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## Relevance of Global Forest Change Data Set to Local Conservation: Case Study of Forest Degradation in Masoala National Park, Madagascar

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### ABSTRACT

A global data set on forest cover change was recently published and made freely available for use (Hansen *et al.* 2013. *Science* 342: 850–853). Although this data set has been criticized for inaccuracies in distinguishing vegetation types at the local scale, it remains a valuable source of forest cover information for areas where local data is severely lacking. Masoala National Park, in northeastern Madagascar, is an example of a region for which very little spatially explicit forest cover information is available. Yet, this extremely diverse tropical humid forest is undergoing a dramatic rate of forest degradation and deforestation through illegal selective logging of rosewood and ebony, slash-and-burn agriculture, and damage due to cyclones. All of these processes result in relatively diffuse and small-scale changes in forest cover. In this paper, we examine to what extent Hansen *et al.*'s global forest change data set captures forest loss within Masoala National Park by comparing its performance to a locally calibrated, object-oriented classification approach. We verify both types of classification with substantial ground truthing. We find that both the global and local classifications perform reasonably well in detecting small-scale slash-and-burn agriculture, but neither performs adequately in detecting selective logging. We conclude that since the use of the global forest change data set requires very little technical and financial investment, and performs almost as well as the more resource-demanding, locally calibrated classification, it may be advantageous to use the global forest change data set even for local conservation purposes.

Abstract in French is available in the online version of this article.

*Key words:* cyclone; Geographic Information System; object-oriented classification; selective logging; slash-and-burn agriculture; tropical forest.

AS TROPICAL DEFORESTATION CONTINUES WORLDWIDE conservation biologists are turning their attention to the state of the remaining forests, most of which are in various degrees of degradation and represent different conservation values for biodiversity (Putz *et al.* 2008, Gibson *et al.* 2011). As such, the emphasis in biodiversity conservation might shift from avoiding deforestation to preventing further forest degradation and facilitating reforestation (Putz & Romero 2014). In Madagascar, as in many other tropical countries, national parks and other protected areas harbor the vast majority of the remaining forests. Although the 'protected' status of these forests might stop large-scale deforestation, it often fails to prevent forest degradation and small-scale forest loss. To successfully manage these remaining forests, it is important to assess the degree to which they have already been degraded.

Forest degradation can be caused by small-scale artisanal mining, fire, and the collection of firewood and non-timber forest products. However, the most common cause of tropical forest degradation by far is selective logging (Asner *et al.* 2005), which involves the extraction of variable densities and species of trees from a forest (Putz *et al.* 2008). Unsustainable selective logging

compromises the carbon storage capacity of the forest and reduces its biodiversity conservation value (Meijaard & Sheil 2007, Putz *et al.* 2008, 2012, Irwin *et al.* 2010). However, selectively logged forests, especially those exploited at very low intensities, do have a substantial value in retaining biodiversity (Berry *et al.* 2010, Edwards *et al.* 2011, Gibson *et al.* 2011, Putz *et al.* 2012, Burivalova *et al.* 2014). Identifying the extent and intensity of degradation would help gauge the value of persisting forests (Putz *et al.* 2000, Burivalova *et al.* 2014).

Tropical forest degradation is difficult to detect and monitor via both ground surveys and remote sensing because it occurs at variable intensities and spatial configurations, and can be indistinguishable from natural tree mortality (Asner *et al.* 2005). Consequently, much less is known about the rate and extent of forest degradation in Madagascar and much of the tropics than is known about clear-felling (Food & Agriculture Organization of the United Nations (FAO) 2012). With the increasing number of Earth observation satellites and the improving quality of satellite data, many remote sensing techniques have been developed to detect forest degradation. For example, Light Detection and Ranging (LiDAR) data are used to detect changes in forest structure associated with forest degradation (Asner *et al.* 2011). Alternatively, high-resolution images are analyzed at a sub-pixel scale

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to expose subtle changes in the canopy cover (Asner *et al.* 2009, Allnutt *et al.* 2013). However, such satellite data are typically either very expensive or require a high degree of remote sensing expertise, and therefore are not readily accessible to many conservation practitioners.

