Sustainable Forestry?

A Sustainability Analysis of the Swedish Forest Sector Applying 'Backcasting from Sustainability Principles' as the Methodology

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Hållbart Skogsbruk? En hållbarhetsanalys av den svenska skogssektorn med "backcasting från hållbarhetsprinciper" som metod

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Summary

Forests are key providers of terrestrial ecosystem services such as climate regulation, water purification, natural pest control, habitats for biodiversity, as well as different forms of wood-based materials and food. Nevertheless, forests are dangerously exposed to great pressures from various kinds of societal activities. This report examines the importance of forests for the (i) maintenance of life-supporting functions of the biosphere as well as for (ii) providing a flexible resource base for the satisfying of human needs on more and more sustainability-driven markets. How can Swedish forestry be managed such that those two essential roles of forests become mutually supportive? The report also relates the results to three relevant and well-cited protocols for the subject: the Sustainable Development Goals in UN’s Agenda 2030, the Swedish Environmental Quality Objectives, and the Swedish National Forest Program. The approach applied Maxwell’s process design for qualitative research. Data have been collected from literature search and interviews of experts and the analytical instrument for modeling of data was the Framework for Strategic Sustainable Development (FSSD).

The report concludes:

(i) Sustainable development for forestry relies on a paradigm shift in civilization’s perception of forestry to a practice where planning departures from envisioning a future where natural forest functions to sustain higher life forms and civilization are safeguarded and prioritized before other usages of forestland, and where diversity is enhanced in terms of tree age and species to foster more resilient and high-quality timber forests.

(ii) When the above points are achieved, the higher diversity of more resilient forests should also have potential to supply markets with \textit{various} kinds of resources offered to more and more sustainability-driven markets. Furthermore, this development of society’s forest use increases the chances for civilization to be sustainable also with relatively smaller forest areas put aside for no forestry at all.

(iii) In such a situation forestry and society have prioritized forest products and usages with long life spans before such with short.

(iv) A future sustainable Swedish forest sector has recognized the above, and drawn an essential conclusion from it: the interdependency of forests with society’s overall sustainability performance calls for a cooperative approach that departures from an understanding of basic sustainability principles that are shared across sectors and disciplines.

(v) The Sustainable Development Goals, the Swedish Environmental Objectives, and the Swedish National Forest Program all fail to take the above broad-systems perspective when it comes to proposing measures for the future, including how to advise further research to explore what the sustainable Swedish forestry could entail.

The study arrives at pointing out an overall approach to analyses, planning and further research in those regards, rather than evaluating details on the path towards sustainable forestry.

\textbf{Keywords:} Framework for Strategic Sustainability, Sustainability Principles, Backcasting from principles, Backcasting from scenarios, Swedish Forest Sector, Clear-cutting, Continuous Cover Forestry, Environmental Objectives, UN Sustainable Development Goals, National Forest Program
Sammanfattning

Skogen är en nyckelresurs i den landbaserade naturen såsom klimatreglering, vattenrenning, naturlig skadedjursbekämpning, habitat för biologisk mångfald, likväl som olika former av träfiberbaserade material och mat. Samtidigt är skogen hotad av kraftigt tryck från olika aktiviteter i samhället. Den här rapporten undersöker skogens betydelse för (i) upprätthållande av biosfärens livsuppehållande funktioner, samt som (ii) flexibel resurs när det gäller att förse mänskliga behov på alltmer hållbarhetsdrivna marknader. Hur bör skogen skötas så att dessa två roller stödjer varandra? Rapporten relaterar också resultaten till tre relevanta och vanligt citerade protokoll: hållbarhetsmålen i FNs Agenda 2030, de svenska miljömålen och det svenska nationella skogsprogrammet. Forskningen har strukturerats med hjälp av Maxwells process-design för kvalitativ forskning. Data har samlats in genom litteraturstudier och från intervjuer med experter. Modellering av data har gjorts genom att använda ramverket för strategisk hållbar utveckling (FSSD) som analyseinstrument. Rapporten kommer fram till att:

(i) Hållbar utveckling för skogsbruket är beroende av ett paradigmskifte. En skogsskötsel där (i) planering utgår från att föreställa sig en framtid där skogens funktioner för högre liv på jorden är säkrade och satta före annan användning av skogsmark, och (ii) mångfald är främjande trädens ålder och antalet arter så att mer resiljenta skogar kan bidra med högkvalitativt timmer.

(ii) När skogen förvaltas på det sättet så bör de mer diversa och resiljenta skogarna ha möjlighet att förse marknader med olika resurser som kan visa sig vara viktiga på alltmer hållbarhetsdrivna marknader. Vidare borde denna utveckling av samhälles skogsanvändning öka chanserna för civilisationen att bli hållbar med relativt mindre ytor reserverade för att skyddas mot skogsbruk.

(iii) Med en sådan förvaltning har skogsägare och samhället i stort prioriterat produkter och användningsområden med långa livslängder före sådana med korta livslängder.

(iv) En framtid för hållbar svensk skogsbruk som beroende av det ovanstående och dragit en väsentlig slutsats från det: beroendet mellan skogen och samhällets övergripande hållbarhetsarbete kräver samarbete och att hållbarhetsprinciper som delas över sektors- och disciplingränser.

(v) Hållbarhetsmålen i Agenda 2030, de svenska miljömålen och det svenska nationella skogsprogrammet saknas ett tillräckligt bredt systemperspektiv när det gäller att föreslå åtgärder för framtiden, inklusive att ge rekommendationer för framtidshandel om hållbart svenskt skogsbruk.

Studien pekar snarare ut en övergripande inriktning för analyser, planering och forskning om hållbart svensk skogsbruk, än utvärderar de exakta stegen på vägen dit.

Nyckelord: Ramverket för strategisk hållbar utveckling, Hållbarhetsprinciper, Backcasting från principer, Backcasting från scenarier, Svenska skogssektorn, Kalhuggning, Trakthyggesbruk, Kontinuitetsskogsbruk, Hyggesfritt skogsbruk, Svenska miljömålen, FNs Hållbarhetsmål, Nationella skogsprogrammet
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Abbreviations and Terms

**ABCD:** the backcasting planning process of FSSD. In (A) a vision for success is formed, in (B) the current situation is assessed, in (C) possible solutions and steps are discovered, and in (D) these are prioritized into a strategic plan.

**Agenda 2030:** the sustainability plan set by the United Nations (UN). Contains 17 sustainable development goals (SDGs) and 169 targets to be accomplished by the year 2030.

**Backcasting:** planning process, which starts with an imagined outcome in the future, and then backcasts to today’s situation to explore ways to get to the outcome. The backcasting planning process of FSSD is called the ABCD-procedure.

**Biosphere:** the combined unit of all Earth’s ecosystems.

**Clear-cut forestry:** a forestry system in which all trees in an area are felled simultaneously, which results in a bare landscape: a clear-cut. Often combined with planting and managing of monocultures, i.e. trees are of the same age and species.

