Science AAAS

Comment on "High-resolution global maps of 21st-century forest cover change"

Robert Tropek *et al.*

Science **344**, 981 (2014);
DOI: 10.1126/science.1248753

TECHNICAL COMMENT

FOREST SURVEYS

Comment on "High-resolution global maps of 21st-century forest cover change"

Robert Tropek,[1,2]* Ondřej Sedláček,[3] Jan Beck,[1] Petr Keil,[4,5] Zuzana Musilová,[6] Irena Šímová,[3,5] David Storch[3,5]

Hansen *et al*. (Reports, 15 November 2013, p. 850) published a high-resolution global forest map with detailed information on local forest loss and gain. We show that their product does not distinguish tropical forests from plantations and even herbaceous crops, which leads to a substantial underestimate of forest loss and compromises its value for local policy decisions.

The high-resolution global map of forest cover loss and gain in Hansen *et al.* (*1*) is a fascinating and much-needed tool for both research and conservation planning. The authors claim that "[t]he information content of the presented data sets...provides a transparent, sound, and consistent basis on which to quantify critical environmental issues, including...(iv) the status of remaining natural forests of the world and threats to biodiversity…(v) the effectiveness of existing protected-area networks…(vi) the economic drivers of natural forest conversion to more intensive land uses." After studying the supplementary data application (http://earthenginepartners.appspot.com/science-2013-global-forest) in detail, we express serious concerns about the appropriateness of the product for these purposes.

The main problem lies in Hansen *et al.*'s definition of forest as "all vegetation taller than 5m in height" [supplementary materials for (*1*)]. Such a structural definition includes types of plantations that have already replaced substantial parts of tropical (and also extratropical) forests. Monocultures of oil palm, rubber, or *Eucalyptus* are recognized as some of the biggest threats to tropical biodiversity (*2*–*4*), and their expansion into forest systems continues at an alarming rate [see (*5*) for details]. Although these plantations are technically "forests" in the definition above, they do not provide the benefits of forest vegetation as enumerated by the authors—i.e., "ecosystem services, including biodiversity richness, climate regulation, carbon storage, and water supplies" (*6*–*9*). Classifying plantations as forests confuses an endangered habitat with its greatest threats and thus underestimates real forest loss.

To evaluate Hansen *et al.*'s forest map, we compiled sites for which we had detailed information (e.g., from our previous fieldwork). We compared these validation sites to the forest map and identified three ways in which the product failed to accurately assess forest cover gain and loss (see Table 1 and Fig. 1 for specific cases):

1) Areas deforested and converted into plantations before 2000 are classified as forests (cases 1 to 19, Table 1, and Fig. 1, A to E), which leads to an overestimation of total forested area. Furthermore, plantation management such as cutting old growth plantation and replanting with new crops is interpreted as forest gain/loss.

2) Areas deforested around 2000 and replanted by tree plantations before 2012 are identified as "forest gain," although their conservation value has been largely lost in such cases (case 20, Table 1).

3) Contrary to the given definition of forest, vegetation lower than 5 m (e.g., pineapple, soybeans, or tea plantations) is often classified as forest. Including these types of vegetation as "forest" further biases estimates of forest cover gain and loss (cases 21 to 24, Table 1, and Fig. 1, F to H).

The ease with which we found classification errors in every examined tropical region suggests that these represent systematic misinterpretations with substantial consequences for inferences based on the product. Following our personal knowledge of several tropical regions and a survey of Hansen *et al.*'s map application, we tentatively estimate that the forest loss may be underestimated by tens of percents in the tropics. Similar issues may also occur outside the tropics, where species-poor wood plantations are widespread (*5*, *10*).

We warn that classification of high-resolution satellite data based on a single and simplistic algorithm can provide only limited insight into real forest dynamics at local scales. This forest map may provide preliminary identification of ongoing changes [e.g., (*11*)], but without locally specific calibration and evaluation and/or accompanying maps of pixel-specific classification uncertainty, it will mislead conservation policy-makers and managers, with potentially serious consequences for biodiversity and socioeconomic issues. The fact that the product comes with an easy-to-use online application further enhances the potential for uncritical use by nonspecialists and various interest groups.

