Received: 26 June 2018 | Revised: 7 November 2018 | Accepted: 22 November 2018

DOI: 10.1111/conl.12622

POLICY PERSPECTIVE

WILEY Conservation Letters
A journal of the Society for Conservation Biology Open Access

Rise and fall of forest loss and industrial plantations in Borneo (2000–2017)

David L.A. Gaveau[1] | Bruno Locatelli[1] | Mohammad A. Salim[1] | Husna Yaen[1] | Pablo Pacheco[1,2] | Douglas Sheil[3]

[1]Center for International Forestry Research, P.O. Box 0113 BOCBD, Bogor, Indonesia

[2]World Wildlife Fund, 1250 24th Street NW, Washington, DC

[3]Department of Ecology and Natural Resource Management (INA), Norwegian University of Life Science (NMBU), Norway

Correspondence
David Gaveau Center for International Forestry Research, P.O. Box 0113 BOCBD, Bogor 16000, Indonesia.
Email: d.gaveau@cgiar.org

Funding information
Department for International Development, Grant/Award Number: KNOWFOR; United States Agency for International Development, Grant/Award Number: GOLS

Abstract

The links between plantation expansion and deforestation in Borneo are debated. We used satellite imagery to map annual loss of old-growth forests, expansion of industrial plantations (oil palm and pulpwood), and their overlap in Borneo from 2001 to 2017. In 17 years, forest area declined by 14% (6.04 Mha), including 3.06 Mha of forest ultimately converted into industrial plantations. Plantations expanded by 170% (6.20 Mha: 88% oil palm; 12% pulpwood). Most forests converted to plantations were cleared and planted in the same year (92%; 2.83 Mha). Annual forest loss generally increased before peaking in 2016 (0.61 Mha) and declining sharply in 2017 (0.25 Mha). After peaks in 2009 and 2012, plantation expansion and associated forest conversion have been declining in Indonesia and Malaysia. Annual plantation expansion is positively correlated with annual forest loss in both countries. The correlation vanishes when we consider plantation expansion versus forests that are cleared but not converted to plantations. The price of crude palm oil is positively correlated with plantation expansion in the following year in Indonesian (not Malaysian) Borneo. Low palm oil prices, wet conditions, and improved fire prevention all likely contributed to reduced 2017 deforestation. Oversight of company conduct requires transparent concession ownership.

KEYWORDS

annual time-series, Borneo, deforestation, Indonesia, industrial plantations, LANDSAT, Malaysia, no deforestation commitments, oil palm, pulpwood

1 | INTRODUCTION

Industrial plantations of oil palm (*Elaeis guineensis* Jacq.) and pulpwood (*Acacia mangium Willd.* and other tree species) have replaced large areas of old-growth forests in Indonesia and Malaysia, where 87% of global palm oil production originates (FAO 2015). This region, rich in threatened forest species, accounts for some of the world's most rapid forest loss (Gaveau et al., 2016; Margono, Potapov, Turubanova, Stolle, & Hansen, 2014).

The links between plantation expansion and deforestation remain debated (Meijaard et al., 2018). Although some plantations replace old growth forests, a substantial fraction make use of land cleared of forests many years previously—indicating that not all plantation developments cause deforestation (Gaveau et al., 2016). Assessing such outcomes have been challenging and controversial. Various industry and government representatives dispute that plantations cause deforestation and highlight that plantations are a reasonable use of already deforested land (Gaveau et al., 2016). At the same

time, many consumers and activists want products that are free from forest loss (Sheil et al., 2009).

Consumer concern has led to various initiatives aimed at distinguishing products that avoid deforestation. A producer-led certification scheme, the Roundtable on Sustainable Palm Oil (RSPO), was established in 2004, requiring oil palm plantation companies to recognize and conserve "high conservation values areas," including species-rich forests within the boundary of their certified concessions (Schouten & Glasbergen, 2011). There have also been national initiatives such as the Indonesian Standard for Sustainable Palm Oil (ISPO) and the Malaysian Sustainable Palm Oil standard (MSPO) (Schouten & Bitzer, 2015). Also In 2011, the Indonesian government instituted a nationwide moratorium on new concessions for oil palm and pulpwood plantations on peatlands and primary forests (e.g., excluding natural forests that have been degraded by selective timber harvesting, and reclassified a "secondary/degraded" forest by the Indonesian government; Busch et al., 2015).