**Continuous cover forestry:** a forestry system in which felling of trees is done regularly over time.

**Forest:** “land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use.” (FAO, 2012)

**Forestry:** “the production of roundwood for the forest-based manufacturing industries as well as the extraction and gathering of wild growing non-wood forest products. Besides the production of timber, forestry activities result in products that undergo little processing, such as fire wood, charcoal, wood chips and roundwood used in an unprocessed form (e.g. pit-props, pulpwood etc.). These activities can be carried out in natural or planted forests.” (UN, 2008)

**Forest Sector:** “the economic, social and cultural contribution to life and human welfare which is derived from forests and forest-based activities” (Gane, 2007).

**FSSD/Framework for Strategic Sustainable Development:** contains a principled definition of sustainability and a systematic operational analytic and planning procedure based on backcasting.

**NFP/National Forest Program:** a forest policy framework that is supposed to set the direction for national sustainable forest management. The Swedish NFP is underway, currently consisting of four background reports.

**SDGs/Sustainable Development Goals:** the 17 goals for sustainable development set up by the UN and included in Agenda 2030.

**SEOs/Swedish Environmental Objectives:** the Swedish system of environmental quality objectives containing a generational goal, 16 environmental quality objectives, specifications for each of the objectives and 24 milestone targets.

**Socio-ecological system:** the combined system consisting of the human society within the biosphere.

**SP/Sustainability principles:** the sustainability principles of FSSD, defines sustainability.
Appendix C
Appendix B
Appendix A: Continuous References

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3.
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Table of Contents

1. Introduction ............................................................................................................................ 1
   1.1. Aim and Research Questions ......................................................................................... 2
   1.2. Delimitations and Disposition of the Report ................................................................. 3

2. Theoretical Background ....................................................................................................... 4
   2.1. Sustainability .................................................................................................................. 4
       2.1.1. Sustainable Development and Sustainability Principles ........................................... 4
       2.1.2. Sustainable Forest Management .............................................................................. 5
   2.2. Forestry Methods in Short ............................................................................................. 6
   2.3. Past and Current Realities, and Predicted Futures for the Swedish Forest Sector .......... 7
       2.3.1. A Brief Review of Swedish Forest History and Today’s Forest Sector ................. 8
       2.3.2. Earlier work on Future Scenarios for the Swedish Forest Sector .......................... 10

3. Methodology and Research Design .................................................................................... 11
   3.1. Maxwell’s Qualitative Research Design and its Application in the Project ................... 11
   3.2. Framework for Strategic Sustainable Development (FSSD) .......................................... 11
       3.2.1. Information Gathering ............................................................................................ 13
       3.2.2. Information Modeling ............................................................................................ 13
   3.3. Summary of Research Design ....................................................................................... 15

4. Results .................................................................................................................................. 17
   4.1. System 1: Applying the FSSD on Civilization at Large .................................................. 17
       4.1.1. FSSD Level 1: System ............................................................................................. 17
       4.1.2. FSSD Level 2: Success in the Global Socio-ecological System ............................... 19
   4.2. System 2: Applying the FSSD on the Swedish Forest Sector ........................................ 23
       4.2.1. FSSD Level 1: System ............................................................................................. 23
       4.2.2. FSSD Level 2: Success in the Swedish Forest Sector ............................................. 24
       4.2.3. Contribution to Programs for Sustainable Forestry .............................................. 30

5. Discussion ............................................................................................................................. 34
   5.1. SDGs, SEOs and NFP’s Compliance with FSSD ............................................................ 34
   5.2. A Sustainable Forest Sector? ......................................................................................... 36
   5.3. Validity ............................................................................................................................. 39

6. Conclusion ............................................................................................................................. 40

References .................................................................................................................................. 41

Appendix A: Continuous-Cover Forestry Terminology ............................................................ 49
Appendix B - Swedish Environmental Objectives (SEOs) ........................................................ 51
Appendix C - UN Sustainability Goals (SDGs) .......................................................................... 52
1. Introduction

Sustainable development is, according to the Brundtland definition (United Nations (UN), 1987), “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. However, from various kinds of societal activities this development is put at risk, meaning that the socio-ecological system - the system constituting the biosphere and human society - is gradually eroding. Examples of ecological impacts are climate change, loss of biodiversity, soil degradation, lowering of groundwater tables and thereby loss of nature’s regulatory capacity relying on coal-cycles, water-cycles, nutrient-cycles, as well as the food production capacity (Steffen et al., 2015). And when it comes to the social system - the system people constitute as a social species and rely on for sustainable development also in ecosystems - it is exposed to erosion of trust, the very glue that sustains a vital and functional social system (Missimer, Robèrt & Broman, 2017a). Sustainable development can therefore also be defined as “the active transition from the current, globally unsustainable society towards a sustainable society” (Robèrt et al., 2012) and sustainability can be defined by eight sustainability principles (SPs) - principles designed as boundary conditions for any society that will not erode the socio-ecological system (Broman & Robèrt, 2017). These principles, and how to use them for analyses, modeling of possible sustainable societies, planning, choice of appropriate tools, and cooperation across sectors and disciplines will be explained in coming sections.

The regulatory capacity of forests, covering about 30 percent of the world’s surface (Food and Agriculture Organization of the United Nations (FAO), 2016), is essential for the biosphere and higher life forms on Earth. In this function, forests are often regarded as providers of “natural capital” assets to civilization: “the living and nonliving components of ecosystems - other than people and what they manufacture - that contribute to the generation of goods and services of value for people” (Guerry at al, 2015). These services consequently provide direct economic benefits to society, but people are not necessarily aware of it. Examples of forest natural capitals are water cycles, pollination, natural pest control, soil fertility, local climate regulation and resilience to changing environmental conditions, habitats for biodiversity and food provision from various forest living plants and animals (FAO, 2016). Forest natural capital is also of great importance for agriculture, as the future food production is dependent on sustained and sound forest ecosystems (Robinson et al., 2012) and for the future sustainable production of various materials: timber, paper, bio-plastics, dye, lacquers and binders, wood fibers with functions such as absorbance, optic transparency, heat and fire resistance, and nanofibers for textiles, packaging and strong composite materials (Berglund, 2015).

However as society faces sustainability related environmental and social challenges in the future the pressure on forests will increase. We can only hope that civilization will realize in time exactly how key this natural resource is for the sustaining of civilization. Estimates suggest that the global forest area has decreased by 50 percent the past 5000 years (FAO, 2016) and it is very likely that it will continue to diminish in the near future due to the above listed ecological sustainability challenges. That forests have a role for sustainable development is something that is recognized in various forms of protocols. The global level Agenda 2030 and the UN Sustainability Goals (SDGs) (UN, 2015) are one of the most recent examples. In Sweden “Sustainable Forests” is one of the 16 Swedish Environmental Objectives (SEO) (Naturvårdsverket, 2016b) and there is furthermore an ongoing initiative by the Swedish Government to create a Swedish National Forest Program (NFP) (Regeringskansliet, 2016). Nevertheless it appears to be a lack of consensus from the named protocols to describe what sustainable forestry really is and how to plan for sustainable use of forests. For instance the “Swedish Forestry Model” is often presented as an effective model for combining high production yields and environmental concerns (The Royal Swedish Academy of Agriculture and Forestry (KSLA), 2009), despite that many public and political voices have warned that this model doesn’t reach up to the environmental goals and targets of the SEO, set to be accomplished by the year 2020 (OECD, 2014).
In order to solve some confusion about sustainable forestry and how forests best can serve the biosphere and its functions as well as more and more sustainability driven markets that compete for renewable resources, there is a need for a broad sustainability assessment that backcasts from basic sustainability principles in order to reveal the full scope of current sustainability challenges as well as the full scope of possibilities to deal with those challenges (Robèrt et al., 2012). Such a wider scope helps to avoid mistakes that may follow from analyses based on a selection of impacts that have already occurred including plans to deal with those. And it helps to avoid mistakes that may follow from scenario planning that implies backcasting from one or a few selected scenarios, i.e. a too narrow scope also for the possible options at hand. Hence different types of backcasting methodologies exist (ibid.). To be robust for wide-scope analyses, envisioning and planning in the context of a future sustainable civilization a backcasting framework is needed that:

