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DESIGNING TARGETED INTERDISCIPLINARY RESTORATION ACTION PLANS FOR ASIA'S DEGRADED TROPICAL PEAT SWAMP FORESTS

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SUMMARY

Between 1985 and 2006 about 47% of tropical peat swamp forest (TPSF), mainly found in South East Asia, became degraded. The degradation of tropical peatlands can lead to large GHG emissions, through logging, drainage and burning. Consequently numerous peatland rehabilitation programs are at the early stages of development across Indonesia. Unfortunately, relevant ecological and social data to base these upon are limited and interdisciplinary case-studies even more so. This study explored the social and ecological factors affecting the regeneration of a degraded TPSF in Central Kalimantan, Indonesia. An ecological investigation revealed that seed rain, animal-dispersal, flooding, increased light levels and lowered soil nutrient and mycorrhizae levels had become forest regeneration barriers, whilst seed banks, drought and competition with invasive species had not. In the adjacent village, focus groups and interviews revealed other factors influencing forest regeneration; the community's lack of livelihood options, their dependency on the forest, the lack of funding for restoration and their dislike of _outsiders'. Not all factors were negative however; the community's ecological knowledge and their attitude towards restoration were positive. Social and ecological data were equally important in understanding the factors influencing the landscape. Furthermore, the data were closely linked and were often combined to better explain each factor. This study therefore describes how to select appropriate methods by which to collect ecological and social data within a degraded tropical peatland location through a process called _anticipation and engagement'. It then proposes a new methodology for integrating these two disciplines in order to describe the factors influencing regeneration. The social and ecological data are combined to explain the factors using the categorizations: _negative', _potential negative', _in-active', _positive', and _compound'. These factors can then be used to develop an appropriate and targeted site-specific restoration action plan.

Keywords: *Restoration action plan, regeneration barriers, tropical peatlands, interdisciplinary, degradation*

INTRODUCTION

Ecological restoration (ER) is the practice of assisting a degraded ecosystem in its recovery of health, integrity and sustainability. Restoration ecology (RE) is the science which supports the practice of ER. ER and RE are relatively new, with a dramatic increase in the number of studies and applications in the last 20 years. This field of science and practice offers great potential in overcoming the problems of land exploitation, loss of ecosystem services (ES) and climate change (Alexander *et al.* 2011). The science and practice of ER encompasses ecology, sociology, politics, geography and economics, amongst other disciplines and all must be investigated and combined to facilitate the design and implementation of appropriate restoration action plans (RAPs) (Tongway & Ludwig 2011). Interdisciplinary science, however, is complex and still in the early stages of development, resulting in a socio-ecological gap with contemporary ER activities having access to few case-study examples of interdisciplinary methods (Clewell & Aronson 2013).

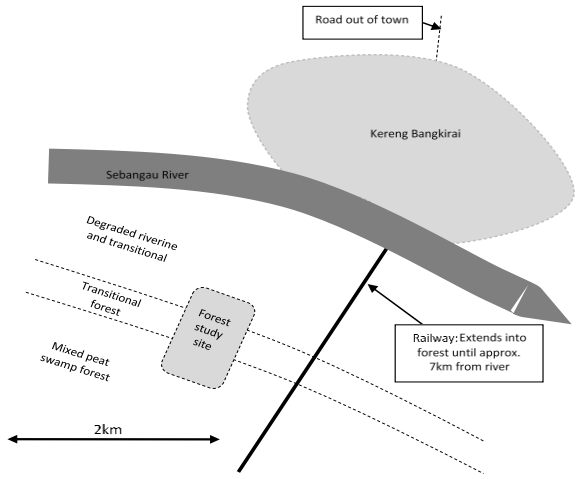
One RE methodology is the exploration of regeneration barriers existing at a specific site and consideration of how to overcome these barriers (Holl *et al.* 2012). These can then be used to help design and implement a RAP for the specific location together with all stakeholders, and to monitor progress (Tongway & Ludwig 2011). The regeneration barriers and appropriate RAP are site-specific reflecting site natural history, disturbance history and sociology (Holl *et al.* 2012). Given the vast areas of degraded land across the globe, landscape-restoration has become an important topic of research and practice (Manning *et al.* 2006). There is a need for large-scale solutions and transferability of data, and yet the site-specific nature of regeneration barriers creates a challenge: how this work can be undertaken in a way that is successful and also has a wide-scale impact?

