Institution: University of York		
Unit of Assessment: 5 - Biological Sciences		
Title of case study: Improving sustainable oil palm		
Period when the underpinning research was undertaken: 2001-2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Jane Hill	Professor of Ecology	2001-present
Jennifer Lucey	PDRA and NERC Knowledge Exchange Fellow	2012-2016
Colin McClean	Senior Lecturer in Environment	1996-present
Chris Thomas	Professor & Director of Leverhulme Centre for Anthropocene Biodiversity	2004-present
Period when the claimed impact occurred: 1 August 2013-31 December 2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact (indicative maximum 100 words)

Research at York has contributed to zero-deforestation policies adopted by members of the leading global sustainable palm oil certification organisation, the Roundtable on Sustainable Palm Oil (RSPO), securing the protection of ~790,000ha of rainforest to-date. We have helped improve the RSPO sustainability criteria which require the protection of patches of rainforest on plantations. Our research has fed into policy on the RSPO's High Conservation Values and High Carbon Stocks policies, which are employed across large parts of the tropics, conserving biodiversity (contributing to protecting ~70% of rainforest species) and reducing carbon emissions (by 1.4m t CO_2 equivalent in emissions per year).

2. Underpinning research (indicative maximum 500 words)

York research examines biodiversity loss following conversion of rainforest to oil palm, quantifying the importance of retaining patches of natural rainforest within plantations, and feeding into policy recommendations which have been taken up by the Roundtable on Sustainable Palm Oil (RSPO) in their High Conservation Values (HCVs) and High Carbon Stocks Approaches (HCSA) for protecting biodiversity and delivering zero-deforestation commitments.

Indicators of the significance and impact of this research include: (i) Dr Lucey's NERC Early Career Researcher Impact Award for 'demonstrable economic and/or societal impact' (2018), (ii) Prof Hill's Marsh Award for Conservation (2011), (iii) Prof Hill's Honorary Fellowship Award from the Royal Entomological Society (2016), and Dr Lucey's membership of the RSPO Biodiversity and HCV Working Group (since 2014).

Key conclusions of York's under-pinning research are:

Conversion of rainforest to agriculture reduces biodiversity
Rainforests of SE Asia are hyper diverse, containing ~17% of the world's bird species, and supporting large numbers of threatened iconic species, including orangutans and tigers. York research has shown that the conversion of forest to oil palm causes the loss of at least half of these rainforest species **(3.1)**, with oil palm biodiversity being dominated by small animal species from lower down the food chain **(3.2)**, thereby altering ecosystem functioning. The remaining forest patches have lower species richness **(3.1)**, but loss of species from patches is idiosyncratic and so these forest patches contribute to maintaining higher levels of biodiversity in the wider landscape **(3.3)**.

Conservation importance of forest patches
Small forest patches <20ha support less biodiversity than planted areas of oil palm, but larger forest patches (>200ha core area) can support ~60-70% of forest biodiversity **(3.1)** and contain above-ground carbon stocks similar to those of primary forest, boosting plantation carbon stocks by ~20% **(3.4)**. Forest patches also provide beneficial spillover effects, raising the biodiversity of neighbouring agricultural areas **(3.5)**.

Benefits of a landscape-wide approach to conservation
Oil palm plantations are inhospitable to many species, resulting in plantations being barriers preventing movement of species between forested areas, but plantation forest patches can improve connectivity and so aid movement across landscapes **(3.6)**. These connectivity benefits are enhanced if patches containing degraded forest are restored **(3.6)**. Biodiversity is greater in patches with more surrounding forest in the wider landscape (because populations in isolated patches are boosted by links to other populations in the wider landscape), revealing the importance of taking a landscape-wide approach to oil palm sustainability policies.

Key York research findings taken up by policy makers:
- Forest patches with a core area (i.e. excluding edge habitat) of at least 200ha support substantial amounts of biodiversity (~60-70% of the species richness of primary rainforest; **3.1**);
- Forest patches boost above-ground carbon stocks (by ~20%; **3.4**) and also enhance biodiversity in surrounding plantations due to spillover effects **(3.5)**;
- Large blocks of forest should be prioritised for conservation **(3.1)**, but smaller patches are valuable because they enhance species richness in the wider landscape **(3.3)**;
- Forest patches improve connectivity and so help species move through inhospitable landscapes **(3.6)**, highlighting the importance of landscape-wide approaches to sustainability policies.

3. References to the research (indicative maximum of six references)

York researchers are in **bold**.