A global data set on forest cover change was recently published and made freely available for use (Hansen *et al.* 2013). Although this data set has been criticized for inaccuracies in distinguishing forests from plantations at the local scale (Tropek *et al.* 2014), it remains a potentially valuable source of forest cover information for areas, such as northeastern Madagascar, where local data are severely lacking. The relatively high spatial resolution of Hansen *et al.*'s (2013) global forest change map, which is based on Landsat images, might be particularly useful for detecting small-scale forest loss and degradation.

In this paper we examine the extent to which the Hansen *et al.* (2013) global forest data set can be used to detect the various types of forest loss and degradation in Masoala National Park in northeastern Madagascar. We compare the global forest data set with a locally calibrated, object-oriented classification implemented with the aim to detect forest degradation. We then evaluate the performance of each type of classification with ground truthing.

## METHODS

**STUDY SITE.**—Masoala National Park, created in 1997, is the largest protected area in Madagascar. With a total area of 2300 km<sup>2</sup>, it spans approximately two-thirds of the Masoala Peninsula, a relatively isolated region in northeastern Madagascar (Kremen *et al.* 1999, Kremen 2003). The Park comprises a core area containing the largest remaining tropical humid forest in Madagascar, as well as several smaller detached marine and terrestrial parcels. In our analysis, we focus only on the core terrestrial block of the national park. The large altitudinal variation, ranging from sea level to 1224 m, and very high precipitation rates (2800–3200 mm/yr) influence the vegetation of the peninsula, which is described as eastern humid rain forest (Du Puy & Moat 1995). The peninsula has a population of over 80,000, mostly relying on subsistence paddy and slope rice agriculture, or vanilla, coffee, and clove production. Illegal selective logging of precious hardwoods (rosewood, *Dalbergia* spp. and ebony, *Diospyros* spp.) and tourism also contribute to the local economy to some extent (Kremen 2003, Ormsby & Mannle 2006, Schuurman & Lowry 2009, Innes 2010).

**GLOBAL FOREST CHANGE DATA SET.**—In June 2014, we downloaded the relevant sections of the global forest change data set (Hansen *et al.* 2013) from <http://earthenginepartners.appspot.com/science-2013-global-forest>. This data set is based on Landsat satellite images and is available at a spatial resolution of 30 m. We clipped all downloaded layers according to the extent of Masoala National Park. The park border layer was obtained from the UNEP and WCMC protected area data base in June 2014 (<http://protectedplanet.net>). We identified all pixels within Maso-

ala National Park that were not forested in 2012 by combining the layers Forest Loss 2000–2012, Tree cover in 2012, and Forest Gain 2000–2012. Forest loss is defined in this data set as stand-replacement disturbance or complete removal of tree canopy cover (Hansen *et al.* 2013), forest gain as the inverse, and tree cover as the percentage of canopy cover in each pixel in 2000. We created a layer of non-forest within Masoala National Park, which included all pixels that either did not have forest cover in 2000 (tree cover <50%) and did not gain forest cover, or that lost forest cover between 2000 and 2012. We excluded pixels that overlapped with a water body from the non-forest class. This global data set is only aimed to include forest degradation and loss that would lead to a non-forest state. Nevertheless, many of the degradation types that we set out to test do cause a small-scale forest loss, and so could potentially be detected by a 30 m resolution data set.

**OBJECT-ORIENTED FOREST COVER CLASSIFICATION.**—We performed a supervised, object-oriented classification of high-resolution satellite images to create a locally calibrated forest cover map for Masoala National Park. We used two types of satellite images. As a training set, we used two tiles (10 km × 10 km each) of a QuickBird satellite image, with a resolution of 2.44 m per pixel. The company DigitalGlobe, Inc. provided these images, taken on 11 May 2011 and 11 June 2011, free of charge, as a part of the DigitalGlobe ESRI Geospatial Research Challenge. We orthorectified and pansharpened these training images using the software ArcGIS 10 (ESRI 2011).

