CHAPTER 12

Potential Restoration Approaches for Heavily Logged Tropical Forests in Solomon Islands

Eric Katovai, Dawnie D. Katovai, and William F. Laurance

12.1 Introduction

Small tropical island countries are becoming more vulnerable to forest loss due to industrial logging. These countries are mostly of lower socio-economic status and often heavily dependent on logging for economic revenue (Sloan and Sayer 2015). This scenario is highly apparent in the Solomon Islands, where log export alone contributes between 50 and 70% to the country's annual export revenue (Katovai et al. 2015). Annual log

E. Katovai (✉)
The University of the South Pacific, Suva, Fiji

James Cook University, Caims, QLD, Australia
e-mail: eric.katovai@usp.ac.fj

D. D. Katovai
The University of the South Pacific, Suva, Fiji

W. F. Laurance
James Cook University, Caims, QLD, Australia
e-mail: bill.laurance@jcu.edu.au

J. L. Roberts et al. (eds.), *Shaping the Future of Small Islands*,
https://doi.org/10.1007/978-981-15-4883-3_12

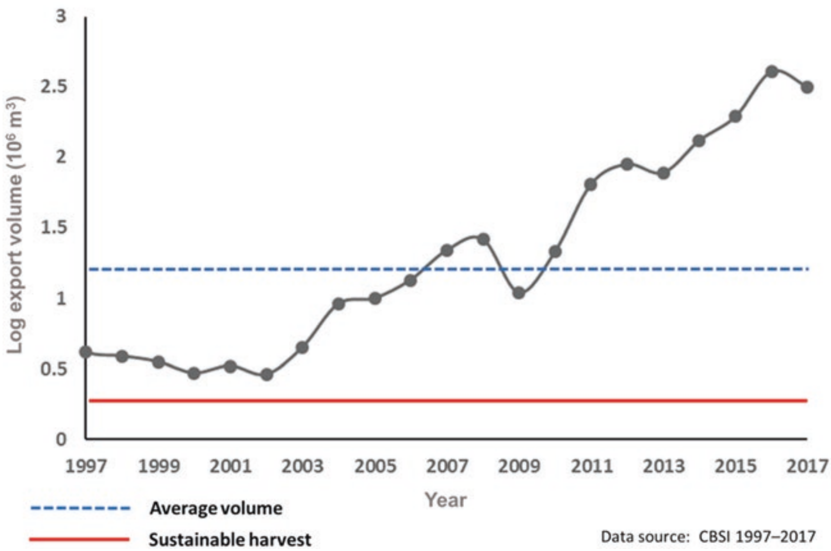

Fig. 12.1 Log export volume for the Solomon Islands between 1997 and 2017. The economy of the Solomon Islands has been heavily reliant on log export, resulting in a steep increase in logging activities in the country, with harvest quadrupling beyond the sustainable yield

exports in the Solomon Islands had been consistent in the 1980s and 1990s but increased steeply within the last decade (Fig. 12.1) (CBSI 1997–2017). Recent research has predicted that log export volumes will soon peak and then sharply decline within the next decade mainly due to unsustainable harvesting associated with bad logging practices (Shearman et al. 2012; Katovai et al. 2015). In spite of many concerns about past and current logging practices, and proposals to address excessive damage through remedial and preventive actions in the Solomon Islands, relatively little has been achieved in this frontier (Laurance et al. 2011, 2012; Katovai et al. 2016).