One recent trend has been the widespread adoption of *No Deforestation* commitments across the private sector. Many of the world's largest traders and producers of palm oil and pulpwood have pledged to eliminate deforestation from their supply chain (Lambin et al., 2018). The coverage of these *No Deforestation* commitments, some immediate and some with 2020 deadlines, is striking. Already, over 74% of internationally traded palm oil is under companies that have committed to *No Deforestation* whereas only 20% is certified by the RSPO (Carlson et al., 2018; Steinweg, Drennen, & Rijk, 2017). Seen from this perspective, these commitments offer a promising means to curtail forest losses.

Our objective is to understand recent trends in Borneo's industrial plantation expansion and forest loss and their relationship. For the first time, we present an annual time-series of plantation expansion, forest loss, and their overlap from 2001 to 2017. These 17 years of data derive from visual interpretation of LANDSAT imagery (see Methods) and previously published sources (Gaveau et al., 2016; Hansen et al., 2013). We separate results for Indonesian Borneo (Kalimantan) and Malaysian Borneo (Sabah and Sarawak) to allow for different contexts. We exclude Brunei Darussalam where industrial plantations remain negligible (Gaveau & Salim, 2017). We have shown previously how the greater extent of scrublands in Indonesian versus Malaysian Borneo has facilitated the expansion of industrial plantations without conversion of old growth forest (Gaveau et al., 2016). Furthermore, the oversight and regulatory context in each country differ, with a less centralized and overlapping jurisdiction among agencies in Indonesia versus Malaysia (Cramb & McCarthy, 2016; McCarthy & Cramb, 2009). In addition, the government in Indonesia has tolerated NGO activity and criticism to a greater degree than in Malaysia suggesting that NGO oversight may also play a role.

2 | RESULTS

Borneo's old-growth forest were reduced by 14% (6.04 Million hectares) between 2000 and 2017 (3.74 Mha and 2.29 Mha lost in Indonesian and Malaysian Borneo, respectively). Annual forest loss trended upwards over most of the period reaching a maximum in 2016 (0.61 Mha lost) before declining to its lowest level since 2004 in 2017 (0.25 Mha lost; Figure 1a). This 2016 maximum is evident in Indonesian Borneo (Figure 1b), but not in Malaysian Borneo where forest loss peaked in 2009 (Figure 1c). This forest loss has been caused by expansion of industrial and smallholder plantations, immigration, urbanization, infrastructure developments, open-pit mining, flooding (dam projects), and fires.

Over the 17 years, Borneo gained 6.20 Mha of industrial plantations (88% oil palm; 12% pulpwood and 4.35 Mha and 1.85 Mha added in Indonesian and Malaysian Borneo, respectively, Figure 1d–f) (see definition in Methods). Thus, the planted area increased 170% since 2000. This expansion peaked in 2009 (0.70 Mha added) and 2012 (0.60 Mha added), then declined year-on-year since 2012 in both countries. In 2017, industrial plantation expansion had dropped to its lowest level since 2003 (0.16 Mha: 0.11 and 0.05 Mha in Indonesian and Malaysian Borneo, respectively).

We estimate that 3.06 Mha of old-growth forest have been converted to industrial plantations since 2000, and 92% (2.83 Mha) were cleared and converted within the same year. Forest conversion exhibits a similar rise and fall pattern to industrial plantation expansion: it peaked in 2009 (0.31 Mha) and in 2012 (0.30 Mha; Figure 1d), then declined year-on-year since 2012 in both countries (Figure 1e, f). By 2017, forest conversion to industrial plantations had dropped to its lowest level since 2003 (0.05 Mha: 0.01 and 0.04 Mha in Indonesian and Malaysian Borneo, respectively).

Unsurprisingly, the variation in annual expansion of industrial plantations is positively correlated with the variation in forest loss, although the correlation is noisier in Indonesian Borneo (Figure 2a, b). The correlation disappears if we subtract forest conversion to plantations from forest loss, to test whether variation in plantation expansion relates to variation in forest areas cleared but not planted as industrial plantations (Figure 2c, d). We explored whether there were any correlations among these annual data with a time difference of 1 or 2 years before or after the plantations are established, but found no clear relationships (results not shown). Forest converted to plantations as a proportion of total plantation expansion in each year has varied, though not declined (it has increased slightly in Indonesian Borneo), throughout the study period, ranging from 16% to 43% and 52% to 80% in Indonesian Borneo, and in Malaysian Borneo, respectively. Furthermore, the variation in the annual conversion of nonforest areas to industrial plantations remains tightly correlated with the variation in the annual conversion of forest to industrial plantations

