Earth Syst. Dynam. Discuss.,
doi:10.5194/esd-2017-2-AC1, 2017

Earth System Dynamics Discussions

Interactive comment on "Managing fire risk during drought: the influence of certification and El Niño on fire-driven forest conversion for oil palm in Southeast Asia" *by* Praveen Noojipady et al.

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Received and published: 29 March 2017

This is a strong paper which addresses an important question regarding the role of RSPO certification for improving management of fire and fire-driven deforestation in permits for oil palm cultivation. The methods are clear, the report is well written and clearly organized, and the graphics are informative.

We appreciate the reviewer's recognition of the importance of our study on fire-driven deforestation in Southeast Asia and the role of RSPO certification.

I have the following questions/ comments for the authors:

1. Compliance benchmark date - The paper refers to 2009 as the year that RSPO

began granting certification, and notes that forest loss and fire-driven deforestation declined after this date. However, the benchmark date used to determine compliance with RSPO criterion 7.3, after which new plantings should not replace primary forest or HCV areas, is November 2005. Why does the study use 2009 to assess compliance, given that RSPO uses an earlier year to assess compliance?

We agree with the reviewer that there are several important dates to consider regarding the evolution of RSPO and related criteria for certified plantations.

While the RSPO standard requires no replacement of primary forests or HCV areas after November 2005, the incentives to follow this requirement, and compliance with the requirement, have changed over time. The RSPO draft standard was piloted for two years (2005-2007) with volunteer oil palm companies who committed to avoid clearing primary intact forest and High Conservation Value (HCV) areas. Although this initial standard was approved in 2007, the first RSPO certificates for sustainable oil palm in Malaysia and Indonesia were not issued until 2008 and 2009, respectively. In 2010, the New Planting Procedure required that all member companies conduct an HCV assessment prior to clearing. In 2014, the Remediation and Compensation procedure recognized that RSPO members had cleared and planted after 2005 without first conducting an HCV assessment, and required companies to compensate for such clearance.

In a revised manuscript, we would clarify the evolution of the RSPO standard and additional requirements.

Specifically, we would discuss the sequence of events that precede certification in the Introduction, including company membership in RSPO and the agreement of all members to follow the Principles & Criteria, including Criterion 7.3:

"Companies interested in certification first become members of the RSPO and agree to the Principles & Criteria, including the prohibition on new plantings through deforestation of primary or HCV forests after Nov. 2005 without compensation (Criterion 7.3, RSPO 2013)."

In the methods, we propose to clarify the key dates for our evaluation of fire-driven deforestation and total fire activity: "Comparisons between certified (ever) and non-certified (never) plantations considered forest loss and fire activity over three time scales: 1) following the benchmark date for compliance with RSPO criterion 7.3 (Nov. 2005), 2) following the first issuance of RSPO certificates to Indonesian producers in 2009, and 3) following the date of certification for individual plantations."

In the results section, we propose to separately consider deforestation and fire activity during 2006-2009, 2009-2015, and the subset of all deforestation and fire activity on plantations with RSPO certification. For example: "In Indonesia, annual rates of forest loss and fire-driven forest loss were higher in certified plantations before the first RSPO certificates were issued (2006-2008, 38,636 ha yr-1) than during 2009-2015 (10,943 ha yr-1). Between 2009 and 2012, the majority of forest loss and fire-driven forest loss occurred on plantations that had not yet received RSPO certification (Table B2), whereas plantations with certificates accounted for most forest losses identified in 2013-2014."

Due to the importance of being able to compare pre- and post- certification trends, I would find it useful to present the proportion of forest loss driven by fire each year in a table. It is difficult to see proportions in Figure 2 for years with low rates of forest loss, and Table 1 only provides this the aggregate proportion over the 2000 – 2014 period. Breakdown by year would help illustrate whether, and when, certification alters fire use for forest conversion.

Below, we present annual forest loss and fire-driven forest loss for certified, non-certified, and buffer areas in Indonesia (Table B2) and certified plantations in Malaysia and Papua New Guinea (Table B3). In a revised manuscript, these tables could be presented online to complement the material in Figure 2 and Figure 4, or added to the main text for completeness. In addition, we have estimated the proportion of total forest loss and fire-driven forest loss on plantations following the receipt of RSPO certification, noting that the first RSPO certificates were issued to plantations in Indonesia

in 2009 and in 2008 to plantations in Malaysia and Papua New Guinea. Table B4 provides a similar breakdown of total fire detections for certified plantations, including post-certification MODIS fire detections.

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2. Buffer areas - The authors should articulate the purpose of the 5 km buffer area, and in particular clarify why they combine the buffer areas of certified and non-certified plantations. Given that the study assesses roughly 12 Mha of non-certified plantations, versus 1.5 Mha of certified plantations, the trends in the combined buffer will largely reflect the characteristics of buffers around non-certified plantations and presumably more closely resemble the trends inside non-certified plantations. Combining the buffers masks potentially divergent trends in the buffer of the certified plantation management type, and obscures whether certification additionally impacts fire activity in areas surrounding the permit itself.

