DEEP-DIVE ANALYSIS ON AUSTRIA AND INDONESIA MAN-MADE CELLULOSIC FIBER PRODUCTION IMPACTS ON BIODIVERSITY, ECOSYSTEMS, AND LAND

REPORT

EXECUTIVE SUMMARY

Transforming the Fashion Sector with Nature is a two-year project funded by the Global Environment Facility (GEF). Conservation International, a GEF Agency, is partnering with The Fashion Pact to work together in executing this project. By using world-class science, this project aims to better understand and mitigate the fashion industry's impact on biodiversity.

Under this project, deep-dive analyses were conducted by Conservation International, along with the International Union for Conservation of Nature (IUCN), Natural Capital Coalition, and the UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), applying the potential Science Based Targets for Nature (SBTN) metrics for land, ecosystem services, and biodiversity to understand the associated impacts of three key commodity supply chains: **cotton in the United States, leather in Argentina, and viscose in Austria and Indonesia.**

The deep-dive analyses included four metrics, Species Threat Abatement and Restoration (STAR), Ecosystem Integrity Index (EII), the SBTN Land Hub Impact Indicators (Land Hub Indicators), and Ecosystem Services. Each metric modeled a variety of interventions. The STAR metric quantifies the potential opportunity to reduce the risk of species extinction and identify conservation and restoration actions. EII measures the alignment between an area of interest and its natural ecosystem counterpart. The SBTN Land Hub Impact Indicators focus on developing targets for land systems, in both natural and working lands. The Ecosystem Services metric demonstrates the benefits to humans from nature. For this metric, the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST), measured the impact man-made cellulosic fiber has on carbon storage and sequestration, crop pollination, and forestry among others.

Based on these analyses, summary reports were produced for each commodity to support companies looking to set science-based targets for nature and to identify opportunities to strengthen actions and investments for biodiversity and nature-positive outcomes. This report focuses on the findings and recommendations for viscose in Austria and Indonesia; the other reports can be found here.

Supported by: gef

Led by: THE FASHION PACT, CONSERVATION INTERNATIONAL

In partnership with: IUCN, UN environment programme WCMC, SPRING

KEY FINDINGS AND RECOMMENDATIONS

Findings from the analyses detail how man-made cellulosic fiber production impacts biodiversity in Indonesia and Austria. Results range from identifying the top threats to threatened and endangered species, the changes to ecosystem integrity with avoided deforestation[1] interventions and land impacts including forest ecosystem loss and soil erosion, among others. These findings can help companies better understand direct and indirect impacts in sourcing locations and prioritize actions to abate or alleviate impacts to sensitive regions or species.

The **key recommendations from the deep-dive** analysis on man-made cellulosic fiber production underscore the importance of:

1.) establishing supply chain traceability to the plantation, pulp mill, or suppliers at a minimum;

2.) working with suppliers to understand and/or establish zero-deforestation[2] and traceability commitments;

3.) identifying when plantation forest and natural forest logging enter your supply chain, as the harvesting impacts to biodiversity and nature are drastically different between these two pulp systems; and

4.) aligning company commitments and targets with global standards and certifications.

For the purposes of this report, we focused on road-testing these metrics, but these are not the types of scientific steps a company must take. Companies should follow the corporate-friendly guidance from SBTN.

[1] Avoided deforestation is the outcome of actual or anticipated impacts on remaining standing forests if an activity stops or diverts. This includes conversion of natural forest to tree plantations and/or pulp plantations.

[2] Zero-deforestation commitments are the actualized avoided deforestation actions taken or committed to by a party.

DEEP-DIVE ANALYSIS ON AUSTRIA AND INDONESIA MAN-MADE CELLULOSIC FIBER PRODUCTION IMPACTS ON BIODIVERSITY, ECOSYSTEMS, AND LAND

REPORT

INTRODUCTION

The Fashion Pact, a global initiative composed of companies in the fashion and textile industry, has committed to transforming the fashion sector to improve sustainability performance across the entire sector. The Fashion Pact focuses on driving change in three areas: climate, biodiversity, and oceans.

With support from the Global Environment Facility (GEF), Conservation International and The Fashion Pact launched Transforming the Fashion Sector with Nature project, which focuses on using science to better understand and mitigate the fashion industry's impact on biodiversity. Through this initiative, we aim to 1) provide companies across the fashion sector with a foundational understanding of the environmental impacts of the production and extraction of raw materials through deep-dive analyses on key production areas for cotton, leather and man-made cellulosic fiber (MMCF); and 2) support companies across these supply chains to identify opportunities for further action, investment and collaboration through a scenario analysis of potential interventions and outcomes. Together, these outputs can help fashion companies prioritize actions that have the greatest beneficial impacts for biodiversity.

This report is an adaptation of one of the primary outputs of the first objective – a deep-dive analysis of the environmental impacts of man-made cellulosic fiber (viscose) production in Indonesia and Austria. This report uses country-level data to assess biodiversity, land, and ecosystem metrics in key viscose production regions. Companies can use this study to better understand the environmental impacts of their supply chain and inform company commitments and actions to protect, restore or regenerate nature in key production regions.

METHODS

One of the goals of the Transforming the Fashion Sector with Nature GEF project is to align corporate actions with The Science Based Targets Network (SBTN), a collaboration of organizations developing guidance to support companies and cities in setting science based targets for land, freshwater, oceans and biodiversity. As the biodiversity pillar's delivery partner, Conservation International seeks to provide sector-specific guidance on how companies across the fashion and textile industry can apply the developing methods of the SBTN, how those methods can inform corporate sustainability commitments and targets, and the utility of the methods and metrics in measuring the impacts of corporate actions.

In this analysis, Conservation International along with the International Union for Conservation of Nature (IUCN), Natural Capital Project (NatCap), and the UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) conducted a series of deep-dive analyses applying the current SBTN metrics for land, ecosystem services, and biodiversity to viscose supply chain.

The study area was defined by two potential viscose production regions in Indonesia and Austria. To spatially identify pulpwood plantation areas, we used [WRI's Spatial Database of Planted Trees]to outline the extent of wood pulp likely to enter the production of man-made cellulosic fibers (Figure 1, 2). Additionally for Indonesia, along with using pulp plantation maps, and to account for exported pulp not within existing plantation footprints, we created a dataset of recent (2016 - 2020) forest loss in proximity to rivers in convertible forest and production forest zones to better understand where natural forests may enter the supply chain[3]. Rivers can be used to transport forest products to mills, and therefore these adjacent areas can experience a greater amount of forest loss. To account for proximity to rivers, we applied a threshold of areas within 15 km of a river to be included in the relevant zone for production and natural forests. To identify areas at risk due to pulp sourcing, we applied the same set of constraints to the 2020 forest extent[4].

The analyses were conducted using four metrics: the Species Threat Abatement and Restoration Metric (STAR), the Ecosystem Integrity Index (EII), the SBTN Land Hub Impact Indicators, and Ecosystem Services. These metrics were applied to both baseline and intervention scenarios to understand the impacts of sustainability interventions companies are looking to make.