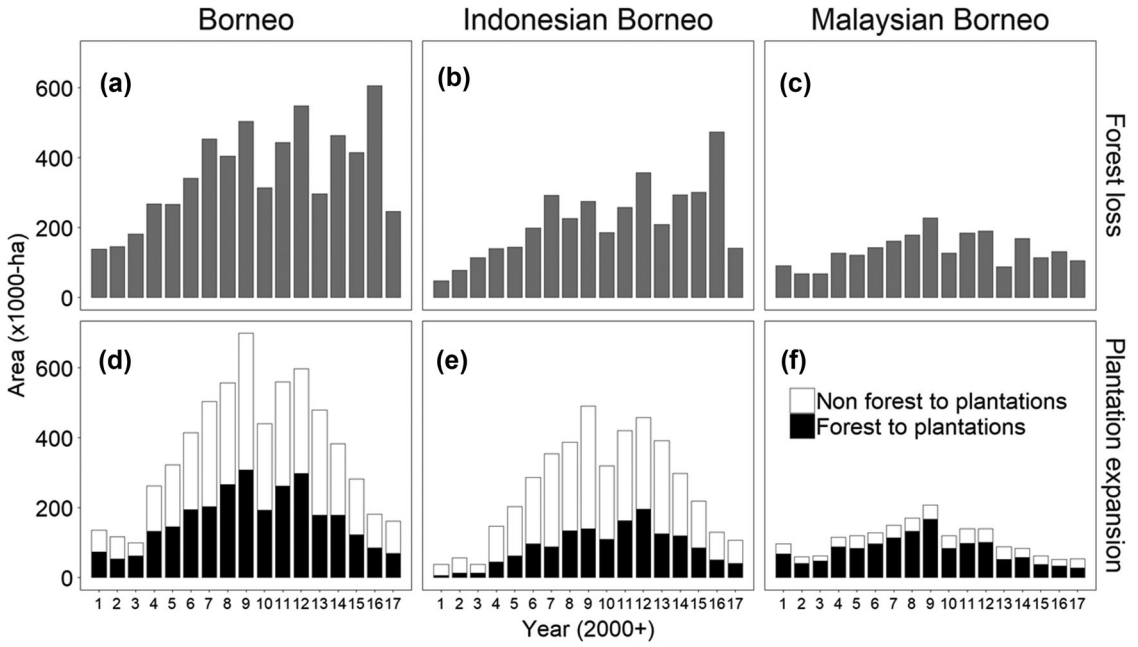

FIGURE 1 Time-series (2001–2017) of Borneo's land-use change, derived by observing LANDSAT imagery. Documents the annual loss of forest area (a, b, c) and the concomitant annual expansion of industrial plantations of oil palm and pulpwood (d, e, f) in Borneo, Indonesian and Malaysian Borneo. Forest loss in Borneo is caused by conversion to industrial and smallholder plantations, forest fires, infrastructures, open-pit mining and reservoirs for hydropower dams. We quantified conversion to industrial plantations in d, e, f. The black bars represent the forested areas cleared and converted to industrial plantations in the same year. This rapid within 1-year conversion (black bars) constitutes 47% of all forest loss since 2000, and 92% (2.83 Mha) of all forests converted to industrial plantations since year 2000 (3.06 Mha). The remaining 8% (0.23 Mha) forests converted were cleared in 1 year, then converted to plantation more slowly (within 2, 3,… .17 years). This slower conversion counts as "Nonforest to plantations" in d, e, f (white bars), and constitutes 7% of the total nonforest area converted to plantations (white bars). Ninety three percent (3.14 Mha) of the white bars were already deforested at least since year 2000

indicating that these rates depend on shared causes throughout the period (Figure 2e, f).

We noticed that overall plantation expansion and the price of crude palm oil (CPO) the previous year had similar trends. A formal test showed a significant and positive correlation for Indonesian but not Malaysian Borneo (Figure 3).

3 | DISCUSSION

We have quantified forest loss, industrial plantation expansion and their overlap each year from 2001 to 2017 in Borneo. We found a peak of forest loss in 2016 in Indonesian Borneo, a sharp drop in 2017 and a steady decline in industrial plantation expansion and in associated forest conversion to industrial plantations since 2012 in both Indonesian and Malaysian Borneo. Expansion of industrial plantations has directly contributed to forest loss throughout the study period as seen in the areas of forest cleared and converted within the same year. It is this shared area (forest converted to industrial plantations) included in both annual industrial plantation expansion and annual forest loss that explains why variation in these two measures are positively related (Figure 2a, b). This correlation is particularly marked in Malaysian Borneo (Figure 2b), where 58% of total deforestation since 2000 resulted in plantations within 1 year (Figure 1c, f). As previously shown, industrial oil palm developments are the main driver of deforestation in the Malaysian states of Sabah and Sarawak (Gaveau et al., 2016). The correlation is less clear in Indonesian Borneo (Figure 2a), where 38% of total deforestation since 2000 involved conversion to plantations within 1 year (Figure 1b, e). More forest was lost in 2015 and 2016 in Indonesia than a linear relationship with industrial plantation developments implies. We know that forests in Indonesian Borneo suffered droughts and fires in these years (Huijnen et al., 2016; Sloan, Locatelli, Wooster, & Gaveau, 2017).