We appreciate the reviewer's suggestion to clarify our analysis of buffer areas surrounding oil palm plantations. Human ignitions are the dominant source of fire activity in Southeast Asia, and recent fire emergencies (e.g., 2013 and strong El Niño events in 1997-1998, 2002, 2006, and 2015) have intensified the debate over the source of fire ignitions. Two questions guided our inclusion of buffer areas surrounding plantations: 1) what is the role of smallholders adjacent to oil palm plantations for total fire activity observed from satellite sensors? 2) do buffer areas exhibit similar patterns of interannual variability in fire-driven forest clearing and fire detections as oil palm plantations? In other words, our main goal was to characterize fire and deforestation immediately surrounding oil palm plantations, not to contrast certified and non-certified buffers.

Buffer areas surrounding non-certified plantations cover a larger land area, as the reviewer correctly points out, but the patterns of remaining forested area and forest loss are similar for buffer areas surrounding certified and non-certified plantations (Figure R1). In addition, oil palm plantations in Southeast Asia are frequently adjacent to other oil palm plantations (Figure 1, see also response to Reviewer #3), meaning that it is difficult to attribute buffer activities to only certified or non-certified neighbors. As a result, we analyzed fire activity and forest loss for a single set of buffer areas surrounding certified and non-certified plantations. The 5km buffer was chosen based on expert judgment to capture the potential influence of forest loss and fire activity on the surrounding landscape, including the direct fire spread from adjacent lands into palm oil plantations, wind-blown embers from nearby fires, and the most acute impacts of smoke on both human health and ecosystems.

In the revised manuscript, we would clarify the characteristics of buffer landscapes in Section 2.1, including the fact that nearly 12% of the area within the 5km buffer was mapped as planted oil palm in 2010 (Gunarso et al., 2013; Carlson et al., 2013). Thus, the buffer region may reflect differences in management, in addition to differences in land use and land cover, based on the abundance of planted palm oil outside of large plantations.

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3. Underestimation of fire activity – The authors discuss limitations in satellite platforms, which detect fires, and suggest that these limitations may result in underestimation of fire activity. Is there any reason to think that this underestimation would bias the results, either by differentially underestimating fire density in time (e.g., after certification date), or in space (e.g., in certified concessions)?

The long-term record of Moderate Resolution Imaging Spectroradiometer (MODIS) active fire detections (MCD14ML) provides a consistent daily assessment of fire activity during the entire study period. MODIS detections therefore provide clear and consistent evidence for interannual (Figure 5) and monthly (Figure A3) variability in total fire detections in and around oil palm plantations. Limitations of MODIS fire detection from orbital coverage, cloud cover, or spatial resolution are also consistent over time, and are therefore unlikely to bias the analysis of fire activity in specific years or specific

plantations.

The launch of additional satellite platforms, including the Visible and infrared Imaging Radiometer Suite (VIIRS) on the Suomi-National Polar orbiting Partnership (S-NPP) and Operational Land Imager (OLI) on Landsat-8, provide higher spatial resolution active fire information to detect smaller (or cooler) active fires and provide an unambiguous attribution of fire activity to specific land holders (see Figure 6). In the original manuscript, we highlighted the potential to improve operational satellite monitoring of fire activity using these new sensors, specifically to monitor land use change and environmental compliance. However, the benefits of new sensor systems do not diminish the value of long-term monitoring using MODIS. We propose to clarify the importance of the long and consistent MODIS data record in a revised manuscript: "We used the time series of active fire detections from the Moderate Resolution Imaging Spectroradiometer (MODIS) instruments on NASA's Terra and Aqua satellites to evaluate the spatial and temporal patterns of daily fire activity during 2002-2015."

"The finer spatial resolution of these fire data capture additional details regarding fire activity that can be difficult to evaluate at MODIS resolution, including the precise location of active fire fronts, separation of flaming and smoldering fires (Elvidge et al., 2015), and detection of small and/or lower intensity fires (Schroeder et al., 2015)âĂŤan important component of fire activity in agricultural landscapes (Randerson et al., 2012)."

The potential for certification or other changes in land use and land management practices to alter the probability of detecting active fires from space is a separate issue from sensor performance. In our original manuscript, we specifically considered one aspect that could influence detection of fire-driven forest lossâĂŤchanges in the size of clearings over time (Figure 3)âĂŤas smaller fires may be more difficult to detect using all satellite platforms. In addition to changes in clearing size, it is possible that land managers have altered the use of fires to avoid detection by burning during cloudy periods when detections are less likely or time intervals with less satellite coverage. New satellite sensors may partially address issues associated with smaller fires, but not with targeted burning to avoid detection. The potential management response to satellite monitoring capabilities is an interesting direction for further research, but a thorough evaluation of this issue is beyond the scope of this study. In a revised manuscript, we would recognize this line of research as a possible extension of this work using multiple sources of satellite-based fire detections.

