**Environmental Impacts of Forestry**

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## Post-workshop summary of impacts

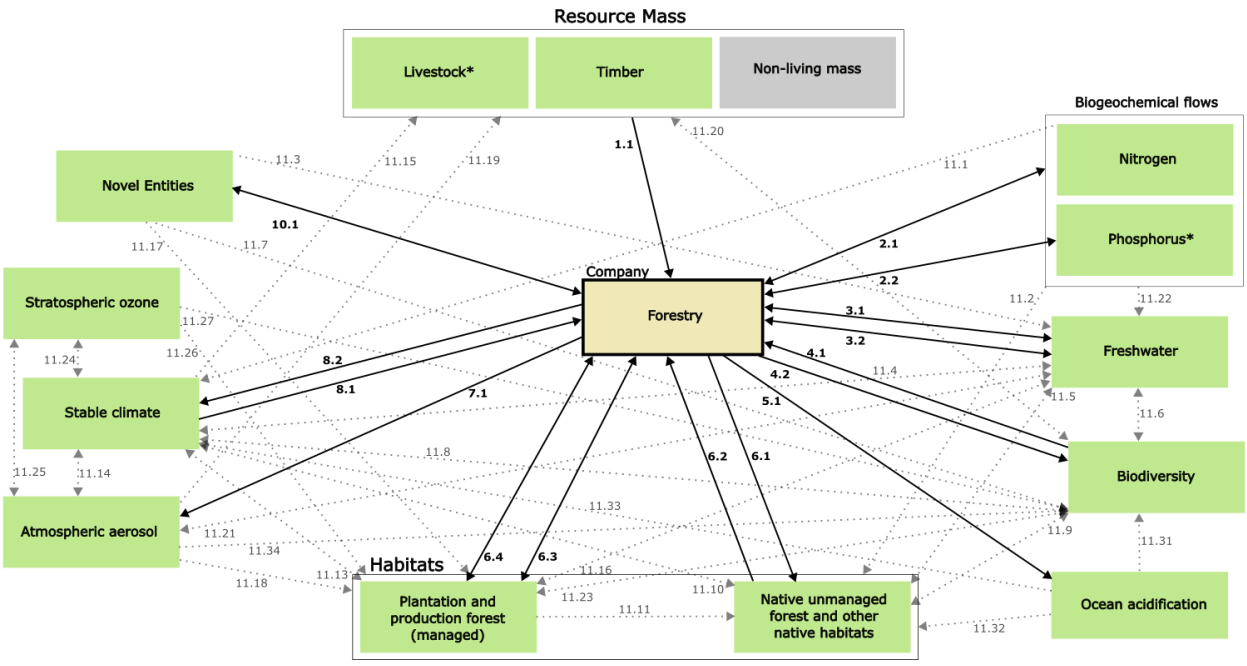


**Figure 1.** Conceptual systems diagram showing potential interactions between a company (yellow box) and various environmental dimensions. Dimensions are based on processes captured by the planetary boundaries framework, with the addition of natural resources. Solid lines represent direct impacts and/or dependencies of the company on various environmental dimensions. Dashed lines represent interactions between environmental dimensions. Viewed together, solid, and dashed lines represent the indirect impacts and dependencies of the company. Numbers refer to Tables 2 and 3 in this document. Boxes are shaded depending on if mechanistic links (i.e. arrows) are present (green) or not (grey).

**Table 1.** Direct environmental impacts and dependencies of forestry sector, shown as solid lines in figure 2. Links between a company operating in this industry, and the different environmental dimensions, are visually represented in Figure 1. References are numbered, 'W' indicates data from the expert elicitation workshop.

| No. | Category | Sub-category | Impact, Dependency or Both | Description of Mechanisms | References |
|---|---|---|---|---|---|
| 1.1 | Resource mass | Living biomass | Dependency | Use of living biomass, e.g. inputs of wood, timber, and fibres, could also include animal-based energy from draught animals. | 1 |
| 2.1 | Biogeochemical flows | - | Both | Nitrogen and Phosphorus provide fertilizer input which increase forest productivity. This has various complex flow-on effects to ecosystems, affecting understory vegetation, mushrooms, berries and soil fauna. Large impact on micella in ground and soil ecosystem. Context-dependent, e.g. existing levels of N in forest soils and location, doses, timing and frequency of fertilization. | 2, 3, W |
| 2.2 | Biogeochemical flows | Phosphorus | Both | Phosphorus provides fertilizer input. However, use contributes to P depletion. | 3, 4 |
| 3.1 | Freshwater | - | Both | Dependency on freshwater. Well-managed forests also regulate flows in the hydrological cycle. | 1 |
| 3.2 | Freshwater | - | Both | Dependency on good water quality. Well-managed forests also regulate provision of clean water. | 1 |
| 4.1 | Biodiversity | - | Dependency | Dependencies based on biodiversity, e.g. better soil quality, bioremediation, filtration, pollination, pest and disease control, and genetic material. | 1 |
| 4.2 | Biodiversity | - | Impact | Impacts on biodiversity, e.g. clear cutting causes biodiversity loss, invasive species and fewer endemic species, cultivating monocultures. | 1 |
| 5.1 | Ocean acidification | - | Impact | Forestry practices affect concentrations of atmospheric $CO_2$. There are emissions from machinery, logging, charcoal making, deforestation, transport. However, there is also $CO_2$ uptake. Influenced by the end use of products: what the products are, their life span and whether they substitute for another material. Any effect of forestry on atmospheric $CO_2$ concentrations has an impact on the acidity of surface seawater. | 1, W |