(i) …has a large enough perspective in time (backcasting from a sustainable future) and space (the biosphere),
(ii) …is well structured from a scientifically relevant world’s view,
(iii) …defines sustainability by basic principles for sustainability. This makes it possible to avoid also impacts that have not yet occurred, as well as analyzing, envisioning, and planning from an open and non-prescriptive sustainability perspective (all sustainable scenarios must comply with basic sustainability principles),
(iv) …provides guidance for strategic setting of system boundaries for modeling of sustainability,
(v) …facilitates strategic handling of trade-offs between different solutions for sustainability and a way to strategically avoid unknown problems,
(vi) …can therefore also be used as a unifying and analytical framework to more effectively cooperate across sectors and disciplines, and determine how various concepts and tools for sustainable development relate to this large strategic perspective and thereby also to each other. This would not compete with, but increase the value of tools and concepts for sustainable development and help using them cohesively in combination.

The Framework for Strategic Sustainable Development (FSSD) is designed to meet those criteria and will therefore be used in this study. It has evolved during a 25 year iterative international learning dialogue between scientists from many disciplines on the one hand, and practitioners from business and municipalities on the other (see Broman & Robèrt, 2017). For more details, see Methods.

1.1. Aim and Research Questions

The aim of this report is to study how Swedish forestry can support rather than threaten the life supporting functions of forests while at the same time serve as resource-bases on more and more sustainability-driven markets. The findings of the study will also be related to the SDGs, SEOs and the Swedish NFP in order to arrive at recommendations for forest policy makers, practitioners, scientists and other stakeholders in the Swedish forest sector. The idea is for this overriding analysis to be helpful for more in-depth forthcoming studies on strategic development of forestry as well as pointing at an approach to assisting cohesion between such studies.

To achieve the aim of the study the ambition is to answer the following research questions:

1. On a general level, how should sustainable forestry best use forestland in order to support the biosphere’s essential functions for higher forms of life including civilization at large?
2. On a general level, how should sustainable forestry best use forestland in order to serve more and more sustainability driven markets with various kinds of resources?
3. How does a sustainable vision for the Swedish forest sector look like and what are the current sustainability challenges in Swedish forestry?
4. What overall measures and prioritizations should be done in the Swedish forest sector?
5. How can the SDSs, SEOs and the Swedish NFP be of support to a systematic transition towards sustainable forestry?
1.2. Delimitations and Disposition of the Report

This study does not aim to explore specific forestry details, such as wanted diameters on trees or suitable tree species for specific locations, only to use such as examples if needed to explain the explored principles and perspectives. Again, the idea is to provide an approach for analyses, envisioning, planning, cooperation across sectors and disciplines, and more in-depth forthcoming studies on strategic development of forestry.

The report starts with a theoretical background (chapter 2) that gives an overview of sustainability, forestry methods and the past and current realities of Swedish forestry, as well as possible futures. The following Methodology chapter (3) covers the Maxwell’s qualitative process design and how FSSD has been used as a frame for data collection, modeling and discussion. The result chapter (4) is divided in two sections: in the first FSSD is applied for civilization at large, in the second forestry is assessed in relation to the findings of the first section. The report ends with a general discussion of the results (chapter 5) covering validity, and how the results of the FSSD assessment relate to the SDGs, SEOs and the Swedish NFP. The last chapter (Chapter 6) is the conclusion.
2. Theoretical Background

The background explains some theory and information that is important to understand when reading the coming sections of this report. It starts with exploring sustainability at the global level and how the most known definition of sustainable development, the Brundtland definition, is elaborated into operational sustainability principles and guidelines for how to approach them in the Framework for Strategic Sustainable Development (FSSD). It then goes into what has been said about sustainable forest management. Then a short overview is given about forestry methods, which is important to read in order to understand the result sections about Swedish forestry. The background finally ends with a section that goes through the past and current situation for the Swedish forest sector as well as looks into what future studies and earlier studies have found about possible Swedish forest futures.

2.1. Sustainability

2.1.1. Sustainable Development and Sustainability Principles

The most known definition of sustainable development is, as presented in the introduction, the United Nation’s Brundtland definition (UN, 1987). In FSSD sustainable development is twofold. It represents the transition from the current unsustainable society to a society complying with basic sustainability principles, as well as the further cultural, technical and biological development within the constraints of those same principles (Robèrt et al., 2012). The funnel-metaphor is used to picture the overall consequences of un-sustainable development (for references see Broman & Robèrt, 2017). Civilization enters deeper and deeper into a “funnel”, the in--leaning wall of which symbolizes the declining potential for social and ecological systems to sustain civilization and higher life forms in general. This is for as long as society keeps breaking the basic sustainability principles (see Figure 1), leading to higher and higher concentrations of pollution (SP-1 and 2), and more and more physical encroaching on fertile land (SP-3) as well as more and more structural obstacles to people’s health (SP4), influence (SP5), competence (SP6), impartiality (SP7) and meaning-making (SP8). When the systematic decline has stopped, meaning that society complies with the basic sustainability principles, the funnel levels out and turns into a cylinder symbolizing sustainability of the remaining natural capital. In the longer run it is possible that society’s space for operation can be increased again and the enlarging cross-sectional area to the right of the cylinder symbolizes such a restorative stage. The funnel metaphor is also used to explain the self-benefit for an organization to step-wise strategic set out a direction towards the funnel opening (sustainability) rather than into its wall (unsustainability) (Robèrt & Broman, 2017). The funnel metaphor can be seen in Figure 2.

<table>
<thead>
<tr>
<th>In a sustainable society, nature is not subject to systematically increasing ...</th>
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<tbody>
<tr>
<td>1. ... concentrations of substances extracted from the Earth’s crust.</td>
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<td>2. ... concentrations of substances produced by society.</td>
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<td>3. ... degradation by physical means.</td>
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and people are not subject to structural obstacles to...

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<td>7. impartiality,</td>
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<td>8. meaning-making</td>
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Figure 1: The eight sustainability principles in the FSSD (for references, see Broman & Robèrt, 2017).
Figure 2: Sustainable development and the funnel metaphor of FSSD. The narrowing wall of the funnel symbolizes how the safe operating space for civilization is degrading for as long as basic sustainability principles are violated. When no more violation of sustainability principles takes place, the funnel turns into a cylinder representing sustainability. The increasing cross-sectional area of the cylinder then represents that it is possible to become restorative for as long as the basic SPs are not violated again, and past damage is repaired. (Created with inspiration from Broman & Robèrt, 2017 and Robèrt et al., 2012).