We carried out an object-oriented classification using the software Definiens Professional Earth 7.0 (formerly eCognition, Definiens AG; Munich, Germany). Object-oriented classification has two stages. Initially, the image is segmented to objects (groups of neighboring pixels), based on shape, texture, and color (spectral signature) of the neighboring pixels (Dingle Robertson & King 2011). In our case, we made several essential assumptions to segment the image into objects meaningful for forest cover classification. For example, new forest gaps created by selective logging will be darker due to the shading by the neighboring canopy. Such areas might also have a smoother texture than a mature forest canopy. Further, we expected that only relatively large trees would be subjected to selective logging, and their removal will therefore cause a canopy gap of a considerable size. During a reconnaissance mission to the Masoala peninsula, we observed that a gap caused by a large treefall is at least 200 m<sup>2</sup>. Equally, we assumed that fields cleared for slash-and-burn agriculture would be at least 1 ha in size, and would have a smoother texture than a forest canopy. Accordingly, we set the segmentation criteria as sensitive to size (influencing the segmentation scale), texture, and color (Wang *et al.* 2004, Diaz-Varela *et al.* 2014). The segmentation also helped to isolate clouds. Individual canopies (or lack thereof) were recognizable on the training satellite image and we adjusted the segmentation criteria until the segmentation agreed with our visual interpretation.

The second stage of object-oriented classification is the assignment of all objects, which were produced during

segmentation, into classes (Willhauck 2000). We developed a hierarchical classification rule set, based on the average texture, size, and color (*i.e.*, spectral signature) of each object. Additionally, we used a hydrography layer with the main rivers on the Masoala Peninsula to distinguish water bodies in our classification. This layer was provided by the Madagascar Wildlife Conservation Society. The resulting classes were cloud, forest, water body, and non-forest. We were unable to successfully distinguish between different non-forest classes, such as agricultural fields and young secondary growth.

We used our training data set to create a classification scheme for the extent of Masoala National Park, using lower resolution previews of satellite images. Satellite image previews from QuickBird are freely available image files of the visible (red, blue, green) bands representing the QuickBird satellite image. The images we obtained dated from 28 May 2011, 14 June 2011, 5 July 2011, 20 October 2011, 22 January 2012, and 22 January 2013, and have a resolution of approximately 15 m per pixel. We georeferenced and orthorectified the preview images in ArcMap 10 and created a composite image, prioritizing cloud-free and most recent images. Sufficiently cloud-free images (<20%) from 2011 and later were available for the whole national park, apart from the eastern-most part.

Similarly to the training data set, we first segmented the composite image to objects according to color, texture, and shape criteria. We adjusted the segmentation settings (scale) so that the resulting objects would correspond to the objects of the training data set in the area where the two types of images overlapped (Wang *et al.* 2004). In the area of overlap, we extracted the new parameters (color, texture, shape) of the objects in the preview data set and the class of each object, according to the training data set. This enabled us to create a new classification rule set for the preview images, which we then applied across the whole national park.

**GROUND TRUTHING.**—We carried out three ground truthing missions on the Masoala Peninsula, in December 2011 (S.H.), May 2012 (Z.B. and N.F.) and in October and November 2012 (Z.B. and N.F.). During the 4 mo of fieldwork we visited several areas of the western, central, and eastern Masoala peninsula and recorded over 300 ground truth points within the national park. At each point we recorded the GPS coordinates (using Garmin GPS 60cx; Garmin Corp, Schaffhausen, Switzerland) and the state of vegetation within a 20 m radius of the point.

The location of ground truth points was chosen opportunistically and was not systematic, for several reasons. First, a systematic sampling would enable us to cover a far smaller area of the park. Second, selective logging happens at a very low spatial density ( $\ll 1$  tree/ha). Through systematic sampling we would therefore obtain very few ground truth points that would enable us to check the ability of the classifications to detect selectively logging. Third, extremely difficult terrain and an almost complete absence of paths in the central mountainous part of the park made systematic sampling impracticable. The factors that influenced the location of ground truth points were proximity to

paths and established research transects, the park border, and rivers.

In addition to the ground truth points we collected, we also used the GPS coordinates (~300 points) of selective logging incidents recorded by the patrols of Masoala National Park in 2008 and 2009. We established that these ~300 points were of a comparable quality to our points through detailed discussion with two of the park rangers who collected the majority of these points. We excluded all points that were described in an incomplete way, such as missing description of forest disturbance.

Overall, we had approximately 600 ground truth points assigned to the following classes: (1) agriculture (currently with a crop); (2) burnt (in preparation for agriculture); (3) forest (no signs of selective logging or other degradation); (4) selective logging (tree stump or a saw pit); (5) cyclone damage (snapped or uprooted trees); (6) loggers' campsite (typically small clearing in the forest with a temporary shelter); (7) forest clearing (unknown origin); (8) landslide; (9) non-timber forest product collection (forest clearing with a hunter's trap, holes in the ground from the collection of wild potatoes, trees damaged through the collection of wild honey); and (10) secondary vegetation (shrubs and other non-forest vegetation).

