Deforestation exposure of US direct imports from October 2021 to November 2023

March 2024

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Trase is a data-driven transparency initiative that revolutionises our understanding of the international trade and financing of agricultural commodities which drive tropical deforestation. Its unique supply chain mapping capabilities bring together disparate, publicly available data to connect consumer markets to deforestation and other impacts in producer countries. Trase’s free online tools and actionable intelligence enable governments, companies, financial institutions and civil society organisations to take practical steps to address deforestation. Trase is a not-for-profit partnership founded in 2015 by the Stockholm Environment Institute and Global Canopy. trase.earth.

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Background

This document sets out the methods and analysis used to explore the exposure of the United States to tropical and subtropical deforestation via its direct imports of seven high-risk commodities between October 2021 and November 2023. It was prepared by Trase (a collaboration between Global Canopy and the Stockholm Environment Institute) at the request of Global Witness in February 2024.

Key findings

- In the time period covered by this assessment (October 2021 to November 2023 inclusive), the United States’ direct imports of seven forest risk commodities were exposed to at least 122,800 hectares (ha) of tropical and subtropical deforestation. This is an area comparable in size to the city of Los Angeles.

- Three quarters (75.4%, or 92,600 ha) of this exposure came from the five commodities specified in the FOREST Act (palm oil, cattle products, soybeans, cocoa and rubber). A further 24.2% (29,700 ha) came from coffee imports, and a smaller amount (0.4%, 459 ha) came from corn imports, neither of which are currently covered by the regulation.

- The highest risk commodities are palm oil, cattle products and coffee, with respective deforestation exposure estimates of 41,500 ha (34%), 39,100 ha (32%) and 29,700 ha (24.2%). These are followed by cocoa (9,300 ha, 7.6%), soybeans (2,500 ha, 2%), corn (459 ha, 0.37%) and rubber (179 ha, 0.15%).

- The top four producer countries associated with this deforestation exposure are Indonesia (41,000 ha, 33%), Colombia (23,200 ha, 19%), Brazil (22,200 ha, 18%) and Australia (11,800 ha, 10%). Together, these countries make up 80% of the United States’ potential deforestation exposure linked to direct imports of these commodities.

- These numbers are likely to be an underestimate, particularly for palm oil and rubber, since (due to the detail available in trade records) it was not possible to include commodities imported in more processed forms (such as palm oil in processed and manufactured goods, or processed rubber products such as tyres). A more complex model-based approach that captures the deforestation associated with the United States’ total consumption activity would likely produce a higher estimate, as would analyses that extend to non-tropical regions. For example, in 2021 alone (the most recent year for which such analysis is available via: www.commodityfootprints.earth), US consumption is estimated to be linked to 85,000 ha of overseas (tropical and non-tropical) deforestation from these same seven commodities.
Results

Between October 2021 and November 2023, the United States’ total exposure to tropical and subtropical deforestation from its direct imports of seven high-risk commodities is estimated at 122,800 hectares.

Most important commodities overall

Oil palm was the most significant contributor to this at 41,500 hectares, making up 33.8% of the US’ total exposure from these commodities (Figure 1). The vast majority of this exposure was from Indonesia (95.4% of the oil palm total), with smaller contributions from Colombia (3%) and Malaysia (1.5%). Overall, cattle products were second-most important (39,100 ha, 31.8%), with exposure concentrated in Brazil, Australia and Mexico. In third place was coffee (29,700 ha; 24.2%), followed by cocoa (9,320 ha; 7.6%), soya (2,500 ha, 2.0%), corn (459 ha, 0.37%) and rubber (179 ha, 0.15%).

Figure 1: Deforestation exposure of US direct imports between October 2021 and November 2023, for the five ‘covered commodities’, plus coffee and corn. Numbers show the totals for each commodity. The top ten origin countries across all seven commodities are shown individually coloured, all other countries are grouped together in the grey ‘other’ category. Trade of these commodities in more processed or ‘derived’ forms were included wherever possible, but exclusions due to an inability to confidently track imports to source commodities within trade statistics classification schemes mean these values should be seen as a conservative estimate of the US’ total direct trade exposure, especially for oil palm and rubber which are often imported in more processed forms that were not possible to include here. The value for rubber captures the trade of the ‘primary’ harvested commodity only, and attributing deforestation to rubber is also more challenging, so this is particularly likely to be an underestimate of the US’ links to deforestation. Note that this direct trade view does not capture tropical deforestation from commodities imported indirectly via other countries.

