INCORPORATING LAND USE IMPACTS ON BIODIVERSITY INTO LIFE CYCLE ASSESSMENT

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patagonia

INTRODUCTION

Global biodiversity is estimated at 8.7 million species (Mora et al., 2011), which provide critical ecosystem services. However, biodiversity has declined approximately 30% in the past 40 years with a main driver being land use (WWF, 2014). The apparel industry uses large amounts of land for production, contributing to this decline. Patagonia Inc. is interested in the development of a robust and accessible method for incorporating biodiversity impacts into life cycle assessment (LCA)—a widely-used tool for evaluating potential environmental impacts of a product system to inform decision-making.

Project Objectives

1. Review methodologies for incorporating land use impacts on biodiversity into LCA, and select a model with high potential for use within the apparel industry.
2. Apply the model to four Patagonia product systems to quantify the potential land use impacts on biodiversity of common textiles (cotton, wool, polyester, and lyocell).
3. Assess the limitations and potential of the model for use by Patagonia and the apparel industry to evaluate the impact of a product's land use on biodiversity within broader LCAs.

METHODS

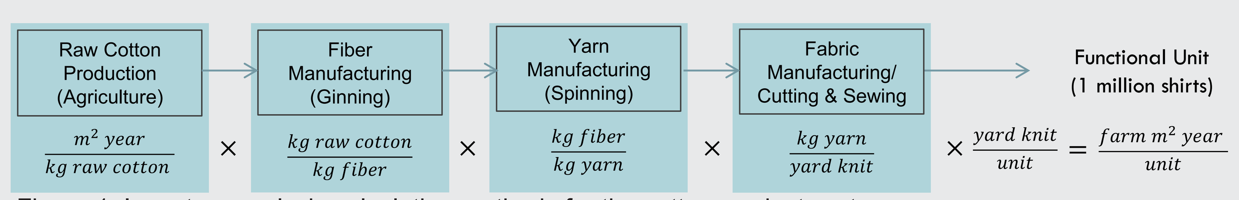
Using the following methods, we evaluated the biodiversity impact of four Patagonia t-shirts using a model published in *Land use in life cycle assessment: global characterization factors based on regional and global potential species extinction* by de Baan et al. (2013):

1. All processes were identified in the life cycle of a t-shirt to be included in the assessment (called unit processes).
2. Primary data from Patagonia's suppliers was used to complete a life cycle inventory analysis (LCI) of each t-shirt, quantifying the amount of land occupied (in m²*years) for each unit process.
3. Each unit process was assigned a characterization factor from de Baan et al. (2013) based on location and land use type.
4. The inventory analysis results for each unit process were multiplied by the assigned characterization factors to calculate a biodiversity impact, measured in potentially lost non-endemic species.

Inventory Result X Characterization Factor = Biodiversity Impact

Inventory Analysis

For each textile, the amount of land occupation needed for each unit process to make one million t-shirts (our functional unit) is calculated. For each unit process, property size is divided by annual output and multiplied by the inverse yield of each subsequent unit process (Figure 1).



$$\frac{m^2\ year}{kg\ raw\ cotton} \times \frac{kg\ raw\ cotton}{kg\ fiber} \times \frac{kg\ fiber}{kg\ yarn} \times \frac{kg\ yarn}{yard\ knit} \times \frac{yard\ knit}{unit} = \frac{farm\ m^2\ year}{unit}$$

Figure 1. Inventory analysis calculation methods for the cotton product system

Characterization Factor

Characterization factors are based on the spatial classification of ecoregion, a large area with distinct species and environmental conditions. Each ecoregion has characterization factors for four land use types. Location-specific data are necessary to capture regional differences in biodiversity. Some characterization factors had to be adapted due to a lack of location-specific data.