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4. Covariates of certification – The study could elaborate on the factors, which could cause different observed fire and fire driven forest loss trends between certified and non-certified plantations. The authors mention that companies preferentially certify older plantations that retain less forest cover. If this is the case, or if there are other characteristics which influence the placement of certified plantations or the outcomes with respect to forest loss and fire activity in certified plantations, then observed differences may not be the result of certification. The authors should clearly caveat the findings by acknowledging these covariates, and/or suggest what steps would be necessary to control for these in order to determine the causal impacts of certification.

We agree with the reviewer that a range of factors will influence fire-driven forest loss on oil palm plantations. In this study, we were primarily interested in the use of fire for forest conversion and interannual variability of fire detections in and around oil palm plantations. For these studies, the larger sample size of all certified and non-certified plantations fills an important data gap in our understanding carbon emissions from oil palm expansionâĂŤthe degree of fire use during forest conversion. Companies and consumers purchasing palm oil are concerned about the amount of "embodied" emissions from forest loss and fire activity. Our study quantifies the amount of fire-driven forest loss embodied in certified palm oil based on a more inclusive look at the aggregate behavior among all certified oil palm plantations. As the reviewer points out, key aspects of the RSPO Principles & Criteria would be known to all RSPO members in the process of certifying plantations, including the Nov. 2005 benchmark date for

deforestation of primary or HCV forest lands and the need to comply with environmental legislation banning fire activity.

Previous work that considered a broad range of matching criteria between certified and non-certified plantations was restricted to very small sample sizes (e.g., 4 plantations on peatlands in Cattau et al., 2016). In a separate study, we have more formally controlled for the diversity of plantation characteristics, including remaining forest cover, planted palm oil, age, and date of certification, among others (Carlson et al., under review). In a revised manuscript, we would specifically recognize that our results do not establish causality for differences between certified and non-certified plantations: For example:

"Following the start of RSPO certification in 2009, certified oil palm plantations in Indonesia had lower fire-driven deforestation and total fire activity during El Niño events than non-certified plantations. These reductions point to the potential for RSPO to contribute to REDD+ and to decrease fire ignitions during drought conditions, but our results do not provide conclusive evidence for a causal relationship between certification and lower fire activity."

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5. Policy implications – The authors could further elaborate on the policy implications of their findings. They suggest that the benefits conferred by RSPO certification could be enhanced through expansion of certified plantations. How would this work? Given that certification is based on performance after the benchmark date, many plantations will poor past performance may not be eligible for certification (or would need to take advantage of a compensation mechanism). Would the expansion of the certified plantation portfolio therefore only apply to new plantations?

As the reviewer suggests, more widespread adoption of RSPO certification could be hindered by poor past performance because the barriers to entrance are likely to be high for a company that cleared after 2005 without an HCV assessment. However, entrance is not impossible due to the 2014 RSPO Remediation and Compensation Procedure that would allow certification of existing plantations in non-compliance with the 2005 cut-off date. Under this procedure, RSPO member companies that clear without an HCV assessment after 2014 are expelled from the RSPO, while non-member companies face steep costs to entrance. In the 2005-2014 period, companies face liability based on clearance date and membership status.

Given our findings that certified plantations in Indonesia had significantly lower fire-driven deforestation, even existing non-certified plantations with remaining forest could benefit from improved management practices associated with certification. However, even with full compliance with the RSPO Principles and Criteria, the overall environmental gains of certification may be limited, as the current Principles & Criteria do not restrict the clearance of all forests, only those designated as HCV or "primary."

Importantly, our study highlights how the RSPO Principles & Criteria differ from existing capabilities for remote monitoring of environmental compliance. In a revised manuscript, we would further emphasize the benefits of revised certification criteria that can be more easily monitored using existing satellite sensors. In addition to improving transparency, updating certification criteria to match monitoring capabilities would also bring RSPO more in line with industry commitments to zero-deforestation goals, including the New York Declaration on Forests.

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Interactive comment on Earth Syst. Dynam. Discuss., doi:10.5194/esd-2017-2, 2017.

Table B2: Total and fire-driven forest loss for oil palm expansion in Indonesia from 2002-2014 within the certified and non-certified plantations.