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| 6.1 | Habitats | Native habitats | Impact | Direct impacts on native habitats, e.g. the relationship between forestry and fire is context-dependent. Forest management may involve fire suppression, which is highly detrimental to fire-dependent ecosystems (such as Boreal forests). Fire suppression, combined with climate change, also increases risk of large, catastrophic fires. | 5, 6, W |
| 6.2 | Habitats | Supporting habitats | Dependency | Dependencies on supporting habitats, e.g. bioremediation, buffering and erosion control, and flood and storm protection. | 1 |
| 6.3 | Habitats | Appropriated habitats | Both | Dependencies on qualities of appropriated habitats, e.g. soil quality. Impacts on appropriated habitats depends on practices, e.g. Forestry can cause soil degradation and compaction which can lead to erosion and landslides, logging can damage undergrowth and remaining trees. Forestry removes dead wood and structures which are important for ecosystem function and biodiversity. | 1, W |
| 6.4 | Habitats | Appropriated habitats | Dependency | Use of space of appropriated habitats to grow timber. | 5, 7 |
| 7.1 | Atmospheric aerosol | - | Impact | Release of atmospheric aerosols, e.g. black Carbon and nitrogen oxides emitted from burning woody biomass and charcoal. | 8, 9 |
| 8.1 | Stable climate | - | Dependency | Climate change affects forestry companies. Positive effects may include increasing tree growth and increased demand for afforestation, reforestation and forest products. Negative effects may include that forestry is also highly dependent on a stable climate. Climate change will make forestry more unpredictable, due to risks including increased storm damage, insect damage and risk of large fires. | 1, W |
| 8.2 | Stable climate | - | Impact | Impacts on climate. Greenhouse gas emissions, e.g. $CO_2$ from machinery, logging, charcoal making, deforestation, transport. Increased $N_2O$ emissions where peatlands are drained for forestry. Climate impact is influenced by the end use of products: what the products are, their life span and whether they substitute for another material. Changing tree species composition through management would change albedo in not-insignificant ways. | 1, 10, 11, 12, W |

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| 10.1 | Novel entities | - | Both | Inputs and release of novel entities, e.g. inputs of pesticides and herbicides to increase production are released into the environment. The fate of chemicals used in forestry depends on various local conditions. Drainage can also create problems with mercury levels in freshwater bodies. Mercury problems can also be created from the physical impact of forest machines (when twigs etc. are pushed into soil). | 13, 14, 15, 1, W |

**Table 2.** Interactions between environmental processes relevant to forestry sector, shown as dashed lines in figure 1. Links are visually represented in Figure 1. References are numbered, 'W' indicates data from the expert elicitation workshop.

| No. | Categories | Description of Mechanisms | References |
|---|---|---|---|
| 11.1 | Biogeochemical flows (Nitrogen), Stable climate | Production of Nitrogen fertilizer by industrial N fixation (Haber-Bosch process) is energy intensive and currently creates a large amount of GHG emissions. However, fertilization can increase carbon sequestration. | 16, W |
| 11.2 | Biogeochemical flows, Habitats (Native unmanaged) | Forest fertilization is associated with risk of nutrient leakage to freshwater ecosystems and groundwater resources, especially nitrate leakage. N fertilization could lead to extensive nitrification and acidify soil. Influencing factors include fertilizer type, dose, frequency, soil properties, topography, weather conditions, vegetation, tillage. Fertilization also influences ground vegetation cover. | 2, 17 |
| 11.3 | Freshwater, Novel entities | Release of novel entities enters freshwater e.g. herbicide and pesticide runoff. | 1, 15, 18 |
| 11.4 | Freshwater, Stable climate | Climate change has driven detectable changes in the global water cycle, including intensification of both heavy precipitation events and droughts, when those occur. Hydrological cycle affects carbon cycling, e.g. hydrological conditions have a great impact on the carbon balance of peatlands, which means draining unmanaged peatland for other land uses, e.g. forestry, changes GHG fluxes. | 19, 20 |
| 11.5 | Freshwater, Habitats (Native unmanaged) | Forest productivity depends on water availability. Forests also regulate water dispersion. | 21, W |
| 11.6 | Freshwater, Biodiversity | Mutual interactions between hydrologic services and biodiversity. Sufficient water flow beneficial for proper ecosystem functioning. Plant roots and microbial communities provide phyto- and bioremediation, removing particles, pathogens, nutrients and chemicals from water and improving water quality. | 22 |
| 11.7 | Biodiversity, Novel entities | Novel entities used in or mobilized by forestry (e.g. herbicides, pesticides, mercury) could affect biodiversity. The fate of chemicals used in forestry depends on various local conditions. | 23, W |
| 11.8 | Biodiversity, Stable climate | Climate change and biodiversity loss are mutually reinforcing; resolving either issue requires consideration of the other, e.g. climate change increasingly alters ecosystems and organisms, and is a key driver of biodiversity loss. | 24 |
| 11.9 | Biodiversity, Habitats (Native unmanaged) | Native unmanaged forests are usually more suitable habitat for a wider range of native forest species, especially compared with non-native plantations. | 25 |
| 11.10 | Habitats (Native unmanaged), Stable climate | Native, unmanaged forests and other native habitats are large carbon sinks, especially compared to plantation forests and other land uses like agriculture. Drainage of peatlands, including for forestry, greatly changes GHG dynamics. | 20, 26, 27, W |