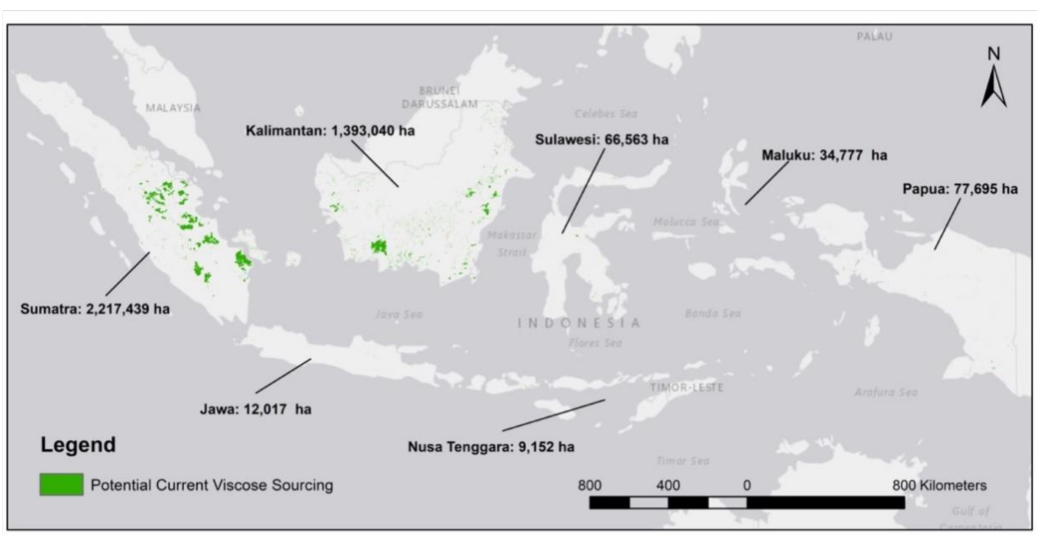


Figure 1. *Potential viscose sourcing areas within Indonesia in green. These areas were derived from pulpwood plantation spatial data and recent forest loss within proximity of rivers.*

[3] Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., Thau, D., Stehman, S. V., Goetz, S. J., Loveland, T. R., Kommareddy, A., Egorov, A., Chini, L., Justice, C. O., & Townshend, J. R. G. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. Science, 342(6160), 850–853. https://doi.org/10.1126/science.1244693

[4] Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., Thau, D., Stehman, S. V., Goetz, S. J., Loveland, T. R., Kommareddy, A., Egorov, A., Chini, L., Justice, C. O., & Townshend, J. R. G. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. Science, 342(6160), 850–853. https://doi.org/10.1126/science.1244693

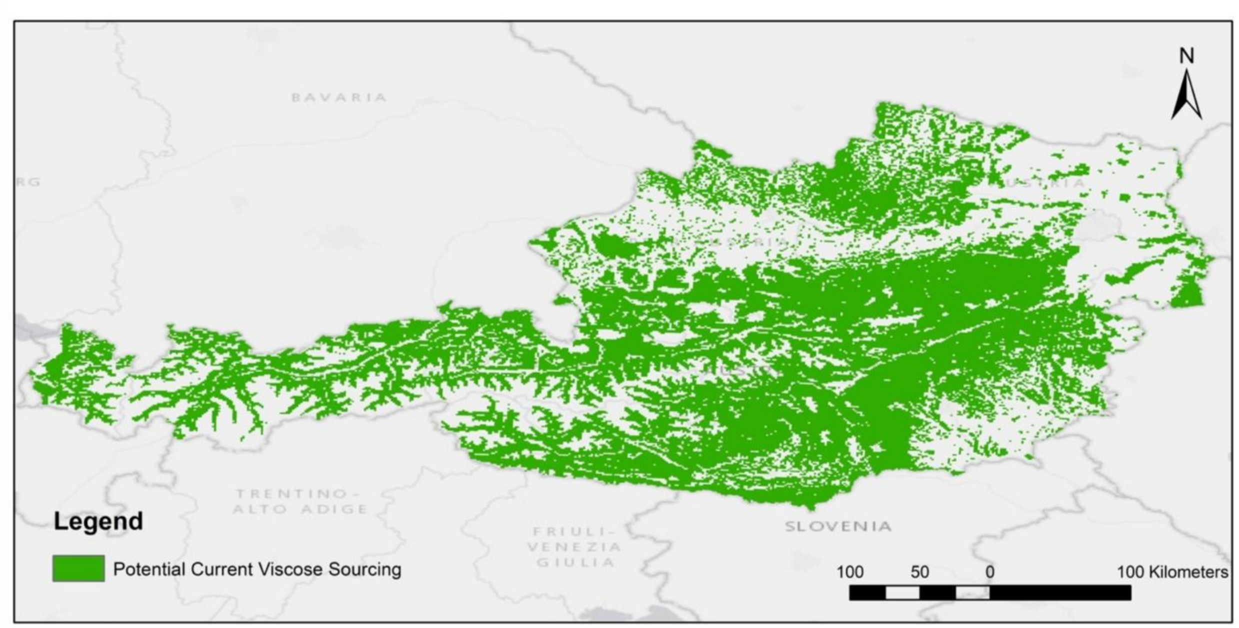


Figure 2. *The potential current viscose sourcing areas within Austria in green. These areas were derived from fiber-producing plantations included in the Spatial Database of Planted Trees.*

STAR: Species Threat Abatement and Restoration Metric

The STAR[5] metric uses data from the IUCN Red List of Threatened Species to quantify the potential opportunity for reducing the risk of species extinction and to identify opportunities and guide conservation and restoration actions (Mair et al 2021)[6]. STAR is a useful metric because it can be used to identify areas where certain actions can abate threats to threatened species or where restoration can help reduce the risk of extinction. The metric currently covers amphibians, birds and mammals, and we added reptiles for this analysis. The metric combines data on species' range (Area of Habitat; AOH), conservation status of species (i.e., Near Threatened, Vulnerable, Endangered and Critically Endangered), and threats from IUCN Red List threats classification scheme (e.g., wood and pulp plantations, oil and gas drilling, agricultural and forestry effluents etc.) to produce two data layers with associated scores on the threat abatement ($STAR_T$) and restoration ($STAR_R$). High $STAR_T$ scores indicate areas where species, individuals, or ecosystems are threatened, indicating key areas for opportunities to reduce threats. High $STAR_R$ scores indicate areas where threatened species habitats have been lost or threatened and can identify key places for restoration.

For the viscose supply chain, we applied a derivative of the STAR metric to the area of interest to assess the level of impact within the current production areas, along with the potential to identify and quantify potential species threat reduction and restoration activities that can reduce species extinction risk. We calculated a score for both species and threats categories to receive an overall score for viscose production and then calculated an overall score if deforestation is avoided.

[5] IUCN STAR Metric

[6] Mair, L., Bennun, L.A., Brooks, T.M. *et al.* A metric for spatially explicit contributions to science-based species targets. *Nat Ecol Evol* 5, 836–844 (2021). https://doi.org/10.1038/s41559-021-01432-0

EII: Ecosystem Integrity Index

The Ecosystem Integrity Index (EII)[7] measures to what degree the area of interest is aligned with characteristics of natural ecosystems using a combination of geospatial layers representing three components:

- Ecosystem Composition – The Biodiversity Intactness Index (BII) summarizes how human pressures change the ecosystem by looking at the percentage of the original species population in an area compared to populations in a natural setting. The impact of human activity on species abundance and the similarity between disturbed ecological communities and their reference sites is calculated. These results are projected onto maps of human pressures (i.e., land use change, population density) to create a map of BII for the area.
- Ecosystem Structure – The structural component of EII includes habitat area, quality, and fragmentation by using multiple input layers including population density, built-up areas, agriculture, roads, railroads, mining, oil wells, and wind turbines and electrical infrastructure.
- Ecosystem Function – This layer includes the interactions between abiotic and biotic components, which describes the ratio between the observed and natural net primary productivity (NPP) level or the rate of production of biomass per land surface. The larger the difference between the observed productivity and natural productivity, the more degradation or loss of ecosystem function.

The three components are rescaled and combined to give a score based on the lowest scores from the ecosystem composition, structure, and function components. The overall EII score can be used to set baselines of ecosystem health in sourcing areas and estimate potential and realized impacts from their supply chain over time.

Land Hub Indicators

The SBTN Land Hub[8] is focused on developing targets for land systems – including both natural ecosystems like forests, grasslands, and woodlands, as well as "working lands" such as pasture and agricultural and the built environment like cities and linear infrastructure. The Land Hub is therefore interested in indicators that both capture change among categories (e.g., from forest to pasture), as well as changes that might occur on land under continual use (e.g., loss of topsoil that might occur in working lands due to poor soil maintenance). To address these impacts through avoidance or reduction of impacts, regeneration, or restoration, the Land Hub identified seven indicators: 1) conversion of native vegetation (forest); 2) conversion of native vegetation (non-forest); 3) infrastructure development; 4) soil organic carbon loss; 5) soil erosion; 6) acidification; 7) biodiversity loss. The Land Hub piloted an assessment tool (CAMEL) for an initial set of commodities. We used pulp production data at the country level in this pilot for six of the seven indicators (infrastructure development is not yet developed).

