Conservation Letter

Managing the risk of biodiversity leakage from prioritising REDD+ in the most carbon-rich forests: the case study of peat-swamp forests in Kalimantan, Indonesia

Mark E. Harrison *[1, 2] and Gary D. Paoli [3]

[1] Department of Geography, University of Leicester, Leicester, UK
[2] Orangutan Tropical Peatland Project, Jl. Semeru No. 91, Palangka Raya 73112, Central Kalimantan, Indonesia
[3] Daemeter Consulting, Jalan Tangkuban Perahu No. 6, Bogor, Indonesia
* Author to whom correspondence should be addressed; Email: mharrison@outrop.com; Tel: +44 1162 523 318.

Abstract

One major concern regarding the biodiversity impacts of Reduced Emissions from Deforestation and Degradation (REDD+) is "leakage" of threats from REDD+ to non-REDD+ forests, particularly if those forests storing the highest amounts of carbon – and thus prioritized under REDD+ – do not coincide with those most important for biodiversity conservation. This concern applies globally, and has been previously discussed in Indonesia, where the highest-carbon forests on peat are known to support lower species diversity and concentrations of threatened species than lowland mineral-soil forests. To help refine management of this risk, we discuss previously overlooked considerations regarding biodiversity threat leakage, suggest three strategies for managing leakage risk, and outline important questions to address with respect to these. We emphasize (1) the need to recognize intrinsic differences in threat displacement vulnerability among forests not currently protected/proposed to be protected under REDD+; and (2) that not pursuing REDD+ in high-carbon forests in an attempt to avoid leakage will not necessarily reduce this risk in low-carbon, non-REDD+ forests, due to the often high intrinsic vulnerability of these forests. Further to previous recommendations, suggested strategies for reducing risk of threat displacement include (1) focusing "traditional" conservation resources on the most vulnerable high-biodiversity forests not scheduled for protection under REDD+; (2) reducing costs, simplifying procedures and encouraging community-based approaches for pursuing REDD+ in low-carbon, high-biodiversity forests; and (3) developing more creative measures, especially fiscal and financial incentives, for protecting vulnerable low-carbon forests. Inter-disciplinary research is urgently needed to evaluate the feasibility and effectiveness of these strategies to successfully manage biodiversity leakage risk from pursuing REDD+ in high-carbon forests and, thus, for ensuring REDD+ achieves its potential for generating biodiversity conservation gains.

Keywords: Biodiversity leakage, REDD+, peat-swamp forest, biodiversity offsetting, payments for ecosystem services

Resumen

Una de las principales preocupaciones con respeto a los impactos sobre la biodiversidad de las medidas de Reducción de Emisiones por Deforestación y Degradación (REDD+) es el "desplazamiento" de las amenazas de bosques REDD+ a los no-REDD+, particularmente cuando los bosques que almacenan las mayores cantidades de carbono - y por lo tanto priorizados en REDD+ - no son los más importantes para la conservación de la biodiversidad. Esta preocupación es global, y ha sido previamente discutida en Indonesia, donde los bosques sobre turba con mayores contenidos de carbono albergan una menor diversidad de especies y concentraciones de especies amenazadas que los bosques de tierras bajas sobre suelo mineral. Para mejorar la gestión de este riesgo, discutimos consideraciones previas sobre estos desplazamientos de las amenazas a la biodiversidad que pasaron por alto, sugerimos tres estrategias para la gestión de este riesgo de desplazamiento y resumimos preguntas importantes para abordar dichos riesgos. Enfatizamos (1) la necesidad de reconocer las diferencias intrínsecas de vulnerabilidad al riesgo de desplazamiento de amenazas entre bosques no protegidos actualmente /propuestos de ser protegidos bajo REDD+; y (2) que la no implementación de REDD+ en los bosques de alto contenido de carbono en un intento de evitar el desplazamiento de las amenazas no necesariamente reducirá este riesgo en bosques no REDD+ de bajo contenido de carbono, debido a menudo a la alta vulnerabilidad intrínseca de estos bosques. Además de las recomendaciones anteriores, las estrategias sugeridas para reducir el riesgo de desplazamiento de las amenazas incluyen (1) centrar recursos "tradicionales" de conservación en los bosques más vulnerables con elevada biodiversidad no aptos para el desarrollo en el marco de REDD+, (2) reducir los costes, simplificar los procedimientos y fomentar los enfoques comunitarios para la implementación de REDD + en los bosques con bajos contenidos de carbono y con una elevada biodiversidad, y (3) desarrollar medidas más creativas, especialmente incentivos fiscales y financieros, para proteger a los bosques con bajos contenidos de carbono más vulnerables. Las investigaciones interdisciplinarias son una necesidad urgente para evaluar la viabilidad y la eficacia de estas estrategias para así gestionar con éxito el desplazamiento de riesgos para la biodiversidad al implementar REDD+ en los bosques de alto contenido de carbono y, por lo tanto, para garantizar que REDD+ alcance su potencial para generar ganancias en la conservación de la biodiversidad.