Forest conversion to plantations is not the sole driver of deforestation. Our provisional assessments suggest that >40% of total forest loss recorded in 2015 and in 2016 was caused by Indonesian forest fires (unpublished results). Fires impacted large areas of Central Kalimantan and its remaining forests in 2015 (August to October). Some of these losses have been recorded only the following year (2016) because of poor imagery due to smoke and cloud in late 2015. Further fires impacted East Kalimantan in early 2016 (February to April). The 2016 deforestation peak seen in Indonesian Borneo (Figure 1b) reflects these fires.

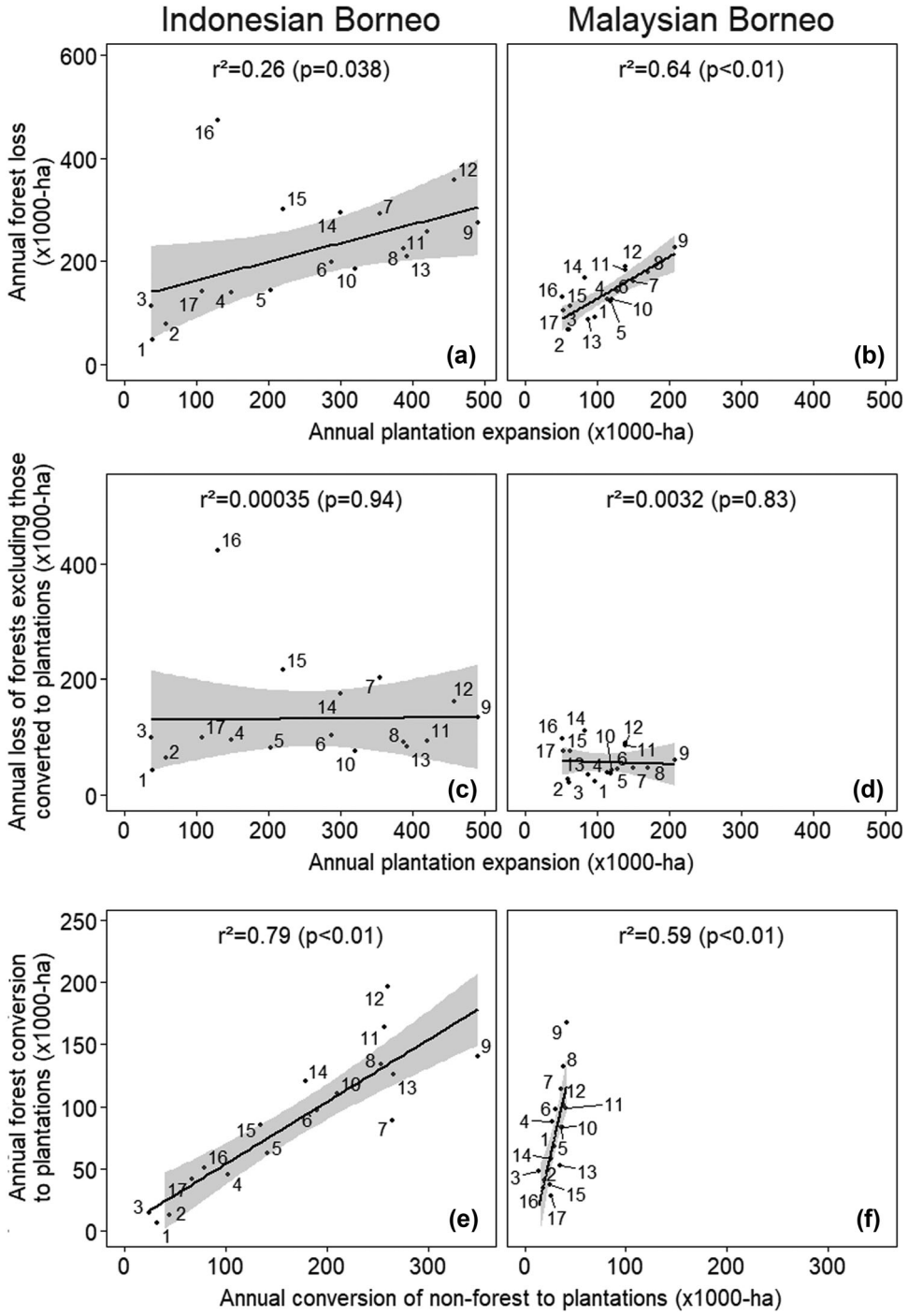

FIGURE 2 Scatter plots and associated correlation line and Pearson's correlation coefficient (r^2) between the annual expansion of industrial plantations and the annual loss of forest in Indonesian (a) and Malaysian Borneo (b). Middle panel: annual expansion of plantations against annual loss of forest excluding forest converted to plantations (c, d). Lower panels: Annual conversion of nonforest to plantations versus conversion of forest to plantations (e, f). The shaded areas show the 95% confidence interval for predictions from the linear model