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| 11.11 | Habitats (Appropriated), Habitats (Native unmanaged) | Forestry can lead to land use change, which negatively impacts native, unmanaged habitats, e.g. Much illegal harvesting occurs in tropical forests and causes loss of habitats rich in biodiversity. Road infrastructure for timber harvest drives habitat loss and fragmentation. Drainage of wetlands for forestry impacts productivity of land, water flow, biodiversity and carbon cycling. | 5, 7, W |
| 11.13 | Habitats (Appropriated), Stable climate | Interactions between appropriated habitats and climate regulation, e.g. non-native trees can contribute to climate regulation (via carbon uptake). Climate regulation provides favorable conditions, climate change increases risk of extreme events. Drainage causes loss of soil C, could increase emissions from water bodies. | 28, 29, W |
| 11.14 | Atmospheric aerosol, Stable climate | Aerosols have complex interactions with the climate system. They have both a cooling effect, by reflecting incoming solar radiation, and a warming effect, by absorbing heat radiation and changing surface albedo, but the net impact is a cooling effect. Uncertainty arises from complexity of aerosol absorption and impacts of aerosols on cloud microphysics. Aerosol black carbon (BC) produced from biomass burning is a powerful climate forcing agent contributing to global warming. | 30, 31, 32, 8 |
| 11.15 | Stable climate, Living biomass | Climate change is projected to cause loss and degradation of much of the world's forests. | 29 |
| 11.16 | Habitats (Appropriated), Freshwater | Interactions between forestry and hydrology are context-dependent. Forests depends on water availability and affects water dispersion and availability. E.g. logging could either lead more or less soil moisture, depending on the location and its associated hydrological patterns, temperature, and various ecosystem features. | 21, W |
| 11.17 | Habitats, Novel entities | Pollution (pesticides, herbicides, heavy metals, POPs) could cause habitat degradation, e.g. mercury problems in freshwater systems | W |
| 11.18 | Atmospheric aerosol, Habitats (Native unmanaged) | Aerosols have harmful impacts on both native and appropriated habitats, e.g. exposure to ozone can damage crops and ecosystems, while forest dieback in Central Europe has been associated with sulphur pollution. Acid precipitation causes acidification of water, soil and forest environments. Pollution from the oil and gas sector impacts more distant habitats due to long-range transport in which vaporised chemicals spread through wind. | 33, 34, 35, 1 |
| 11.19 | Atmospheric aerosol, Biomass | Aerosols have harmful impacts on flora and fauna, e.g. exposure to ozone can damage crops and kill freshwater fish. Particulate matter can have toxic effects depending on chemical and physical properties, e.g. dioxins can accumulate in foods such as meat and dairy products, fish and shellfish, causing human health effects. | 33, 30, 34, 36 |
| 11.20 | Living biomass, Biodiversity | Extraction of biomass at harvest affects ecosystem structure and function, e.g. clear-cutting or high levels of timber extraction in industrial forestry are detrimental to biodiversity. | 37 |
| 11.21 | Atmospheric aerosol, Freshwater | Aerosols influence the hydrological cycle by altering mechanisms that form precipitation in clouds. Aerosols may substantially influence the Asian monsoon circulation. | 38, 39,40 |