The FSSD-principles of sustainability are formulated as operational re-design principles of the Brundtland definition of sustainability (see Introduction, section 1). It means that they can be used for redesign of society at any scale, including individual sectors, organizations or planning-topics. The principles are created to fulfill the criteria ‘necessary’, ‘sufficient’, ‘general’, ‘concrete’ and ‘non-overlapping’ for any vision that complies with the Brundtland definition (Broman & Robèrt, 2017).

‘Structural obstacles’ of principles 4-8 are referring to “social constructions — political, economic and cultural — which are firmly established in society, upheld by those with power and, due to a variety of dependencies, difficult or impossible to overcome or avoid by the people exposed to them” (Missimer, Robèrt & Broman, 2017b). For an individual organization, or sector such as “forestry”, the eight sustainability principles are re-phrased by adding “not contributing to…”. Sustainable forestry does not contribute to systematically increasing 1. …concentrations of… etc.. This way of phrasing success, by boundary conditions designed as exclusion criteria for re-design, allows for an open and non-prescriptive dialogue between people taking part in the planning. Any successful goal proposed, including various details into an imagined scenario, can be tested for its compliance with all the basic sustainability principles, and then be evaluated and compared with other possible scenarios that are also sustainable (Broman & Robèrt, 2017).

2.1.2. Sustainable Forest Management
The concept sustainable forest management was first initiated at the United Nations Conference on Environment and Development (UNCED) in 1992 through the 15 Forest principles (Wilkie et al., 2003). The Forest principles alone cannot be used to guide and plan for sustainable forest management; instead they recognize the need for national and international complementing measures and frameworks. Sustainable forest management can be defined in several ways, but one of the most widely known definitions were framed at the Second Ministerial Conference on the Protection of Forests in Europe in Helsinki, Finland, 1993:

‘‘The stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems’’.
The implementation of sustainable forest management is done with help of other approaches and actions throughout the world (Wilkie et al., 2003): national forest programs, the development of criteria and indicators, protected area management, forest auditing and conservation, etc. In contrast to the sustainability principles of FSSD, “sustainable forest management” recognizes economic sustainability as a part of sustainable development. In FSSD the economic dimension is regarded as a subset of the social system, designed as one of many means to reach a fulfillment of the ecological and social sustainability principles (Broman & Robèrt, 2017).

The definition above (Helsinki, Finland 1993) is a description of a desirable outcome for forestry rather than an approach and a process suggesting research, measures and steps for implementation (Rist & Moen, 2013). According to Rist and Moen (2013) the two most widely known management paradigms are the Ecosystem Approach and Adaptive Management. The authors also see potential in Resilience Thinking as a third approach. The ecosystem approach is focused on biodiversity and “sustainable use”, whereas Adaptive Management “aims to reduce uncertainties through an experimental, hypothesis-based process of management” (ibid.). Resilience is according to the Stockholm Resilience Center (n.d.) defined as: “the capacity to deal with change and continue to develop”. This means that in terms of system dynamics resilience thinking stand out from the other two approaches, since it accepts change and thereby do not focus on historical reference conditions (Rist & Moen, 2013). Sustainability is also addressed differently. The Ecosystem Approach frames sustainability in terms of “sustainable use”, whereas adaptive management embraces “renewable resource management” and Resilience Thinking appears to go beyond sustainability to “reduced vulnerability, greater redundancy and adaptability and a focus on maintaining options” (Rist & Moen, 2013).

This project is not in conflict with any of the described paradigms. Instead it should be seen as a possible approach to embrace all of them while at the same time offering a concrete strategic approach for sustainable re-design.

2.2. Forestry Methods in Short
Adding to the above relatively theoretical “forest paradigms” there are also different forestry methods that are outlined more in detail. Whereas the paradigms outline philosophies, the forestry methods rather contain a selection of basic management routines and practices. This section (2.2.) explains the difference between the two main forestry methods, important to understand before reading the result sections about sustainable forestry.

Forestry always represents some level of deviation away from, or disturbance to, the natural state of forest ecosystems. Swedish forestry mainly consists of one forestry practice: clear-cut forestry. In the latter all trees in an area are felled simultaneously resulting in a bare landscape: a clear-cut. Clear-cutting is most often combined with planting of monoculture forests and unwanted species are sorted out in several clearings and thinning sessions together with trees that have low potential of becoming good timber. In thinning the sorted trees are removed from the forest to become pulp- or fire wood. Final felling of pine often happens after 90-100 years. Spruce is felled after 60-80 years (Niklasson & Nilsson, 2005). Clear-cutting is often presented as a way to imitate a fire (e.g. Jentzen et al., 2014; Pleijel, 2013), however in contrast to clear-cutting a fire leaves large amounts of deadwood, an important habitat for many species. After a fire the first pioneer species are birch and aspen - the deciduous period can last for 100 years. In the modern clear-cutting forestry this period barely exists, and if so it is relatively short (20-30 years) since planting of monocultures often takes place instead (Pleijel, 2013).

Besides the dominant clear-cut forestry another approach exists - continuous-cover forestry\(^1\) - in which trees constantly cover the landscape and felling is done regularly over time (Bengtsson & Rosell, 2012).

\(^1\) In Swedish terminology the term *hyggesfritt* is used. It has recently replaced the term *kontinuitetsskogsbruk*, which better correlates with the English term continuous cover forestry (Rosell, 2012).
Continuous cover forestry is a collection name for a diverse set of solutions that share two basic attributes: (1) the forest area is always covered by forest and (2) no clear-cuts are created (Rosell, 2012). Different approaches to continuous cover forestry can be seen over the world and a word/name can have different meanings in different countries and regions (an overview of terminology can be found in Appendix A). Fostering multispecies forests is also more common in continuous cover forestry, which is visualized in Figure 3 where the difference between clear-cut forestry and continuous cover forestry is presented.

Figure 3: In continuous cover forestry the forestland is always covered by trees and felling is done constantly over time. In clear-cut forestry the forest generally consists of one single species layer of coeval age. The clear-cut forest is felled every 60-120 years leaving a bare landscape, a clear-cut, and after final felling monoculture planting often takes place in front of natural regeneration.

This study includes an outline of so called “close-to-nature forestry” and its application in Sweden such as through Silvaskog AB (Karlsson, n.d.). In short, close-to-nature forestry is built up from two principles (Karlsson, 2016):

- **Potential Natural Vegetation (PNV):** the nature type and species composition that would be dominant in a given forest area if no or little human interference would be present. PNV is a dynamic concept that changes over time with processes such as climate change and evolution.
- **Minimal Intervention (MI):** the nature and its ecosystems shall be affected as little as possible from forestry activities.

2.3. Past and Current Realities, and Predicted Futures for the Swedish Forest Sector

In order to be able to evaluate the sustainability performance of the Swedish forest sector it is necessary to have some background knowledge about the analysis’ context. This is gained by looking at forest history, which explains why the current situation looks like it does. It shows that societal needs fulfilled by forestry have varied over time, as well as concerns and policies regarding various negative impacts from forestry. There is practical knowledge to be learnt from this, which is relevant to keep in mind for the further reading of this report.