Indonesia supports the world's largest area of tropical peat swamp forest (TPSF) (Page *et al.,* 2011). Following Indonesian independence in 1945, an authoritarian regime was established (1966-1998) who prioritized economic growth through commercialization of the country's natural resources, which left many local communities feeling exploited and abused (Tsing 2005). In the last 15 years, democracy has been established, corruption is being challenged and repair of land exploitation is starting to be addressed (Ricklefs 2008). Indonesia's TPSFs, however, continue to be degraded at a rapid rate through logging, burning, drainage or conversion to agricultural use, and only 4% of the TPSF in Sumatra and Kalimantan is still in an intact condition, with 37% classified as degraded forest (Mietinnen & Liew 2010). TPSF provides important ES; biodiversity support, hydrological regulation and particularly, carbon storage (Page *et al.,* 2011). In light of recent developments in international policy targeting climate change, especially REDD+ (Alexander *et al.,* 2011), the restoration of Indonesia's tropical peatlands and its TPSF has become a topic of international interest. Restoration, however, requires intimate knowledge of an ecosystem's processes, and the study of TPSF has only developed in the last 30 years with, at present, little of that knowledge being applied to ecosystem restoration (Page *et al.,* 2009).

The aim of this study was, firstly, to investigate regeneration barriers, both ecological and social, at the local scale influencing the recovery of a specific site, then secondly, to consider whether these data or methods could be applied at a landscape-scale. The study explored how the ecological and social disciplines might be bridged during this process. It considered new methods and approaches to facilitate inter-disciplinarity in a multi-faceted practice and the transferability of methods in a science governed by its site-specific nature. The aim of this paper is to present briefly the ecological and social findings from this study, then to address the larger question of how this information was combined to create an interdisciplinary RAP and how these methods might be transferred.

METHODS

The ecological study took place in the TPSF within the Sabangau peat dome, Central Kalimantan, Indonesia. These forests were previously continuous and undisturbed but during recent years concessional and illegal logging and fires have resulted in areas near the river becoming severely degraded. Kereng Bangkirai is the closest village to the ecological study site, and the location of the community study Fig. 1).



The ecological component comprised of five 600 m transects running parallel to the forest edge, encompassing a gradient of forest degradation: the natural forest (representing the control or reference site approx. 1 km within the forest), closed-canopy disturbed forest (50 m inside the forest), the forest edge, open-canopy disturbed forest (50 m outside the forest) and degraded forest (200 m outside the forest). Vegetation study plots were established in each FZ which showed increasing environmental degradation in all recorded attributes - species diversity and composition, forest dynamics, forest structure and productivity.

Figure 1: Map of the forest study site, river, access railway and Kereng Bangkirai.

Within each of these FZs, the following ecological conditions were selected, based on other tropical RE studies and a review of TPSF ecology, and then studied for one year: seed rain, seed dispersal, seed bank (representing the process of seedling recruitment), nutrient availability and pH of the peat, water table, light intensity, competition with herbaceous vegetation and mycorrhizal availability (representing the process of seedling survival and growth), with 5-8 replication points in each FZ for each condition. These conditions were analysed in comparison to the natural forest to determine if they differed significantly. Seedlings of three native TPSF early-succession species, *Dyera polyphylla, Shorea balangeran* and *Combretocarpus rotundatus,* were cultivated and transplanted into 32 mixed seedling plots in each forest zone. Eight plots per FZ were the control or natural environmental conditions plots. Eight plots had slow-release nutrient tablets added to each seedling. Eight plots were provided with shade cover and eight plots had the non-tree vegetation regularly cleared from the plots, i.e. competition removed. The survival and growth of the seedlings was recorded for seven months, and these data were analysed to investigate the impact of the seedling treatments in relation to the control seedlings and in relation to the FZ for each species. Analysis was carried out using ANOVA or Mann-Whitney U tests.