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| 11.22 | Biogeochemical flows, Freshwater | Leaching of nutrients (e.g. Nitrate) from forest fertilization is a potential stress factor for water quality. Influencing factors include fertilizer type, dose, frequency, soil properties, topography, weather conditions, vegetation, tillage. | 3, 17 |
| 11.23 | Habitats (Appropriated), Biodiversity | Plantation forests of non-native monocultures reduce plant and animal biodiversity. Production forests, especially longer-rotation forests and those managed with conservation objectives, can contribute to biodiversity conservation by providing valuable habitat, including for threatened and endangered species. However, it depends on management practices. Native unmanaged forests are usually the most suitable habitat for a wider range of species. | 25, W |
| 11.24 | Stable climate, Stratospheric ozone | Complex interactions between GHGs and ozone-depleting substances. Nitrous oxide ($N_2O$) is both a powerful GHG and the dominant ozone-depleting substance emitted in the 21$^{st}$ century, because it decomposes in the stratosphere to form nitrogen oxides ($NO_x$), which catalyze ozone destruction. However, other GHGs reduce the effectiveness of $N_2O$ in destroying ozone ($CO_2$, $CH_4$). | 41, 42 |
| 11.25 | Atmospheric aerosol, Stratospheric ozone | High stratospheric aerosol loading reduces the ozone depletion potential (ODP) of $N_2O$, because $NO_x$ is converted to $HNO_3$ on aerosol surfaces. In addition, aerosols affect ozone loss through $Cl_y$ chemistry. | 41 |
| 11.26 | Stratospheric ozone, Habitats | Stratospheric ozone depletion leads to increased solar UVB radiation, causing DNA damage in plants | 43 |
| 11.27 | Stratospheric ozone, Biodiversity | Stratospheric ozone depletion leads to increased solar UVB radiation, causing DNA damage in fauna, such as marine Antarctic organisms. | 44 |
| 11.31 | Ocean acidification, Biodiversity | Many marine organisms are highly sensitive to changes to ocean $CO_2$ chemistry, especially those using carbonate ions to form calcium carbonate shells or structures. Ocean acidification could be deleterious to such organisms, which would constitute a major disturbance to marine ecosystems with highly uncertain impacts. Marine plankton are also vulnerable. | 30 |
| 11.32 | Ocean acidification, Habitats | Ocean acidification may have serious impacts on various marine and coastal habitats. | 30 |
| 11.33 | Ocean acidification, Climate | Oceans remove a large proportion of anthropogenic $CO_2$, but acidification threatens the ability of oceans to continue to function as a carbon sink. | 30 |
| 11.34 | Atmospheric aerosol, Biodiversity | Aerosols have harmful impacts on flora and fauna, e.g. exposure to ozone can kill freshwater fish. | 30, 34 |

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# ELICITATION RECORD – Part 1

The Workshop Context

| | |
|---|---|
| **Elicitation title** | Essential Environmental Impact Variables |
| **Workshop** | Forestry |
| **Date** | 25 November 2022 |
| **Part 1 start time** | 14:15 |

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| **Attendance and roles** | Facilitator, Note taker, Experts 1, 2 and 3 |
| **Purpose of elicitation** | 1. Assessment of background review: assess the background review of impacts and ensure that all significant and salient impacts from an industry on the environment are captured in the conceptual systems diagram and the associated tables.<br><br>2. Assessment of greatest impact: assess which of these impacts have the greatest impact on the environment. By 'greatest' we mean that impacts have either 1) a large globally cumulative impact; or 2) impacts that are locally incurred but are identified as generally having the largest local effect. |
| **This record** | Participants are aware that this elicitation will be conducted using an adapted Sheffield Elicitation Framework, and that this document, including attachments, will form a record of the session. |
| **Orientation and training** | Participants received a pre-workshop participant brief. |
| **Participants' expertise** | <u>Expert 1</u><br><br>*Expertise:* Forest related issues all career, nature conservation, biodiversity issues. Forest history, forest dynamics and providing input to forest management and conservation issues. In past, connected to dead wood. Species connected, and what happens to it with management. 3-4 years, sucked into carbon/climate issue. Complex and contentious but unavoidable. Some background in climate issues.<br><br><u>Expert 2</u> |

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| | *Expertise:* Mainly working with restoration issues, biodiversity connected to boreal forest. Disturbances like forest fire and how to generate different habitats. What type of dead wood to put out to generate biodiversity. Upcoming issue. Working more with continuous cover forestry, especially next year. Hot issue.<br><br><u>Expert 3</u><br><br>*Expertise:* Soil physics, but also have knowledge about chemistry connected to forestry. Also working with practical forestry. Siviculture, regeneration of new forests. Covering different parts of the forest cycle. |
| **Declarations of interests** | No competing interests |
| **Strengths and weaknesses** | <u>Expert 1</u><br><br>*Strengths:* Nature conservation, biodiversity. Forest history, dynamics, and management and conservation. Role of dead wood, connections to species, past 3-4 years carbon/climate. Primarily Sweden, the further from Sweden the less I know. Mainly boreal, but occasionally temperate issues.<br><br>*Weaknesses:* Tropical forests, and not an expert on all topics in this exercise.<br><br><u>Expert 2</u><br><br>*Strengths:* Topics related to forest habitats, biodiversity<br><br>*Weaknesses:* The climate/forest debate. Not an expert in pollution, atmospheric dynamics<br><br><u>Expert 3</u><br><br>*Strengths:* Boreal forests<br><br>*Weaknesses:* Tropical forests, though have a small amount of experience with tropical agroforestry, biodiversity |

