Palm oil is everywhere – but where did it come from?

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Abstract

What do lipstick, frozen pizza, and laundry detergent have in common? Palm oil. This tropical vegetable oil that most people have never heard of is in half the packaged goods sold in the supermarket. Almost certainly, people are going to continue to use it. That makes it important to know when and where forests were cut down to make the palm tree plantations (from which we get the palm oil), where future plantations might be, and how they endanger plant and animal species.

The largest areas of palm plantations are in Southeast Asia. Here, farmers have cleared the forest (an activity called deforestation) quite recently. Similarly, palm plantations in South America are also from recent deforestation. Elsewhere though, the forest was cleared decades ago, often for other purposes before people even thought much about palm oil.

Our research shows that in the future, major palm plantations are likely to emerge in Africa and South America and continue to spread through Indonesia, Malaysia, Papua New Guinea. Palm plantations in any of these regions though would put at risk many plant and animal species.

Introduction

Palm oil goes by a variety of names on product labels – such as palmate, palmitate, glyceryl, stearate, stearic acid, sodium laureth sulfate, sodium lauryl sulfate – and serves many purposes. In chocolate and lipstick, palm oil prevents melting; in shampoo and soap, it keeps our hair and skin from drying out. Palm oil is everywhere, but where does it come from?

Palm oil comes primarily from the fruit of a single species of tree, the tropical African palm *Elaeis guineensis*. Oil palms are the highest yielding, least expensive of all vegetable oil crops (producing 5 times as much oil per acre than soybeans and for 25% less money). Roughly 185 million tons of palm oil worth $190 billion are produced in the tropics and then traded globally, going primarily to the US and Europe. Unfortunately, the highest concentrations of plant and animal species (or highest biodiversity) are also in the tropics, and so the doubling in palm oil production from 2003 to 2013 raises concerns about possible wildlife extinctions.
Currently, Indonesia and Malaysia produce the most palm oil (first column in Table 1). In these countries, palm plantations threaten iconic and endangered wildlife, including orangutans (who can use 150 signs and other meaningful gestures to communicate), Bornean pygmy elephants (about half the size of an African elephant), and the Sumatran tiger (which is about half the size of the Siberian tiger). What's more, tropical deforestation also releases the carbon stored in the tree tissues and in the soil, contributing to an estimated 10% of the greenhouse gas emissions that causing global warming.

Demand for palm oil is increasing so there is concern that palm plantations will spread, deforesting other parts of the world (Fig. 2). To understand the situation better, we set out to answer some key questions:

1. **How much of the current palm plantation area came directly from deforestation?**
2. **Where are new palm oil plantations likely to emerge?**
3. **Which of these palm plantations pose the biggest threat to biodiversity?**

### Table 1: Data for each country:

<table>
<thead>
<tr>
<th>Country</th>
<th>2013 FAO reported palm plantation acreage (km²)</th>
<th>Percent increase in palm plantations from 1989-2013</th>
<th>Percent area from deforestation 1989-2013</th>
<th>Percent vulnerable forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indonesia</td>
<td>70,800</td>
<td>91.7%</td>
<td>53.8%</td>
<td>37.1%</td>
</tr>
<tr>
<td>Malaysia</td>
<td>45,500</td>
<td>63.3%</td>
<td>39.6%</td>
<td>33.4%</td>
</tr>
<tr>
<td>Nigeria</td>
<td>20,000</td>
<td>24.7%</td>
<td>6.6%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Thailand</td>
<td>6,264</td>
<td>85.5%</td>
<td>0.0%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Ghana</td>
<td>3,600</td>
<td>63.9%</td>
<td>0.4%</td>
<td>6.7%</td>
</tr>
<tr>
<td>Ivory Coast</td>
<td>2,700</td>
<td>82.0%</td>
<td>4.1%</td>
<td>3.9%</td>
</tr>
<tr>
<td>Colombia</td>
<td>2,500</td>
<td>69.5%</td>
<td>0.0%</td>
<td>53.3%</td>
</tr>
<tr>
<td>Ecuador</td>
<td>2,188</td>
<td>74.7%</td>
<td>60.8%</td>
<td>64.4%</td>
</tr>
<tr>
<td>Dem. Rep. Congo</td>
<td>2,100</td>
<td>16.0%</td>
<td>0.7%</td>
<td>71.1%</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>1,500</td>
<td>72.3%</td>
<td>25.3%</td>
<td>48.7%</td>
</tr>
<tr>
<td>Cameroon</td>
<td>1,350</td>
<td>59.3%</td>
<td>16.5%</td>
<td>42.4%</td>
</tr>
<tr>
<td>Honduras</td>
<td>1,250</td>
<td>81.0%</td>
<td>0.4%</td>
<td>17.5%</td>
</tr>
<tr>
<td>Brazil</td>
<td>1,220</td>
<td>77.0%</td>
<td>39.4%</td>
<td>62.6%</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>745</td>
<td>73.2%</td>
<td>0.0%</td>
<td>35.4%</td>
</tr>
<tr>
<td>Guatemala</td>
<td>650</td>
<td>95.4%</td>
<td>10.4%</td>
<td>37.1%</td>
</tr>
<tr>
<td>Phillippines</td>
<td>500</td>
<td>72.1%</td>
<td>0.0%</td>
<td>11.0%</td>
</tr>
<tr>
<td>Peru</td>
<td>475</td>
<td>87.0%</td>
<td>53.1%</td>
<td>86.5%</td>
</tr>
<tr>
<td>Mexico</td>
<td>461</td>
<td>97.8%</td>
<td>1.6%</td>
<td>9.0%</td>
</tr>
<tr>
<td>Venezuela</td>
<td>270</td>
<td>90.0%</td>
<td>0.0%</td>
<td>52.1%</td>
</tr>
<tr>
<td>Dominican Republic</td>
<td>170</td>
<td>94.1%</td>
<td>0.0%</td>
<td>18.9%</td>
</tr>
</tbody>
</table>