Palabras clave: Desplazamiento de las amenazas para la Biodiversidad, REDD +, bosques de turba pantanosos, compensación de la biodiversidad, pagos por servicios ambientales.

Received: 14 September 2012; Accepted: 1 November 2012; Published: 10 December 2012.

Cite this paper as;: Harrison, M. E. and Paoli, G. D. 2012. Managing the risk of biodiversity leakage from prioritising REDD+ in the most carbon-rich forests: the case study of peat-swamp forests in Kalimantan, Indonesia. *Tropical Conservation Science* Vol. 5(4):426-433 . Available online: www.tropicalconservationscience.org

1. Introduction

A major concern regarding the biodiversity impacts of Reduced Emissions from Deforestation and Degradation (REDD+) is "leakage", i.e., displacement of threats from high-carbon forests prioritized for REDD+ to forests not currently protected or proposed to be protected under REDD+ [1, 2]. This may occur either as a result of "activity shifting", in which destructive activities are displaced from inside to outside a REDD+ project's boundaries, and/or "market effects", in which alterations to the supply, demand or equilibrium of a forest product may lead to an increase in its value and subsequent pressure to convert less well protected forests elsewhere [3].

Recent experience in Indonesia illustrates this risk: to date, most project-based REDD+ investment is targeting carbon-rich peat-swamp forests (which contain carbon stocks averaging ca. 2,680 t C ha^{-1}), despite generally lower species diversity and concentrations of threatened species compared to lowland mineral-soil forests (which contain carbon stocks averaging ca. 353 t C ha^{-1}) [4]. If protecting high-carbon forests, such as those in Indonesia's peat swamps, intensifies conversion or other pressures on higher-biodiversity forests, the overall biodiversity impacts of REDD+ could be negative. This is an important consideration, particularly in light of the fact that, of the 42 REDD+ projects in Indonesia listed on the CIFOR Global Database of REDD+ and Other Forest Carbon Projects (http://www.forestclimatechange.org/redd-map) for which we could obtain adequate project descriptions, exactly half (21) are located wholly or partly in peat-swamp forest, despite the fact that peat-swamp forest (best estimates vary from 206,950 km^2 [5] to 209,490 km^2 [4]) covers a much smaller land area in Indonesia than do forests on mineral soils (1,281,000 km^2 [4]). Carbon *vs*. biodiversity 'conflicts' of this nature are a concern globally wherever there is incongruence between forests that are prioritised under REDD+ on the basis of carbon content, and those containing the richest and/or most threatened biological communities [6].

Of course, in highlighting this concern, it is important to note that the funders for more "traditional" approaches to conservation (governments, NGOs and private sector) and REDD+ (carbon markets) will not typically overlap, except during the developmental stages of REDD+ when set-up and pilot funds may be provided through development aid and other sources that may also fund traditional conservation activities. Thus, REDD+ is anticipated to bring substantial additional sources of funding towards forest conservation, which might generally be expected to yield net positive benefits for biodiversity [1, 7]. Reported global estimates of the potential income for forest conservation attainable through REDD+ are as high as USD 1.2 billion/year (with USD 100 million potentially attainable for Indonesia [8]) to USD 10 billion/year [9]. This figure is substantially higher than the estimated USD 695 million being spent on protected area conservation in the developing world in the mid-1990s [10] and more closely approximates the estimated USD 39 billion/year revenue estimated from forestry exports from the developing world in 2006 [11]. Such potential funding notwithstanding, the risk remains of threat leakage from forests targeted by REDD+ into forests not protected through REDD+, particularly where forests prioritised under REDD+ contain lower richness and/or abundances of species [1, 2, 4].