Although the global loss of tree cover reported by Hansen *et al.* (*1*) represents a serious environmental issue, the replacement of natural forests by plantations (often with comparable tree cover) is a more important environmental and biodiversity problem at the local scale. Plantations are often characterized by considerably lower diversity than extensively used open countryside, including nonintensive pastures and small fields (*2*, *12*). In this respect, the results of Hansen *et al.* are misleading and can potentially lead to abuse by local policy-makers who could consider an increase of tree cover a conservation success, even if this change is accompanied by decreases in biological diversity. The stated conservation relevance and utility of the approach of Hansen *et al.* is thus seriously compromised and calls for a critical reevaluation.

[1]Department of Environmental Science (Biogeography), University of Basel, St. Johanns-Vorstadt 10, CH-4056 Basel, Switzerland. [2]Institute of Entomology, Biology Centre, Academy of Sciences of the Czech Republic, Branisovska 31, CZ-370 05 Ceske Budejovice, Czech Republic. [3]Department of Ecology, Faculty of Science, Charles University in Prague, Vinicna 7, CZ-128 44 Praha 2, Czech Republic. [4]Department of Ecology and Evolutionary Biology, Yale University, 165 Prospect Street, New Haven, CT 06520, USA. [5]Center for Theoretical Study, Charles University in Prague and Academy of Sciences of the Czech Republic, Jilska 1, CZ-110 00 Praha 1, Czech Republic. [6]Zoological Institute, University of Basel, Vesalgasse 1, CH-4051 Basel, Switzerland.
***Corresponding author. E-mail: robert.tropek@gmail.com**

REFERENCES AND NOTES

1. M. C. Hansen *et al*., *Science* **342**, 850–853 (2013).
2. J. Barlow *et al*., *Proc. Natl. Acad. Sci. U.S.A.* **104**, 18555–18560 (2007).
3. L. P. Koh, D. S. Wilcove, *Conserv. Lett.* **1**, 60–64 (2008).
4. D. S. Wilcove, X. Giam, D. P. Edwards, B. Fisher, L. P. Koh, *Trends Ecol. Evol.* **28**, 531–540 (2013).
5. E. G. Brockerhoff, H. Jactel, J. A. Parrotta, C. P. Quine, J. Sayer, *Biodivers. Conserv.* **17**, 925–951 (2008).
6. R. Guo, R. M. Gifford, *Glob. Change Biol.* **8**, 345–360 (2002).
7. E. B. Fitzherbert *et al*., *Trends Ecol. Evol.* **23**, 538–545 (2008).
8. L. Gibson *et al*., *Nature* **478**, 378–381 (2011).
9. A. D. Ziegler *et al*., *Glob. Change Biol.* **18**, 3087–3099 (2012).
10. F. T. Maestre, J. Cortina, *For. Ecol. Manage.* **198**, 303–317 (2004).
11. R. Koenig, *Science* **320**, 1439–1441 (2008).
12. H. M. Pereira, G. C. Daily, *Ecology* **87**, 1877–1885 (2006).

ACKNOWLEDGMENTS

We thank K. Mertes for English proofreading and valuable comments on the manuscript. This work was partly supported by the Czech Science Foundation (14-36098G).

20 November 2013; accepted 4 April 2014
10.1126/science.1248753

Table 1. Examples of serious misclassifications by Hansen *et al*. (*1*). Geographic coordinates allow easy checking of current vegetation in the supplementary online map application (http://earthenginepartners.appspot.com/science-2013-global-forest). Hundreds of additional examples of similar errors can easily be found in the application map by simply following plantation maintenance roads. Often, even details such as individual oil palms or soybean rows are clearly visible.