If we compare variation in industrial plantation expansion versus just those forest losses that were not converted to plantations we don't find a clear correlation (Figure 2c, d). This result was surprising as we know that new plantations require new infrastructure (e.g., roads), cause in-migration of labor, and often encourage small scale plantations through outgrower schemes—each of which may lead to forest conversion (Meijaard et al., 2018). We underline that our results are not evidence against such links. Rather, the impacts of plantation developments on forests occur over substantially longer time scales rather than the discrete year-by-year periods of our analyses.

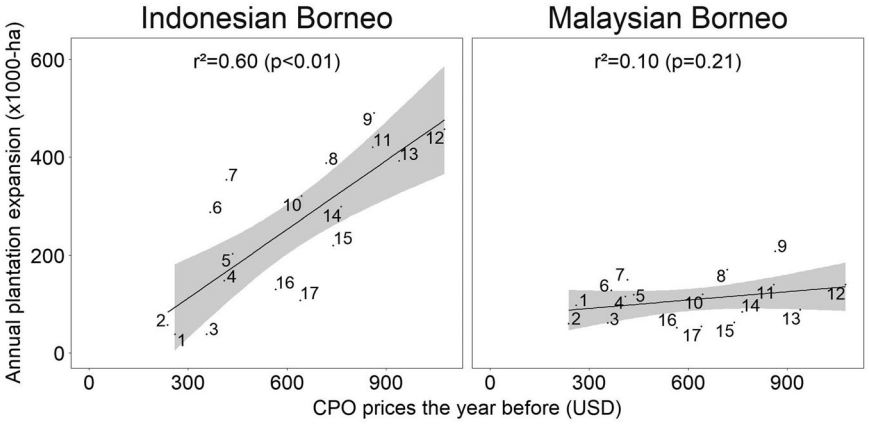

FIGURE 3 Scatterplot and associated correlation lines and Pearson's correlation coefficient (r^2) between the annual expansion of industrial plantations and the average yearly crude palm oil (CPO) price the year before. The shaded areas show the 95% confidence interval for predictions from the linear model. Average yearly price was calculated from monthly prices in USD using IMF data (CPO prices 2018)

We were also surprised that the area of forest converted to plantation annually remains tightly correlated with the annual plantation expansion in nonforest areas in both parts of Borneo throughout the study period (Figure 2e, f). These correlations suggested year-by year variation in the factors that influence investments in new plantations (e.g., business forecasts, land-availability). Exploring these patterns, we noted that the peak rates in plantation expansion seen in 2009 and 2012 followed peaks in the price of CPO in 2008 and 2011, leading us to assess and identify the strong correlation between CPO prices and plantation expansion in the subsequent year in Indonesian Borneo (Figure 3). The pattern in Malaysian territory remains less clear, though we speculate that Malaysian plantation developments are less responsive to short-term prices with expansion determined by more centralized long-term planning (see, e.g., Cramb & McCarthy, 2016; McCarthy & Cramb, 2009). Whatever the causes, Figure 2(e, f) and Figure 3 jointly indicate a stronger and more rapid short-term coupling of the variation in these investment decisions than we had anticipated.

Why did forest loss slow so markedly in 2017? One plausible factor is the implementation of the national peat conversion moratorium, that aims to protect peatland forests from conversion and fires (Norwegian Government, 2016). Additionally, 2017 a non-El Niño year, brought wetter conditions with fewer fires compared to 2015 and 2016 (BMKG, 2017). Reduced use of fire in land management has likely followed intensive awareness campaigns and enhanced enforcement (Medrilzam et al., 2017). Our data show that industrial plantation expansion and associated forest conversion had slowed year on year since 2012, and in 2017 had dropped to their lowest level since 2003 (Figure 1). So why has this expansion slowed?