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| **Evidence** | *Clarifying question asked:* (Expert 3) Want definition of plantation forestry. North America would see Sweden as plantation. But in Sweden we think of Brazil.<br><br>*Answer:* (Facilitator) Perhaps you can tell us about your perspectives. There are many views on this discussion. Would be interesting to hear your thoughts on it, for the contexts.<br><br>*Expert 1:* Dichotomy between natural and plantation not helpful. Plantation is the planting and growing of trees with non-native provenances – an agriculture system with trees. Then, plantation forest in Sweden, Northern Europe, where we plant native trees. Still managed systems. Good first step to have three categories.<br><br>*Expert 3:* Can also have natural regions that are managed a lot, depends on regeneration method. Don't know if managed enough.<br><br>*Expert 1:* Production forest?<br><br>*Expert 3:* Yes, production forest.<br><br>*Facilitator:* Then in this exercise, by natural we mean native and not managed for production<br><br>*Expert 3:* In your studies, know which of these 3 it is taken from as it influences interpretation.<br><br>*Facilitator:* Expert 2, do you agree?<br><br>*Expert 2:* Yes, very relevant.<br><br>*Clarifying comment:* (Expert 3) Main comments what is written there – needs to be modified depending on boreal or tropical context. Always need to state context of statements. Soil hydrology and chemistry should be altered. Have not done that yet but have highlighted alterations.<br><br>*Facilitator:* Reiterate that context is important.<br><br>*Expert 1:* So, is the idea they should be generic enough for boreal, temperate, and tropical forests*?*<br><br>*Facilitator:* We want to be able to compare, but not at the expense of scientific validity.<br><br>*Clarifying question:* (Expert 1) Did not understand what you mean with livestock and draught animals.<br><br>*Facilitator:* Animals that perform work, like in harvesting timber. |

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| | *Expert 1:* Then I misunderstood. I thought it meant game, and other non-timber resources extracted from the forest.<br><br>*Expert 3:* Game is a big part of Swedish forest companies. They can sell it, or it is a benefit. Important when talking about how to manage forest, as lots of people are interested in hunting.<br><br>*Facilitator:* A good clarifying point.<br><br>*Expert 3:* Not many people, but important for those people.<br><br>*Expert 1:* Part of the business- selling hunting rights. Definitely a resource use based on forest land.<br><br>*Clarifying question:* (Expert 1) What do you mean environment in this context, is it non-human? There are values connected to forest. Strong impact on the human dimension. The reindeer husbandry, indigenous, local people, recreation, tourism business. None of this in the diagram. Is it deliberate?<br><br>*Facilitator:* It is deliberate because we needed to put boundaries somewhere. However for some things it can be very intertwined regarding how the forest is managed, we can discuss it more. Mention it where you feel it is relevant but we have tried to cap it at the environment.<br><br>*Expert 1:* There was a reference to IPBES on business and biodiversity, and they have a recent values assessment. They span these interests.<br><br>*Facilitator:* Of course, very interconnected. It is a bit of a messy interface. We are looking at environmental but interested in social side if you think it affects decisions made in forestry sector.<br><br>*Expert 1:* It could go very wrong if the impact variables completely exclude social impacts.<br><br>*Facilitator:* We will make it clear we should have social impacts. We are trying to get comprehensive enough understanding of this.<br><br>*Expert 1:* About primary and secondary sectors. On extraction biomass from forests, the impact is not independent of what the biomass is used for. Is that something to reflect on?<br><br>*Facilitator:* It is useful to reflect on, especially how much of that decision is made by the same company that cuts down forest.<br><br>*Expert 1:* Then it is obvious Swedish forestry industry is also producing things from the biomass, not just cutting down forest. They are also processing. |

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| | *Facilitator:* In this case it is important. What we meant is that we are not targeting companies with no connection to land, water, only buy products from other companies and manufacture. We want to target companies with direct impact on environment. If they do more things we can include.<br><br>*Expert 3:* Also the issue, mostly in the Swedish context, that we have half the forest owned by private forest owners – 300,000 in Sweden. They manage the forest how they want and sell to a forest company. The company is just buying the wood, maybe cuts it. Different systems. Cannot always influence whole cycle up to finished tree.<br><br>*Facilitator:* We can revisit how much influence the companies can have on the private owners. Do owners do what they want, or is it mandated from the companies?<br><br>*Expert 3:* Also important, one of the big actors in Sweden is the Forest Association. They are like companies, but associations.<br><br>*Expert 1:* But they have saw and pulp mills.<br><br>*Expert 3:* It is easy to think about SEA, Stora Enso. But it is more diverse than that.<br><br>*Facilitator:* I think this diversity is important to try and capture. It is mainly targeting companies, but if these organisations act like companies. I don't know if they report the way companies do. If they do, maybe it is targeting them.<br><br>*Expert 3:* They would be reporting on their carbon inputs, outputs.<br><br>*Expert 1:* They would be influenced by impact variables. They are part of the market. |
| **Structuring** | The variables were not elaborated or rephrased at this stage. |
| **Definitions** | 1. Assessment of background review of impacts, ensuring all significant and salient impacts from an industry sector on the environment are captured.<br><br>2. Assessment of which are the *greatest* impacts on nature, meaning that impacts have either 1) a large globally cumulative impact, or 2) impacts are more locally incurred but are the largest for individual firms. |