---

[7] Hill, S. L. L. et al., (2022). The Ecosystem Integrity Index: a novel measure of terrestrial ecosystem integrity with global coverage. bioRxiv 2022.08.21.504707; doi: https://doi.org/10.1101/2022.08.21.504707

[8] SBTN Land Hub

To generate these impact estimates, the CAMEL Tool requires exact amounts of commodity sourcing (e.g., metric tons of chemical pulp) specific to a company's supply chain. In future company specific cases, we can use supply chain data, but since this analysis is at the country-level we examined the impact by i) regional and country-level impacts per metric ton of dissolving wood pulp production, and ii) country-level total impacts from dissolving wood pulp production.

Ecosystem Services

Ecosystem services are the benefits from nature that sustain human life. There are several methodologies to quantify ecosystem services, and, in this study, we used a spatial model that demonstrates ecosystem processes in a mechanistic way. Specifically, we used the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST), a free and open-source software tool developed by the Natural Capital Project, with services including carbon storage and sequestration, crop pollination, crop production, forestry, livestock production, annual and seasonal water yield, coastal risk reduction, sediment retention, nitrogen retention, recreation, and scenic quality. This tool uses land-use/land cover maps to show ecosystem services across a landscape and if an ecosystem is altered the reciprocal impacts it will have on nature and the people who depend on the associated benefits.

Modeled Interventions:

The metrics for viscose measured a variety of interventions including avoided deforestation, the impact on land from wood production and the impacts if expansion is avoided.

	STAR	EII	Land Hub Indicators	Ecosystem Services
Avoided deforestation	x	x		
Land Impacts from wood production			x	
Avoided expansion				x

LIMITATIONS

The metrics used in this analysis provide valuable assessments to companies, especially when deciding where to prioritize efforts and identifying the impact to biodiversity. Across all the metrics , a major limitation is access to supply chain level data. In all cases, the more granular data the more accurate the analysis. Each metric has limitations and nuances that are important to note, though this list is not exhaustive of all known limitations. STAR values are directly dependent on the total area that is assessed (i.e., the larger the areas, the more species at threat) but do not consider other factors such as the production practices or the production yields. This metric is also just focused on terrestrial vertebrates (amphibians, birds, mammals, reptiles) and insects and aquatic species, which are not accounted for in the metric. Having access to spatially explicit data to determine the impact on biodiversity is key to STAR, and without that level of detail, the metric remains more general.

EII is limited by mismatched data resolution for the required datasets. Although by global standards EII may be considered high resolution at ~1km^2, when compared to some local datasets that are tens of meters the resolution is mismatched and may result in transforming the data.

For the Land Hub Indicators, the CAMEL tool could provide more robust and exact estimates with additional supply chain data, and similar to STAR cannot easily capture changes to production practices. Currently, CAMEL tool only represents plantation systems in the tropics, meanings that any land impact results for tropical areas should be assumed to be an underestimate, again highlighting the importance of understand which pulp comes from plantation systems and which comes from natural forest logging.

FINDINGS AND RECOMMENDATIONS

These findings focus specifically on the impacts viscose production and deforestation have on biodiversity and natural ecosystems. Deforestation is defined as replacing natural forests with an alternative land use or land cover. It is important to note that the majority of forest loss and deforestation is driven by the conversion of remaining standing forests to plantations, including pulp production plantations.

INDONESIA

STAR

Impacts

Each threat received a score based on its contributions to the $STAR_T$ score, with logging and wood harvesting ranking second and wood and pulp plantations rank fifth for threats for Indonesia pulp production regions (Figure 3.). Given the high percentage of threats associated with pulp production, pulp sourcing likely has a negative impact on biodiversity in Indonesia.

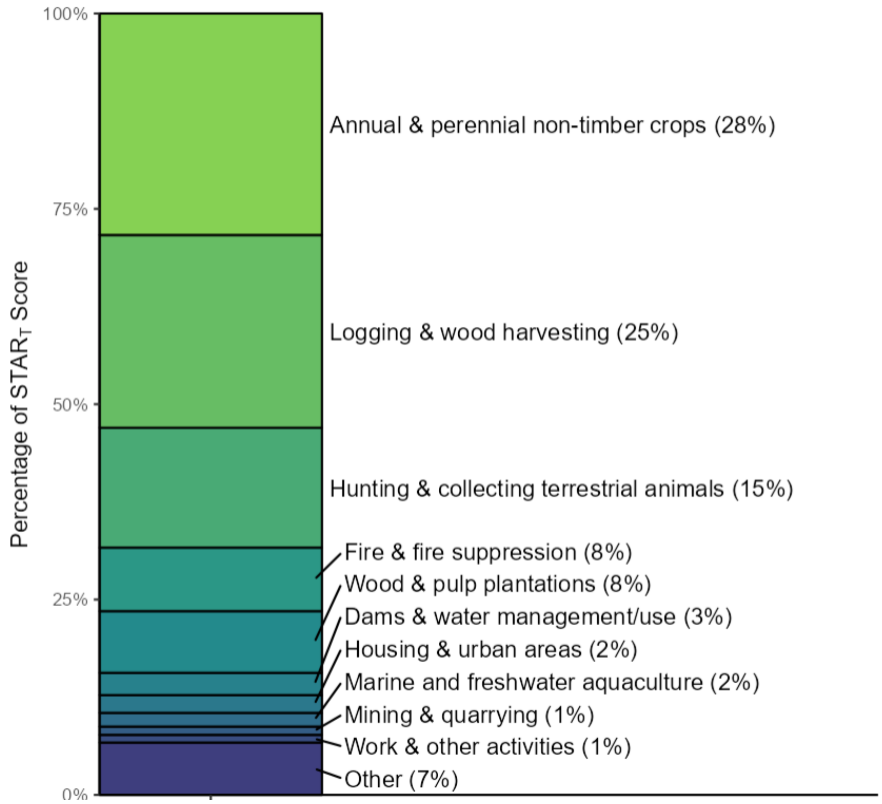


Figure 3. *Contribution of threats to $STAR_T$ score for viscose production in Indonesia*

In Indonesia, the threats of logging and wood harvesting (25%) and wood and pulp production (8%), impact a variety of species. The species with the highest threats are: Yellow-handed Mitered Langur (*Presbytis melalophos*), the Agile Gibbon (*Hylobates agilis*), and the Storm's Stork (*Ciconia stormi*), among several more species (highest contributors to STAR across all threat categories) (Figure 4).

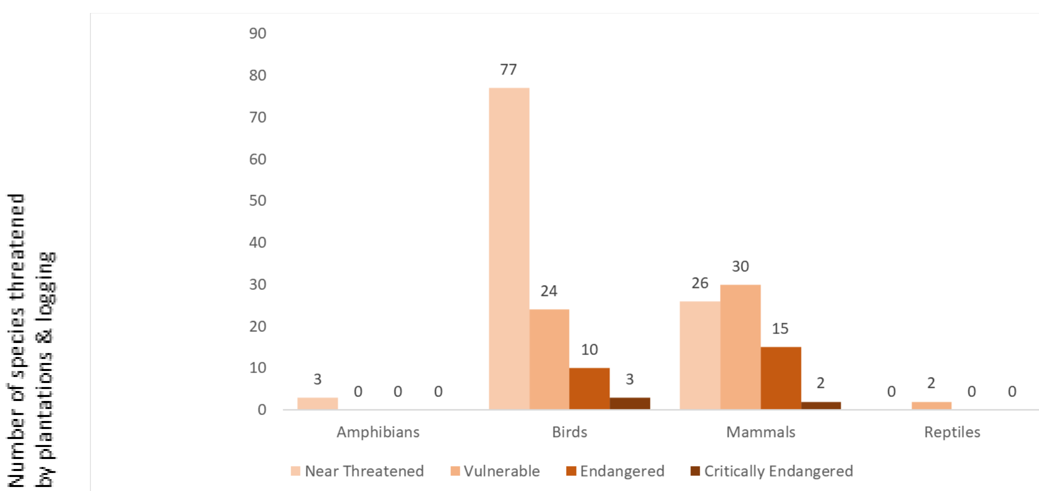


Figure 4. *Viscose production in Indonesia present threats to the following species categories (see appendix for full species list for Indonesia) from the STAR metric*

Interventions

STAR modeled avoided deforestation intervention. By expanding the range of production in Indonesia, the contributions to the STAR score and species impacted changed significantly, with additional species threatened by expansion along with a higher STAR score. To further explore this score, additional information is needed on future sourcing to better understand which species could be most impacted.