Year	Certified				Non-Certified		Buffer 5km	
	Total loss (ha)	Post-Certification loss (%)	Fire-driven loss (ha)	Post-Certification loss (%)	Total loss (ha)	Fire-driven loss (ha))	Total loss (ha)	Fire-driven loss (ha)
2002	12,646		4,961		86,179	21,890	184,140	29,713
2003	7,043		2,552		53,578	18,693	104,882	23,135
2004	32,885		12,587		158,904	62,232	288,634	71,538
2005	33,795		9,170		140,345	42,260	244,178	56,281
2006	54,313		12,023		224,249	85,081	320,690	88,869
2007	34,218		6,905		203,990	61,875	303,782	67,606
2008	27,376		876		252,538	31,337	355,449	47,793
2009	29,229	(1)	2,543	(0)	335,246	62,356	446,635	79,842
2010	6,267	(8)	306	(0)	120,598	14,330	228,111	28,634
2011	7,105	(23)	308	(42)	240,864	22,776	316,644	34,771
2012	9,163	(25)	495	(25)	334,453	45,787	512,886	80,585
2013	6,628	(50)	480	(82)	176,080	21,815	245,738	32,635
2014	7,264	(82)	774	(96)	195,885	31,298	302,012	48,848

Fig. 1.

Table B3: Total and fire-driven forest loss for oil palm expansion in certified plantations in Malaysia and Papua New Guinea during 2002-2014. All areas are given in hectares (ha).

Year	Malaysia				Papua New Guinea			
	Total loss (ha)	Post-Certification loss (%)	Fire-driven loss (ha)	Post-Certification loss (%)	Total loss (ha)	Post-Certification loss (%)	Fire-driven loss (ha)	Post-Certification loss (%)
2002	14,870		912		3,959		1,244	
2003	6,563		791		1,645		301	
2004	13,522		1,912		3,279		721	
2005	6,410		506		1,242		252	
2006	12,312		465		2,893		718	
2007	12,045		15		2,099		479	
2008	7,381	(2)	91	(0)	1,188	(34)	116	(7)
2009	15,467	(8)	69	(0)	938	(71)	3	(0)
2010	10,378	(19)	155	(8)	716	(85)	14	(96)
2011	8,222	(35)	120	(65)	1,065	(85)	4	(98)
2012	7,432	(48)	235	(63)	1,235	(79)	3	(77)
2013	3,261	(50)	85	(78)	756	(100)	0	(100)
2014	4,096	(82)	114	(81)	477	(100)	3	(100)

Fig. 2.

Table B4: Total MODIS fire detections for certified plantations, including post-certification fire detections.

	Indonesia		Malaysia		Papua New Guinea	
Year	Total fire detections	Post-Certification fire detections (%)	Total fire detections	Post-Certification fire detections (%)	Total fire detections	Post-Certification fire detections (%)
2001	169		124		37	
2002	1782		87		130	
2003	716		71		64	
2004	1821		87		130	
2005	1008		128		39	
2006	2712		17		83	
2007	197		12		61	
2008	87		9	(0)	43	(7)
2009	483	(0)	22	(0)	31	(0)
2010	72	(8)	18	(28)	44	(95)
2011	196	(29)	12	(50)	18	(67)
2012	191	(39)	21	(33)	44	(84)
2013	128	(55)	11	(55)	54	(100)
2014	361	(73)	35	(69)	52	(100)
2015	656	(100)	26	(100)	136	(100)

Fig. 3.

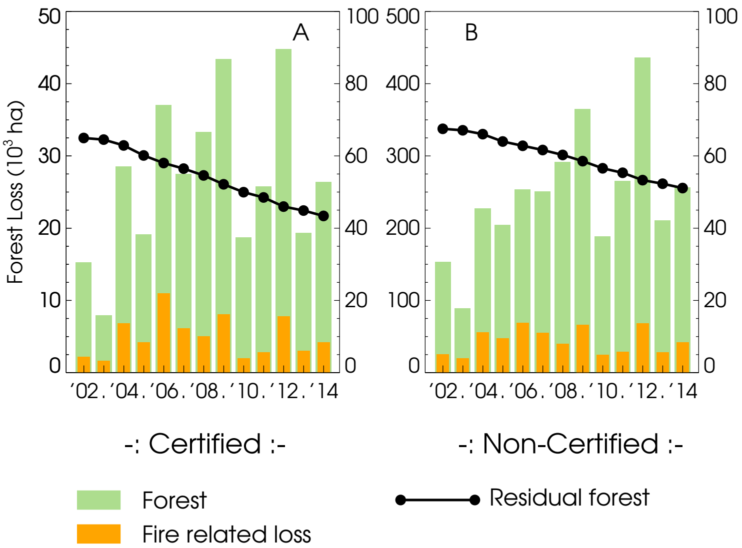

Figure R1: Forest (green) and fire-driven (orange) forest loss within the buffer (5km) areas of certified and non-certified oil palm plantation boundaries. Solid black lines indicate residual forest cover as a percentage of the buffer area adjacent to certified and non-certified plantations.