Only five of these commodities are currently specified in the Act as ‘covered commodities’, with coffee and corn not included. These excluded products make up 24.6% of the total exposure identified here, with coffee making up the vast majority of this. Including coffee in the assessment (in addition to the five already covered) increases the US’ exposure to tropical deforestation by 32%.
The estimated exposure from rubber imports was low (179 ha), although this is likely to be an underestimate (see Methods). The most important origin countries for rubber deforestation exposure were Vietnam (62.1%) and Thailand (19.1%).

**Most important countries overall**

Indonesia was the largest source of deforestation exposure for US imports by a substantial margin (41,000 ha, 33.4% of the total) (Figure 2), followed by Colombia (23,200 ha, 18.9%) and Brazil (22,200 ha, 18.0%). Together, these top three countries account for 70.3% of the US’ deforestation exposure, and adding in Australia takes the figure to 80.0%. Remaining countries that make up the top ten are concentrated in Central and South America (Mexico, Peru, Ecuador, Nicaragua and Honduras), with only one African country, Côte d’Ivoire, making the top ten.

For most origin countries, a single commodity dominates the US’ deforestation exposure profile. For Indonesia, oil palm dominates the US’ exposure (96.7%), along with relatively small contributions from cocoa (2.0%) and coffee (1.3%). For Colombia, the exposure is mostly from coffee (93.8%) with a smaller amount from oil palm (5.4%). For Brazil, cattle products dominate the picture (91.8%) with smaller contributions from soya (3.6%), coffee (2%) and corn (1.6%). Cattle products were the only commodities exposing the US to deforestation in Australia, Mexico and Nicaragua, while exposure in Côte d’Ivoire and Ecuador was solely due to cocoa imports. In Peru, the US’ exposure was split between coffee (69%) and cocoa (30.9%).

![Figure 2: Most important origin countries for US deforestation exposure from direct imports of seven high-risk commodities (October 2021 to November 2023). Numbers show the totals for each country. The top ten origin countries across all seven commodities are shown, all other countries are grouped together in the ‘other’ bar at the bottom of the chart. Bars are broken down into different colours according to the commodity responsible for the deforestation.](image-url)
Direct trade vs total consumption

As discussed in more detail in the methods below, the direct trade results summarised above provide one fairly narrow view of the US’ links to tropical and subtropical deforestation. SEI York have also developed a means of assessing links to deforestation from a ‘consumption-based’ perspective, which combines trade data with global inter-sectoral financial flows to understand how countries’ final consumption is linked to environmental impacts such as deforestation. Because this captures US demand for more processed products and ‘embedded’ sources of deforestation exposure, and because the US is a net importer of more processed products, the US’ exposure is likely to be larger from this perspective. For example, in 2021 alone US consumption was linked to 85,000 hectares of deforestation from the same seven commodities. The most recent update to SEI York’s consumption-based measure also includes non-tropical sources of deforestation (only tropical and subtropical estimates are included in our direct trade estimates above) but whilst therefore not directly comparable, scaling down the total from the direct trade analysis to an ‘annual equivalent’ equates to a total of around 56,700 hectares, suggesting that taking a consumption-based perspective could significantly increase estimates of the US’ total exposure to deforestation. More information about this approach and further commodity-specific detail on the impacts of US consumption can be found at https://commodityfootprints.earth/.