Industrial logging in Solomon Islands is mostly selective and operated by companies from Asia. Trees are usually harvested based on size and species preference (Katovai et al. 2015). However, unregulated harvesting and the lack of monitoring by authorities often result in highly degraded forest landscapes across the country (Fig. 12.2a). Furthermore, unregulated logging practices lead to the deforestation of large forest tracts within logging concessions for temporary logging, machinery and fuel storage, logging

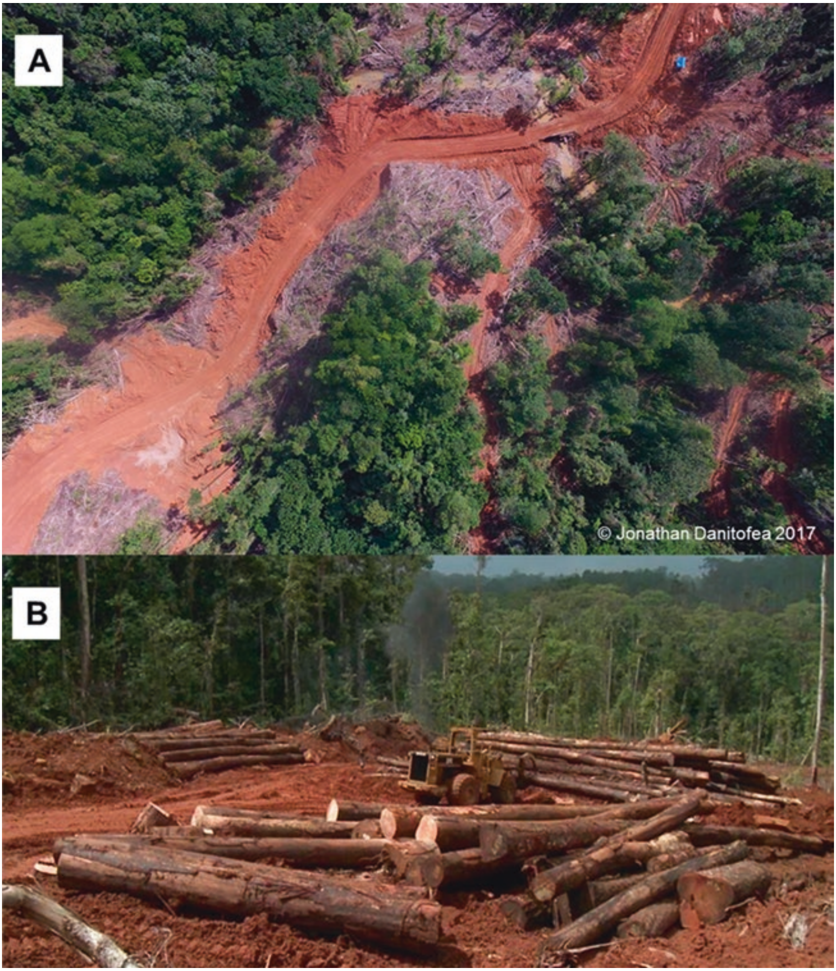

Fig. 12.2 A highly logged forest landscape (**a**) and a large forest tract deforested for temporary log storage (**b**) in Solomon Islands

camps and dense networks of roads and skidding trails (Fig. 12.2b) (Jackson et al. 2002). In heavily or repeatedly logged stands, damage incurred from tree harvest and the associated land uses can be so intense that natural regeneration is insufficient to allow floristic and functional recovery to pre-cut levels. Permanent shifts in climax vegetation in these logged stands may consequently trigger changes in the faunal diversity structure (Katovai et al. 2016). Here we outline restoration approaches that have been successfully implemented in human-degraded tropical landscapes that can potentially assist the recovery of highly logged forests in Solomon Islands.

12.2 Passive Restoration Approaches

Restoration of forest gaps is vital for the sustainability and livelihood of the forest. However, the question remains: how comparable will the restored forest be to the pre-disturbed stand in terms of ecological and biological values? There is no universal answer to this question as forest and gap dynamics vary spatially and temporally. To understand how gap dynamics influence the process of regeneration, let us consider the synergies of four primary sources that determine the quality of natural regeneration in gaps. Each of these factors varies in their role in gap regeneration.