In response to this concern, well-defined regulatory procedures within national REDD+ strategies have been recommended to ensure REDD+ biodiversity co-benefits are delivered where most needed [4]. These procedures include (1) preparing, evaluating and updating explicit national targets for ecosystem and species protection across the full range of native ecosystem types and bio-geographic sub-regions, as needed; (2) conducting gap analyses under these targets to identify ecosystem types under-represented in the protected area network and new areas that deserve management attention to maintain viable populations of priority species; and (3) redefining acceptable land-use practices within priority areas thus identified and, where applicable, using co-financing from REDD+ to offset direct costs of restricted development that this might cause.

Here, we highlight some additional considerations, using Indonesian Borneo (Kalimantan) as an example. Observations from this region readily illustrate under-recognised, globally-relevant issues concerning both potential leakage of threats to biodiversity from pursuing REDD+ in high-carbon forests, and practical options to manage this risk.

2. Novel considerations regarding biodiversity leakage: peat-swamp forests in Kalimantan as a case study

Two particularly important previously overlooked considerations deserve attention in this context. First, Kalimantan's relatively low-carbon lowland mineral-soil forests will differ in their vulnerability to threat leakage that may occur from prioritizing REDD+ in high-carbon peat-swamp forests, and this should be taken into account by conservation planners. The largest remaining mineral-soil forest blocks in Kalimantan occur in remote, interior regions, which presently face relatively low conversion risk due to their inaccessibility and rugged terrain (*de facto* protection [12, 13]). In contrast, lowland mineral-soil forests in more accessible areas, on gentle slopes and close to roads, are more vulnerable to threat displacement, especially where formal protection status is lacking. The vulnerability of these forests has been further intensified by a recent Presidential Instruction (Inpres No. 10/2011) to postpone for two years the issuance of new forestry licences on peatlands and "primary natural forests," but not on previously logged lowland mineral-soil forests. This leaves vast areas of logged mineral-soil forest – which are often rich in biodiversity [14, 15] – even more vulnerable.

Secondly, given current spatial plans and government support for expanding industrial plantations in Indonesia [3], these "vulnerable" lowland mineral-soil forests face high risk of conversion in the near future, regardless of whether or not peat-swamp forests are prioritized under REDD+. Thus, slowing REDD+ implementation in peat-swamp forests to manage threat leakage would risk loss/degradation of those peat-swamp forests that could have been protected under REDD+, as well as the already vulnerable dryland forests that might come under additional threat from resultant leakage. Further, because traditional conservation activities and up-and-running REDD+ projects are not funded from the same sources, non-pursuance of REDD+ in peat-swamp forests is unlikely to lead to increases in funding to protect non-peat-swamp forests. Consequently, discouraging REDD+ in peat-swamp forests cannot be recommended as an optimal strategy to manage biodiversity threat leakage, especially considering the important populations of many rare and endemic species that these forests harbour [16-18].

3. Potential strategies for managing the risk of biodiversity leakage under REDD+

One market-based approach to achieve greater balance between high-carbon and low-carbon forests under REDD+ is to sell emission reduction credits generated in higher biodiversity forests at a premium price. Opinions about the potential effectiveness of this approach vary. Some consider it unlikely to succeed, as most buyers would be expected to seek lowest prices for credits on carbon markets [2], while some surveys suggest that most buyers are willing to pay a premium of at least USD 1/t CO_2 emission reduction for projects certified under the Carbon, Community and Biodiversity Alliance (CCBA) standards [19]. Relying

entirely on this approach to balance REDD+ investment between peat and non-peat forests would be very risky, however, as even in this latter survey, (a) 21-29% of corporate respondents in different world regions and 11% of carbon companies expressed no willingness to pay premiums for CCBA-certified projects; and (b) relatively few corporate respondents (26-44%) and very few carbon companies (11%) were willing to pay premiums in excess of USD 3 /t CO_2 emission reduction [19].