Case no.	Figure	Country	Region	Latitude	Longitude	Hansen *et al*.	Actual vegetation
1	1A	Philippines	Davao, Mindanao	7°26'1.29''N	125°38'6.26''E	Stable forest	Banana
2	1B	Ecuador	Quevedo, Los Rios	1°0'46.76''S	79°29'59.33''W	Forest with large regrowth	Oil palm
3	1C	Costa Rica	Damas, Puntarenas	9°31'59.50''N	84°14'16.20''W	Forest with large regrowth	Oil palm
4	1D	Malaysia	Sepang, Kuala Lumpur International Airport	2°43'55.97''N	101°40'49.64''E	Forest with large regrowth	Oil palm
5	1E	Cameroon	Mundemba, Southwest	4°57'1.16''N	8°52'18.66''E	Forest with large clearings and regrowth	Oil palm
6		Cameroon	Bafut-Ngemba, Forest Reserve Northwest Province	5°54'11.90''N	10°11'43.61''E	Stable forest	Eucalyptus
7		Cameroon	Penda Mboko, Southwest Province	4°16'14.68''N	9°26'12.66''E	Stable forest	Rubber
8		Malaysia (Borneo)	Left bank of Kinabatangan River, Sabah	5°32'40''N	118°16'6''E	Forest with clearings and regrowth	Oil palm
9		Philippines	South of Tagum, Davao del Norte	7°21'28.04''N	125°47'52.59''E	Stable forest	Coconut
10		Papua New Guinea	Gusap, Morobe	6°4'53.08''S	146°0'12.95''E	Large forest regrowth	Oil palm
11		Indonesia	Bogor, West Java	6°30'47.64''S	106°43'35.64''E	Large forest regrowth	Oil palm
12		Indonesia	North Konawe, Southeast Sulawesi	3°12'40.73''S	122°7'30.66''E	Large forest regrowth	Oil palm
13		Venezuela	Ciudad Guayana, Bolívar State	8°35'33.84''N	62°35'54.19''W	Forest with large clearings and regrowth	Pine tree
14		Peru	Santa Lucía, San Martín	8°19'40.71''S	76°29'50.67''W	Forest with large regrowth	Oil palm
15		Benin	Saketé, Plateau Department	6°48'36.02''N	2°30'10.52''E	Forest with clearings and regrowth	Oil palm
16		Côte d'Ivoire	Ebobo, Sud-Comoé	5°15'43.42''N	3°1'46.12''W	Forest with clearings and regrowth	Oil palm
17		Nigeria	Benin City, Edo State	6°9'39.23''N	5°41'0.33''E	Forest with large regrowth	Oil palm
18		Liberia	Kakata, Margibi	6°32'6.47''N	10°22'57.34''W	Forest with clearings and regrowth	Rubber tree
19		Guinea - Conacry	Samaya/Kemaya, Dubréka	10°2'28.65''N	13°48'44.74''W	Large forest regrowth	Oil palm
20		Cameroon	Northern border of Campo Ma'an National Park, South Province	2°40'47.17''N	10°13'8.11''E	Large forest regrowth	Newly established rubber trees instead of freshly cut forest
21	1F	Madagascar	Ambatoharanana, Sava	14°32'30.80''S	49°35'44.26''E	Large forest regrowths	Various field crops
22	1G	Brazil	Tailândia, Pará	2°39'50.20''S	48°53'17.43''W	Forest with large regrowth	Soybeans
23	1H	Philippines	Tupi, South Cotabato	6°18'31.14''N	124°58'17.75''E	Stable forest	Pineapple
24		Cameroon	Ndawara Belo Ranch, Northwest Province	6°4'41.37''N	10°22'46.00''E	Forest with large regrowth	Tea