### Figure 2:

A palm oil plantation on the left and forest on the right. This area represents roughly 0.01 km² (or two football fields). Satellite images like this can be used to determine how people use the land, e.g. if it is natural forest or man-made palm plantation. The conversion of natural forests to man-made plantations is an example of land use change.

### Methods

The Food and Agriculture Organization of the United Nations (FAO) provides estimates of the area used for palm plantations for each country. We want to know how much of this area came from recent deforestation and how much was converted from other types of agriculture to palm oil. To do so, we compared satellite images (like Fig. 2) from 2013-2014 to those from three older time periods: 1984-1990, 1994-2000, and 2004-2010.

The next step was to determine what additional areas might be suitable for oil palm plantations, both now and in the future. We can predict reasonably well the suitability of a site for oil palms based on the climate (for example, temperature and precipitation), and soil nutrients. We input the palm trees’ requirements and the climate projections into a computer program simulating the real world, called a scientific model. We ran a model, created by the FAO, using current and future climates (Step 1 in Fig. 3).

We then mapped global forest areas as well as protected
areas within the oil palm suitable area. This way we could show which forests are more vulnerable to deforestation (all green, dark blue, red, and purple areas in Step 2 in Fig. 3). We wanted to know which of the vulnerable forests should be our priorities for conservation. So we looked at the ranges of many species to determine which vulnerable forests have the highest numbers of IUCN threatened mammals and birds (all red, blue, and purple areas Step 2 in Fig. 3). The overlapping areas would be very high priority for wildlife conservation.

Figure 3:
Top: predictions of the areas where oil palms could be grown, or “suitable” areas for palm plantations (light blue). Bottom: areas that are palm-suitable and overlap with forests (all green, dark blue, red, and purple areas), regions with numerous mammal species (dark blue), numerous bird species (red), or both numerous mammal and bird species (purple). Keep in mind that the bottom figure shows just the very highest biodiversity areas for threatened mammals and birds globally. ALL tropical forests are generally very biodiverse, so the areas highlighted in the figure are not the only areas to worry about!

Results

Countries in tropical regions across the world - Asia, Africa, Central and South America - have seen dramatic increases in palm plantations (Table 1, second column). In some cases, e.g. Indonesia, Malaysia, Ecuador and Peru, most of the plantations are on land deforested since 1990 (third column in Table 1). Probably oil palm was the cause of much of this deforestation.
For other countries, like Thailand, Philippines, Ghana, the Democratic Republic of Congo, Colombia, Venezuela, Honduras, Costa Rica, Mexico, and the Dominican Republic, we detected little deforestation despite a dramatic increase in palm plantations (third column in Table 1). In these cases, oil palm may not be a direct driver of deforestation.

We found that Peru, the Democratic Republic of Congo, Ecuador, and Brazil have the largest percent of vulnerable forest (>60%) (fourth column in Table 1).

Figure 3 shows the areas suitable for palm plantations that also have high biodiversity. They include large parts of Indonesia, Malaysia, Papua New Guinea, and Brazil (particularly in the Amazon). New palm plantations in South America could threaten species like the Little Woodstar (a hummingbird smaller than your pinky finger!), the largest species of armadillo, and numerous brightly-colored poison frogs.

Discussion

Our estimates of deforestation for palm plantations are similar to those of other studies which estimated 56% deforestation in Indonesia and 55-59% in Malaysia (compare to Table 1). Understanding why different methods provide different results would be an important topic for future studies.