12.2.1 Regeneration of Pre-existing Forest Vegetation

Regeneration of pre-existing forest species that have survived following a disturbance may utilize the abundance of light, which was often a limiting factor for growth and recruitment of understorey and sub-canopy plants at the pre-disturbed stage. These species may include juveniles of climax species that dominate the canopy prior to disturbance, which are in dormancy in the undergrowth awaiting an appropriate environment to flourish (Denslow et al. 2001). Gap re-growth represents an amalgamation of shade-intolerant pioneers and shade-tolerant plants. Yet due to the complexities of vegetation responses and the lack of detailed information, regeneration of pre-existing forest vegetation (termed "advanced regeneration") remains excluded from gap dynamic models (Dietze and Clark 2008).

12.2.2 Germination from the Soil Seed Bank

Germination from the soil seed bank is important for gap regeneration and diversification. Prior studies have shown that this natural process occurs in forests in response to the availability of light, with seed germination triggered by certain light wavelengths that result from direct sunlight (Brokaw and Busing 2000; Rüger et al. 2011). However, not all forest stands possess seed banks capable of dormancy for extended periods of time. For instance, a study of 18 late succession species on Barro Colorado Island showed no dormancy capability among them (Augspurger 1984). The absence of pioneers in the soil seed bank across the Bornean heath forest also illustrates the lack of dormancy of certain succession specialists (Whitmore and Hadley 1991). It is also important to note that by definition forest gap dynamics are not applicable to all forest stands as the concept revolves around sapling growth from seed banks. Much is still unknown about the temporal and spatial scales of seed banks in tropical forests.

12.2.3 Sprouting from Damaged Roots and Stems

Sprouting from damaged roots and stems also plays an important role in gap regeneration (Dietze and Clark 2008). This is particularly common in forests within the cyclone and hurricane zones, that is 7–20° latitude, where wind damage is highly intense and frequent (Laurance and Curran 2008). In cases where the seed bank regeneration does not occur, sprouting regrowth may dominate the gap restoration phase. Therefore, it is possible that species composition at the early gap phase regeneration will resemble the pre-existing flora but have a lower floral diversity as not all pre-disturbance species would survive through the disturbance regime (Dietze and Clark 2008).

12.2.4 Seed Rain

The fourth source of regeneration is termed "seed rain", which is a practical description of how seeds disperse into a gap via vectors such as animals, particularly frugivorous birds and bats (Ceccon and Hernández 2009) but also including some scansorial animals such as mammals and ants. The role of birds in re-seeding degraded forests in the tropics has been well documented (Pejchar et al. 2008; Graham and Page 2012; Reid et al. 2012). A widely anticipated challenge in tropical forest regeneration, particularly in heavily degraded landscapes, is the lack of seed diversity to permit the later stages of regeneration and succession (Chazdon 2008; Budiharta et al. 2014). Numerous studies have since focused on ways to actively restore degraded forests through appropriate re-seeding approaches (e.g. Chazdon

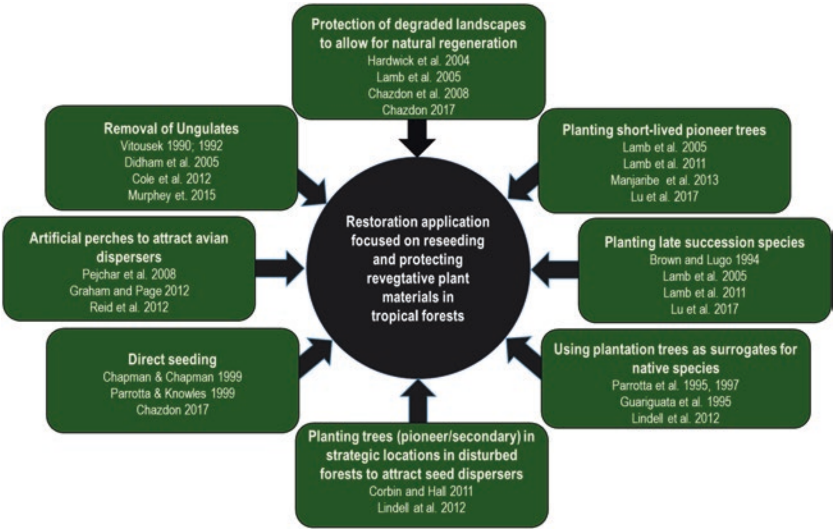

Fig. 12.3 Ecological restoration approaches widely used in tropical landscapes. An integrated approach whereby several techniques implemented concurrently can potentially aid success in heavily logged forests

2008; Cole et al. 2010; Graham and Page 2012). Through these efforts, a range of approaches have been developed and trialled, some of which have shown considerable success (Fig. 12.3).