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2 Personal communication with Mikael Karlsson, forestry practitioner, entrepreneur and Director of Silvaskog AB.
2.3.1. A Brief Review of Swedish Forest History and Today’s Forest Sector

Today 28 of 41 million hectares (69%) are covered by forest in Sweden (SLU, 2016a). This has however not always been the case, as Sweden has a relatively short history of inhabitable land. The last glacial period ended about 10 000 years ago. When the ice left everything was a barren landscape. With time more and more species returned: the first pioneers were dwarf birch and other species of willow, followed by species like willow, alder, pine and winding in the given order. About 1000 BC the beech started to inhabit southern parts of the country and around year 0 spruce had reached the border to Scania, leaving little deciduous forest in the North (Lagerqvist & Lindqvist, 1999).

Even though wood was the main material for construction and other household things during the Viking age, little pressure was put on the forest in large since the population was small. The forest also contributed with other important resources for the humans besides wood such as birch bark, quarry, berries, fruits, other edible and acorn for the pigs (Lagerqvist & Lindqvist, 1999). It was not until the time of the Swedish Empire (17th to beginning of 18th century) large-scale cutting of forests began (ibid.). During this time Sweden started to produce and export vast amounts of cannons and weapons. Sweden had materials like iron and copper in combination with large forestall assets that could contribute with fuel, charcoal, fire wood and tar to the mines and oak to the Empire fleet. When it was time to harvest the latest oak-plantations aimed for the Empire fleet, it was clear that warships where no longer made from wood. In areas with intensive mining forests were clear-cut and new mines were not allowed to open in areas where extensive clear-cutting had been taken place. The first regulations were therefore constructed, containing requirements of planting when felling (Enander, 2007; Lagerqvist & Lindqvist, 1999).

Wood was also an important material for farmers when they built their farms and households. Lagerqvist and Lindqvist (1999) tell that Carl von Linné in the end of the 18th century noted that only a few forests in the inland of Norrland had been left untouched from human hands. Some farmers were also burning forests to clear it from trees and bushes, something seen as a large waste of resources by the state (Enander, 2007). During the 19th century deadwood started to be removed from the natural forests, mostly as a preventive measure to fires. Natural woods were said to contain about 10-20 percent of deadwood at the time (Lagerqvist & Lindqvist, 1999). Politicians in the mid 19th century anyway thought that the northern forests could be used better. Sawmills were constructed as a consequence of the early industrialization in Europe and logs were driven downstream floods (ibid.). Clear-cutting was introduced as a mean to achieve larger returns from the forest than the earlier selective cutting had been given (Enander, 2007). 1859 the Swedish Forest Agency (Skogsstyrelsen) was formed with mission to organize and master the management of public forests.

In the beginning of the 20th century the debate was intense regarding whether or not to use clear-cutting instead of selective cutting. Much effort was put into the forest in form of workers and time and many people were dependent on the forest as their livelihood. With clear-cutting everything was changed in a moment and nothing could be taken out from the forest until a new one had grown up. Clear-cutting was forbidden by the Swedish Forest Agency in 1931 (at that time called Domänsstyrelsen). However in practice thinning was carried out to such an extent that small clear-cuts were created anyway, i.e. the forests were very fragmented. In the 50s large areas in Northern Sweden were clear-cut due too “poor quality” trees and large planting activities followed. Log driving was carried out in Sweden until 1990. Horses transported trees from the felling site to the flood. In the mid 20th century tractors started to replace horses and more and more forest roads were built. Today all transportation is carried out by road or railway. (Lagerqvist & Lindqvist, 1999)

Sweden holds about one percent of the world’s productive forestland, but provides 10 percent of the world’s sawn timber, pulp and paper (KSLA, 2009). That makes Sweden the third largest world exporter of paper, wood pulp and sawn wood (Skogsindustrierna, 2015). Almost 70 000 people are

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3 A cutting technique that is the opposite to clear-cutting, i.e. trees are cut selectively in order to have a continuous forest cover.
directly employed in the Swedish forest sector, which includes pulp- and paper industry, carpentry and wood-panel industry, sawmills, packaging and other paper industry, as well as forestry (ibid.).

The forest raw material becomes sawn wood, pulp, paper and paperboard, other refined products, or goes to the energy sector. Most of it becomes pulp and paper (see Figure 4). Wood fuel can be produced through: (i) chipping or crushing of logging residues; (ii) chipping or crossing of bark and wood waste by the forest products industry; or (iii) production of wood fuels such as briquettes, pellets and pulverized wood. In year 2012 the use of biofuel, peat and waste accounted for 37 percent of the Swedish energy sector. However, the forest product industry stands for most of the biofuel use (35-40%) by burning its own by-products. A large and increasing portion is consumed as district heating. The use in transport has also increased. (Skogsstyrelsen, 2014)

![Use of Wood Fiber](image)

**Figure 4:** Forest industry's consumption of wood fiber 2012 (Skogsstyrelsen, 2014)

Today Sweden has very few untouched natural or virgin forests. Most of the forests today are “cultural forests” - results from a long history of human interference and forestry practices like clear-cutting followed by monoculture planting (Pleijel, 2013). Forests older than 140 years are rare, most of them are found in Norrland (Swedish University of Agricultural Sciences (SLU), 2016a). Table 1 shows some facts about the Swedish forest sector.

<table>
<thead>
<tr>
<th>Forest Area</th>
<th>Sweden total: 40.8 million hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protected forest area in nature reserves</td>
<td>of which Forest total: 28.2 million hectare</td>
</tr>
<tr>
<td>Productive forestland</td>
<td>4 % of the productive forestland.</td>
</tr>
<tr>
<td>Forest owners</td>
<td>Spruce 41 %, scots pine 39%, and birch 12 %</td>
</tr>
<tr>
<td></td>
<td>Private individual owners 49%</td>
</tr>
<tr>
<td></td>
<td>Private companies 23%</td>
</tr>
<tr>
<td></td>
<td>Other owners 28%</td>
</tr>
</tbody>
</table>

Since 1993 an environmental goal and a production goal are two equally important goals in Swedish forest legislation. The environmental goal comprises preservation of the forest’s natural production capacity, biodiversity, natural and endangered species, and social and cultural values. The production goal states that the forest and forestland shall be managed efficiently and responsibly so that consistent good returns are achieved. Furthermore the forest owner shall be free to decide what the forest produces. (Skogsstyrelsen, 2012)

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4 Low presence of deadwood, most trees are of the same species and in the same age distribution (Pleijel, 2013).
5 Productive forestland is defined as “land suitable for forestry that is not used for other purposes and that has an ideal production of at least 1 m3sk (cubic meter standing volume) per hectare and year”. (SLU, 2016a)
6 For instance the National Property Board, other state owners, companies with the state as majority owner (Sveaskog), municipalities and other private owners such as commons and the Swedish church (SLU, 2016a).
2.3.2. Earlier work on Future Scenarios for the Swedish Forest Sector

The Swedish forest sector is a sector under transformation. Future demand for energy, food and various forest products, as well as climate change are considered as important drivers and triggers of global land use change (Nilsson, 2015; Beland Lindahl & Westholm, 2011). The increased demand is connected to predicted population growth and to that more and more people are expected to increase their consumption levels (Malmberg, 2015). Nilsson (2015) concludes:

“The scenarios demonstrate further that the global forest sector is in the process of transformation. The authors also indicate that a transition/transformation of the Nordic forest sector will not be easy. The conventional markets for both standard products and volumes produced in the boreal region are contracting over time and it will be difficult for them to be competitive with these products on other markets. Therefore, the boreal forest industry must change its business concept to new products with higher value-added and produce more value from less. The forest industry in the Nordic region is currently utilizing only a fraction of the wood and fiber potential. New products could be bio refinery products, green chemicals, advanced fuels, advanced constructions, smart packaging, and advanced hygienic and health products. These new products often have a value-added that is 10–100 times higher than for conventional forest products.”