Alternative strategies are therefore needed to manage the risk of leakage from prioritising high-carbon forests, such as Kalimantan's peat-swamp forests, under REDD+. Beyond regulatory approaches suggested previously [4], key elements that might be including in an effective strategy to combat the risk of leakage are described below.

1. *Increased efforts to focus non-REDD+ conservation resources on those high-biodiversity forests most vulnerable to leakage, while ensuring this does not lead to increased vulnerability for previously relatively secure forests.* In Kalimantan, for example, this might include focusing traditional non-REDD+ conservation funds and efforts on relatively accessible and not too heavily degraded dryland forests that are deemed unattractive to REDD+ developers, due to relatively low carbon content, or even high-biodiversity value peat-swamp forest that is unsuitable for development under REDD+.

2. *Reducing costs and simplifying procedures for obtaining REDD+ forest concession licenses, particularly on low-carbon, high-biodiversity areas to improve these forests' appeal to REDD+ project developers.* In Indonesia, for example, the formal USD 5 million Ecosystem Restoration Concession license fee is currently the same for both peat and non-peat areas, despite much higher potential financial returns to REDD+ on peat. This likely dissuades potential REDD+ project developers from establishing REDD+ projects in non-peat areas, reducing their ability to compete with other land-use options. It also suggests why only half of the existing REDD+ pilot projects in Indonesia are on non-peat soils (http://www.forestclimatechange.org/redd-map), despite the much larger area of land covered by mineral-soil forests, compared to those on peat [4]. Further, 'altruistic' desires to protect natural heritage notwithstanding, the lower potential financial returns from REDD+ on non-peat may also discourage governments from adopting this recommendation. Extra incentives are therefore needed to support both REDD+ and more traditional conservation initiatives on mineral soils. One promising movement in this regard is recent government commitments to accelerate legal recognition of community-based forest management [20], much of which covers at-risk lowland mineral-soil forests, highlighting the potential feasibility for pursuing community-based REDD+ in such areas in Indonesia. Other potential avenues for this are discussed in Recommendation 3.

3. *A major research and policy drive to develop more creative measures, especially fiscal and financial incentives, for protecting vulnerable high-biodiversity forests, such as those on accessible lowland mineral soils.* These incentives could occur both outside of the REDD+ framework (i.e., alternatives) and within it (i.e., supplemental support, to enable successful implementation of REDD+ where this would otherwise be uneconomical). Potential incentives might include providing tax relief for timber, oil palm and other companies that set aside High Conservation Value areas; better regulation of Ecosystem Restoration Concession processes, to reduce the influence of land speculators and increase attractiveness for serious applicants; and promoting well-managed eco-tourism, for which there is naturally more potential in high-biodiversity areas. The provisions of Indonesia's 2006 Spatial Planning Law and 2009 Environmental Law create a legal

framework for developing such incentives with the explicit goal of encouraging or discouraging certain kinds of land use in specified locations.

Potential incentives falling under this third recommendation also include biodiversity offsetting or other (non-carbon-based) payment for environmental services (PES) schemes, which can provide alternative or supplementary finance alongside REDD+ to protect forests [2, 21, 22]. We anticipate that many of the policy development and research needs for establishing an effective REDD+ system would also be directly applicable to other non-carbon PES schemes (e.g. biodiversity offsets, watershed protection), which are explicitly encouraged under Indonesia's 2009 Environment Law. Necessary developments include establishing clarity of land tenure; effective valuation, measuring, reporting and verification systems for demonstrating provision of anticipated biodiversity benefits and monitoring threat leakage from PES project areas, plus effective systems of information flow for these; equitable and transparent financial revenue distribution to local communities and between levels of government; and effective safeguards to ensure provision of co-benefits (e.g., to avoid net negative biodiversity impacts through focussing on promoting a particularly desired ecosystem service, at the expense of the ecosystem as a whole) [23, 24]. We therefore expect development of REDD+ policy to facilitate development of non-carbon-based PES schemes.