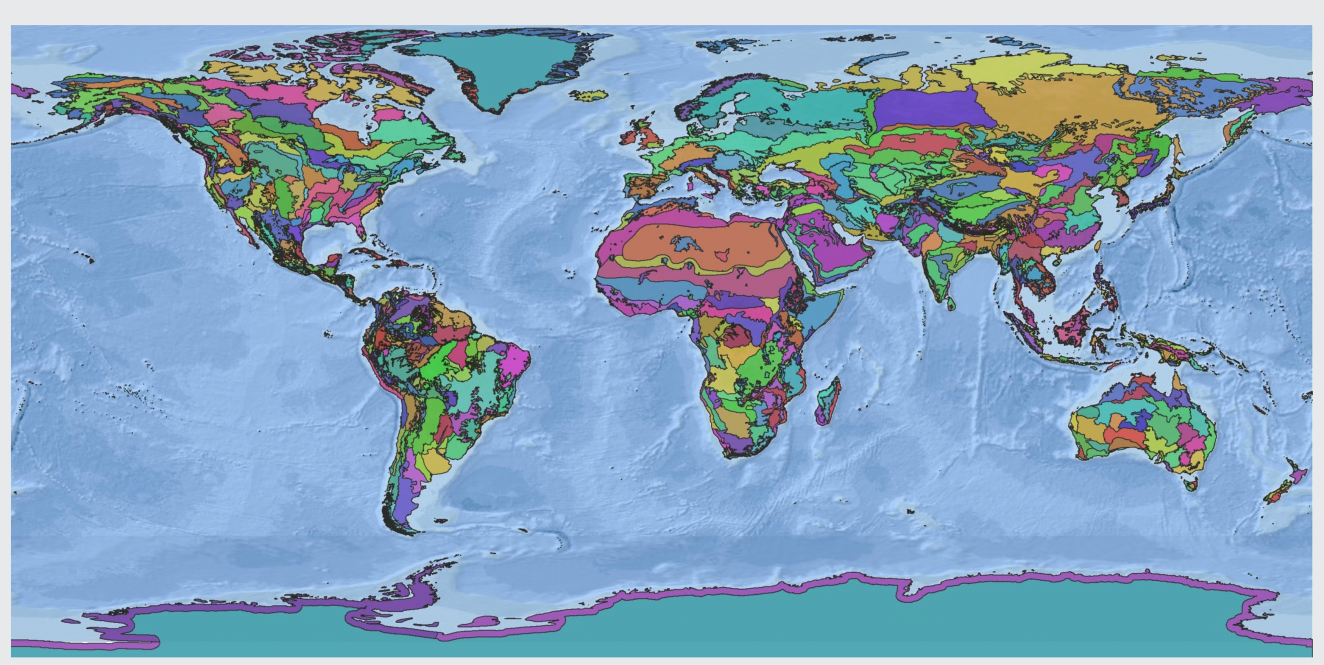


Figure 2. The 867 terrestrial ecoregions, as defined by Olson et al. (2001) and the World Wide Fund for Nature

ASSESSED T-SHIRTS AND TEXTILES

Cotton

100% organic cotton grown and ginned in Texas; fabric manufactured in Texas and Mexico.

Polyester

Petroleum-based polymers spun into polyester fiber in South Carolina; fabric manufactured in the United States and El Salvador.

Lyocell

Eucalyptus grown in South Africa and Swaziland; beech and spruce grown in central Europe. Manufactured in Czech Republic, England, South Africa, USA, Thailand, South Korea, and Sri Lanka.

Wool

Wool shorn from sustainably grazed sheep and spun into yarn in Argentina; fabric manufactured in China, Thailand, and Vietnam.

RESULTS

High Biodiversity Impact of Wool

Total biodiversity impact of four textiles				
	Wool	Cotton	Lyocell	Polyester
Total Land Occupation	1.77×10^9	1.59×10^7	9.77×10^5	1.92×10^4
Total Biodiversity Impact	0.04751	0.00229	0.00030	0.00001
Ratio of Textile to Wool	1:1	1:21	1:157	1:9461

Table 1. Total land occupation in m²*years, total biodiversity impact in potentially lost non-endemic species, and ratio of each textile's biodiversity impact to the biodiversity impact of wool

- Wool has the highest biodiversity impact of the four evaluated textiles, which can be attributed to the high land requirements of grazing and the model's inability to account for sustainable grazing practices.

High Contribution of Raw Materials

Biodiversity impact of raw materials				
	Wool	Cotton	Lyocell	Polyester
Raw Material Land Occupation	1.77×10^9	1.59×10^7	9.54×10^5	7.53×10^3
Percent of Total Land Occupation	99.97%	99.96%	97.62%	39.20%
Raw Material Biodiversity Impact	4.71×10^{-2}	2.28×10^{-3}	2.77×10^{-4}	7.95×10^{-7}
Percent of Total Biodiversity Impact	99.04%	99.90%	91.72%	15.83%

Table 2. Contribution of raw material land occupation and biodiversity impact to total land occupation and biodiversity impact for the four textiles

- Raw material production contributes greater than 90% of the total biodiversity impact for wool, cotton, and lyocell t-shirts, which require agriculture- and pasture-based land use.
- These processes have significantly lower yields and higher land occupations than the urban manufacturing processes.