Various factors have likely influenced the spread of industrial plantations and whether they replace forest. The 2011 moratorium on new plantations in Indonesia likely reduced investments in developing new areas in Indonesian Borneo (Busch et al., 2015). We also note that the improved legal context for community based land claims in Indonesia have likely made it harder for companies to access land (Astuti & McGregor, 2017). In addition, lower CPO prices appear to have discouraged investors from pushing expansion in Indonesian Borneo, and it is likely that it would impact Malaysian plantation expansion too given time. Many of the big plantation companies are expanding their concessions elsewhere, for example, in Papua, in Central and Western Africa and the Americas (Austin et al., 2017; Furumo & Aide, 2017). Such trends are likely drawing on the large but finite sources of investment that were previously focused on Borneo (Potter, 2015).

Much remains uncertain. The overall impact of past initiatives to regulate expansion of plantations into forests are unknown. For example, although comparative studies indicate that RSPO obligations have had little impact in certified concessions (Carlson et al., 2018; Meijaard, Morgans, Husnayaen, & Ancrenaz, 2017)—these concessions tend to be older with little forest and we don't know how these company obligations have influenced the development of new concessions. Similarly, though *No Deforestation* commitments have had little obvious effect so far—the proportion of plantation expansion that involves direct conversion of forest has not noticeably declined—they may influence longer term investment choices. We also suspect that land and labor are becoming harder to source and sustain in Borneo. Furthermore, attention from NGOs and journalists, pressure from consumers and consumer nations, and (at least in Indonesian Borneo) increased government oversight, may all have constrained expansion. We also underline that we have not been able to quantify the expansion of small-scale smallholder plantations, which from our own informal observations and discussions, we suspect are playing an increasing role in recent years (Meijaard et al., 2018).

Regulations and commitments are necessary but insufficient to halt forest loss. Companies alone cannot prevent all significant losses such as that due to fires and smallholder expansion that arise inside, let alone outside, their concessions (Carlson et al., 2018; Cattau, Marlier, & DeFries, 2016;

Gaveau et al., 2017). Good policies and strong enforcement remain crucial.

Some policies to address forest conversion have potential for perverse outcomes. For example, we feared that delayed *No Deforestation* commitments might encourage some plantation companies to accelerate forest clearance while they can to avoid possessing stranded assets (forested lands that they cannot use). Thus, we anticipated that some companies might rush to clear such lands ahead of their self-asserted deadlines. Reassuringly, when we examined our data concerning forest losses by concessions by year over the period we see no evidence that the rates of clearance in the concessions with the most rapid losses have been increasing (unpublished results). Another concern is that unscrupulous plantation owners may seek to actively conceal their ownership so as to avoid accountability (see, e.g., Greenpeace, 2018; Jacobson, 2018). Indeed while current technology is sufficient to explore forest loss and link this to local concessions and their commitments, our concerns over unverified ownership have prevented us from making such an assessment (see Methods for a fuller discussion of the technical caveats). Companies who have nothing to hide have no reason to accept this murky situation and—despite the often complex and sometimes obstructive legal context (various personal communication to authors)—should look for ways to publish and share the locations, boundaries and ownership details of all their suppliers. Without such information company conduct, including adherence to any *No Deforestation* commitments, cannot be overseen.

For those concerned for the future of Borneo's forests the bigger picture remains mixed. On the positive side *No Deforestation* commitments hold promise, and our results show that plantation expansion and deforestation have both slowed. On the negative side, transparency remains incomplete. Fires and industrial plantations continue to cause deforestation. We see no sign that plantation developments are seeking to avoid forest conversions. The links between the price of CPO and plantation expansion, and between plantation expansion and forest loss, indicate that markets play a major role in driving recent trends. Although our observations justify cautious optimism, much work remains to be done to ensure a future for Borneo's forests.

4 | METHODS

4.1 | Definition of forest

Our definition of old-growth forests (abbreviated to "forests") excludes young forest regrowth, scrublands, tree plantations, forests that have been cleared by wildfires, agricultural land, and nonvegetated areas. These old-growth forests are closed-canopy (>90% cover) and high carbon stock (Above Ground carbon: 150−310 Mg C/Ha) evergreen dipterocarps growing on either mineral or peat soils. On peat domes, forests include low carbon stock pole forests. In highland regions, forests include "kerangas" and in coastal areas, mangroves. Our definition of "forests" includes intact and selectively harvested forests. See Supplementary Methods for more detailed information.

4.2 | Annual loss of natural forest

Annual forest loss represents the area of old-growth forest (including selectively logged forest) that has been cleared (or burned) year since 2001 until 2017. It is caused by conversion to industrial and smallholder plantations, forest fires, infrastructure developments, open-pit mining, and reservoirs for hydropower dams. We extracted annual forest loss from the most recent annual tree loss map created by Hansen et al. (2013), revealing areas of tree cover (>30%; tree height >5 m) cleared every year from 2001 to 2017. See Supplementary Methods for more detailed information.