3.1. **Lucey, J.M., Palmer, G.**, Yeong, K. L., Edwards, D.P., **Senior, M.J.M., Scriven, S.A.**, Reynolds, G., **Hill, J.K.** (2017) Reframing the evidence base for policy-relevance to increase impact: a case study on forest fragmentation in the oil palm sector. *Journal of Applied Ecology* 54, 731-736. https://doi.org/10.1111/1365-2664.12845

3.2. **Senior, M.J.M.,** Hamer, K.C., Bottrell, S., Edwards, D.P., Fayle, T.M., **Lucey, J.M.**, **Mayhew, P.J.**, Newton, R., Peh, K.S-H., Sheldon, F.H., Stewart, C., Styring, A., **Thom, M.D.**, Woodcock, P., **Hill, J.K.** (2013) Trait-dependent declines of species following conversion of rain forest to oil palm plantations. *Biodiversity & Conservation* 22, 253-268. DOI 10.1007/s10531-012-0419-7

3.3. **Stride, G.**, **Thomas, C.D**, Benedick, S., Hodgson, J., Jelling, A., Senior, M.J.M., **Hill, J.K**. (2019) Divergent tree seedling communities indicate different trajectories of change among rainforest remnants. *Diversity & Distributions* 25, 1751-1762. https://doi.org/10.1111/ddi.12977

3.4. **Fleiss, S., Waddell, E.H.**, Ola, B.B., Banin, L.F., Benedick, S., Sailim, A.B., Chapman, D.S., Jelling, A., King, H., **McClean, C.J**., Yeong, K.L., **Hill, J.K**. (2020) Conservation set-asides improve carbon storage and support associated plant diversity in certified sustainable oil palm plantations. *Biological Conservation* 248, 108631. https://doi.org/10.1016/j.biocon.2020.108631

3.5. **Lucey, J.M**., Tawatao, N., **Senior, M.J.M.**, Chey, V.K., Benedick, S., Hamer, K.C.,

Woodcock, P., Newton, R.J., Bottrell, S.H., **Hill, J.K.** (2014) Tropical forest fragments contribute to species richness in adjacent oil palm plantations. *Biological Conservation* 169, 268-276. https://doi.org/10.1016/j.biocon.2013.11.014

3.6. Scriven, S.A., Carlson, K.M., Hodgson, J.A., **McClean, C.J.**, Heilmayr, R., Lucey, J.M., **Hill, J.K.** (2019) Testing the benefits of conservation set-asides for improved habitat connectivity in tropical agricultural landscapes. *Journal of Applied Ecology* 56, 2274–2285. https://doi.org/10.1111/1365-2664.13472

Indicators of quality

All references **3.1-3.6** are published in international peer-reviewed journals.
References **3.2**, **3.3**, **3.4** and **3.5** are from NERC-funded research.

4. Details of the impact (indicative maximum 750 words)

Background and context

Globally, about 30% of vegetable oil is sourced from palm oil, but expansion of oil palm plantations has caused widespread deforestation, resulting in substantial losses of biodiversity, releasing huge quantities of CO_2 and reducing ecosystem CO_2 uptake and storage thereafter. Concerns about these detrimental environmental impacts led to the Roundtable on Sustainable Palm Oil (RSPO) being set up in 2004 as the main voluntary sustainability certification body for palm oil, currently with ~5000 members across 98 countries, comprising >4,400,000ha of certified land **(5.1)**. In 2012, the UK set a goal "*to source 100% credibly certified sustainable palm oil*" **(5.2)** and has recently consulted on new legislation to remove deforestation from supply chains.

RSPO sustainably certified palm oil represents ~19% of the global palm oil market **(5.1)**. RSPO certification requires the conservation of areas of forest with High Conservation Values (HCV; **5.3**; e.g. containing rare, threatened or endangered species), prohibits new plantings on primary forest and peatland, and in November 2018 strengthened its certification standards by implemented a zero-deforestation policy **(5.1)**. This zero-deforestation policy is implemented via the High Carbon Stocks Approach (HCSA; **5.4**), which identifies areas of forest to protect from conversion to plantation. Thus, new oil palm plantings must implement a combined HCV-HCSA assessment prior to establishment.

York researchers Lucey and Hill lead the Socially and Environmentally Sustainable Oil Palm Research (SEnSOR) programme to evaluate the environmental consequences of RSPO certification **(5.5)**. This York research has provided evidence of the benefits of RSPO certification for boosting biodiversity, conserving carbon stocks, and improving connectivity on plantations, via Science-for-Policy reports to the RSPO **(5.5)**. [Text removed for publication].

Contributions of York research to key impact outcomes

1) Demonstrating biodiversity benefits of RSPO High Conservation Values (HCVs) approach

RSPO plantation members are required to identify and manage patches of forest containing High Conservation Values (HCVs) on their plantations. York research has quantified the biological diversity of forest patches, their ecosystem functioning and contribution to landscape connectivity. This research has provided the scientific evidence-base for the ecological benefits of conserving HCV forest patches. York research has underpinned policy recommendations on the minimum effective size of forest patches, and how their placement within the wider landscape improves landscape connectivity and boosts biodiversity, thereby contributing to HCV design across millions of hectares of oil palm plantations **(5.1)**. [Text removed for publication].