**ANALYSIS.**—For each ground truth point we established whether it overlapped with a non-forest class in the object-oriented classification and in the global forest change classification. We used a 20 m radius around each point, to allow for GPS error. We calculated the proportion of different forest degradation classes detected as non-forest. For each type of classification, we calculated the percentage of the national park extent classified as non-forest.

## RESULTS

Field observations and ground truth collection revealed four broad types of forest loss and degradation on the Masoala peninsula (Fig. 1). We observed many small-scale landslides on steep slopes and close to rivers, most likely caused by cyclones and subsequent flooding (Fig. 1A). The areas affected by landslides ranged from a few m<sup>2</sup> to several hundred m<sup>2</sup>. Older landslides were typically colonized by pioneer species, such as *Aframomum sp.*, various herbaceous *Melastomataceae*, ferns, and *Clidemia birta*. We found that small-scale deforestation for slash-and-burn agriculture is relatively common, especially in areas close to the park border, even though some slash-and-burn activity occurs also within the park, far from the border and any permanent human settlements (Fig. 1B). The deforested plots, often surrounded by relatively undisturbed forest, are used predominantly for rain-fed slope rice agriculture (*tavy*). The third type of forest degradation that we encountered was selective logging (Fig. 1C). This was typically associated with a small gap in the forest, on average 100–200 m<sup>2</sup>, with occasional larger clearings used for saw pits. In some cases, the felling of a larger hardwood tree, designated for export, was accompanied by the extraction of several lighter-wood trees, which were then used for the transportation of





FIGURE 1. The most important drivers of forest degradation and deforestation in Masoala National Park: (A) landslide, likely caused by cyclone and consequent flooding; (B) slash-and-burn agriculture; (C) selective logging; (D) canopy damage caused by a cyclone (photography: Zuzana Burivalova).

logs as rafts along rivers. We encountered both selective logging of precious hardwood (rosewood, *Dalbergia* spp., and ebony, *Diospyros* spp.), aimed mainly for illegal export, as well as selective logging of other species (e.g., *Weinmania* spp.), used for local and domestic consumption. Finally, the fourth type of degradation we saw was a partial damage to the forest canopy, presumably caused by cyclones (Fig. 1D). This was especially common along mountain ridges and steep slopes. Typically, this included a few larger snapped or uprooted trees, and a large amount of debris from fallen branches.

The object-oriented classification (OOC) successfully assigned 38 percent of the degradation ground truths to the non-forest class, whereas the global forest change classification (GFCC) successfully assigned 19 percent of the degradation ground truths as non-forest (Fig. 2). We also compared the performance of the OOC and the GFCC separately for each degradation category (Table 1). The two classification types performed relatively well in detecting small-scale agriculture, secondary non-forest vegetation, and landslides (Table 1). The GFCC detected agriculture and secondary vegetation as non-forest in 45 percent and 50 percent of the cases, respectively. The OOC successfully

detected agriculture in 75 percent of the cases, and secondary vegetation in 71 percent of the cases. Whereas the OOC was unable to detect recently burnt forest, the GFCC detected this type of degradation in 46 percent of the cases. The OOC performed better at detecting forest clearings (43% vs 13%), cyclone damage (59% vs 9%), and landslides (78% vs 40%). Whereas loggers' campsites and non-timber forest product collection was detected as forest loss in 45 percent and 81 percent of cases by the OOC, it was detected in <1 percent of the time by the GFCC. Forest was falsely detected as forest loss more often by the OOC than by the GFCC, however, the false positive rate was relatively low for both classification types (2% for GFCC and 6% for OOC). Finally, selective logging (Fig. 3) was detected in slightly more cases by the OOC (24%) than by the GFCC (19%).