12.2.5 Protection of Logged Forest Landscapes to Enhance Natural Regeneration

It is evident that forest restoration through natural regeneration can be improved by protecting previously logged forests (Margules et al. 2002; Chazdon 2008, 2017). The inclusion of adjacent undisturbed forest in these protected zones is important for provisioning an influx of seeds and faunal seed dispersers (Chazdon 2008, 2017). This strategy is feasible in areas where forests are not entirely cleared, hence leaving fragmented patches of forests capable of producing seeds that would then be vectored into forest gaps by animals or natural dispersal processes (Lamb et al. 2005). Nevertheless, forest recovery through this approach may fail in heavily logged landscapes if the system has crossed an ecological threshold that inhibits the perseverance and proliferation of forest species (Hobbs et al. 2006), or if logged forests are severely hunted or burned leading to defaunation or further forest degradation. Exceeding this ecological threshold limits natural regeneration to an altered state, generally associated with light-demanding vegetation (Lamb et al. 2005). For example, the loss of topsoil and/or increased soil compaction associated with heavy logging equipment hinder the establishment and growth of late successional vegetation, resulting in the high influx of non-tree and other invasive non-forest species (Vieira and Scariot 2006). Such floristic change increases the risk of wildfires, consequently reducing woody plant recruitment and favouring the proliferation of grasses and other fire-tolerant vegetation (Lamb et al. 2005; Lamb 2011). Many examples of fire-induced vegetation communities are evident throughout the tropics (e.g. Connell 1978; Zanne and Chapman 2001; Maeto et al. 2009).

12.3 Active Restoration Approaches

12.3.1 Tree Planting

In cases where unaided recovery is not possible for logged forest landscapes, several restoration strategies have been proposed. Most studies on tropical forest restoration have highlighted three broad approaches by which floral diversity can be actively restored. These are centred on the concept of restoration through planting. Though an expensive and in most cases an extensive exercise, restoration planting has been proven successful in many empirical studies (e.g. Parrotta and Knowles 1999; Chazdon 2008; Cole et al. 2010; Lamb 2011).

The first approach includes restoration plantings using several pioneer ephemeral nurse trees. The early establishment and rapid growth of nurse trees usually shade off light-demanding non-tree vegetation, including grasses and other undesirable alien species (Lamb et al. 2005). This effect creates a favourable environment for the regeneration of secondary forest species, some of which lay dormant in the topsoil awaiting the right conditions for germination (Lamb et al. 2005).

The second approach involves planting a range of species from later successional stages that improves the chances for a species-rich climax stand (Cole et al. 2011). This approach is particularly useful in the event where the soil seed bank has few live seeds of late successional species. The resultant species and structural assemblage of the restored community heavily depends on the variety and viability of the introduced seeds and therefore can be predetermined to a certain extent (Cole et al. 2011). Where seed collection is done within the proximity of logged forests, local knowledge is vital when selecting native species for re-seeding as this ensures that the restored forest has a high value for forest-dependent communities (Lu et al. 2017).