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| **Part 1 end time** | 14:54 |
| **Attachments** | |

# ELICITATION RECORD – Part 2: Outcome 1

Eliciting Expert Knowledge on Qualitative Outcomes

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| **Elicitation title** | Essential Environmental Impact Variables |
| **Workshop** | Forestry |
| **Date** | 25 November 2022 |
| **Outcome** | 1. Assessment of background review: assess the background review of impacts and ensure that all significant and salient impacts from an industry on the environment are captured in the conceptual systems diagram and the associated tables. Specify if any impacts are missed, should be rewritten/rephrased or removed. |
| **Anonymity** | Experts are identified as Experts 1, 2 and 3 (aligned across all elicitation records). |
| **Start time** | 15:04 |

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| **Definition** | Assessment of background review of impacts, ensuring all significant and salient impacts from an industry sector on the environment are captured. |
| **Evidence** | A participant brief was provided in advance, containing a background review and evidence. |
| **Individual elicitation** | **Missed –**<br><br><u>Expert 2:</u><br><br>Reindeer husbandry should be included<br><br>5.3 Losing dead wood/ structures which are important for biodiversity<br><br>5.4 wetland drainage for forestry an important land use change. Could be in the water category, but also impacts productivity of land, biodiversity and carbon.<br><br><u>Expert 3:</u><br><br>Drainage has been a big problem historically |

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| | Links on N to capture that fertilization can be good for climate but bad for the environment because the most efficient measure to sequester C as a forest owner.<br><br><u>Expert 1:</u><br><br>Climate – drainage causes loss of soil carbon, could increase emissions from water bodies. Research ongoing.<br><br>Novel entities – Mercury in freshwater systems, at least in Sweden<br><br>Climate - consider end use of products<br><br>Climate – changing tree species composition through management would change albedo in not-insignificant ways. About choices of tree species in managed forests.<br><br>**Rewritten/rephrased –**<br><br><u>Expert 2:</u><br><br>Extraction and land are not separate<br><br>Change description about fire – 5.1 Habitats, there is fire suppression. Context dependent – Boreal forest, lack of fire a biodiversity issue. At same time, big risk of hazardous fires due to climate change.<br><br>Add to link on the impact of climate change on forestry, increased tree growth.<br><br>Increase the emphasis on dependency on stable climate<br><br>Clarify the three categories of forest for 9.8, 9.10<br><br>Make 9.11 more stepwise or a gradient<br><br><u>Expert 3:</u><br><br>Water points, use terminology of 'water dispersion' for rain, precipitation, infiltration etc.<br><br>Clarify what is meant by genetic pollution<br><br>Hydrology claims – it is context dependent. Says less water will infiltrate, but clear cutting in Boreal forest means more water in soil. |

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| | However, in other locations like Burkina Faso, removing trees does lead to less infiltration due to shade.<br><br>Fire – agree with Expert 2, forestry has little fire. US and Canada different<br><br>Reconsider aerosols – have not seen any studies suggesting there is increase in aerosols from forest fires, due to forestry. Can be opposite (because less fire). Aerosols arise from forest fires so important to know whether forestry increases fires or not.<br><br>Nitrogen is context-dependent, try to capture that better. Depends on how much N is in soil, where you fertilize, when, how much, how often.<br><br><br><u>Expert 1:</u><br><br>In the participation brief/ material there is a false dichotomy between plantation and natural forest. There should instead be three categories. Plantation, which is the planting and growing of non-native species (essentially agriculture of trees), production or managed forest which is a highly managed but uses native species and thirdly natural or un-managed forest.<br><br>Main effect of fertilization is on mushrooms and micella in the ground. If you fertilize properly, leakage is not a problem. But how and when you do it matters, so need to consider fertilization in impact variables.<br><br>Nuance the climate dependency (same point as Expert 2) – at Northern latitudes, might get more forest growth. However, unpredictability will increase significantly – pests, diseases, storms, fires, droughts. Face serious damage as a result of climate change.<br><br><br>**Removed –**<br><br><u>Expert 2:</u> None<br><br><u>Expert 3:</u><br><br>Reconsider sawdust leakage, I don't understand how it could be a problem.<br><br><u>Expert 1:</u> None |