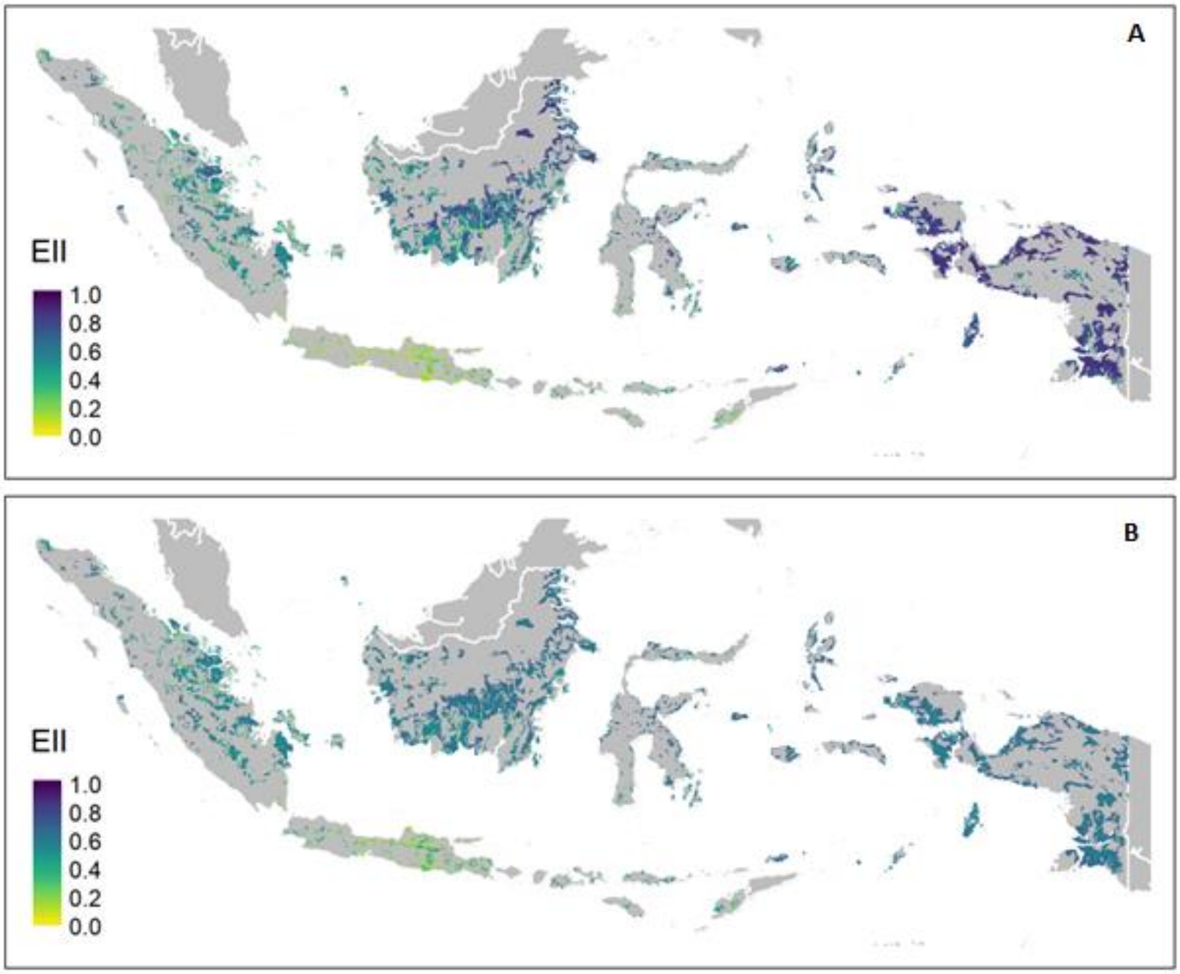
EII

Impacts

The EII metric score ranges from 0-1, with scores from 0.8 – 1 indicating a healthy, natural ecosystem. For Indonesia's current production landscapes, the mean EII score is 0.57. This means that either the viscose production landscapes vary between healthy, natural ecosystems and severely degraded, though the driver of the degradation is unknown without further detailed study.

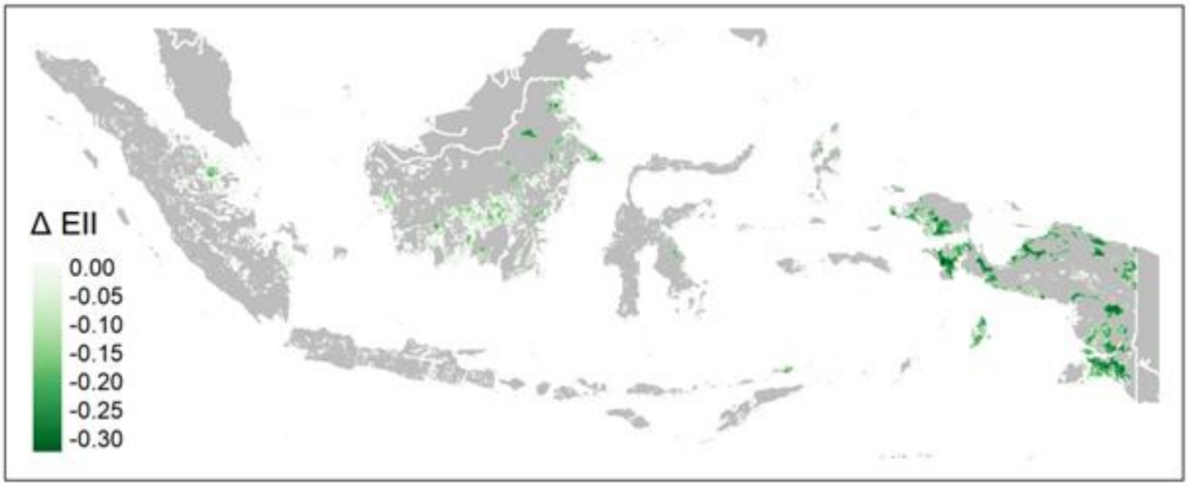
Interventions

In an avoided deforestation scenario, if all areas currently predicted to be deforested are instead protected through zero-deforestation commitment actions, the mean EII would be 0.611. If deforested, the EII is 0.576. If the intervention is implemented, it would mean forest avoidance would lead to a 6.1% EII increase (Fig 6.). Importantly, forests protected that would most greatly contribute to ecosystem integrity are represented in dark green in Figure 7, with eastern Indonesia showing the largest benefits to enacting zero-deforestation commitments for ecosystem integrity.



Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Figure 6. *(A. Intervention) EII of current viscose footprint with areas predicted to be deforested that are instead left intact, and (B. No Intervention) deforestation occurring in predicted areas.*



Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Figure 7. *Map showing change in EII between scenarios of preservation of natural forest and deforestation in predicted areas*

Land Hub Indicators

Biomass sourcing for dissolving wood pulp production in Indonesia comes from both pulpwood producing plantations as well as clearcutting of natural forest during the conversion of forest to other land uses (e.g., oil palm). Approximately 87% of pulp production (including dissolving wood pulp) is derived from plantation forests, whereas the remainder is likely sourced from clear-cut natural forests.[9]

Here, we only estimate the impacts from hardwood plantation forests given that the Land Hub CAMEL Tool does not provide a means to calculate impacts from clearcutting of natural tropical forests. It is important to note that not including impacts of natural forest loss is likely underestimating impacts across CAMEL indicators, and especially, for example, with biodiversity loss.