The third approach involves planting commercial tree species on deforested landscapes. Tree plantations can offer restoration values for native understorey vegetation (Parrotta 1995; Guariguata et al. 1995; Parrotta and Knowles 1999; Lindell et al. 2013). For instance, the successful germination and establishment of late successional species are potentially enhanced by planting commercial trees, as they shade out light-demanding pioneer competitors such as lianas and woody shrubs (Guariguata and Ostertag 2001). The soil may also aid restoration via high nutrient levels retained from the decomposition of pre-existing vegetation. The range of seed dispersers attracted to tree plantations may also aid in the rejuvenation of the topsoil, enhancing successful restoration of understorey native vegetation (Parrotta 1995; Parrotta and Knowles 1999; Katovai et al. 2012).

Despite the restoration values that tree plantations offer, the development of many tree plantations in the tropics is influenced solely by economic considerations. Many commercial plantations have been converted from large forest areas that had previously been cleared for agriculture and cattle ranching (Chazdon 2008). Successful efforts in restoring heavily degrading landscapes by tree plantations depend entirely on future management strategies. Current strategies such as cyclic clear-felling and replanting strategies prevailing in many tropical regions need to be reassessed. The effects of this process on the regeneration of native vegetation are still unknown. However, it may be suggested that further degradation of soil seed banks may result from repeated mechanical disturbances during the process of harvesting and extraction of logs, and soil clearing during preparation for replanting.

Nucleation may be an alternative approach to restore heavily degraded landscapes. This strategy involves planting small clusters of selected tree species (sometimes termed "framework tree species"; Goosem and Tucker 2013) within the degraded site and allowing them to disperse as well as attract seed dispersers, subsequently increasing seed rain into the disturbed landscape (Corbin and Holl 2012; Lindell et al. 2013; Goosem and Tucker 2013). This approach was successful with bird dispersers but not for larger mammalian seed dispersers (Corbin and Holl 2012). Although implementation of this approach is relatively inexpensive, restoration efforts may be impractical or too expensive at large spatial scales (Corbin and Holl 2012). However, there are still gaps in our understanding of the optimal design and long-term viability of such approaches (Corbin and Holl 2012; Lindell et al. 2013).

12.3.2 Direct Seeding

Direct seeding is an approach that involves dispersing seeds directly within disturbed landscapes. Such an approach requires a greater number of seed species of more mature successional stages (Chapman and Chapman 1999; Lamb et al. 2005; Lamb 2012). Planting usually requires high densities (e.g. 92,500 seeds per hectare; Parrotta 1995). The climax forest stand depicted in this approach is practically a function of the competitive interactions among the seedlings as they grow and mature. Ideally, this approach resembles a degraded forestland with an initial seed bank that, given the appropriate conditions, will undergo successful regeneration. The number of species that can be successfully established by direct seedling is limited by seed supply, although establishment costs may be lower than other approaches. Reforestation of open fields under appropriate conditions is possible (e.g. with the control of grasses or other competing species); however, it may be most useful in enhancing diversity where some tree cover is already present (Lamb et al. 2005). This approach is not as versatile as those previously discussed as ecophysiological conditions needed for initial germination are often narrowly specific because most seeds of climax species germinate and dominate only in the late successional stages.

12.3.3 Artificial Perches

The most important seed dispersers in tropical forests are birds, which are responsible for dispersing >50% of trees across forested landscapes (Graham and Page 2012). Hence, an approach that is widely used to maximize seed dispersal in degraded sites is the erection of artificial perches. Birds are known to use tall trees on gap edges for perching; by increasing artificial perches in gaps, bird colonization, and seed populations and diversity are increased, particularly under the perches (Pejchar et al. 2008). Although seed recruitment has been enhanced through artificial perches, the composition of seed rain largely depends on the foraging sites of visiting dispersers, which may include degraded forest sites, as evident in a recent study in Indonesian peat swamp forests (Graham and Page 2012). Studies have also shown that seed recruitment into degraded forests is coupled with the structural complexity within a given degraded environment, whereby simple environs such as abandoned grazed pastures usually have lower zoochorous recruitment (i.e. seeds dispersed by animals) than more complex environs (Pejchar et al. 2008; Graham and Page 2012; Reid et al. 2012).