4. Discussion

Progress in these areas is limited, partly because REDD+ is still in its infancy, especially in Indonesia, and partly also due to the great complexity of biological communities and ecosystems, the inherent difficulties in valuing and monitoring biodiversity and ecosystem services, and less scientific attention to these areas than to carbon monitoring. Methods therefore remain poorly developed for assessing, valuing and monitoring biodiversity benefit and ecosystem service provision, and the impact of threat leakage on these under REDD+. As a result, our ability to assess and track the impacts of leakage from REDD+ on biodiversity and ecosystem services is severely limited.

Further research is therefore urgently needed to develop effective systems for monitoring leakage of biodiversity benefits under REDD+, and to evaluate thoroughly the strategies suggested herein and monitor their effectiveness. Key research questions and areas of development that need to be addressed under each of our three suggested strategies include (but are not necessarily limited to) the following:

Recommendation 1: Focussing non-REDD+ resources on high-biodiversity forests most vulnerable to leakage.

1. How can the "biodiversity value" of REDD+ and non-REDD+ forests be objectively assessed and compared? Should assessments be based on overall biological community richness, on the number of IUCN-listed threatened species supported (with "viable" population sizes?), or the abundance of selected priority species with an important place in local conservation policy (e.g., big cats, primates or other selected threatened species)? Should bio-geographic considerations be incorporated? Might some metric of the above, or criteria such as those laid out in the High Conservation Value assessment guidelines [25] be most suitable? Further, how can the biodiversity value of forests that cannot be surveyed directly due to financial and/or logistical considerations be objectively assessed by proxy?
2. How should those high-biodiversity areas that are most vulnerable to leakage under REDD+ be identified, and which factors govern the vulnerability of a forest within the defined area of interest? Systematic assessments of the potential drivers of forest loss,

forest degradation and biodiversity declines (e.g., [26]) are needed to answer this question.

3. How should the impacts of this strategy be monitored? While progress is being made in integrating within-site monitoring of biodiversity impacts in REDD+ project design [27-29] and monitoring leakage of carbon emissions from REDD+ projects [3, 30], to our knowledge, studies that specifically address methods for monitoring leakage of biodiversity benefits under REDD+ are still lacking.

Recommendation 2: Reducing costs and simplifying procedures for obtaining REDD+ forest concession licenses, particularly on low-carbon, high-biodiversity areas.

1. How can such costs be reduced, without creating disincentives for governments to issue REDD+ permits in these areas? Which aspects of the administrative procedure could be simplified and streamlined without putting safeguards at risk?
2. How can forests that might classify as "low-carbon, high-biodiversity", and that might therefore benefit from the above incentive to REDD+ developers, be objectively identified and selected? This relates also to Question 1 under Recommendation 1.
3. How can community-based approaches to REDD+ be developed for areas unattractive to private sector investment? Which political changes are needed to facilitate this?

Recommendation 3: A major drive to develop more creative measures, especially fiscal and financial incentives, for protecting vulnerable high-biodiversity forests.

1. What are the likely biodiversity impacts of the alternative proposed land uses for an area? This involves establishing clear definitions of the "biodiversity values" upon which the impact of these potential approaches are to be assessed; plus development of effective mechanisms for monitoring and predicting these impacts.
2. How can biodiversity and ecosystem services be effectively, objectively and cost-efficiently assessed, valued and monitored under non-carbon-based PES schemes?
3. What are the net revenues associated with alternative land uses (i.e., economic feasibility) and how might these revenues be shared among actors, particularly local communities?
4. What is the social and political feasibility of introducing and successfully implementing these strategies within a particular geographic area?

We hope this letter will help stimulate research to help answer these questions. Progress in these areas is vital for understanding, and therefore effectively managing, the risk of biodiversity threat leakage from pursuing REDD+ in high-carbon forests, both in Kalimantan and other tropical areas facing similar challenges. This will help ensure that REDD+ not only reduces land-based carbon emissions, but also realises its significant potential for generating lasting biodiversity conservation gains.