Depending on societal interest, different stakeholder groups have different visions for the future. “Pathways to sustainability” are either framed by ecological modernization theory or sustainable development (Beland Lindahl, 2015). In agreement with the ecological modernization theory “environmental problems may be resolved without the course of societal development being completely redirected” (ibid.). This is in contrast to sustainable development line with the Brundtland view (see Introduction, chapter 1) where biophysical limits to growth are recognized and the existing growth paradigm is consequently questioned at a basic level. The traditional forest industry sector is according to Beland Lindahl (2015) expected to delimit their problem formulations and find solutions within the theory of ecological modernization, since this fits their existing perceptions of reality. The following citation from Beland Lindahl (2015) is another example of how different stakeholder interest affect the desired outcome of forests:

“For forestry- and forest industry-related actors accordingly emphasize the idea of growing young forests as carbon sinks, as it is biased in favor of action to intensify tree planting and forest production. Actors in the bioenergy sector with a stake in securing their share of the raw material base construct frames in which the climate benefits of substituting bioenergy for fossil fuels take precedence. The idea of standing forests as carbon reservoirs fits well with the traditional conservation strategies of some E-NGOs and is used as an additional argument for not logging forests. We can thus see how new issues and trends are conceptualized in ways that are compatible with actors’ traditional forest-related frames and strategies of social change. Uncertainty, ignorance, and ambiguity appear to have little room in a highly politicized field in which the actors need solid arguments to maintain their political positions and momentum.”

Another example of how bias from various stakeholder interests affect future visions is found from Sandström et al. (2016) who has used participatory backcasting to compare desired forest futures. For instance the biomass and bioenergy group promotes the current forest law and technological development in contrast to the conservation group that instead promotes decentralization and forest conservation at half of the forestland. The vision from the Sami group is framed by their own interest of being able to sustain themselves on reindeer management all year round.

The future is impossible to predict - something that this short section about predicted futures and trends is an example of. The need to do backcasting from scientifically agreed sustainability principles thereby becomes even more essential. Culturally different dreams for the future must exist within, and be distinguished from, basic sustainability constraints. Understanding the difference is essential for creative management of trade-offs and conflicts between different interest groups (Broman & Robèrt, 2017). The next methodology section goes into how backcasting has been applied in the project and why this study needs a framework for sustainable development.
3. Methodology and Research Design

The methodology section starts with explaining how research has been designed with help of Maxwell (2005), and then how the Framework for Strategic Sustainable Development (FSSD) has served as a base for information gathering and modeling. The methodology chapter ends with a section summarizing methodology and research design in a visual way.

3.1. Maxwell’s Qualitative Research Design and its Application in the Project

The study has been structured after Maxwell’s qualitative research design, which balances between five dimensions as visualized in Figure 5 (Maxwell 2005).

Figure 5: Maxwell’s qualitative research design (2005) balances between five dimensions: goals, conceptual framework, research questions, methods and validity in an iterative process. The figure explains how these dimensions have been handled in the project.

3.2. Framework for Strategic Sustainable Development (FSSD)

The framework for strategic sustainable development (FSSD) is a conceptual framework: “a mental model that allows people to categorize a complex issue in a way that aids understanding” (Robèrt et al., 2012). The framework contains five levels that should be used to structure information so that
effective analyses and planning in complex systems are possible: “*It is not a sequential process leading from one level to the next. Instead, it is important to understand all levels and the connections among them simultaneously*” (ibid.). Table 2 explains the different levels and in what ways they have been handled in the project.

Table 2: The Framework for Strategic Sustainable Development (FSSD) contains five different levels for enabling structured handling of information to aid planning in the complex socio-ecological system (Broman & Robert, 2017). The table generally describes what the different levels include and how they have been explored in this project.

<table>
<thead>
<tr>
<th>Levels in FSSD</th>
<th>Handled accordingly in the project</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1: System</strong></td>
<td>The context, in which the analysis is placed, is explored. It outlines a systems perspective on how human society relates to the biosphere and builds on knowledge about thermodynamics, conservation laws, biogeochemical cycles, climate regulating capacity, biodiversity, resource flows between nature and society, trust between people and societal functions as a vital part of a functional social system, etc. For sustainability planning, this level outlines that the system as such is under increasing pressure and decline pictured by the funnel metaphor as described earlier (Section 2.1). This first level is elaborated enough in order to understand what the overall mechanisms are that make the system un-sustainable, which leads to level 2, “Success”..</td>
</tr>
<tr>
<td><strong>2: Success</strong></td>
<td>A vision for success (A of ABCD-procedure) of a sector or organization is outlined. For sustainability planning, this level is informed by the sustainability principles. These provide exclusion criteria for sustainable re-design, or boundary conditions for any sustainable scenario. This level may also contain any other success-principles that planners want to include, for as long as this does not violate the sustainability principles. The success level (A of ABCD-procedure) was explored and modeled for the two systems mentioned above i.e. “society at large” followed by “Swedish forestry”. This was in order to provide answers to research questions 1-3 (see Section 1.1 above). Information was gathered through literature studies and interviews (see Section 3.2.1) modeled with the ABCD-procedure (see Section 3.2.2 below).</td>
</tr>
<tr>
<td><strong>3: Strategic</strong></td>
<td>Includes development of strategies for how to reach the vision of success in a step-wise fashion while considering also economic and other process-aspects to sustain the transition. The ABCD-backcasting planning procedure provides guidelines for this (see further in Section 3.2.2). The strategic level was explored by applying the ABCD-procedure for the second system analysis (the Swedish forest sector) in order to provide answers to research questions 3-5 (see Section 1.1 above). Information was gathered through literature studies and from interviews (see Section 3.2.1) and theoretically modeled with the ABCD-procedure (see Section 3.2.2).</td>
</tr>
<tr>
<td><strong>4: Actions</strong></td>
<td>The level where possible actions are prioritized by use of the Strategic guidelines into a strategic plan. This study points at an approach and relates this to various actions that have been discovered in literature and interviews. For more detailed recommendations of future actions, we point at a need for further research aligned with the approach.</td>
</tr>
<tr>
<td><strong>5: Tools</strong></td>
<td>Contains methods, tools and other support for analysis, planning, decision support, monitoring and communication that often are needed in order to secure that (4) actions are chosen in accordance with the (3) strategic guidelines for arriving at (2) success in the (1) system. Methods in this project are applied for information gathering (literature search, interviews and excursions) as well as for modeling of information (interviews, literature analyses and modeling sessions informed by the ABCD-procedure).</td>
</tr>
</tbody>
</table>
3.2.1. Information Gathering