Overview of approach and methods

We considered the US’ imports of seven forest-risk commodities, selected to follow those covered by 2023 FOREST Act (palm oil, soybeans, cattle products, cocoa and rubber), plus two not currently covered by the legislation: coffee and corn. We obtained trade records from UN Comtrade covering these commodities over the time period since the FOREST Act was introduced (October 2021) up to the more recent November 2023 Act, and for each import record, estimated their exposure to tropical and subtropical deforestation using the latest available globally-relevant, country-specific and commodity-specific estimates of deforestation per tonne of production. We used the most recently published deforestation statistics of this nature, covering the period 2016–2018, which we extrapolated to the time period covered by the trade records. For this relatively simple and narrow ‘direct trade’ view, we make the assumption that commodities were produced in the countries they were imported from (e.g. that a shipment of soybean cake from Brazil was produced from soybeans grown and crushed in Brazil).

It is important to note that this analysis covers the US’ exposure via direct imports only; for example, the palm oil directly shipped from Indonesia to the US. The US is likely also to be exposed to tropical deforestation from products imported indirectly via other countries, such as West African cocoa that is processed into cocoa powder in the Netherlands before being imported into the US, but this is not captured in this direct trade perspective. Similarly, any deforestation exposure from commodities that are in

fact re-exported after initial import to the US will remain in the US’ exposure from this direct trade approach. SEI has developed methods to account for these re-export flows based on FAO’s global trade and supply utilisation statistics, which we have presented in analyses on Germany’s⁵ and Belgium’s⁶ commodity imports using FAOSTAT data. The data required for this analysis currently only cover a period up to the end of 2021.

Even after adjusting for re-exports, this approach fails to capture the US’ deforestation exposure from more complex supply chains, e.g. where deforestation is ‘embedded’ in products where the forest-risk commodity is not necessarily even an ingredient. For example, the US may be exposed to deforestation from Brazilian soy that was fed to cattle in Italy to produce leather goods destined for the US market. As mentioned above, SEI has developed a more complex model-based approach that captures these more indirect and embedded forms of deforestation exposure linked to final consumption. For comparison, we have also provided the US’ deforestation exposure from this consumption-based approach for 2021, along with an ‘annual equivalent’ version of the direct trade results that are the focus of this analysis and report, but noting that the scope of deforestation covered is different given the inclusion of non-tropical sources in the consumption-based data.

The direct trade perspective presented here is therefore one, somewhat narrow, way of understanding the US’ links to deforestation. However, it is a relatively transparent and data-driven (rather than modelling-driven) approach, and arguably reveals the trade flows over which the US has the most ability to exert more direct influence via policy decisions.

Methods detail

Commodity coverage

The commodities included in this analysis follow those included in the 2023 FOREST Act, as well as selected coffee and corn products through which the US may also be exposed to deforestation. The Act covers selected Harmonised System (HS) codes of cattle, soy, palm oil, cocoa, and rubber, as well as those of some products derived from these commodities (such as chocolate bars derived from cocoa). The full list of covered commodities (HS codes) relevant for the Act is available here. We sought to include every HS code covered by the Act in this analysis, although this was not always possible: we needed to be able to link the commodities in the trade records back to the primary commodities in the deforestation attribution dataset. This is possible where the links between more ‘derived’ commodities and their harvested form are clear, and an equivalence factor to connect them can be calculated (see section below on calculating primary commodity equivalents). For example, we were able to include the trade of soybean oil and soybean cake as derivatives of raw soybeans, or palm oil and palm kernels as a derivative of oil palm fruit. However, we were not able to include imports of more processed products included in the Act (such as ‘chocolate and other food


preparations containing cocoa’, or the oil palm derivative ‘palmitic acid’, for example) because there is no information available within trade data to specify the cocoa-content which may vary within a single product code.

A full list of commodities and HS codes that were included, and also a list of HS codes that are relevant under the FOREST Act but excluded from this analysis, is provided in the accompanying Data and Annex file.

This analysis should therefore be considered a conservative (i.e. under-)estimate of the deforestation associated with US direct imports of the relevant commodities. It is perhaps most likely to underestimate the US’ deforestation exposure from palm oil and rubber, which are often imported in more processed forms that we were unable to link to deforestation in this analysis. Rubber is particularly likely to be an underestimate since we were only able to include the trade of the primary commodity (Natural rubber, whether or not prevulcanised, HS code 400110).