Acknowledgements

MEH thanks the Indonesian Ministry for Research and Technology (RISTEK), the Indonesian Institute of Sciences (LIPI) and Centre for the International Cooperation in Sustainable Management of Tropical Peatlands (CIMTROP) for permission to conduct research in Indonesia over the years. Discussions with a number of colleagues, in particular Simon Husson, contributed towards some of the ideas outlined here. We thank Betsy Yaap and one anonymous reviewer for comments that helped improve our manuscript. Bernat Ripoll Capilla assisted with the abstract translation. The writing of this manuscript was supported financially by the Orangutan Tropical Peatland Project (OuTrop) and was conducted as part of the OuTrop multi-disciplinary research project, conducted in collaboration with CIMTROP, University of Palangka Raya.

References

[1] Harvey, C. A., Dickson, B. and Kormos, C. 2010. Opportunities for achieving biodiversity conservation through REDD. *Conservation Letters*. 3: 53-61.

[2] Grainger, A., Boucher, D. H., Frumhoff, P. C., Laurance, W. F., Lovejoy, T., McNeely, J., Niekisch, M., Raven, P., Sodhi, N. S., Venter, O. and Pimm, S. L. 2009. Biodiversity and REDD at Copenhagen. *Current Biology*. 19: R974-R976.

[3] Schwarze, R., Niles, J. O. and Olander, J. 2002. Understanding and managing leakage in forest-based greenhouse-gas-mitigation projects. *Philosophical Transactions of the Royal Society of London A*. 360: 1685-1703.

[4] Paoli, G. D., Wells, P. L., Meijaard, E., Struebig, M. J., Marshall, A. J., Obidzinski, K., Tan, A., Rafiastanto, A., Yaap, B., Slik, J. W. F., Morel, A., Perumal, B., Wielaard, N., Husson, S. and D'Arcy, L. 2010. Biodiversity conservation in the REDD. *Carbon Balance and Management*. 5: 7.

[5] Page, S. E., Rieley, J. O. and Banks, C. J. 2010. Global and regional importance of the tropical peatland carbon pool. *Global Change Biology*. 17: 798-818.

[6] Siikamäki, J. and Newbold, S. C. 2012. Potential biodiversity benefits from international programs to reduce carbon emissions from deforestation. *Ambio*. 41: 78-89.

[7] Miles, L. and Kapos, V. 2008. Reducing greenhouse gas emissions from deforestation and forest degradation: global land-use implications. *Science*. 320: 1454-1455.

[8] Niles, J. O., Brown, S., Pretty, J., Ball, A. S. and Fay, J. 2002. Potential carbon mitigation and income in developing countries from changes in ose and management of agricultural and forest lands. *Philosophical Transactions of the Royal Society of London A*. 360: 1612-1639.

[9] Dutschke, M. and Wolf, R. 2007. *Reducing Emissions from Deforestation in Developing Countries: The Way Forward*. GTZ Climate Protection Progamme, Eschborn, Germany.

[10] James, A., Gaston, K. J. and Balmford, A. 2001. Can we afford to conserve biodiversity? *BioScience*. 51: 43-52.

[11] FAO. 2008. *FAOSTAT – Production - ForesSTAT.* http://faostat.fao.org/DesktopDefault.aspx?PageID=381&lang=en.

[12] Andam, K. S., Ferraro, P. J., Pfaff, A., Sanchez-Azofeifa, G. A. and Robalino, J. A. 2008. Measuring the effectiveness of protected area networks in reducing deforestation. *Proceedings of the National Academy of Sciences*. 105: 16089-16094.

[13] Joppa, L. and Pfaff, A. 2010. Reassessing the forest impacts of protection: The challenge of nonrandom location and a corrective method. *Annals of the New York Academy of Sciences*. 1185: 135-149.

[14] Meijaard, E., Sheil, D., Nasi, R., Augeri, D., Rosenbaum, B., Iskandar, D., Setyawati, T., Lammertink, M., Rachmatika, I., Wong, A., Soehartono, T., Stanley, S. and O'Brien, T. 2005. *Life after logging: Reconciling wildlife conservation and production forestry in Indonesian Borneo*. Center for International Forestry Research, Jakarta.

[15] Cannon, C. H., Peart, D. R. and Leighton, M. 1998. Tree species diversity in commercially logged Bornean rainforest. *Science*. 281: 1366-68.