12.3.4 Removal of Ungulates

Removal of ungulates from restoration sites is complimentary to both natural and assisted regeneration. Studies have shown that non-native ungulates can supress regeneration in the forest understorey through rooting, trampling and browsing of plant materials above and within the topsoil (Ickes et al. 2001; Didham 2011; Cole et al. 2012). Areas with a high population density of native ungulates may also produce the same effect (Cole et al. 2012). In contrast, the absence of ungulates may result in the high proliferation of invasive non-native plants, subsequently changing the vegetation structure of restored forests (Cole et al. 2012). Before embracing this approach, it is necessary to take into account the ecological importance of ungulates within the ecosystem.

12.4 Conclusions

We have outlined various restoration approaches that have been successfully trialled in highly degraded and deforested tropical landscapes. Although some stand-alone approaches have been successful, we strongly suggest that an amalgamation of carefully selected approaches is applied to any restoration effort. Such an integrative approach may achieve better outcomes and perhaps be more economically viable than stand-alone efforts. With increasing land use intensification through poor logging practices in the Solomon Islands, the need for landscape-scale restoration will certainly grow. It is therefore critical that forest restoration models and policies pertaining to their implementations should be developed. Meanwhile, the need for future research is critical to examine the cost, effectiveness and limitations of these approaches in highly logged forests. Information from this research can aid the development of forest restoration models and policies specifically designed for the Solomon Islands, as well as provide critical information for other small tropical islands vulnerable to industrial logging.

References

Augspurger, C. K. (1984). Seedling Survival of Tropical Tree Species: Interactions of Dispersal Distance, Light-gaps, and Pathogens. *Ecology, 65*, 1705–1712.

Brokaw, N., & Busing, R. T. (2000). Niche Versus Chance and Tree Diversity in Forest Gaps. *Tree, 15*, 183–188.

Budiharta, S., Meijaard, E., Erskine, P. D., Rondinini, C., Pacifici, M., & Wilson, K. A. (2014). Restoring Degraded Tropical Forests for Carbon and Biodiversity. *Environmental Research Letters, 9*, 114020.

CBSI. 1997 – 2017. *Annual Reports, Central Bank of Solomon Islands*. http://www.cbsi.com.sb/index.php?id=105. Accessed Jan 2018.

Ceccon, E., & Hernández, P. (2009). Seed Rain Dynamics following Disturbance Exclusion in a Secondary Tropical Dry Forest in Morelos, Mexico. *Revista de Biologia Tropical, San Jose, 57*, 257–269.

Chapman, C. A., & Chapman, L. J. (1999). Forest Restoration in Abandoned Agricultural Land: A Case Study from East Africa. *Conservation Biology, 13*, 1301–1311.

Chazdon, R. L. (2008). Beyond Deforestation: Restoring Forests and Ecosystem Services on Degraded Lands. *Science, 320*, 1458–1460.

Chazdon, R. L. (2017). Landscape Restoration, Natural Regeneration, and the Forests of the Future. *Annals of the Missouri Botanical Garden, 102*, 251–257.

Cole, R. J., Holl, K. D., & Zahawi, R. A. (2010). Seed Rain Under Tree Islands Planted to Restore Degraded Lands in a Tropical Agricultural Landscape. *Ecological Applications, 20*, 1255–1269.

Cole, R. J., Holl, K. D., Keene, C. L., & Zahawi, R. A. (2011). Direct Seeding of Late-Successional Trees to Restore Tropical Montane Forest. *Forest Ecology and Management, 261*, 1590–1597.

Cole, R. J., Litton, C. M., Koontz, M. M., & Loh, R. K. (2012). Vegetation Recovery 16 Years After Feral Pig Removal From a Wet Hawaiian Forest. *Biotropica, 44*, 463–471.

Connell, J. H. (1978). Diversity in Tropical Rain Forests and Coral Reefs. *Science, 199*, 1302.

Corbin, J. D., & Holl, K. D. (2012). Applied Nucleation as a Forest Restoration Strategy. *Forest Ecology and Management, 265*, 37–46.