Trade data

Data on imports of the above commodities were downloaded from the UN Comtrade database API7 using R package comtradr8. These data provide annual and monthly records of global imports and exports, with information on the trade monetary value, quantity, and origin/destination country for each HS code. Import records were downloaded for the HS codes detailed in Annex 1, summarised by commodity code and origin country, for the period October 2021 to November 2023 inclusive. For records for the year 2022, a significant number of those available at the monthly level were flagged as having estimated (rather than reported) net weight values, which would be associated with greater uncertainty. Since we were including the whole of 2022, and therefore monthly resolution was not required here, instead we downloaded records for 2022 at the annual level. This greatly reduced the overall proportion of trade across the study period that was flagged as being estimated (down from 45% to just 0.17% by net weight).

Calculating trade quantities in primary commodity equivalents

Because many commodities are traded in more processed forms, rather than in their harvested or ‘primary’ form, and because the deforestation attribution data from Pendrill et al. includes primary forms only, we needed to calculate the trade quantities of these ‘derived’ commodities in ‘primary commodity equivalents’. Failing to do so, and just relying on the trade quantities of these derivatives as stated in the import records, would underestimate the amount of deforestation where the raw commodity has become more concentrated in its derived forms or where processing steps result in loss of the primary commodity via waste.

For a given HS code from trade data, this was done by identifying the relevant commodity in FAO commodity classification and calculating an appropriate ‘primary
commodity equivalence factor’ according to information on the processing of primary commodities provided by FAO ‘Commodity Tree’ documentation9 (an example is provided below). We could then calculate the trade quantity in primary commodity equivalents by simply multiplying the trade quantity for each import record by the relevant equivalence factor.

For a given processing step, equivalence factors were calculated using the inverse of the sum of the relevant Technical Conversion Factors in the FAO documentation. This accounts for the concentration of raw commodity in more processed forms or the loss of primary commodity in processing steps as waste, but avoids double counting the primary commodity where processing steps result in multiple traded commodities. For example, when oil palm fruit is processed, on average 75% of the mass of the original fruit is lost (see Fig 1), while 19% is retained as palm oil and 6% is retained as palm kernels, resulting in an equivalence factor of 4 (i.e. 1 / (0.19 + 0.06) ). In other words, to produce one tonne of palm oil and palm kernels (split in their appropriate ratios), four tonnes of oil palm fruit must have been processed. In the case of soy cake and oil, the primary commodity equivalents are almost identical to the mass of these more processed forms (the equivalence factor is 1.03), since the whole soy bean is used with very little waste.

For an example of a commodity tree (with included conversion factors), see FAO documentation for oil palm fruit (p747). In this case, we considered up to 2nd level derivatives, since all of the 3rd level derivatives may be produced from primary commodities other than oil palm fruit (hence the ‘ex’ in the commodity tree diagram), and because multiple possible ‘paths’ back to the the primary commodity (via oil of palm kernels, or oil of palm) make the link back to the primary commodity unclear.

These equivalence factors were used for as many derived commodities as possible that could be mapped to the HS codes relevant under the FOREST Act. No commodity tree exists for rubber. For rubber, since equivalence factors are likely to be necessary to quantify the amount of rubber harvested to produce tyres, especially given that rubber may be of synthetic or natural origins, we were only able to include the trade of natural rubber in its ‘primary’ form.

See Annex 1 for a full list of included commodities, their ‘primary’ forms matching the FAO commodity classification, and equivalence factors.

Assessing deforestation linked to primary commodity production

Data on the deforestation attributed to particular countries and primary commodities was obtained from Pendrill et al. (2022)10, the most comprehensive and globally consistent published dataset on commodity-driven deforestation. Data are available at the national level and cover dozens of primary commodities matching the FAO commodity classification, for the time period 2005 to 2018. Importantly, this dataset covers tropical and subtropical deforestation only.


We used the Pendrill data to calculate the deforestation intensity of production (hectares per tonne of production) for a given commodity in a given country. We did this by dividing the total amount of deforestation (in hectares) for a given commodity and country by the total amount of production. Production statistics were taken from FAOSTAT\(^{11}\).