Approximately 40% of palm oil is produced by smallholders, and the RSPO has developed a

smallholder standard **(5.1)**. Smallholders are required to check new planting areas against an HCV 'risk map' so as to avoid damage to priority conservation areas, based on a number of key criteria, which include the size of any remnant forest patches. York staff Lucey and Hill were technical consultants in the development of this tool, which was co-led by the global not-for-profit NGO 'Proforest'. The letter of support from Proforest **(5.3)** states that York research outputs "*were used in the development of RSPO's simplified High Conservation Value (HCV) assessment tool for smallholder*s" and that "*the tool … was informed by York evidence on viable patch size of forest areas*" **(5.3)**. Increasing numbers of smallholder farmers are adopting the new standard, and York research has contributed to ~ 330,000ha of smallholdings being RSPO certified.

2) Developing the High Carbon Stock Approach for delivering zero-deforestation pledges
Concerns about tropical deforestation led to zero-deforestation commitments in RSPO's updated certification standards in November 2018. To meet this commitment, the RSPO has developed the High Carbon Stocks Approach (HCSA; in partnership with Greenpeace; **5.4**), to provide a standard methodology for producers to achieve these pledges. York staff Hill and Lucey provided policy-relevant research which has been incorporated into the HCSA Toolkit. A comprehensive synthesis by York researchers determined minimum thresholds of forest patch size to achieve the co-benefits of maintaining biodiversity and carbon stocks simultaneously. The forest patch size thresholds specified in the HCSA Toolkit **(5.4)** were informed by York research. [Text removed for publication]. This HCSA Toolkit is co-authored by York researcher Dr Lucey, and cites supporting evidence on the biodiversity importance of forest patch size from six papers with York co-authors **(5.4)**. Dr Lucey's NERC KE fellowship supported her work with Greenpeace and HCSA stakeholders as a member of the HCSA scientific advisory committee. [Text removed for publication].

Magnitude and significance of this policy impact:
York research has contributed to RSPO sustainability criteria which have secured protection of ~240,000ha of tropical forest through protection of HCVs **(5.1)**, a further ~550,000ha of forest protected via the HCSA process **(5.6)**, and contributed to reducing greenhouse gas emissions by ~1.4m t CO_2 equivalent in emissions per year from avoided land clearance, peat avoidance and conservation areas (**5.1**; equivalent to ~300,000 cars driven for 1 year). Forest patches which are conserved in RSPO certified plantations protect many International Union for Conservation of Nature (IUCN) Red List species (~200 critically endangered, endangered or vulnerable animal species are threatened by palm oil; **5.7**), and York research is used by the IUCN Oil Palm Task Force to highlight the benefits of HCV forest patches for improving connectivity and minimum patch size thresholds for conserving biodiversity **(5.7)**.

The HCSA process has been adopted by some of the largest oil palm growers who now have the tools to deliver on no-deforestation commitments, providing access to European, American and Australian markets. The HCSA process is also reaching beyond the palm oil sector to the pulp and paper sector, to include ~6% of global paper production.

5. Sources to corroborate the impact (indicative maximum of 10 references)

5.1. The Roundtable on Sustainable Palm Oil (RSPO) website (https://rspo.org) includes guidelines and impacts of certification, information for smallholder farmers (https://rspo.org/smallholders/rspo-smallholder-strategy) and zero-deforestation commitments (new Criterion 7.12). The RSPO letters of support outline how York research has contributed to these sustainability standards.

5.2. Defra report in 2017 outlines the UK Government commitment to sourcing sustainable palm oil, and that the RSPO is the key sustainability standard for achieving this commitment.

5.3. The High Conservation Values (HCV) Resource Network (www.hcvnetwork.org) provides guidance on conserving patches of rainforest within plantations. The support letter from

Proforest (co-developer of RSPO simplified HCV assessment tool), explains how York research contributed to the new tool for HCV assessment by smallholder farmers.

5.4. The High Carbon Stocks Approach (HCSA) is used by the RSPO to deliver their Zero-Deforestation Commitment, using the HCSA toolkit. York research contributed to module 5, and York researcher Lucey is a co-author of the toolkit.

5.5. Science-for-Policy Reports (http://www.sensorproject.net/) have informed RSPO policy revisions for sustainability standards (see 5.1). For example, Scriven et al. (2017). The Impact of RSPO Membership on Avoiding Biodiversity Losses in Oil Palm Landscapes A science-for-policy brief for the RSPO by the SEnSOR programme.

5.6. Support letter from Greenpeace, co-chair of the High Carbon Stocks Approach (HCSA) steering group, explaining how York research was used to develop the HCSA toolkit, and evidence to support Dr Lucey's NERC Early Career Researcher Impact Award.

5.7. Meijaard, E., Garcia-Ulloa, J., Sheil, D., Wich, S.A., Carlson, K.M., Juffe-Bignoli, D., and Brooks, T.M. (eds.) (2018). Oil palm and biodiversity. A situation analysis by the IUCN Oil Palm Task Force. IUCN Oil Palm Task Force Gland, Switzerland: IUCN. xiii + 116pp. The report cites six published papers with York co-authors.