Denslow, J. S., Ellison, A. M., & Sanford, R. E. (2001). Treefall Gap Size Effects on Above and Below Ground Processes in a Tropical Wet Forest. *Journal of Ecology, 86*, 597–609.

Didham, R. K. (2011). Life After Logging: Strategic Withdrawal From the Garden of Eden or Tactical Error for Wilderness Conservation? *Biotropica, 43*, 393–395.
Dietze, M. C., & Clark, J. S. (2008). Changing the Gap Dynamics Paradigm: Vegetative Regeneration Control on Forest Response to Disturbance. *Ecological Monographs, 78*, 331–347.
Goosem, S., & Tucker, N. I. J. (2013). *Repairing the Rainforest* (2nd ed.). Cairns: Wet Tropics Management Authority and Biotropica Australia Pty. Ltd.
Graham, L. L. B., & Page, S. E. (2012). Artificial Bird Perches for the Regeneration of Degraded tropical Peat Swamp Forest: A Restoration Tool With Limited Potential. *Restoration Ecology, 20*, 631–637.
Guariguata, M. R., & Ostertag, R. (2001). Neotropical Secondary Forest Succession: Changes in Structural and Functional Characteristics. *Forest Ecology and Management, 148*, 185–206.
Guariguata, M. R., Rheingans, R., & Montagnini, F. (1995). Early Woody Invasion Under Tree Plantations in Costa Rica: Implications for Forest Restoration. *Restoration Ecology, 3*, 252–260.
Hobbs, R. J., Arico, S., Aronson, J., Baron, J. S., Bridgewater, P., Cramer, V. A., Epstein, P. R., Ewel, J. J., Klink, C. A., Lugo, A. E., Norton, D., Ojima, E., Richardson, D. M., Sanderson, E. W., Valladares, F., Vilà, M., Zamora, R., & Zobel, M. (2006). Novel Ecosystems: Theoretical and Management Aspects of the New Ecological World Order. *Global Ecology and Biogeography, 15*, 1–7.
Ickes, K., Dewalt, S. J., & Appanah, S. (2001). Effects of Native Pigs (*Sus scrofa*) on Woody Understorey Vegetation in a Malaysian Lowland Rain Forest. *Journal of Tropical Ecology, 17*, 191–206.
Jackson, S. M., Fredericksen, T. S., & Malcolm, J. R. (2002). Area Disturbed and Residual Stand Damage Following Logging in a Bolivian Tropical Forest. *Forest Ecology and Management, 166*, 271–283.
Katovai, E., Burley, A. L., & Mayfield, M. M. (2012). Understory Plant Species and Functional Diversity in the Degraded Wet Tropical Forests of Kolombangara Island, Solomon Islands. *Biological Conservation, 145*, 214–224.
Katovai, E., Edwards, W., & Laurance, W. F. (2015). Dynamics of Logging in Solomon Islands: The Need for Restoration and Conservation Alternatives. *Tropical Conservation Science, 8*, 718–731.
Katovai, E., Sirikolo, M., Srinivasan, U., Edwards, W., & Laurance, W. F. (2016). Factors Influencing Tree Diversity and Compositional change Across Logged Forests in the Solomon Islands. *Forest Ecology and Management, 372*, 53–63.
Lamb, D. (2011). *Regreening the Bare Hills: Tropical Forest Restoration in the Asia-Pacific Region*. Dordrecht: Springer.
Lamb, D. (2012). The Third Big Silvicultural Challenge. *Journal of Tropical Forest Science, 24*, 295–299.
Lamb, D., Erskine, P. D., & Parrotta, J. A. (2005). Restoration of Degraded Tropical Forest Landscapes. *Science, 310*, 1628–1632.

Laurance, W. F., & Curran, T. J. (2008). Impacts of Wind Disturbance on Fragmented Tropical Forests: A Review and Synthesis. *Austral Ecology, 33*, 399–408.