The social component of the study focused on understanding what the ‗local community' (defined as residents of Kereng Bangkirai who regularly use the adjacent degraded study site) saw as barriers preventing natural regeneration, and how these might be alleviated. Focus groups and interviews were conducted to discuss past, present and future uses, changes and concerns about the land and forest surrounding their village. At the time of study (2009) Kereng Bangkirai had a population of approximately 5550. The total number of participants involved in the activities was 154, or 2.8% of the village. Three topics were covered, one topic per meeting: Topic 1: History of the land - historical uses, events, ownership and access, in particular which led to the land's degradation. Topic 2: Present uses of the land, both degraded and non-degraded, and Topic 3: Future of the land: concerns and hopes. Within these topics, sub-themes were addressed; physical barriers to recovery of the land, issues relating to land ownership, land rights and access, issues of social tension, and conflict over land-use. These topics and the methods were flexible such that new directions could be taken as the discussions proceeded. The activities were recorded and transcribed and analysed, and as the topics progressed so did recurrent themes or factors perceived to be influencing the regeneration of the forest.

During the data collection, maximum opportunity for cross-transfer of knowledge from the ecological study site and the village, with regard to the emerging barriers, was provided. Having one focal researcher at the heart of the study, dealing with the both the ‗ecological' and ‗social' aspects, allowed themes and concepts to flow across the so-called ‗socio-ecological gap', so that the findings evolved as a whole rather than two halves. N.B. For more details on all the ecological and social methods including an in-depth description of the participants, their gender, age, religion, occupations etc., discussion on the community's social structure and, mine and the facilitators' positionality, and related potential trust, biases and impacts upon the social data see Graham (2013).

RESULTS

The ecological results revealed some distinct differences in the environmental conditions between the NF and the disturbed FZs; seed rain and the number of tree species in the seed rain were reduced in the more disturbed FZs, and a lower percentage of the seeds that did reach the FZs arrived through animal dispersal. %-orgC, %N and Total-P values for the surface peat were reduced in some of the disturbed FZs, however pH was unaffected by level of degradation. In both the wet and dry seasons, the water table in the disturbed FZs was higher than in the NF, resulting in issues of flooding but not drought. Light levels significantly increased in the disturbed FZs, although this effect was somewhat ameliorated by the ground-cover vegetation; but even beneath this cover, the light levels were still greater than under the canopy cover created by the forest. The ground cover of pandan and lianas reduced outside the forest whilst cover of sedges increased, and overall non-tree vegetation ground cover was greater outside the forest. Finally, levels of mycorrhizae in the degraded FZs appeared to be below optimal levels for the species investigated. The impact of forest degradation on seedling survival and growth further indicated alterations to the environmental conditions. Providing nutrient additions to the seedlings improved the growth of two of the three tree species planted in some of the disturbed zones; shade cover was advantageous to only one species outside the forest; removal of invasive ground cover vegetation either had no effect or actually reduced survival of one species and the growth of another; finally, mycorrhizal inoculation improved nutrient uptake in two species of seedlings, and, given the higher colonisation levels of the inoculated seedlings, the results suggest some additional advantages (Graham 2013).

The social results revealed several regular themes that explained how the community engaged with the landscape and which, in their view, were impacting upon the regeneration of the area. Key themes are described below, for the complete list see Table 1, with further detail provided in Graham (2013).

- *Importance of the forest:* This was the most recurrent theme: The forest provided the community with most of their livelihoods: logging, fishing, jelutong, gemur etc. It was the source of many of their foods, timber and medicines. It linked to their culture, identity, tradition, heritage, and sense of well-being.
- *High awareness of ecology:* Their knowledge of the forest and ecology was very high. They described the water, atmosphere and soil and how this was affected by different forest qualities. They had knowledge on tree and animal species, and their habits and seasons, which allowed them to work year-round in the seasons of the forest.
- *Feelings of being observers:* Most of the degradation was perceived as coming from external forces. The community felt they were not to blame for what happened to their land and felt overwhelmed and pushed out.
- *Outsiders:* Strong resentment was felt towards ‗outsiders', perceived as people or groups that came to the area, exploited a resource, then left again. They acknowledged that they themselves had partaken in some of the degradation activities, but they felt it was due to an increased competition and need that resulted from outsiders.