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| **Matches/ Mismatches** | Overall, many points were raised. There was mainly agreement and almost no disagreement. |
| **Group discussion** | **Categories of Forest**<br><br>Expert 1: Dichotomy between natural and plantation not helpful. Plantation is the planting and growing of trees with non-native provenances – an agriculture system with trees. Then, plantation forest in Sweden, Northern Europe, where we plant native trees. Still managed systems. Good first step to have three categories.<br><br>Expert 3: Can also have natural regions that are managed a lot, depends on regeneration method. Don't know if managed enough.<br><br>Expert 1: Production forest?<br><br>Expert 3: Yes, production forest.<br><br>Facilitator: Then in this exercise, by natural we mean native and not managed for production<br><br>Expert 3: In your studies, know which of these 3 it is taken from as it influences interpretation.<br><br>Facilitator: Expert 2, do you agree?<br><br>Expert 2: Yes, very relevant.<br><br>**Aerosols, climate and secondary products**<br><br>Expert 2: A few small things, in response to Expert 3's comments. First, I was thinking about aerosols. If you harvest wood and burn it as biofuels, that would cause burning. Not forest fires.<br><br>Expert 3: But you would also get aerosols if you burn oil<br><br>Expert 2: Of course. But also with wood, you get aerosols. But impact on the environment. Some say it is substitution. Requires thinking about.<br><br>Expert 3: I also go into secondary products, one step further.<br><br>Facilitator: Yes, Expert 2, your point is that if the wood produced is burnt to create heat the aerosols are released then.<br><br>Expert 2: Is it outside the study?<br><br>Facilitator: To summarize, it connects to Expert 1's point that it is important for the climate impact of forestry sector what you use the products for. |

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| | Expert 1: For me it is fine. This is also context-dependent. When we use biomass in Sweden, the burning is controlled. $CO_2$ still released. But bad combustion and aerosols in other parts of world. Companies sell firewood. For local communities access to firewood is important impact. Your own small burner might release quite a lot of aerosols.<br><br>Expert 3: But you could get it without forestry, just stealing trees. It's not forestry.<br><br>Expert 1: Depends on border of analysis. Forest owners and companies sell wood for different purposes. What they choose to market has an impact on their impact.<br><br>Expert 3: For climate, the product is the biggest thing. What you do with wood and whether substitutes and the life span of product. Looking at environmental impacts, it is more difficult to include products, but it is important.<br><br>**Drainage**<br><br>Expert 2: Thinking about drainage. Not really allowed to drain new areas. But I have seen people are overly ambitious cleaning old ditches. They use excavators, not a shovel.<br><br>Expert 3: From my experience, I agree with you this is done, but it is illegal. Not sure if we are including illegal activities. But grey area. Sometimes they use cleaning of ditches to do too much ditching. Should not be so.<br><br>Expert 2: A question – when you do this kind of assessment, are illegal activities included?<br><br>Facilitator: This is the case with multiple sectors. But no one would disclose that.<br><br>Expert 3: On this, I must say, ditch cleaning … they still have to report to agency. Not so common. The planners at companies would probably not say to do it. It is the people doing the work who might take liberty.<br><br>Expert 1: But the use of these impact variables. Comes from business themselves. Would be critical to see they have a system in place [to prevent it].<br><br>Facilitator: Probably all would say that. Because of the context dependence, I would push for knowledge about where. Spatial data. |

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| | What do we need from companies to match with third party data sources.<br><br>Expert 1: And if they know they will be checked. I agree. Remote sensing and high resolution.<br><br>Expert 3: The authorities work with illegal logging checks. Globally could be very useful. |
| **Group elicitation** | **Missed**<br><br>All points made in workshop (see above)<br><br>**Re-written/re-phrased?**<br><br>All points made in workshop (see above)<br><br>**Removed?**<br><br>Potentially remove point about saw dust and point about pesticides – check context and either specify context or remove. |
| **Chosen outcome** | See above |
| **Discussion** | Would be good to get some insights from tropical forest people, and potentially even a temperate, deciduous forest expert. This group had a very clear boreal focus, with some awareness of broader issues.<br><br>Some participants had a lot of detailed comments – also wanted to send material later on with more comments. Need to follow up.<br><br>Added the interesting and useful thoughts on the temporal sustainability – that you also have to consider when impacts are happening during the forest rotation/life cycle. But also that you need to think about the age structure of the forest in order to not overharvest.<br><br>It was useful that they provided a suggested classification for 3 types of forest, this can be implemented throughout.<br><br>They emphasized the context specificity, which supports the above note that we should find supplementary information on tropical or temperate forests, if we want the scope to cover those. |

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| **End time** | 16:59 |
| **Attachments** | None |