Average and total country-level impacts

We estimated total impacts associated with dissolving wood pulp production in Indonesia. To do so, we first derived province-level impacts using the CAMEL Tool. The tool does not directly estimate impacts for dissolving wood pulp production, so we calculated this based on production efficiencies and the percentage of Indonesia's plantation forests in each province using the WRI Spatial Database of Planted Trees. We used these province-level percentages to weight the state-level impact estimates. We summed values for regionally-weighted estimates for each indicator (Table 2 – WEIGHTED row). Land occupation, soil erosion, and soil organic carbon loss show the largest differences across Indonesia's production provinces.

[9] Trase.earth - https://www.trase.earth/

Lastly, we estimated the total impacts from dissolving wood pulp production in Indonesia. Per the FAOSTAT database, Indonesia produced a total of 567,786 Mg of dissolving wood pulp in 2020. We used this value and our regionally-weighted country-level impacts to estimate the total country-level impacts from dissolving wood pulp production in Indonesia (Table 2 – TOTAL IMPACTS). Each year there is a total loss of approximately 10,000 hectares of forest and three million metric tons of soil erosion due to pulp production.

Table 2. *Region-specific impacts per 1 Mg of Dissolving Wood Pulp production and region-weighted country-level average impacts and total impacts from Dissolving Wood Pulp production in Indonesia.*

	Weight	Land Occu-pation [ha.yr]	Soil erosion [Mg/yr]	SOC loss [Mg C/yr]	Forest loss [ha/yr]	Non-forest loss [ha/yr]	Eutrophi-cation [mol N eq/yr]	Acidifi-cation [mol H+ eq/yr]	Potential Species Loss [PDF*yr/yr]
Region-specific Impacts per 1 Mg of Dissolving Wood Pulp production									
Bali	0.000	0.36	25.16	0.39	0.02	0.00	1.16	0.33	3.78E-08
Bangka Belitung	0.000	0.70	2.33	0.05	0.01	0.02	1.16	0.33	1.53E-08
Banten	0.000	0.44	8.49	0.12	0.02	0.00	1.16	0.33	6.41E-08
Bengkulu	0.000	0.37	13.32	0.24	0.02	0.00	1.16	0.33	3.25E-08
Jambi	0.130	0.39	13.12	0.24	0.02	0.00	1.16	0.33	2.60E-08
Jawa Barat	0.008	0.38	8.65	0.14	0.02	0.00	1.16	0.33	8.06E-08
Jawa Tengah	0.002	0.41	6.51	0.11	0.02	0.00	1.16	0.33	7.71E-08
Jawa Timur	0.002	0.39	16.33	0.22	0.02	0.00	1.16	0.33	3.48E-08
Kalimantan Barat	0.019	0.48	1.56	0.02	0.02	0.00	1.16	0.33	1.77E-08
Kalimantan Selatan	0.009	0.49	19.11	0.27	0.01	0.01	1.16	0.33	1.32E-08
Kalimantan Tengah	0.141	0.45	6.96	0.11	0.01	0.01	1.16	0.33	1.18E-08
Kalimantan Timur	0.065	0.52	4.15	0.07	0.01	0.01	1.16	0.33	1.22E-08
Riau	0.326	0.45	1.38	0.02	0.02	0.00	1.16	0.33	1.37E-08
Sulawesi Tengah	0.002	0.38	18.72	0.30	0.02	0.00	1.16	0.33	3.13E-08
Sumatera Barat	0.005	0.32	17.94	0.27	0.02	0.00	1.16	0.33	3.33E-08
Sumatera Selatan	0.291	0.89	3.35	0.06	0.02	0.01	1.16	0.33	1.56E-08
Sumatera Utara	0.020	0.39	14.70	0.19	0.01	0.00	1.16	0.33	1.66E-08
Region-Weighted Country-Level average impacts and total impacts from dissolving wood production									
WEIGHTED (per 1 Mg DWP)		0.58	5.12	0.09	0.02	0.01	1.19	0.34	1.68E-08
TOTAL IMPACTS (all DWP production [a])		329,593	2,906,076	49,094	10,284	3,089	673,933	191,887	9.51E-03

Ecosystem Services

In Indonesia, the InVEST mapping tool gives several outcomes on current and possible expanded production of viscose and the impacts to ecosystem services. Under current viscose production, there is an 18% decline in sediment retention and a 293% area loss of nitrogen retention, meaning viscose production is having a significant impact on the quality and condition of soil in Indonesia. Current viscose production systems are losing 21% or 91 million metric tons of carbon as compared to baseline. If viscose production in Indonesia avoids expansion, it will result in a 31% improvement to sediment retention and a 68% improvement in nitrogen retention. Additionally, avoiding expansion would save 1.5 billion metric tons of carbon. Current viscose production occurs on 2% of total land area and future viscose could expand to 15% (see appendix for indicator findings for Indonesia).

AUSTRIA

The analyses for Austria are focused on the STAR and Land Hub Indicators impacts and interventions. We focused more heavily on analyzing viscose production impact on Indonesia because of its historically high biodiversity and amount of natural resource extraction and production.

STAR

Impacts

STAR identified the top threats in Austria come from livestock farming and ranching at 64% (Figure 4). The threats related to viscose production, such as wood and pulp production were also accounted for to measure their impact on biodiversity but was far from being the in the top threats to biodiversity for this country.

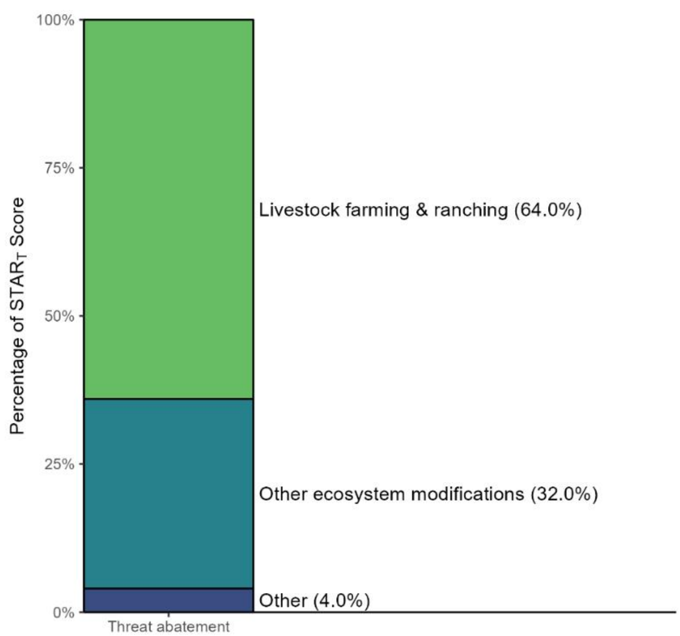


Figure 4. *Contribution of threats to STAR$_T$ for viscose production footprint in Austria.*

In Austria, logging and wood harvesting (0.3%) and wood and pulp production (0.3%) impacted a much smaller list of species, with some of the species impacted including: Great Bustard (*Otis tarda*), the Eastern Imperial Eagle (*Aquila heliaca*), and the European Rabbit (*Oryctolagus cuniculus*) (Table 1).

Table 1. *Threats from viscose production in Austria*

Group	Species	IUCN Red List Category	Logging & Wood Harvesting	Wood & Pulp Plantations
Birds	Saker Falcon	Endangered		x
	Great Bustard	Vulnerable	x	x
	Eastern Imperial Eagle	Vulnerable	x	x
	Red-footed Falcon	Near threatened	x	
Mammals	European Souslik	Endangered		x
	European Rabbit	Endangered		x
	Western Barbastelle	Near threatened	x	
	Bechstein's Myotis	Near threatened	x	x

Land Hub Indicators

Biomass sourcing for dissolving wood pulp production in Austria comes from a well-managed forest estate. Approximately half of Austria is forested, with most forests managed for commercial or multiple uses (including production). Of these productive forests, approximately 54% are believed to naturally regenerate, whereas 46% do not have sufficient natural regeneration and are likely planted.