- *Feelings of lack of options*: The community tried to maintain their forest livelihoods with the few resources that were left. They were aware their activities were no longer sustainable, that the money they made was only just sufficient and with general prices rising, they struggled to make ends meet.
- *Attitude towards restoration:* They were extremely motivated towards restoring the forest, and saw the restoration and subsequent management as a long-term solution to their current situation. They had suggestions for how to bring this about, but did not feel financially or authoritatively empowered to do it. They said they would want to be involved in all the activities, and that the commitment, the period of commitment and recipients of future benefits should be made clear from the start.
- *Relationship with government:* They were honest about the ways they felt the government had not managed the area well, regarding the logging, illegal logging and fires. Despite this, they looked to the government as the main potential source of funding for restoration and to provide the laws and authority necessary to bring about restoration.

DISCUSSION

The ecological results presented above could form the basis of the ‗usual' ecological component of a restoration action plan (RAP) for this specific site. These findings do not stand-alone, however, as the social factors should also be incorporated. Furthermore, as this study progressed, it became apparent that the ‗active' regeneration barriers only told half of the story. Some factors which might have been regeneration barriers, were in fact only potential or inactive barriers. Equally there were factors that could have a positive impact on regeneration. These factors are just as important to include in a RAP. In order to successfully combine social and ecological data, and to show the array of factors influencing the degraded landscape, new terminology was needed (Table 1). All the factors found to be affecting this landscape could now be categorised within this new terminology, with the ecological and social components of each combined (Table 2), and a more targeted RAP could be designed.

Table 1: A summary of the terminology developed in this study to describe the factors influencing the regeneration of the degraded landscape.

Factor	Definition
Negative	Also called regeneration barriers, these are factors acting upon the degraded area such that they would need to be directly removed or overcome in order for regeneration to take place.
Potential negative	Factors causing some degree of negative impact on regeneration, or which may become active negative factors based on an external trigger.
In-active	Factors that have neither a negative nor a positive effect on regeneration, and as such, would not need to be addressed in restoration activities.
Positive	Factors shown to support regeneration activities, and awareness of these factors and their incorporation into a RAP would be advantageous.
Compound	Factors that are may not be negative or positive, but which are complex, affected by numerous events and as yet unresolved. Awareness of the factors would be needed when designing an RAP.

Regeneration barriers, or, as proposed here influencing regeneration ‗factors', can have ecological, social, economic and political components, which develop both pre- and post-disturbance. The result is that although the regeneration factors for one site may be known, one cannot then simply extrapolate these barriers to other sites. Whilst it would therefore be inappropriate to try to develop a one-for-all RAP, one can instead stream-line the route by which these factors are identified. This can be done by the method used in this study - ‗anticipation and engagement'. ‗Anticipation' refers to using the available literature and local knowledge to outline the most likely regeneration factors at a specific site, whilst ‗engagement' refers to exploring these potential factors directly in the location and with the community. As used in this study, this results in a comprehensive overview of the factors influencing the site, enabling the next step to be facilitated, that of developing a RAP.

Given the large area of degraded TPSF in SE Asia, the desire to have a one-for-all RAP is tempting, especially with the increased application of landscape-scale restoration theory (Manning *et al.,* 2006). However, this study argues that by over-looking the local-scale, by side-stepping true engagement with each study-site, the success of restoration can be compromised. This study endeavoured to show a stream-lined method to determining the regeneration factors that need to be incorporated in a RAP for a particular site. The method of anticipation and engagement would, in the space of one year of study, facilitate an economical, appropriate and long-lasting RAP.