[16] Posa, M. R. C., Wijedasa, L. S. and Corlett, R. T. 2011. Biodiversity and conservation of tropical peat swamp forests. *BioScience*. 61: 49-57.

[17] Morrogh-Bernard, H., Husson, S., Page, S. E. and Rieley, J. O. 2003. Population status of the Bornean orang-utan (*Pongo pygmaeus*) in the Sebangau peat swamp forest, Central Kalimantan, Indonesia. *Biological Conservation*. 110: 141-52.

[18] Cheyne, S. M., Thompson, C. J. H., Phillips, A. C., Hill, R. M. C. and Limin, S. H. 2008. Density and population estimate of gibbons (*Hylobates albibarbis*) in the Sabangau catchment, Central Kalimantan, Indonesia. *Primates*. 49: 50-56.

[19] Neeff, T., Ashford, L., Calvert, J., Davey, C., Durbin, J., Ebeling, J., Herrera, T., Janson-Smith, T., Lazo, B., Mountain, R., O'Keeffe, S., Panfil, S., Thorburn, N., Tuite, C., Wheeland, M. and Young, S. 2009. *The Forest Carbon Offsetting Survey 2009*. EcoSecurities, Dublin, Ireland.

[20] Ministry of Forestry. 2011. *Ministerial Regulation Number 6 on Establishment of Key Performance Indicators for the Ministry of Forestry (P.6/Menhut-II/2011)*. Ministry of Forestry, Jakarta, Indonesia.

[21] Kumaraswamy, S. and Udayakumar, M. 2011. Biodiversity banking: a strategic conservation mechanism. *Biodiversity and Conservation*. 20: 1155-1165.

[22] BBOP 2009. *Biodiversity Offset Design Handbook*. Business and Biodiversity Offsets Programme, Washington, D.C., USA.

[23] Angelsen, A., Brockhaus, M., Sunderlin, W. D. and Verchot, L. V. 2012. *Analysing REDD+: Challenges and Choices*. Centre for International Forestry Research, Bogor, Indonesia.

[24] Redford, K. H. and Adams, W. M. 2009. Payment for ecosystem services and the challenge of saving nature. *Conservation Biology*. 23: 785-787.

[25] Jennings, S., Nussbaum, R., Judd, N. and Evans, T. 2003. *The High Conservation Value Forest Toolkit*. ProForest, Oxford, UK.

[26] Marshall, A. J., Nardiyono, Engström, L. M., Pamungkas, B., Palapa, J., Meijaard, E. and Stanley, S. A. 2006. The blowgun is mightier than the chainsaw in determining population density of Bornean orangutans (*Pongo pygmaeus morio*) in the forests of East Kalimantan. *Biological Conservation*. 129: 566-78.

[27] Gardner, T. A., Burgess, N. D., Aguilar-Amuchastegui, N., Barlow, J., Berenguer, E., Clements, T., Danielsen, F., Ferreira, J., Foden, W., Kapos, V., Khan, S. M., Lees, A. C., Parry, L., Roman-Cuesta, R. M., Schmitt, C. B., Strange, N., Theilade, I. and Vieiram, I. C. G. 2012. A framework for integrating biodiversity concerns into national REDD+ programmes. *Biological Conservation*. 154: 61-71.

[28] Harrison, M. E., Boonman, A., Cheyne, S. M., Husson, S. J., Marchant, N. C. and Struebig, M. J. 2012. Biodiversity monitoring protocols for REDD+: can a one-size-fits-all approach really work? *Tropical Conservation Science*. 5: 1-11.

[29] Danielsen, F., Skutsch, M., Burgess, N. D., Jensen, P. M., Andrianandrasana, H., Karky, B., Lewis, R., Lovett, J. C., Massao, J., Ngaga, Y., Phartiyal, P., Poulsen, M. K., Singh, S. P., Solis, S., Sørensen, M., Tewari, A., Young, R. and Zahabu, E. 2011. At the heart of REDD+: a role for local people in monitoring forests? *Conservation Letters*. 4: 158-167.

[30] Henders, S. and Ostwald, M. 2012. Forest carbon leakage quantification methods and their suitability for assessing leakage in REDD. *Forests*. 3: 33-58.