Laurance, W. F., Camargo, J. L. C., Luizão, R. C. C., Laurance, S. G., Pimm, S. L., Bruna, E. M., Stouffer, P. C., Williamson, G. B., Benítez-Malvido, J., Vasconcelos, H. L., Van Houtan, K. S., Zartman, C. E., Boyle, S. A., Didham, R. K., Andrade, A., & Lovejoy, T. E. (2011). The Fate of Amazonian Forest Fragments: A 32-Year Investigation. *Biological Conservation, 144*, 56–67.

Laurance, W. F., Useche, D. C., Rendeiro, J., Kalka, M., et al. (2012). Averting Biodiversity Collapse in Tropical Forest Protected Areas. *Nature, 489*, 290–294.

Lindell, C. A., Reid, J. L., & Cole, R. J. (2013). Planting Design Effects on Avian Seed Dispersers in a Tropical Forest Restoration Experiment. *Restoration Ecology, 21*, 515–522.

Lu, Y., Ranjitkar, S., Harrison, R. D., Xu, J., Ou, X., Ma, X., & He, J. (2017). Selection of Native Tree Species for Subtropical Forest Restoration in Southwest China. *PLoS One, 12*, e0170418.

Maeto, K., Noerdjito, W., Belokobylskij, S., & Fukuyama, K. (2009). Recovery of Species Diversity and Composition of Braconid Parasitic Wasps After Reforestation of Degraded Grasslands in Lowland East Kalimantan. *Journal of Insect Conservation, 13*, 245–257.

Margules, C. R., Pressey, R. L., & Williams, P. H. (2002). Representing Biodiversity: Data and Procedures for Identifying Priority Areas for Conservation. *Journal of Biological Sciences.* (Suppl. 2*, 27*, 309–326).

Parrotta, J. A. (1995). Influence of Overstory Composition on Understory Colonization by Native Species in Plantations on a Degraded Tropical Site. *Journal of Vegetation Science, 6*, 627–636.

Parrotta, J. A., & Knowles, O. H. (1999). Restoration of Tropical Moist Forests on Bauxite-mined Lands in the Brazilian Amazon. *Restoration Ecology, 7*, 103–116.

Pejchar, L., Pringle, R. M., Ranganathan, J., Zook, J. R., Duran, G., Oveido, F., & Daily, G. C. (2008). Birds as Agents of Seed Dispersal in a Human-dominated Landscape in Southern Costa Rica. *Biological Conservation, 141*, 536–544.

Reid, J. L., Katsuki, K. N., & Holl, K. D. (2012). Do Birds Bias Measurements of Seed Rain? *Journal of Tropical Ecology, 28*, 421–422.

Rüger, N., Berger, U., Hubbell, S. P., Vieilledent, G., & Condit, R. (2011). Growth Strategies of Tropical Tree Species: Disentangling Light and Size Effects. *PLOS ONE, 6*, e25330.

Shearman, P., Bryan, J., & Laurance, W. F. (2012). Are We Approaching 'Peak Timber' in the Tropics? *Biology Conservation, 151*, 17–21.

Sloan, S., & Sayer, J. A. (2015). Forest Resources Assessment of 2015 Shows Positive Global Trends But Forest Loss and Degradation Persist in Poor Tropical Countries. *Forest Ecology and Management, 352*, 134–145.

Vieira, L. M., & Scariot, A. (2006). Principles of Natural Regeneration of Tropical Dry Forests for Restoration. *Restoration Ecology, 14*, 11–20.
Whitmore, T. C., & Hadley, M. (1991). *Rain Forest Regeneration and Management, Man and Biosphere Series* (Vol. 6). UK: The Parthenon Publishing Group.
Zanne, A. E., & Chapman, C. A. (2001). Expediting Reforestation in Tropical Forests Grasslands: Distance and Isolation from Seed Sources in Plantations. *Ecological Applications, 11*, 1610–1621.