# ELICITATION RECORD – Part 2: Outcome 2

Eliciting Expert Knowledge on Qualitative Outcomes

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| **Elicitation title** | Essential Environmental Impact Variables |
| **Workshop** | Forestry |
| **Date** | 25 November 2022 |
| **Outcome** | 2. Assessment of greatest impact: assess which of these impacts have the greatest impact on the environment. By 'greatest' we mean that impacts have either 1) a large globally cumulative impact; or 2) impacts that are locally incurred but are identified as generally having the largest local effect. |
| **Anonymity** | Experts are identified as Experts 1, 2 and 3 (aligned across all elicitation records). |
| **Start time** | 15:04 |

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| **Definition** | Assessment of which are the *greatest* impacts on nature, meaning that impacts have either 1) a large globally cumulative impact, or 2) impacts are more locally incurred but are the largest for individual firms. |
| **Evidence** | A participant brief was provided in advance, containing a background review and evidence. |
| **Individual elicitation** | <u>Expert 2</u><br><br>**Impact:** Habitat loss and degradation<br><br>**Reason:** Forestry really changes the habitat, takes away a lot of really important structures, which impacts biodiversity a lot.<br><br><u>Expert 3</u><br><br>**Impact:** Habitat change<br><br>**Reason:** Agree with Expert 2, especially plantation forestry. Going from natural to plantation, the change of habitats is the biggest. That influences everything else. Brazil as an example. Usually, you have other crops in between. Maybe rainforest – then sugarcane – plantation forestry, like eucalyptus, short rotation period 5-10 years. |

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| | Big change. That would definitely be the biggest environmental impact.<br><br>**Other comment:** Much more difficult question if there is already forest and you manage it. Depends on many things. I know some, like aerosols and sawdust are at the end of the list. What is in the top of the list is not easy. Maybe still: habitat change.<br><br><u>Expert 1</u><br><br>**Impact:** Transformation of natural forests to either plantation or management.<br><br>**Reason:** That is the main cause of biodiversity loss, that goes for the global scale.<br><br>**Impact:** How we use forest in relation to climate change. The carbon sequestration in relation to substitution.<br><br>**Reason:** When we talk climate impact from forestry, issue is whether forests should store carbon or use biomass for substitution. That aspect needs to be addressed when talking environmental impacts. You will get different answers. In my opinion, shorter time periods (decadal) the biomass use will not compensate for loss of sink. Critical issue for whole forest sector.<br><br>**Impact:** [Dependency] The uncertainty for forestry in the future<br><br>**Reason:** Unpredictability will increase significantly in future. Issue of pest, diseases, storms, fires, droughts. That will be a major challenge. |
| **Matches/ Mismatches** | All agreed on habitat loss and degradation, and effects on biodiversity.<br><br>In particular, land use change from natural to other type of forest (especially plantation). However, habitat was also a key issue for forest management.<br><br>Expert 1 also raised the issue about how we think of forests in relation to climate impact, whether forests should remain standing as a sink or should be used to substitute other goods. Here, the end use of product was important.<br><br>There was also consensus around the dependency on climate, namely that some forests might grow more, but that unpredictability will increase and this will be a major challenge. |
| **Group discussion** | **Secondary products – Climate impact** |

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| | Expert 1: On the climate part, that's why I ask whether to consider secondary use when we talk climate impact from forestry. Issue of whether forests should store carbon or use biomass for substitution. That aspect needs to be addressed when talking environmental impacts. You will get different answers. In my opinion, shorter time periods (decadal) the biomass use will not compensate for loss of sink. Critical issue for whole forest sector.<br><br>Facilitator: Is it that [it's better to] keep forest, then also what kinds of products?<br><br>Expert 1: Yes. Maybe we can see 3 perspectives: natural old forest, it might be several 100 years old. Might not capture carbon but contains a lot of carbon. Most becomes $CO_2$. If you have growing forests, not as old, sequester a lot of carbon. So, depends how much you would substitute of fossil fuels. This is heavily debated and a sensitive thing.<br><br>Experts 2 agreed, said that the substitution argument should be considered. Expert 3 agreed and would also go one step further into secondary products. |
| **Group elicitation** | **Impact:** Habitats<br><br>**Reason:** The change between habitation categories (3 categories) has a very big impact.<br><br>**Impact:** Climate<br><br>**Reason:** Big impact depending on what forest is used for. But NB this dependent on the secondary product more than the management style. |
| **Chosen outcome** | See above |
| **Discussion** | Would be good to get some insights from tropical forest people, and potentially even a temperate, deciduous forest expert. This group had a very clear boreal focus, with some awareness of broader issues.<br><br>Some participants had a lot of detailed comments – also wanted to send material later on with more comments. Need to follow up.<br><br>Added the interesting and useful thoughts on the temporal sustainability – that you also have to consider when impacts are happening during the forest rotation/life cycle. But also that you need to think about the age structure of the forest in order to not overharvest. |

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| | It was useful that they provided a suggested classification for 3 types of forest, this can be implemented throughout.<br><br>They emphasized the context specificity, which supports the above note that we should find supplementary information on tropical or temperate forests, if we want the scope to cover those. |

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| **End time** | 16:59 |
| **Attachments** | None |