Because the Pendrill data only go up to 2018, we calculated an average deforestation intensity value for the three most recent years of available data (2016–2018), in effect extrapolating these deforestation values to the more recent time window considered for the trade data. If deforestation rates have in fact increased or decreased since 2018, this will therefore not be captured in the data presented here. A three year window was selected to balance the need for recency with the potential for year-on-year variability in deforestation.

In some cases, because of more complex trade patterns and re-export behaviour, US imports from a particular country may actually exceed the amount of production in a given year in that country (for example, if a country is an important trade/processing hub but not an important producer). In such cases, applying the deforestation intensity factor to all direct imports would likely misattribute deforestation to that origin country (which is in fact an intermediary country), and violates our simplifying assumption that production has taken place in the origin country of those direct imports. Therefore in such cases, we capped the trade quantity (in raw commodity equivalents) used for the deforestation exposure calculation at the production quantity of the raw commodity. Annual production data was taken from the same source as before (FAOSTAT), which goes up to the year 2022. To match the 26 month period considered in this assessment, this 12 month period was scaled up by a factor of 26/12 to obtain a suitable import quantity cap for applying deforestation intensity factors. Because in most cases imports of a given commodity from a given country are smaller than production, this step only affected the US’ deforestation exposure in a single case (cocoa from Malaysia), where it avoided misallocating large amounts of deforestation to Malaysia (when in fact cocoa production here is low, and the country is re-exporting cocoa products from elsewhere).

**Pendrill deforestation data: interpretation notes and caveats**

It is important to note that the Pendrill dataset does not attribute deforestation to specific crops in a spatially explicit way. This is because finely resolved maps of individual crop types are generally not available at the global scale, meaning that it is not possible to overlay global maps of specific crops with maps of recent deforestation across all relevant deforestation-risk commodities. Instead, the Pendrill deforestation data are derived from a relatively simple ‘land-balance’ model. Observed forest loss (from the Global Land Analysis and Discovery (GLAD) lab in the University of Maryland) is first attributed to different land use types. Here, based on FAO statistical records, cropland expansion first takes place into pastures (where there is any gross pasture loss according to FAO), then into forest loss areas. Plantation forest expansion is also accounted for. In essence, forest loss is attributed across expanding cropland, pasture...
or plantations based on their relative areas of overall increase, capped at total regional forest loss. Cropland-attributed forest loss is further linked to individual crops or crop groups in proportion to their relative expansion in harvested area. Forest loss attributed to pasture is linked to cattle grazing. Generally speaking, the data depends on national-level statistics, although modelling is done at the subnational level for Brazil and Indonesia.

The lack of spatially explicit deforestation attribution adds uncertainty to the Pendrill data, particularly for commodities where national-level statistics on area of production are less likely to be accurate. Rubber, in particular, is likely to be substantially underestimated as a driver of deforestation in the Pendrill data owing to its smallholder-dominated production in small and fragmented areas that are difficult to detect in satellite imagery, leading to underreporting in national crop statistics.

We expect a revised deforestation account from the Chalmers University of Technology that builds upon the Pendrill et al dataset to be available in the coming months. This will extend the time-series to 2022 and include non-tropical deforestation sources (an earlier version of this dataset was used in the commodityfootprints.earth consumption-based estimates referred to above, but has subsequently been revised and – in its unpublished state – was not available for this direct trade analysis). It may be worth re-running results with this newer data when it becomes available.

Calculating the deforestation exposure of US imports

The final step was to take the deforestation intensity values (hectares per tonne) and simply multiply them by the import quantity (tonnes of primary commodity equivalents, capped by the total production in that country). This results in a measure of direct deforestation exposure (in hectares) for a given import record.

Data availability

Data and supporting information (including details of HS code coverage) are available to download at the following link: resources.trase.earth/data/US_FOREST_Act_Annex_1_Data_and_supporting_information.xlsx
Trase was commissioned by Germany's development agency (GIZ) on behalf of the Federal Ministry of Economic Cooperation and Development (BMZ) to assess Germany's association with tropical and subtropical deforestation via its consumption of imported agricultural commodities and products to inform the development of measures to achieve deforestation-free supply chains.

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