CONCLUSION

This study could have been a discreet exploration into the specific regeneration barriers for this particular site. It was, however framed within a bigger context, of developing methods which incorporate both social and ecological factors, thus creating a holistic RAP. The division of ecological and social factors is somewhat arbitrary as they overlap on numerous occasions. The separation of these combined ecological and social factors into negative, potential, inactive, positive and compound factors provides a more functional and holistic route to guiding the development of a RAP.

Table 2: All the factors found in this study to be affecting the regeneration of the forest, described by their factor type and their ecological and social dimensions.

Factor	Factor type	Ecological dimension	Social dimension
Seed dispersal	Negative	Present	Present
Flooding	Negative	Present	Present
Nutrient availability	Negative	Present	Present
Lack of options/money	Negative	Absent	Present
No funding for restoration	Negative	Absent	Present
Outsiders	Negative	Absent	Present
High light intensity	Negative	Present	Present
Fire	Negative	Not studied	Present
Mycorrhizae availability	Potential	Present	Absent
Selecting transplant species	Potential	Present	Present
Drought	Potential	Present	Present
Community‘s dependence on the forest	Potential	Not studied	Present
Community‘s ideas for forest restoration	Potential	Absent	Present
Community‘s desire manage the restoration	Potential	Absent	Present
Seed banks	Inactive	Present	Absent?
Competition with non-tree vegetation	Positive	Present	Present
Community‘s attitude to the forest	Positive	Not studied	Present
Community‘s awareness of the state of the forest	Positive	Not studied	Present
Community‘s forest and restoration knowledge	Positive	Absent	Present
Community‘s attitude to restoration	Positive	Absent	Present
Community‘s relationship with the government	Compound	Absent	Present
Logging	Compound	Not studied	Present
Issues of access and ownership	Compound	Absent	Present

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REFERENCES

1. Alexander, S., Nelson, C. R., et al. (2011) Opportunities and challenges for ecological restoration within REDD+. Restoration Ecology 19: 683–689
2. Clewell, A. F. and Aronson, J. (2013) *Ecological restoration: Principles, values and structure of an emerging profession.* 2nd Edition. Island Press, Washington.
3. Graham, L. L. B. (2013) Restoration from Within: An interdisciplinary methodology for tropical peat swamp forest restoration, Indonesia. PhD thesis submitted to the University of Leicester.
4. Holl, K. D. (2012) Chapter 9: Restoration of tropical forests. In*:* van Andel, J. and Aronson, J. (2012) *Restoration Ecology: The New Frontier*. Second edition. Wiley-Blackwell Press.
5. Manning, A. D., Lindenmayer, D. B. and Fischer, J. (2006) Stretch-goals and backcasting: approaches for overcoming barriers to large-scale ecological restoration. Restoration Ecology 14: 487–492.
6. McManus, P. (2006) Mangrove Battlelines: culture/nature and ecological restoration. Australian Geographer 37: 57-71

7. Miettinen, J. and Liew, S. C. (2010) Degradation and development of peatlands in Peninsular Malaysia and in the islands of Sumatra and Borneo since 1990. Land Degradation and Development 21: 285-296
8. Page, S.E., Hoscilo, A., Wosten, H., Jauhiainen, J., Ritzema, H., Tansey, K., Silvius, M., Graham, L., Vasander, H., Rieley, J. and Limin, S. (2009) Ecological restoration of lowland tropical peatlands in Southeast Asia – Current knowledge and future research directions. *Ecosystems* 12: 888-905
9. Page, S. E., Rieley, J. O. and Banks, C. J. (2011) Global and regional importance of the tropical peatland carbon pool. Global change biology 17: 798-818
10. Ricklefs, M. C. (2008) A *modern history of Indonesia since c.1200*. Fourth edition.
11. Tongway, D. J. and Ludwig, J. A. (2011) *Restoring disturbed landscapes: Putting principles into practice*. Island Press, Washington, USA.
12. Tsing, A. L. (2005) Friction: An ethnography of global connection. Princeton University Press.