Influence of Characterization Factors

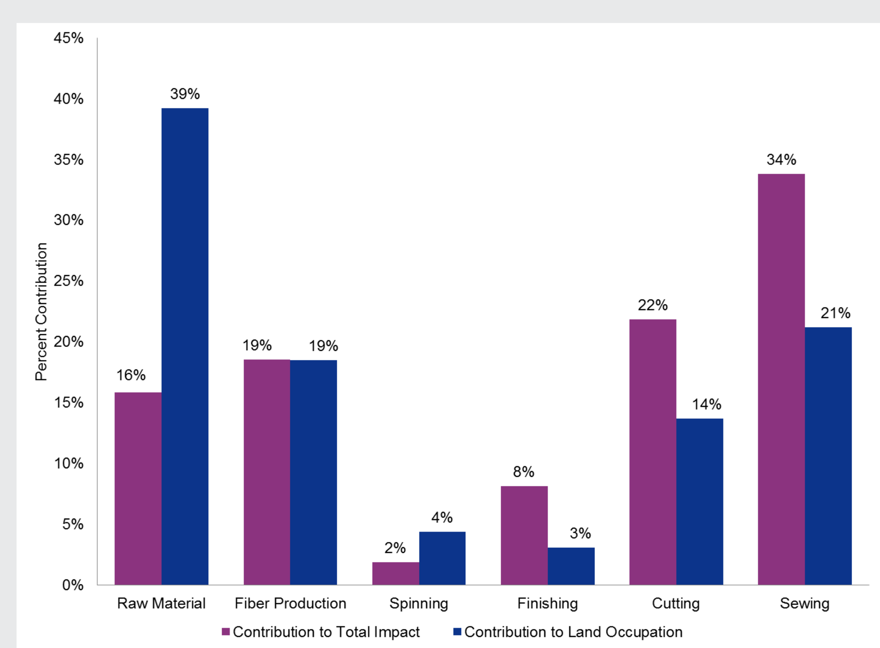


Figure 3. Contribution of polyester unit processes to total impact and land occupation of polyester

Polyester

- Polyester production processes are all classified as urban land use and raw material extraction has much lower land occupation than the raw material processes of the other textiles, leading to a more even distribution of land occupation and biodiversity impact than other textiles.
- The pattern of the unit processes' percent contribution to land occupation differs from contribution to total impact (Figure 3), indicating that the location of the process influences total biodiversity impact.

Lyocell

- The composition of lyocell is dominated by eucalyptus pulp, which accounts for 60% of the total pulp mix (Figure 4a).
- Land occupation for eucalyptus harvest is less than half of that for beech harvest (Figure 4b), yet the biodiversity impact of eucalyptus is 7 times greater than the impact of beech (Figure 4c).
- If land occupation alone drove biodiversity impact, then eucalyptus would have a much lower biodiversity impact than beech.
- Beech wood is sourced from managed forests and has much greater land requirements than the agricultural land requirements for eucalyptus. The more intensive agricultural land use of eucalyptus, combined with the sensitive ecoregions of South Africa and Swaziland, create a discrepancy between land occupation and biodiversity impact.

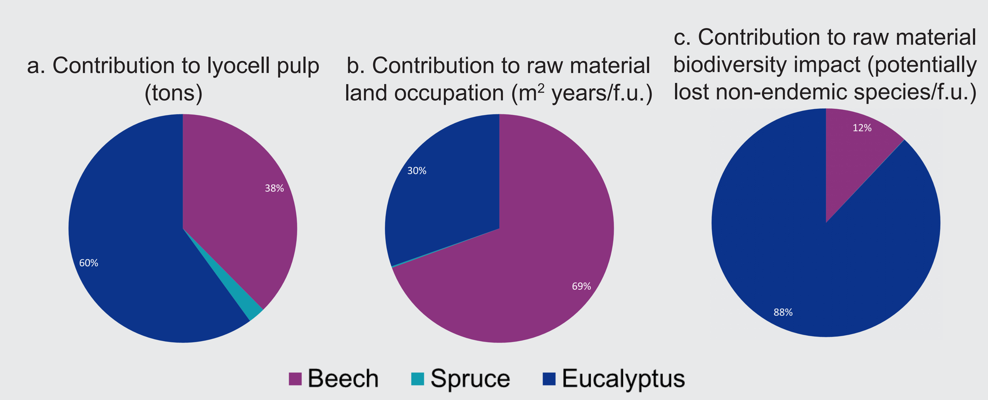


Figure 4. Percent contributions of beech, spruce, and eucalyptus to lyocell pulp, raw material land occupation, and raw material biodiversity impact