We used these differences in forest regeneration (i.e., natural regeneration vs. planting) to estimate impacts under two different forest management practices. To do so, we modeled dissolving wood pulp production from both "natural forests" – clearcutting of naturally regenerating forest; and "planted forests" – clearcutting of planted forests managed on rotations > 30 years). We also modeled all roundwood sourcing for pulp production as coming from softwood species given that most commercial forests in Austria are coniferous softwood species (~60%).

Average and total country-level impacts

Similar to our approach for Indonesia, we produced regionally-weighted impact estimates. Using these regionally-weighted impacts, we then estimated the total country-level impacts from dissolving wood pulp production.

We calculated the percent of Austria's productive forests that are found in each state using the WRI Spatial Database of Planted Trees. We summed these values to arrive at regionally-weighted country-level impact estimates (Table 3 – WEIGHTED row).

Per the FAOSTAT database, Austria produced a total of 441,167 Mg of dissolving wood pulp in 2020. We used this value and our regionally-weighted country-level impacts to estimate the total country-level impacts from dissolving wood pulp production in Austria (Table 3 – TOTAL IMPACTS). This shows a total forest loss of 6,484 hectares per year from pulp production and 1.1 metric tons of soil erosion.

Table 3. *Region-specific impacts per 1 Mg of Dissolving Wood Pulp production and region-weighted country-level average impacts and total impacts from Dissolving Wood Pulp production in Austria.*

	Weight	**Land Occu-pation [ha.yr]**	**Soil erosion [Mg/yr]**	**SOC loss [Mg C/yr]**	**Forest loss [ha/yr]**	**Non-forest loss [ha/yr]**	**Eutro-phica-tion [mol N eq/yr]**	**Acidifi-cation [mol H+ eq/yr]**	**Potential Species Loss [PDF*yr/yr]**
Region-specific Impacts per 1 Mg of Dissolving Wood Pulp production									
Burgenland	*0.035*	1.99	0.77	0.01	0.03	0.00	1.57	0.41	4.88E-09
Kärnten	*0.149*	1.80	3.57	0.05	0.01	0.00	1.57	0.41	5.32E-09
Niederösterreich	*0.193*	1.71	1.17	0.01	0.02	0.00	1.57	0.41	4.85E-09
Oberösterreich	*0.128*	1.49	1.53	0.02	0.01	0.00	1.57	0.41	2.02E-09
Salzburg	*0.091*	1.62	3.09	0.04	0.00	0.00	1.57	0.41	2.74E-09
Steiermark	*0.239*	1.91	2.64	0.03	0.02	0.00	1.57	0.41	9.71E-09
Tirol	*0.136*	1.97	4.47	0.06	0.01	0.00	1.57	0.41	5.35E-09
Vorarlberg	*0.028*	1.84	2.76	0.04	0.02	0.00	1.57	0.41	8.57E-09
Region-Weighted Country-Level average impacts and total impacts from dissolving wood production									
WEIGHTED (per 1 Mg DWP)		1.78	2.58	0.03	0.01	0.00	1.57	0.41	5.70E-09
TOTAL IMPACTS (all DWP production [a])		785,515	1,137,801	14,550	6,484	59	691,906	179,553	2.51E-03

[a] 441,167 Mg of dissolved wood pulp production in 2020, per FAOSTAT database.

CONCLUSION AND NEXT STEPS

This deep-dive analysis was conducted for viscose producing regions in Indonesia and Austria. The metrics used in this study can help companies determine production impacts on biodiversity and meaningful interventions to impacts to decrease or avoid additional impacts. STAR identifies key species threatened by activities related to viscose production. This information and this sort of metric is useful to better understand the species directly impacted by production and should be incorporated into relevant management plans associated with those production regions (i.e., avoiding removing areas of natural habitats, riparian protection etc.). This is important from a biodiversity standpoint to ensure that production is not directly impacting critical biodiversity and species, especially those species listed as endangered or critically endangered.

For both Austria and Indonesia, viscose production has an impact on the biodiversity, soil health, forests and carbon loss etc. Regardless of sourcing regions, companies must be acutely aware of their supply chain, have solid traceability of materials, and measure the impact on the ground. In this study, we saw evidence of these impacts. In particular, Indonesia, along with many other pulp producing countries in southeast Asia, is known as a key biodiversity hotspot. If companies obtain supply chain data, direct production impacts can be measured. Wood pulp can be traced to specific plantations[10], and even with general plantation location information, assessing production impacts can be straightforward[11]. To help avert biodiversity loss and stop deforestation related to production, companies must have a granular understanding of their own supply chain while encouraging the sector to work at a larger landscape-level scale to stop deforestation and its associated issues.

As companies analyze their supply chains and identify significant risk areas for biodiversity and forests, it is also important to establish whether existing suppliers have committed to zero-deforestation/conversion commitments. If suppliers are committed to zero-deforestation practices, it will be important to understand what is being implemented and how. For those who have not yet established these types of commitments, we recommend companies work directly with suppliers to impress the importance of such commitments to zero-deforestation/conversion actions. This should include assurances, traceability, and transparency. We suggest using resources such as the Accountability Framework Initiative[12] (AFi), to give suppliers clear and accessible guidelines of best practices to follow when making these commitments. Given viscose production landscapes frequently intersect with areas prone to deforestation, and despite all efforts to avoid these areas, it is crucial to establish confidence in suppliers to ensure sourcing is not negatively impacting highly sensitive and critical ecosystems. Plantation establishment dates will be crucial to understand if a plantation was associated with recent natural forest deforestation.

[10] http://resources.trase.earth/documents/Indonesia_woodpulp_v3.0.0.pdf

[11] https://supplychains.trase.earth/flows?selectedColumnsIds=0_10-1_27-2_23-3_11&toolLayout=1&countries=107&commodities=87

[12] https://accountability-framework.org/

As a company considers its commitments to nature and interventions in its viscose supply chain, it will be important to align with recognized best practices, such as SBTN. This will ensure not only the credibility and ambition of commitments, but also allows the sector as a whole to work toward common targets and streamlining engagement with producers and suppliers on traceability data needs. As SBTN launches their version 1.0, we recommend reviewing the guidance and recommended metrics and indicators, and to apply a Science-Based Targets process to any nature and biodiversity commitments in the future.

APPENDIX

Group	Species	IUCN Red List Category	Logging & Wood Harvesting	Wood & Pulp Plantations
Amphibians	Reinwardti's Frog	Near threatened	x	
	Lesser Swamp Frog	Near threatened	x	
	Blyth's Wart Frog	Near threatened	x	
Birds	Yellow-crested Cockatoo	Critically endangered	x	
	White-shouldered Ibis	Critically endangered	x	
	Helmeted Hornbill	Critically endangered	x	x
	Wrinkled Hornbill	Endangered	x	x
	White-winged Duck	Endangered	x	
	White-crowned Hornbill	Endangered	x	x
	Storm's Stork	Endangered	x	
	Milky Stork	Endangered	x	
	Masked Finfoot	Endangered	x	
	Maleo	Endangered	x	
	Javan White-eye	Endangered	x	
	Far Eastern Curlew	Endangered	x	
	Chestnut-capped Thrush	Endangered	x	x
	Wallace's Hawk-eagle	Vulnerable	x	
	Sulawesi Hornbill	Vulnerable	x	
	Short-toed Coucal	Vulnerable	x	
	Rhinoceros Hornbill	Vulnerable	x	x
	Malay Crestless Fireback	Vulnerable	x	
	Malay Crested Fireback	Vulnerable	x	
	Lesser Adjutant	Vulnerable	x	