4.3 | Annual expansion of industrial plantations

Annual expansion of industrial plantations represents the area of land (whether forest on nonforest) that has been converted to a large- and medium-scale industrial plantation of oil palm or pulpwood in a given year since 2001 until 2017. To map plantations, we scanned seventeen annual cloud-free LANDSAT image mosaics to detect plantations. We declared an area "developed (or under development)" by companies, the moment we observed large rectangular elements, long linear boundaries, and distinctive grid- or contour-planting patterns appear on our sequence of images. See Supplementary Methods for more detailed information.

4.4 | Annual conversion of forest and nonforest to industrial plantations

We determined the area of forest (and nonforest) converted every year into industrial plantations across Borneo from 2001 until 2017. This was determined by measuring the overlap between the annual plantation map and the annual forest loss map. We declared an area of forest converted to plantations, if it became a plantation in the same year that it lost forest cover. This rapid within-1-year conversion captures 92% of all forest conversion to industrial plantations since 2000. Ninety three percent of the nonforest areas converted to plantations since 2000, were already nonforested prior to year 2000. Seven percent of the nonforest areas converted, were forests cleared in 1 year (in 2001, 2002,…2015), then converted to plantation more slowly (within 2, 3,….17 years). See Supplementary Methods for more detailed information.

ACKNOWLEDGMENT

This work was funded by the Department for International Development of the UK Government (DFID); Project name: *KNOWFOR,* and by USAID; Project name: GOLS

REFERENCES

Astuti, R., & McGregor, A. (2017). Indigenous land claims or green grabs? Inclusions and exclusions within forest carbon politics in Indonesia. *The Journal of Peasant Studies*, *44*, 445–466.

Austin, K. G., Mosnier, A., Pirker, J., McCallum, I., Fritz, S., & Kasibhatla, P. S. (2017). Shifting patterns of oil palm driven deforestation in Indonesia and implications for zero-deforestation commitments. *Land Use Policy*, *69*, 41–48.

BMKG. (2017). *Monthly precipitation data, Meteorological Climatological and Geophysical Agency*, Accessed: September 2018. Retrieved from http://www.bmkg.go.id/tag/?tag=informasi-hujan-bulanan&lang=EN

Busch, J., Ferretti-Gallon, K., Engelmann, J., Wright, M., Austin, K. G., Stolle, F., … Hansen, M. C. (2015). Reductions in emissions from deforestation from Indonesia's moratorium on new oil palm, timber, and logging concessions. *Proceedings of the National Academy of Sciences*, *112*, 1328–1333.

Carlson, K. M., Heilmayr, R., Gibbs, H. K., Noojipady, P., Burns, D. N., Morton, D. C., … Kremen, C. (2018). Effect of oil palm sustainability certification on deforestation and fire in Indonesia. *Proceedings of the National Academy of Sciences*, *115*, 121–126.

Cattau, M. E., Marlier, M. E., & DeFries, R. (2016). Effectiveness of Roundtable on Sustainable Palm Oil (RSPO) for reducing fires on oil palm concessions in Indonesia from 2012 to 2015. *Environmental Research Letters*, *11*, 105007.

CPO prices. (2018). Average yearly price calculated from monthly prices in USD using IMF data, Federal Reserve Bank of St. Louis, citing: International Monetary Fund. Retrieved from https://fred.stlouisfed.org

Cramb, R., & McCarthy, J. F. (2016). *The Oil palm complex: Smallholders, agribusiness and the state in Indonesia and Malaysia*. Singapore: NUS Press.

FAO. (2015). FAOstat. Retrieved from http://faostat.fao.org/

Furumo, P. R., & Aide, Tll. (2017). Characterizing commercial oil palm expansion in Latin America: Land use change and trade. *Environmental Research Letters*, *12*, 024008.

Gaveau, D. L. A., & Salim, M. A. (2017). Atlas of deforestation and industrial plantations in Borneo. Center for International Forestry Center. Retrieved from www.cifor.org/map/atlas

Gaveau, D. L. A., Pirard, R., Salim, M. A., Tonoto, P., Yaen, H., Parks, S. A., & Carmenta, R. (2017). Overlapping land claims limit the use of satellites to monitor no-deforestation commitments and no-burning compliance. *Conservation Letters*, *10*, 257–264.

Gaveau, D. L. A., Sheil, D., Husnayaen, Salim, M. A., Arjasakusuma, S., Ancrenaz, M., … Meijaard, E. (2016). Rapid conversions and avoided deforestation: Examining four decades of industrial plantation expansion in Borneo. *Scientific reports*, *6*, 32017.

