does biodiversity benefit when logging stops? An analysis of conservation risks and opportunities, in active versus inactive logging concessions in Borneo. *Bioll Conserv* **241**: 108369.

Cerullo GR and Edwards DP. 2019. Actively restoring resilience in selectively logged tropical forests. *J Appl Ecol* **56**: 107–18.

Chazdon R. 2014. Second growth: the promise of tropical forest regeneration in an age of deforestation. Chicago, IL: University of Chicago Press.

Chisholm RA, Wijedasa LS, and Swinfield T. 2016. The need for long-term remedies for Indonesia’s forest fires. *Conserv Biol* **30**: 5–6.

CPLC (Carbon Pricing Leadership Coalition). 2017. Report of the High-Level Commission on Carbon Prices. Washington, DC: The World Bank.

Euler M, Schwarze S, Siregar H, and Qaim M. 2016. Oil palm expansion among smallholder farmers in Sumatra, Indonesia. *J Agr Econ* **67**: 658–76.

Fagan ME, Reid JL, Holland MB, et al. 2020. How feasible are global forest restoration commitments? *Conserv Lett*; doi.org/10.1111/conl.12700.

Fisher B, Edwards DP, Giam X, and Wilcove DS. 2011a. The high costs of conserving Southeast Asia’s lowland rainforests. *Front Ecol Environ* **9**: 329–34.
Fisher B, Edwards DP, Larsen TH, et al. 2011b. Cost-effective conservation: calculating biodiversity and logging trade-offs in Southeast Asia. Conserv Lett 4: 443–50.

Gilroy JI, Woodcock P, Edwards FA, et al. 2014. Optimizing carbon storage and biodiversity protection in tropical agricultural landscapes. Glob Change Biol 20: 2162–72.

Laurance WF, Useche DC, Rendeiro J, et al. 2012. Averting biodiversity collapse in tropical forest protected areas. Nature 489: 290–94.

Maier Ferreira T, de Miranda Benini R, Fachini C, and Alves de Santana PJ. 2018. Financial analysis of enrichment model using timber and non-timber products of secondary remnants in the Atlantic Forest. Rev Árvore 42: e420602.

MOEF (Ministry of Environment and Forestry). 2018. The state of Indonesia’s forests 2018. Jakarta, Indonesia: MOEF.

Peña-Claros M, Fredericksen TS, Alarcón A, et al. 2008. Beyond reduced-impact logging: silvicultural treatments to increase growth rates of tropical trees. Forest Ecol Manag 256: 1458–67.

Philipson CD, Cutler MEJ, Brodrick PG, et al. 2020. Active restoration accelerates the carbon recovery of human-modified tropical forests. Science 369: 838–41.

Postel SL and Thompson Jr BH. 2005. Watershed protection: capturing the benefits of nature's water supply services. Nat Resour Forum 29: 98–108.

Putz FE and Romero C. 2015. Futures of tropical production forests. Bogor, Indonesia: Center for International Forestry Research.

Putz FE and Ruslandi. 2015. Intensification of tropical silviculture. J Trop For Sci 27: 285–88.

Rahmawati A. 2013. An economic analysis of ecosystem restoration concession policy in Indonesia: a new strategy for sustainable forest management? Int J Green Econ 7: 56–70.

Rigblio V and Reyes M. 2016. Restoration through formalization? Assessing the potential of Peru’s Agroforestry Concessions scheme to contribute to restoration in agricultural frontiers in the Amazon region. World Dev Persp 3: 42–46.

Ruslandi, Cropper WP, and Putz FE. 2017a. Effects of silvicultural intensification on timber yields, carbon dynamics, and tree species composition in a dipterocarp forest in Kalimantan, Indonesia: an individual-tree-based model simulation. Forest Ecol Manag 390: 104–18.

Ruslandi, Romero C, and Putz FE. 2017b. Financial viability and carbon payment potential of large-scale silvicultural intensification in logged dipterocarp forests in Indonesia. Forest Policy Econ 85: 95–102.

Rutishauser E, Hérault B, Baraloto C, et al. 2015. Rapid tree carbon stock recovery in managed Amazonian forests. Curr Biol 25: R787–88.

Sitompul AF, Linkie M, Gunaryadi D, et al. 2011. Ecosystem restoration concessions: a new strategy for conserving elephant habitat in Sumatra? Gajah 34: 26–31.

Sloan S, Edwards DP, and Laurance WF. 2012. Does Indonesia’s REDD+ moratorium on new concessions spare imminently threatened forests? Conserv Lett 5: 222–31.

Swinfield T, Afriandi R, Antoni F, and Harrison RD. 2016. Accelerating tropical forest restoration through the selective removal of pioneer species. Forest Ecol Manag 381: 209–16.

Walsh TA, Asmui, Hidayanto Y, and Otomo AB. 2012. Supporting ecosystem restoration concessions in Indonesia’s production forests: a review of the licensing framework 2004–2012. Bogor, Indonesia: Burung Indonesia and Climate & Land Use Alliance.

Wolman A. 2004. Review of conservation payment initiatives in Latin America: conservation concessions, conservation incentive agreements and permit retirement schemes. William & Mary Environ Law Policy Rev 85: 859–84.

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

Supporting Information

Additional, web-only material may be found in the online version of this article at http://onlinelibrary.wiley.com/doi/10.1002/fee.2265/suppinfo

1Burung Indonesia, Bogor, Indonesia, and PT Restorasi Ekosistem Indonesia, Jambi-Sumsel, Indonesia; 2World Agroforestry Centre, Jalan CIFOR, Bogor, Indonesia; 3Forest Restoration, Forest Research Development and Innovation, Ministry of Environment and Forest, Jakarta, Indonesia