	Large Green-pigeon	Vulnerable	x	
	Large-billed Blue-flycatcher	Vulnerable	x	
	Knobbed Hornbill	Vulnerable	x	
	Hook-billed Bulbul	Vulnerable	x	x
	Grey-cheeked Bulbul	Vulnerable	x	x
	Great Slaty Woodpecker	Vulnerable	x	
	Great Hornbill	Vulnerable	x	x
	Great Argus	Vulnerable	x	
	Fairy Pitta	Vulnerable	x	
	Chestnut-necklaced Partridge	Vulnerable	x	
	Bornean Wren-babbler	Vulnerable	x	x
	Bornean Crestless Fireback	Vulnerable	x	
	Bornean Crested Fireback	Vulnerable	x	
	Bonaparte's Nightjar	Vulnerable	x	
	Blue-headed Pitta	Vulnerable	x	
	Black Partridge	Vulnerable	x	
	Black Hornbill	Vulnerable	x	x
	Zappey's Flycatcher	Near threatened	x	
	Yellow-crowned Barbet	Near threatened	x	x
	White-necked Babbler	Near threatened	x	
	White-chested Babbler	Near threatened	x	
	Sumatran Woodpecker	Near threatened	x	
	Sumatran Drongo	Near threatened	x	x
	Sumatran Babbler	Near threatened	x	
	Sulawesi Dwarf-kingfisher	Near threatened	x	x
	Striped Wren-babbler	Near threatened	x	
	Streaked Bulbul	Near threatened	x	

	Spot-billed Pelican	Near threatened	x	
	Sooty-capped Babbler	Near threatened	x	
	Short-tailed Babbler	Near threatened	x	
	Scarlet-rumped Trogon	Near threatened	x	
	Scarlet-breasted Flowerpecker	Near threatened	x	
	Scaly-breasted Kingfisher	Near threatened	x	x
	Rufous-throated Flycatcher	Near threatened	x	
	Rufous-tailed Shama	Near threatened	x	
	Rufous-crowned Babbler	Near threatened	x	
	Rufous-collared Kingfisher	Near threatened	x	x
	Rufous-bellied Eagle	Near threatened	x	
	Reddish Scops-owl	Near threatened	x	
	Red-throated Sunbird	Near threatened	x	
	Red-throated Barbet	Near threatened	x	x
	Red-naped Trogon	Near threatened	x	x
	Red-crowned Barbet	Near threatened	x	x
	Red-backed Thrush	Near threatened	x	
	Rail-babbler	Near threatened	x	x
	Pygmy Hanging-parrot	Near threatened	x	
	Puff-backed Bulbul	Near threatened	x	
	Pied Cuckooshrike	Near threatened	x	x
	Olive-backed Woodpecker	Near threatened	x	x
	Ochre-bellied Boobook	Near threatened	x	
	Moustached Hawk-cuckoo	Near threatened	x	
	Maroon-breasted Philentoma	Near threatened	x	
	Mangrove Pitta	Near threatened	x	
	Malay Honeyguide	Near threatened	x	x

	Malay Brown Barbet	Near threatened	x	x
	Malay Blue-flycatcher	Near threatened	x	
	Malay Blue-banded Kingfisher	Near threatened	x	
	Malay Banded Pitta	Near threatened	x	
	Long-billed Partridge	Near threatened	x	
	Lesser Green Leafbird	Near threatened	x	
	Large Wren-babbler	Near threatened	x	
	Large Frogmouth	Near threatened	x	
	Japanese Paradise-flycatcher	Near threatened	x	
	Jambu Fruit-dove	Near threatened	x	
	Hose's Broadbill	Near threatened	x	x
	Grey-chested Jungle-flycatcher	Near threatened	x	
	Green Iora	Near threatened	x	x
	Green Broadbill	Near threatened	x	x
	Gould's Frogmouth	Near threatened	x	
	Giant Pitta	Near threatened	x	x
	Garnet Pitta	Near threatened	x	x
	Fiery Minivet	Near threatened	x	x
	Dwarf Sparrowhawk	Near threatened	x	
	Diard's Trogon	Near threatened	x	x
	Dark-throated Oriole	Near threatened	x	x
	Crested Partridge	Near threatened	x	
	Crested Jay	Near threatened	x	
	Cinnamon-rumped Trogon	Near threatened	x	x
	Cinnamon-headed Green-pigeon	Near threatened	x	
	Chestnut-naped Forktail	Near threatened	x	
	Chestnut-bellied Malkoha	Near threatened	x	

	Chequer-throated Yellownape	Near threatened	x	
	Bushy-crested Hornbill	Near threatened	x	
	Buff-vented Bulbul	Near threatened	x	
	Buff-necked Woodpecker	Near threatened	x	x
	Brown Fulvetta	Near threatened	x	
	Brown-backed Flowerpecker	Near threatened	x	
	Bornean Ground-cuckoo	Near threatened	x	
	Bornean Bristlehead	Near threatened	x	x
	Blue-rumped Parrot	Near threatened	x	
	Blue-headed Kingfisher	Near threatened	x	x
	Black-bellied Malkoha	Near threatened	x	
	Black-and-yellow Broadbill	Near threatened	x	x
	Black-and-white Bulbul	Near threatened	x	
	Asian Woollyneck	Near threatened	x	
Mammals	Sunda Pangolin	Critically endangered	x	
	Bornean Orangutan	Critically endangered	x	x
	Yellow-handed Mitered Langur	Endangered	x	x
	Tiger	Endangered		x
	Smoky Flying Squirrel	Endangered	x	
	Siamang	Endangered	x	x
	Proboscis Monkey	Endangered	x	
	Otter Civet	Endangered	x	x
	Malay Tapir	Endangered	x	x
	Lowland Anoa	Endangered	x	
	Hairy-nosed Otter	Endangered	x	x
	Greater Slow Loris	Endangered	x	x

	Flat-headed Cat	Endangered	x	x
	Borneo Bay Cat	Endangered	x	x
	Bornean White-bearded Gibbon	Endangered	x	x
	Asian Elephant	Endangered	x	x
	Agile Gibbon	Endangered	x	x
	Whitehead's Sundaic Maxomys	Vulnerable	x	
	White-fronted Langur	Vulnerable	x	x
	Whiskered Flying Squirrel	Vulnerable	x	
	Tufted Ground Squirrel	Vulnerable	x	
	Tonkean Macaque	Vulnerable	x	
	Temminck's Flying Squirrel	Vulnerable	x	
	Sunda Clouded Leopard	Vulnerable	x	x
	Sun Bear	Vulnerable	x	x
	Sulawesi Giant Squirrel	Vulnerable	x	
	Sulawesi Fruit Bat	Vulnerable	x	
	Sulawesi Babirusa	Vulnerable	x	x
	Southern Pig-tailed Macaque	Vulnerable	x	x
	Smooth-coated Otter	Vulnerable	x	
	Silvery Lutung	Vulnerable	x	x
	Sambar	Vulnerable	x	x
	Red Langur	Vulnerable	x	x
	Rajah Sundaic Maxomys	Vulnerable	x	
	Philippine Slow Loris	Vulnerable	x	x
	Malayan Tailless Leaf-nosed Bat	Vulnerable	x	
	Mainland Serow	Vulnerable	x	
	Hose's Langur	Vulnerable	x	

	Gray Flying Fox	Vulnerable	x	x
	Dian's Tarsier	Vulnerable	x	
	Brooks’s Dyak Fruit Bat	Vulnerable	x	
	Broad-nosed Sumatran Maxomys	Vulnerable	x	
	Binturong	Vulnerable	x	x
	Bearded Pig	Vulnerable	x	x
	Bear Cuscus	Vulnerable	x	
	Banded Langur	Vulnerable	x	
	Asian Small-clawed Otter	Vulnerable	x	
	White-thighed Surili	Near threatened	x	x
	Wallace's Stripe-faced Fruit Bat	Near threatened	x	
	Trefoil Horseshoe Bat	Near threatened	x	x
	Tail-less Leaf-nosed Bat	Near threatened	x	x
	Sulawesi Warty Pig	Near threatened	x	x
	Small Woolly Bat	Near threatened	x	
	Small Sulawesi Cuscus	Near threatened	x	
	Shrew-faced Squirrel	Near threatened	x	
	Short-tailed Mongoose	Near threatened		x
	Pale Giant Squirrel	Near threatened	x	
	Painted Woolly Bat	Near threatened	x	
	Marbled Cat	Near threatened	x	x
	Malayan Slit-faced Bat	Near threatened	x	
	Malayan Free-tailed Bat	Near threatened	x	
	Lesser Wooly Horseshoe Bat	Near threatened	x	
	Least Woolly Bat	Near threatened	x	
	Island Flying Fox	Near threatened		x