UNCERTAINTY ANALYSIS

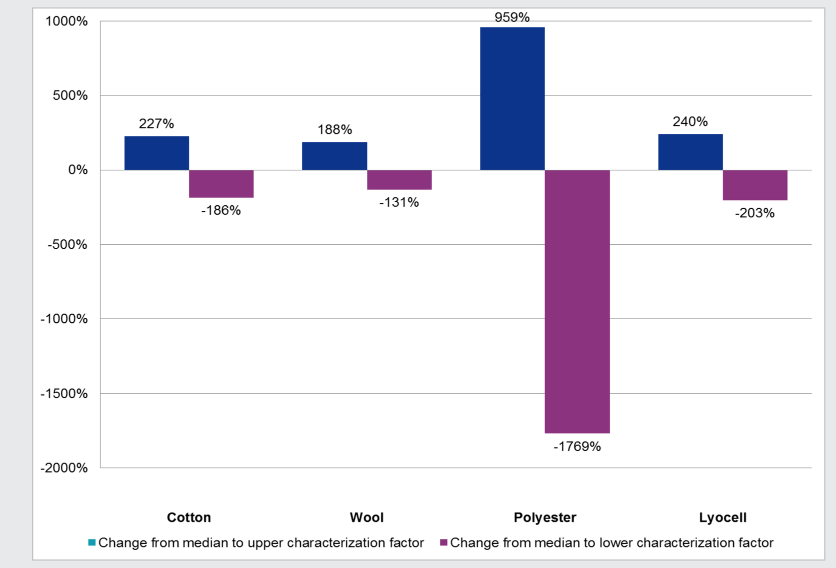


Figure 5. Percent change in total biodiversity impact from a median to a high (blue) and to a low (pink) characterization factor

- Results calculated using high and low uncertainty characterization factors differ more than 100% from the median for all materials—and up to 1700% for polyester.
- The results for each textile range from a positive to a negative impact value, with a negative value representing a potential benefit to biodiversity.
- Uncertainty is largely due to a lack of taxa- and ecoregion-specific data, which required that some values be aggregated across larger spatial units than ecoregions, such as biomes.

CONCLUSIONS

- This model is currently better suited for providing broad generalizations than for conducting refined product system assessments, though it has potential for future use in LCA alongside other indicators.
- It may be possible for companies producing products dependent on agriculture or grazing to approximate total biodiversity impacts without characterization factors and without looking beyond those raw material processes.
- Increasing the yield of the raw material processes could potentially reduce per-unit biodiversity impacts but would require more intensive land use, placing greater pressure on the ecosystem and increasing extinction risk. Higher yield land management may also shift land occupation impacts to other impact categories.
- The benefits of sustainable land management practices are not captured by the model as it exists and should be measured using other, possibly qualitative, methods.

Limitations of the Model

Uncertainty of Characterization Factors	High uncertainty of the characterization factors limits ability to draw concrete and reliable conclusions.
Captures Limited Aspects of Biodiversity	Model based on species richness fails to capture all aspects of biodiversity.
Dependence on Specific Location	Because location specific data is often unavailable, the advantage of this model in providing regional results can be lost.
Coarse Land Use Classification	The use of four broad land use types means that distinction between land use management strategies is not possible.

RECOMMENDATIONS FOR PATAGONIA

- Look qualitatively at supply chain land use, with a particular focus on identifying methods for reducing habitat impacts of agricultural and pastoral processes.
- Continue to develop partnerships with NGOs and suppliers that expand and develop innovative sustainable land management strategies.
- Stay informed about sustainable land management practices and strategies, and support and source from suppliers using such practices.
- Work with suppliers to minimize inputs other than land use that may cause biodiversity loss. Decreasing water use, chemical use, water pollution, and fertilizer may all help to minimize impacts on biodiversity.

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