Greenpeace. (2018). *World's largest palm oil trader linked to rainforest destruction twice the size of Paris*. Retrieved from https://www.greenpeace.org/usa/news/worlds-largest-palm-oil-trader-linked-to-rainforest-destruction-twice-the-size-of-paris/

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., … Loveland, T. R. (2013). High-resolution global maps of 21st-century forest cover change, *Science*, *342*, 850–853.

Huijnen, V., Wooster, M. J., Kaiser, J. W., Gaveau, D. L. A., Flemming, J., Parrington, M., … Van Weele, M. (2016). Fire carbon emissions over maritime southeast Asia in 2015 largest since 1997′, *Scientific Reports*, *6*, 26886.

Jacobson, P. (2018). *Revealed: Paper giant's ex-staff say it used their names for secret company in Borneo*. Mongabay News. Retrieved from https://news.mongabay.com/2018/07/revealed-paper-giants-ex-staff-say-it-used-their-names-for-secret-company-in-borneo/

Lambin, E. F., Gibbs, H. K., Heilmayr, R., Carlson, K. M., Fleck, L. C., Garrett, R. D., … Walker, N. F. (2018). The role of supply-chain initiatives in reducing deforestation. *Nature Climate Change*, *8*, 109–116.

Margono, B. A., Potapov, P. V., Turubanova, S., Stolle, F., & Hansen, M. C. (2014). Primary forest cover loss in Indonesia over 2000—2012. *Nature Climate Change*, *4*, 730–735.

McCarthy, J. F., & Cramb, R. A. (2009). Policy narratives, landholder engagement, and oil palm expansion on the Malaysian and Indonesian frontiers. *The Geographical Journal*, *175*, 112–123.

Medrilzam, Rahayu, N. H., Widiaryanto, P., Rosylin, L., Firdaus, R., Suprapto, U., Sumantri, H.P., … Nugraha, M. (2017). Grand Design: Pencegahan kebakaran hutan, kebun dan lahan 2017–2019. Bogor, Indonesia: Center for International Forestry Research.

Meijaard, E., Garcia-Ulloa, J., Sheil, D., Wich, S. A., Carlson, K. M., Juffe-Bignoli, D., & Brooks, T. M. (2018). *Oil palm and biodiversity: A situation analysis by the IUCN Oil Palm Task Force*. Gland, Switzerland: International Union for Conservation of Nature.

Meijaard, E., Morgans, C., Husnayaen, N. K.Abram., & Ancrenaz, M. (2017). *An impact analysis of RSPO certification on Borneo forest cover and orangutan population* (pp. 28). Brunei Darussalam: Borneo Futures.

Norwegian Government. (2016*). Press release: Indonesia's Peat Moratorium could benefit people, welfare and climate*. Ministry of Climate and Environment. Retrieved from https://www.regjeringen.no/en/aktuelt/indonesias-president-forbyr-a-odelegge-torvmyrer/id2522663/

Potter, L. (2015). Managing oil palm landscapes: A seven-country survey of the modern palm oil industry in Southeast Asia, Latin America and West Africa. Occasional Paper 122. Bogor, Indonesia: CIFOR.

Schouten, G., & Bitzer, V. (2015). The emergence of Southern standards in agricultural value chains: A new trend in sustainability governance? *Ecological economics*, *120*, 175–184.

Schouten, G., & Glasbergen, P. (2011). Creating legitimacy in global private governance: The case of the Roundtable on Sustainable Palm Oil. *Ecological economics*, *70*, 1891–1899.

Sheil, D., Casson, A., Meijaard, E., van Noordwijk, M., Gaskell, J., Sunderland-Groves, J., … Kanninen, M. (2009). *The impacts and opportunities of oil palm in Southeast Asia: What do we know and what do we need to know*? Bogor: Center for International Forestry Research.

Sloan, S., Locatelli, B., Wooster, M. J., & Gaveau, D. L. A. (2017). Fire activity in Borneo driven by industrial land conversion and drought during El Niño periods, 1982–2010′. *Global Environmental Change*, *47*, 95–109.

Steinweg, T., Drennen, Z., & Rijk, G. (2017). *Unsustainable palm oil faces increasing market access risks- NDPE sourcing policies cover 74% of Southeast Asia's refining capacity, Chain Reaction Research*. Retrieved from https://chainreactionresearch.com/report/report-unsustainable-palm-oil-faces-increasing-market-access-risks-ndpe-sourcing-policies-cover-74-percent-of-southeast-asias-refining-capacity/

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

How to cite this article: Gaveau DLA, Locatelli B, Salim MA, yaen H, Pacheco P, Sheil D. Rise and fall of forest loss and industrial plantations in Borneo (2000-2017). *Conservation Letters*. 2018;e12622. https://doi.org/10.1111/conl.12622