A total of 1.91 percent of the main part of Masoala National Park was classified as non-forest by the OOC, whereas 2.93 percent of the same extent was classified as non-forest by the GFCC. Both classifications show that the occurrence and density of forest loss and degradation is not homogeneously distributed across Masoala National Park (Figs. 2 and 3). Particularly affected are areas along the border of the park, and a small area in the

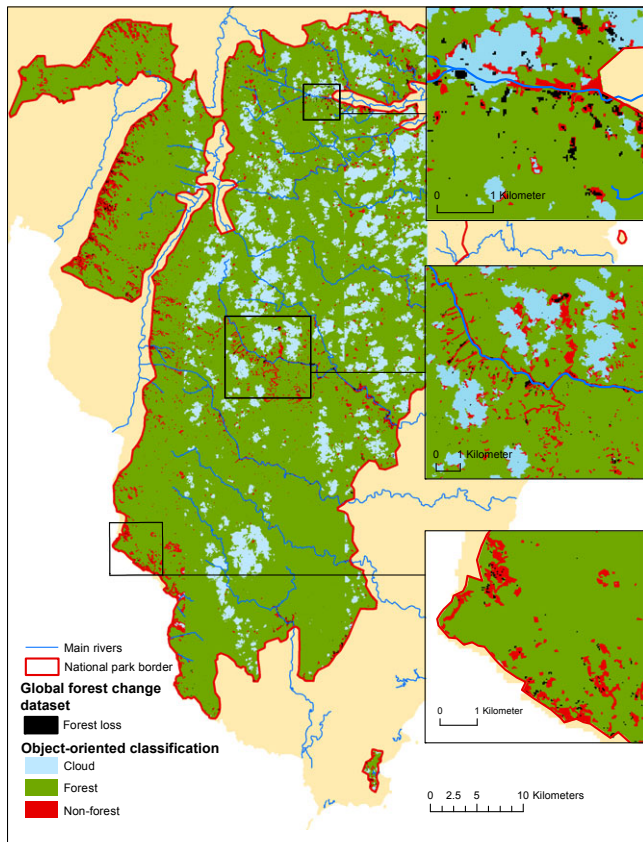


FIGURE 2. Forest cover classification of Masoala National Park, Madagascar. The object-oriented classification is based on QuickBird satellite images (2011–2013) and the global forest cover change data set (Hansen *et al.* 2013) is based on Landsat satellite images (2000–2012).

center of the park, within the watershed of the river Ampanio (Fig. 2 top inset map). The two connected forest blocks in the western part of the national park seem to be most severely affected by forest degradation and small-scale forest loss.

## DISCUSSION

The northeastern tropical humid forests of Madagascar are subjected to a wide variety of small-scale deforestation and forest degradation, including illegal extraction of rosewood (*Dalbergia* spp.) and ebony (*Diospyros* spp.) (Patel 2007, Schuurman & Lowry 2009). As resources and land become scarcer outside of protected areas, exploitation increasingly encroaches into national parks (Schuurman & Lowry 2009, Barrett *et al.* 2010). In 2009, the year of a coup d'état, ~52,000 tonnes of hardwoods were illegally logged from northeastern Madagascar, including the national parks of Marojeje and Masoala (Schuurman & Lowry 2009, Innes 2010). During the following years of political instability, illegal rosewood and ebony logging continued to be a serious issue. Consequently, several of these hardwood species were brought close to extinction (Patel 2007, Barrett *et al.* 2010).

TABLE 1. Accuracy assessment of the global forest cover change data set (Hansen *et al.* 2013) and a locally calibrated object-oriented classification. Values indicate the percentage of ground truth points ( $N = 600$ ) within each degradation type that were classified as non-forest.

Type of forest degradation	% of ground truths classified as non-forest	
	Locally calibrated classification	Hansen <i>et al.</i> (2013)
Slash-and-burn agriculture	70	45
Secondary non-forest vegetation	71	40
Burnt (part of slash-and-burn)	1	46
Landslide	78	40
Cyclone-damaged canopy	59	9
Logging (tree stumps or saw pit)	24	19
Loggers' camp	45	0
Clearing (unknown origin)	43	13
Hunting traps and NTFP	81	0
Forest (control)	6	2

Both types of satellite image classification that we evaluated in this study heavily underestimated this serious cause of forest degradation, with only 19 percent and 24 percent detection success of selective logging by Hansen *et al.* (2013) and the object-oriented classification, respectively. It is challenging to detect selective logging even with a locally calibrated classification and high-resolution satellite images, because the canopy opening caused by the extraction of one tree is relatively small, and only temporary (Souza 2003, Asner *et al.* 2004a). Pioneer species and lianas can effectively 'seal' the canopy gap within months after the tree extraction (Asner *et al.* 2004b), and some of our selective logging ground truths date several years before the satellite images that we used. To further complicate the matter, anecdotal evidence suggests that illegal loggers in northeastern Madagascar are pushed to extract trees of ever decreasing sizes, as large rosewood and ebony specimens are no longer available.