	Horse-tailed Squirrel	Near threatened	x	
	Hodgson's Bat	Near threatened	x	
	Groove-toothed Trumpet-eared Bat	Near threatened	x	
	Dayak Fruit Bat	Near threatened	x	
	Collared Mongoose	Near threatened	x	x
	Clear-winged Woolly Bat	Near threatened	x	x
	Bornean Leaf-nosed Bat	Near threatened	x	
	Banded Civet	Near threatened	x	x
	Asiatic Golden Cat	Near threatened	x	x
Reptiles	King Cobra	Vulnerable	x	
	False Gharial	Vulnerable	x	

Ecosystem Services

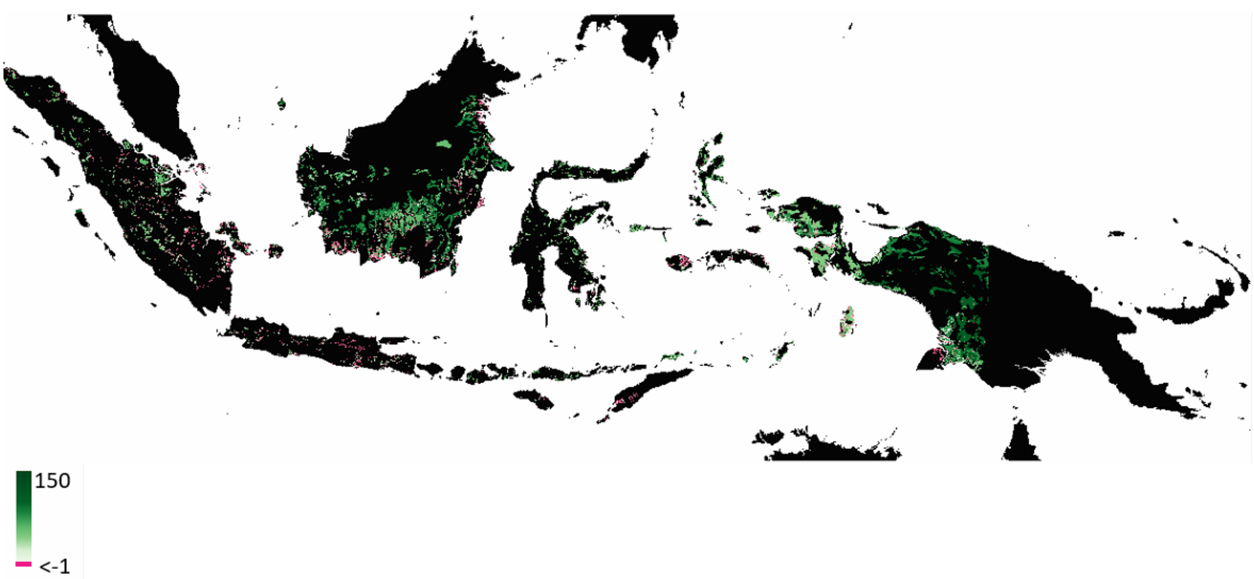


Fig. a1. *Sediment and nitrogen retention values in Indonesia as a result of viscose production. Impact of current viscose (relative to potential natural vegetation): 18%-per-area loss of sediment retention, 293%-per-area loss of nitrogen retention*

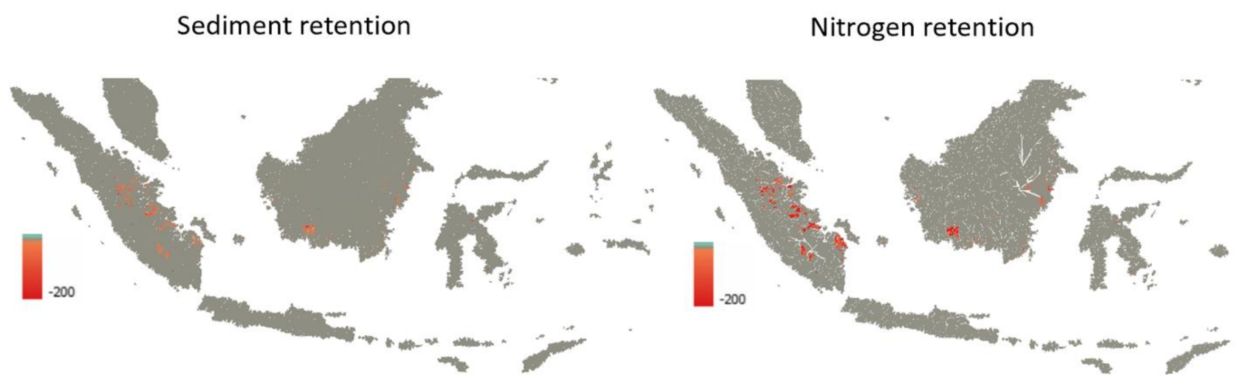


Fig. a2. *Indonesia impact of current viscose (relative to potential natural vegetation): 91 million Mg carbon, a 21% loss from potential. This was calculated by applying average values per LULC and ecoregion for PNV, and subtracting 2010 (remotely-sensed) biomass carbon, which is why there are higher values in 2010 than PNV for certain pixels; this is in the pixels that are higher than the average for their LULC-ecoregion class.*

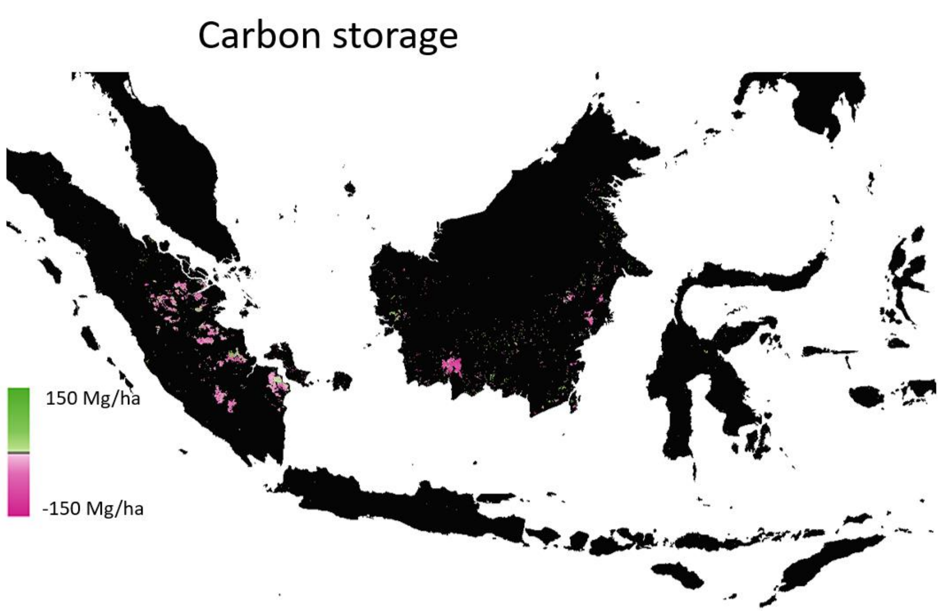


Fig. a3. *Current production occurs on 2% of total land area; future viscose could expand to 15%. Sediment retention: 31% improvement (204% per area) with avoided viscose expansion*

Fig. a4. *Nitrogen retention: 68% improvement (452% per area) with avoided viscose expansion*

Fig a5. *Carbon storage: 1.5 billion Mg saved (450% of current viscose footprint) with avoided expansion*

The authors would like to thank the members of the Transforming the Fashion Sector with Nature project's Technical Advisory Group, in particular the SBTN and Oscar Sabag (Science Translation Lead), for lending time and expertise in reviewing this material.