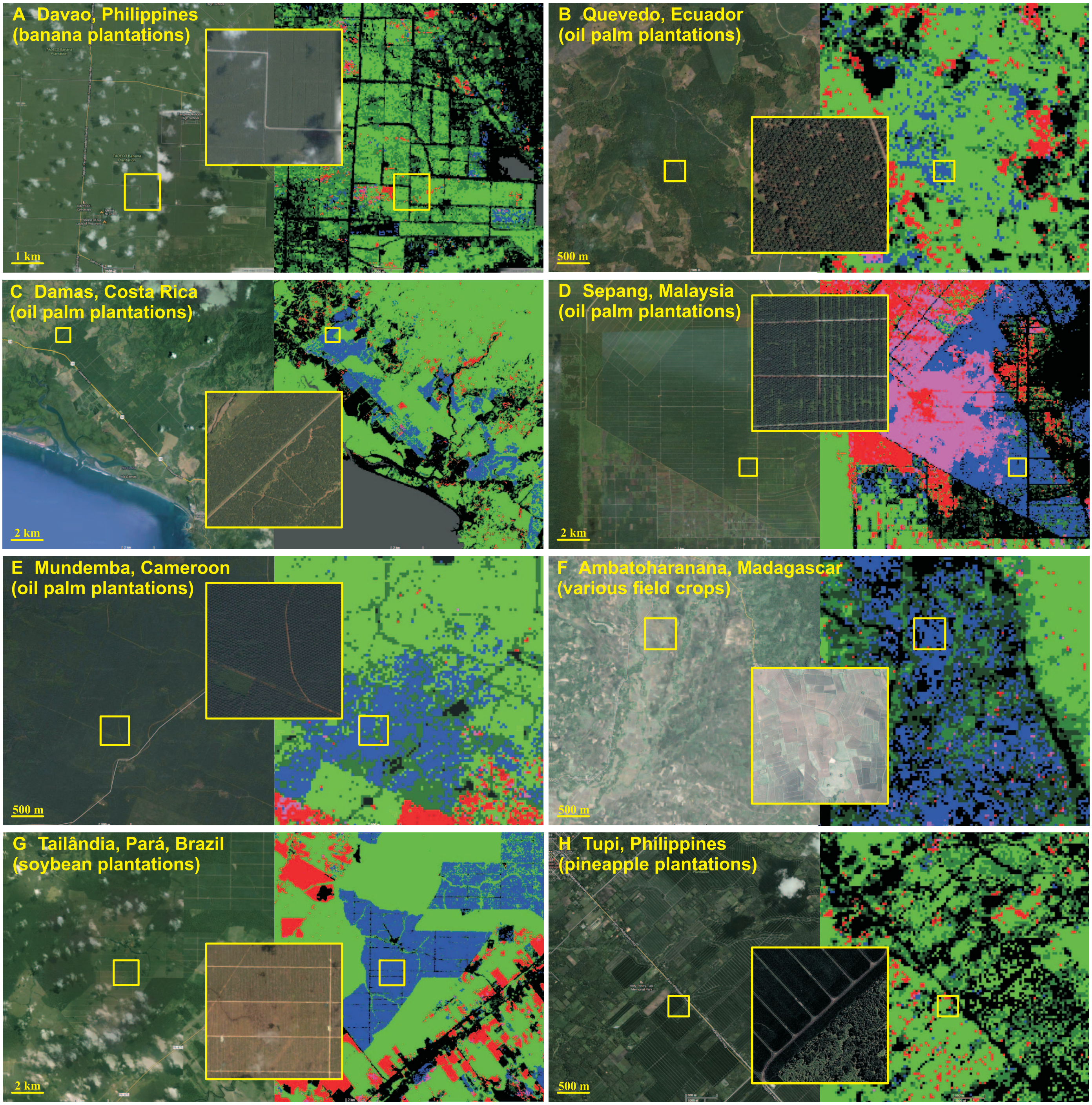

Fig. 1. Selected examples of Hansen *et al.*'s (*1*) failures in classifying of tree plantations (A to E) and herbal crops (F to H) as forest. All the maps are screenshots from Hansen *et al.*'s supplementary online map application (http://earthenginepartners.appspot.com/science-2013-global-forest) taken in November 2013 and modified to highlight details by adding the yellow squares. The colors in the right halves of each panel indicate stable forest (green), forest loss (red), forest gain (blue), and forest loss and gain (magenta). See Table 1 for more details, including coordinates, and for several additional examples.