New tools need to urgently be developed to detect the illegal selective logging in northeastern Madagascar and elsewhere. Although the selective logging of hardwoods *per se* has likely a relatively low impact on the forest biomass and biodiversity at such low intensities (Gibson *et al.* 2011, Burivalova *et al.* 2014, Pearson *et al.* 2014), it could have an indirect effect by mediating the rate of deforestation driven by slash-and-burn agriculture. The results of recent studies suggest that when the ban on hardwood logging was strictly enforced in Masoala National Park, its forests experienced higher rates of general deforestation than when the hardwood ban was more laissez-faire (Innes 2010, Ran-



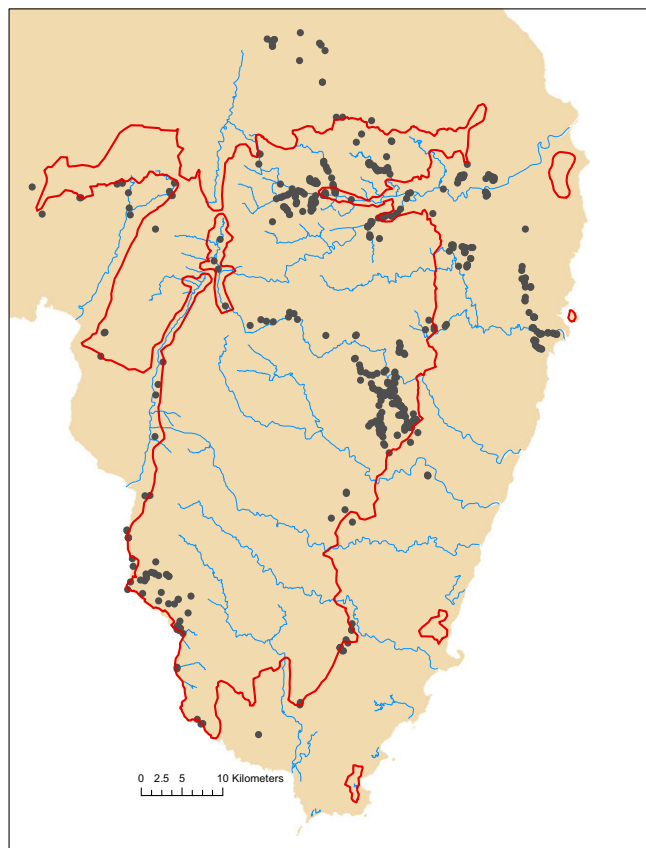


FIGURE 3. Ground truth points referring to the illegal selective logging of rosewood and ebony, collected during fieldwork and by Masoala National Park patrols.

driamalala & Liu 2010, Allnut *et al.* 2013). This phenomenon might be attributed to activity ‘leakage’ (Wunder 2008): when local communities are effectively prevented from extracting hardwoods, they might intensify slash-and-burn agriculture to make up for lost logging income.

Slash-and-burn agriculture and secondary vegetation on fallow fields were relatively successfully detected by both types of classification. This is likely due to the more dramatic vegetation change that is caused by clearing of forest for subsistence rice agriculture, albeit over small areas. We hypothesize that slash-and-burn agriculture might often be an indicator of previous forest degradation, such as selective logging, as argued above, or cyclone damage.

Seasonal cyclones frequently make landfall on the eastern coast of Madagascar, including the Masoala Peninsula, destroying forests and entire villages (Birkinshaw 2003). Communities from cyclone-affected areas often move further inland and consequently, also slash-and-burn agriculture is displaced further toward the national park border (Z. Burivalova, pers. obs.). Moreover, when a cyclone sweeps through a forest, debris from broken tree trunks and branches increases the fuel load in the understory (Turton 2012). At the same time, the cyclone-damaged canopy facilitates desiccation of soil and fuel load, which increases the risk

of fire (Laurance & Curran 2008). Once a cyclone-hit forest has been burnt, it tends to be repeatedly burnt for agriculture in subsequent years, leading to a permanent loss of forest (Birkinshaw 2003). The frequency of high intensity cyclones in Madagascar is projected to increase over the next 100 yr due to climate change (Direction Générale de la Météorologie 2008). As such, cyclones might become a growing and insidious threat to Madagascar’s forests.