Studying different regions, we found distinct trends in each one:

1. In South America and Southeast Asia, increases of palm plantations led to deforestation,
2. unlike in Africa and Central America where increasing palm plantations did not.
3. We noticed that Mexico and Central American countries also did not cut down forest to make room for palm plantations (Table 1, third column). The most likely explanation for this is that plantations there emerged on lands already cleared for agriculture or pasture (which may explain some low deforestation rates elsewhere in the world too). Simply, the forest had already been cut before oil palm became a big commodity.

Further studies could explore whether Central American countries (such as Costa Rica, with its thriving ecotourism trade) have policies that may have helped prevent deforestation over the last 30 years. Or it might just be that there is a lack of roads and machinery, hard-to-access terrain or maybe some cultural reasons. This may also explain why some countries that have a lot of areas that could support palm plantations do not currently grow much oil palm (Venezuela, for example).

Regardless of whether deforestation occurred recently or decades ago, areas used for palm plantations are no longer suitable habitat for many plant and animal species. Scientists are working hard to understand how best to protect forests and biodiversity in the tropics.

Conclusion

If you avoid buying products containing palm oil you could be helping protect wildlife! However, buying palm-oil-free groceries is almost as difficult as avoiding the plastic packaging these products come in! We can make a difference by raising awareness about environmental impact of palm oil production.

If enough people take notice and call for change, we can actually influence companies and governments to protect forests from further deforestation. Check the scorecard in the list of references to find out which companies are making efforts to stop purchasing palm oil that comes from deforestation.
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Glossary of Key Terms

**Anthropogenic** – caused by human activity.

**Biodiversity** – the variety of life in a particular area. This is typically the number of species (also called species richness). Usually, a particular group of species is being discussed: birds, mammals, plants, etc.

**Carbon** – a ubiquitous element on Earth, stored in the atmosphere as CO₂ (2%), in plants and soils (5%), in fossil fuels (8%, which is carbon that got buried from long dead plants and animals), and in the oceans (85%). By burning fossil fuels and cutting down forests, humans are putting more carbon into the atmosphere and making the world warmer.

**Climate change** – a change in the average and variability in weather conditions (not to be confused with weather, which is a temporary state - hot, cold, cloudy, rainy - of the atmosphere). Scientists overwhelmingly agree that the observed increase in temperature of 0.8 degrees Celsius (1.4 degrees Fahrenheit) since 1980 is due to the release of greenhouse gases by human activities.

**Deforestation** – cutting down trees, or reducing the amount of forests in the world.

**IUCN** – International Union for the Conservation of Nature is the premier international organization working on global conservation through data gathering and analysis, research, advocacy, lobbying, and education. For species with enough data to make a distinction, the IUCN is the authority on listing species extinction vulnerability: Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened, Conservation Dependent, and Least Concern. These categories are primarily based on species’ population sizes and trends and the rate of potential recovery. The 35-member-country Organization for Economic Cooperation and Development (OECD) provides 61% of IUCN funding.

**Greenhouse gas** – a gas, like CO₂, that absorbs infrared (heat) radiation from the sun, contributing to the greenhouse effect (the process by which a planet’s atmosphere warms the plant’s surface to a temperature above what it would be without the atmosphere).

**Land Use Change** – a process by which human activities transform the landscape.

**Protected Areas** – any location that receives protection because of its recognized natural, ecological or cultural value.

**Scientific model** – a model is a simple representation of a thing or system. A paper airplane is a very simple model of a Boeing 747. The simpler the model, the fewer the details that it can incorporate. Models can be material (like the paper airplane), conceptual, or mathematical. A scientific model uses our knowledge of natural processes to predict outcomes, make hypotheses, and explain phenomena.

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http://www.worldwildlife.org/pages/which-everyday-products-contain-palm-oil

Palm Oil Scorecard (Union of Concerned Scientists):


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Check your understanding

1. What is up with Mexico? Why has there been an increase in palm oil plantations without deforestation in Mexico?

2. Think more about how the suitability model works. What climate variables should they consider?

3. What is a model? Give examples of material, conceptual, and mathematical models.

4. Guess how many species of plants, reptiles, amphibians, mammals, birds, insects, and fish there are in the world. Look these numbers up on the internet, paying attention to the website where you recorded the number. Compare numbers among classmates. Do they vary (see question 5). Are all sources of information on the internet equally reliable?

5. Why might it be hard to get estimates of biodiversity? Which groups of species might be harder than others?

6. Why might some countries with high suitability to palm oil might not have a lot of plantations? The study lists some reasons, but can you think of more?

7. How many orangutans are left? Bornean elephants? Sumatran tigers? What is their IUCN status? What other species are at risk due to palm oil in Southeast Asia? South America? Central America? Africa?

8. What is an average and variability? Give an example of average and variability in real life.