In our study both types of classification were able to detect landslides caused by cyclones and consequent flooding. The locally calibrated classification was also able to distinguish cyclone-caused canopy damage. The successful mapping of cyclone damage might be crucial in preventing post-cyclone fires that might lead to permanent forest loss. We suggest using the Hansen *et al.* (2013) data set for the detection of illegal slash-and-burn agriculture and cyclone damage within Masoala National Park. In addition to being publicly available, the use of this data set requires neither advanced geoprocessing skills nor expensive software. It might therefore be an affordable tool for conservation practitioners in northeastern Madagascar.

We have assessed to what extent it is possible to detect various types of forest degradation with two very different forest cover classifications: a part of a global forest change data set (Hansen *et al.* 2013) and a locally calibrated, object-oriented analysis. The two classifications, together with substantial ground truthing, suggest that forest degradation is a serious concern in Masoala National Park. Both classifications underestimate forest degradation to a certain extent. The degradation detection rates are 19 percent and 38 percent for the Hansen *et al.* (2013) and the object-oriented classification, with false positive rates of 1 percent and 6 percent, respectively. Therefore, we estimate that overall, between 4.7 percent and 15.2 percent of Masoala National Park has likely been recently degraded to some extent.

IMPLICATIONS BEYOND MADAGASCAR.—Our results contribute to the ongoing debate on the usability of the global forest change data set in conservation at a local level (Hansen *et al.* 2013, Tropek *et al.* 2014). We identify a set of conditions under which this Landsat-based data set can be particularly useful. First, it is valuable in situations where diffuse slash-and-burn agriculture is the principal proximate cause of forest degradation or small-scale deforestation, which is frequently the case in countries with insecure or undefined land tenure and weak governance, such as in many African regions (Lambin *et al.* 2001, Geist & Lambin 2002). Second, as the data set is also not able to (nor designed) distinguish between natural and anthropogenic sources of forest degradation, it is more suitable for areas with low rates of cyclones, hurricanes, and destructive tropical storms. Third, the global forest change data set may prove less valuable in regions with industrial forest activities, such as in Southeast Asia. This is because the data set’s ability to distinguish plantations from natural forest is poor (Tropek *et al.* 2014), therefore inferred degradation rates might be misleading. Finally, the global forest change data set is especially valuable in under-studied regions where little financial and technical resources are available for rigorous field observation or expensive technologies.



**LIMITATIONS.**—We were unable to produce a classification that would successfully distinguish between anthropogenic forest degradation (slash-and-burn agriculture, selective logging, *etc.*) and non-anthropogenic degradation (landslides and cyclones damage to the canopy). However, it may be possible to distinguish between these two types of degradation by modeling the spatial correlates of recorded degradation occurrences. For example, landslides and cyclone damage to the canopy might be more common in forests on steeper slopes and with eastern orientation (Birkinshaw 2003). It is also likely that anthropogenic degradation is correlated with distance from the national park border, and with distance to main rivers. Streams and rivers are used instead of paths for traveling and transport of illegally logged wood (GW & EIA 2009, 2010). Unfortunately, we were unable to perform this type of analysis, as the location of our ground truth points is non-random and likely correlated with several of the potential explanatory variables.

## CONCLUSIONS

The remaining forests in northeastern Madagascar face a barrage of anthropogenic and climatic threats, which have already led to the degradation of between 5 percent and 15 percent of Masoala National Park. A more cost effective approach to quantify and monitor these threats is crucial for formulating effective conservation policies. We found that a global forest change data set performs similarly to a locally calibrated classification in detecting small-scale vegetation loss. Neither type of classification performed sufficiently at detecting illegal selective logging within Masoala National Park. We conclude that the most recent global forest change data set (Hansen *et al.* 2013) is a valuable resource in detecting small-scale and diffuse deforestation caused by slash-and-burn agriculture and landslides. It is therefore a relevant tool to local conservation, especially in regions without industrial plantations, where artisanal land clearing is the main proximate cause of forest loss and degradation.

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