Literature Search
Literature search was mainly done through the KTH Library’s search engine “Primo” (KTH Library, 2015). Scientific articles have also been found from the publication list of the Swedish research project Future Forests (SLU, 2016c). The latter has helped providing a good overview of the sector, summarizing ongoing research (SLU, 2016b). The city library of Stockholm’s collection of forest related books, such as books about forestry history and ecology, has also been an important literature base. So has information obtained from the Swedish Forest Agency and the Swedish Environmental Protection Agency. All data from the literature studies have been collected and strategically related to each other by use of the FSSD structure and its ABCD procedure. In summary the literature search can be described as rolling a snowball: one source of information often provided more sources to examine, all inspired by the FSSD lens, i.e. first putting knowledge from literature where it belonged in the structure of the conceptual framework, while using the structure also to find gaps in knowledge inspiring a search for more knowledge. When enough information was obtained this way, to create a sense of comprehension in context of the research questions of this study, the UN-sustainability goals (SDGs), the Swedish environmental objectives (SEOs) and the background reports for the Swedish National Forest Program (NFP) were brought in as sources of information and ideas to be compared with the information already collected, structured and modeled. In this way some added important aspects were found and put in the FSSD structured information. A number of important aspects for sustainable forestry were also identified as missing in the three listed sources. Finally, the comprehensive FSSD structure does not only point at essential elements to be considered and not forgotten, but also provided guidelines for how to manage them in cohesion and step-by-step.

Interviews
• More or less informal interviews have been carried out in order to gather information for the FSSD-modeling and for improving the general understanding of the subject: Meeting and discussion with Carl Appelqvist, project leader for Swedish Forest Agency’s project about continuous cover forestry.
• Discussion and e-mail conversations with Miguel Brandão, Associate Professor in Industrial Ecology and Life Cycle Assessment at KTH.
• Several conversations by mail with Martin Jentzen, forest consultant and practitioner of continuous cover forestry.
• Several conversations by mail with Artur Granstedt, professor in plant nutrient science.
• Conversations with Mattias Skeare, forest owner and forestry practitioner in Västra Götaland.
• Informal discussions with a forest owner in Dalarna.

Excursions
Excursions have helped to build up the general understanding and hence the conceptual framework (see Maxwell in Section 3.1):
• Study trip organized by Silvaskog AB (Mikael Karlsson) to Lübeck, spring 2016. The trip focused on close-to-nature forestry and how it is practiced in Lübeck.
• Attendance at the Swedish Government Offices’ hearing for the new National Forest Program.
• Attendance at Silvaskog’s course about close-to-nature forestry in Gothenburg, where the City of Gothenburg also presented their work with close-to-nature forestry.

3.2.2. Information Modeling
As already mentioned information has been handled with an intersystem approach, meaning that the subsystem “forests” has been identified in relation to the large global socio-ecological system. There are consequently two system analyses in this case: (1) the overall global socio-ecological system, i.e. the human civilization in the biosphere, and (2) the Swedish forest sector and its use of forestland, put in context of the overall global socio-ecological system. This is done since all sectors must become sustainable together i.e. comply with basic sustainability principles (Broman & Robèrt, 2017). For each of the two analyzed systems, the world at large and Swedish forestry respectively, analyses were done as an exploration of the system-level of FSSD informing an exploration of the second Success-
level (sustainability for the respective analyzed system). In turn, the success-level was allowed to reflecting back to the systems level in a search for lacking information there, followed by another round of “success” exploration (sustainability for the respective systems). The “dialogue” between the two systems, and sustainability for the two systems respectively, in turn informed the strategic level – guidelines for how to find step-wise approaches to sustainable Swedish forestry in a sustainable world. Discussions informed in this way by the levels of FSSD, have been shared with a small group of persons (see below) taking part in the modeling.

**Stakeholders involved in Theoretical Modeling**
- Mikael Karlsson, Silvaskog AB.
- Karl-Henrik Robèrt, professor at Blekinge Institute of Technology and the Natural Step.
- Jonas Oldmark, the Natural Step.

**Backcasting and the ABCD-procedure**

Backcasting can be described as a planning technique where “planners start by building a vision of success in the future, and then ask: what do we need to do today to reach this vision? … Taking a backcasting perspective allows planners to take into account what is realistic, but not being limited to what is realistic today” (Robèrt et al., 2012). There are two main types of backcasting: **backcasting from scenarios** and **backcasting from principles** respectively (ibid.). In the first alternative future success is defined as simplified images of the future, desired outcomes of planning at some level of detail, and often derived from a process with many stakeholders with different interests. Biases and judgments are in this way exposed and dealt with in an open manner. In backcasting from principles, on the other hand, the future image is framed by basic principles or boundary conditions for success. Planning can then either occur directly towards the principles, i.e. exploring current challenges in relation to the principles, followed by a brainstorming of all possible steps towards compliance with the principles, followed by prioritizations of those possible steps into a plan. The following “scenario” may then materialize more and more as the planning, actions, reviews of actions, and more actions, unfold into the future. Alternatively, backcasting from principles can also make use of scenarios upfront, perhaps to increase the attractiveness of visions by putting some details in there. However, first of all scenarios are then scrutinized so that they really comply with the basic sustainability principles. Secondly, it is important for participants to realize that certain details of the original scenario may need to change during development, perhaps because technical and/or cultural evolution may bring about more attractive solutions than could be anticipated upfront. Nobody can look into the future.

In FSSD’s backcasting from sustainability principles the third strategic level of the framework come to the fore. This strategic procedure is referred to as the ABCD Strategic Planning Process. When a sustainable vision has been created in “dialogue” between the first two FSSD levels (see 3.2.2 above) this is referred to as (A). A planner backcasts from A to the current state (B) in order to assess current challenges as well as current strengths and assets for the future planning. Then possible solutions and steps (C) are discovered for the bridging of the current un-sustainable situation with the sustainable vision, and finally these possible measures are prioritized into a strategic plan in (D), informed by logical guidelines:

1. Are the solutions in the right direction in relation to all SPs and other possible success-parameters of the vision?
2. Can the solutions serve as flexible platforms for forthcoming steps? “Flexible” stands for a platform allowing for different possible routes to various possible sustainable scenarios. This is opposed to platforms that would only serve one specific path i.e. a “path-dependency” (Hukkinen, 2003) towards one specific scenario. An example of the latter mistake could be to spend a huge investment to improve something inherently un-sustainable, thereby tying resources away from sustainable development.
3. Do the suggested measures bring sufficient and early-enough return on investment to fertilize the further process? Or in other words, do we strike a balance between advancement-speed on the one hand, and return on investment on the other, to avoid the “funnel-wall” (see2.1.1)
Modeling with help of the ABCD-procedure of FSSD can be described as a sort of ping-ponging thought-evolvement. A finding in one step gives inspiration to findings in other steps, with more feedback to the first step and so on, in an iterative explorative and learning process. Its efficiency is built on very clear boundaries and definitions of the steps, to allow for such a communicative process between them. In that way the ABCD process’ vision (A), current situation in relation to the vision (B), possible solutions (C) and prioritization steps for launching a plan (D) are elaborated and modeled simultaneously. Figure 7 describe the ABCD-procedure in general and how it helps generating information to an action plan that can then be implemented (on the fourth, action level, of FSSD). When the ABCD-procedure is conducted in companies regions and other organizations it is often a large group of experts from different sectors and disciplines involved that provide information from different angles for each of the steps. Conducting such large brainstorming sessions has not been possible in this project, hence the ABCD-procedure has only functioned as a theoretical guide when collecting and modeling information regarding Swedish forestry’s sustainability performance. By finding information about current challenges in relation to SPs it was possible to say what activities that shouldn’t be a part of sustainable forestry (the vision), as well as what possible activities (C) that could bridge the “gap” between the current situation (B) and the sustainable vision (A). Again it should be pointed out that this analysis only provides a first sketch for forthcoming analyzes on the same subject. Such coming analyzes will probably find more details under each of the steps, especially possible measures (C) and how these should be prioritized (D) into strategic action plans.

3.3. Summary of Research Design
The project’s interactive FSSD approach between theory and practice has built on keeping conceptually different aspects in the framework distinct from each other to allow for creative modeling, or “communications”, between the different levels (see Table 2). It lends itself well to be organized after Maxwell’s process methodology (2005), just as portrayed in Figure 7.
Figure 7: Maxwell’s qualitative research design was used to structure the study. According to Maxwell (2005) qualitative research design balances between five dimensions. FSSD is built up from five levels. When information has been gathered the five levels have been used as a lens for placing out information at the right place of the framework. Both Maxwell and FSSD highlight that research is a ping-pong-thought evolvement, meaning that the research process and information search and modeling is not a static process that goes from one dimension or level to another in a linear fashion, but rather something that jumps back and forth between different dimensions and levels to allow for an interactive enrichment and evolution of all the levels.
4. Results

An important aspect of the ABCD planning process is to qualitatively model an overall image of full sustainability for all sectors before planning of individual sectors takes place. As shown in Figure 8 sustainable development relies on that all sectors eventually become sustainable together within the constraints of the SPs (Robèrt et al., 2017). The need to do modeling in this way follows from sectors being interdependent, i.e. decisions in one sector to comply with the SPs may positively or negatively influence the sustainability potential of other sectors. Examples are how mismanaged farmland may lead to felling forests for new farmland, how the growing of crops for production of biofuels may lead to food scarcity and increased food-prizes, and how urban sprawl may lead to a reduction of productive ecosystems. Positive, mutually supportive examples, are how grazing in forests can be part of agriculture, e.g. contributing to the maintenance of sufficient amounts of humus and nutrients in cropland, or how forests serve as protection of farmland e.g. regarding drafts, floods, pests, wind-erosion etc.

![Diagram showing the relationship between the whole system and its components](image)

Figure 8: Modeling sustainability for one sector is first dependent on an image of full sustainability within the constraints of sustainability principles (SPs) for all sectors together before individual planning can take place.

Therefore the result is divided into two main chapters that present the results of an exploration of two systems: (1) the whole global socio-ecological system i.e. the human civilization in the biosphere and (2) the Swedish forest sector and its use of forestland. For the first system the two first levels of FSSD are explored, namely the system level and the success level. For the second intersystem, focusing on forestry, the same two levels are explored in combination with the third strategic level and the fourth actions level.

The FSSD framework is used to derive results from the data collected in literature studies, interviews, field studies and modeling with colleagues. This inherently implies that the structuring of data to respond to the research questions is motivated in line with the framework. This creates a sort of discussion-format of the Result section. The wider implications of the results are discussed and concluded in separate sections (Chapters 5 and 6).

4.1. System 1: Applying the FSSD on Civilization at Large

4.1.1. FSSD Level 1: System

The planetary boundary concept can be helpful to envision the acuteness of un-sustainability at the planetary level (Steffen et al., 2015). As the SPs of FSSD have been systematically and increasingly violated since decades a situation has arrived where the planetary system has reached boundaries above which the whole system erodes and is put at increasing risk (Broman, Robèrt & Basile, 2013). The biosphere has, according to Steffen et al. (2015), two key roles in the Earth System: (1) serving as a “gene bank” and (2) provide “the value, range, distribution and relative abundance of the functional traits of the organisms presents in ecosystems or biota” (Steffen et al., 2015). The first function determines how life can coevolve with abiota in the most resilient way, meaning that it is highly important for how well the biosphere can persist and adapt to abrupt and gradual abiotic changes. The second role highlights the importance of all the interlinked functions of organisms in ecosystems.
These functions are a part of the bio-geophysical processes that regulate the exchange of energy, water and momentum between the land surface and the atmosphere.

Today the capacity of the biosphere to sustain civilization and higher life forms is systematically eroded from a variety of societal activities, such as over-consumption, harmful sourcing of energy and materials, and agricultural techniques that decrease soil and water quality as well as destroying natural habitats. The impacts from these societal activities often have an effect on multiple sectors and regions, even though the impact source may have a local origin. Local emissions of fossil CO2 add to the collected emissions of this greenhouse gas. Another example can be products consumed far away from production sites, for instance exhausting freshwater reserves at the production site for values brought to consumers elsewhere. Another example of a local activity with widely spread impacts is how local clearing of forests, for production of foods to cattle and people e.g. soya beans, contributes to global climate change. Solving these issues inherently implies a need for cross-sector cooperation, and such can be effectively enabled by use of sustainability principles applied as a shared mental model across sectors and disciplines (Robèrt et al., 2016).

When exploring the overall global socio-ecological system four interlinked and logically sequenced perspectives can be used. Success in one perspective is highly dependent on the success in others (Robèrt et al., 2017):
1. **the resource-base perspective**: including the sourcing of energy- and raw materials in agriculture, fisheries, mineral ores and forestry;
2. **the spatial perspective**: dealing with how to prioritize land-use for providing the above resources such as food, energy, materials, and areas needed for infrastructure;
3. **the technical perspective**: representing the technical challenges society has to solve in order to comply with the priorities following the above spatial considerations;
4. **the governance perspective**: containing the structures that must be in place for governance and decision-making power to ensure that the other three planning perspectives are coordinated, communicated, monitored, and sufficiently sourced.

The second, spatial, perspective is particularly crucial, puts forests at the top priority of planning for the future, and determines how the other three should be interlinked. In the future sustainable society, complying with SP1 (see below), energy-flows are no longer intimately linked to linear material flows from finite mineral ores to increasing pollution and other problems in the biosphere and in society. Sustainable energy sources – biofuels, hydro, solar, waves etc. – are relatively more area consuming than fossil fuels and nuclear power and sustainable development inherently implies a need to putting more pressure on land use and thereby spatial planning (Dijkman & Benders, 2010). It’s about areas needed to capture primary energy for sustaining the life-supportive functions of natural systems as well as for all kinds of societal activities. Examples of the latter are areas needed for food and energy production, forestry, human housing and infrastructure (Robèrt et al., 2017).

When handling this competition for land, it is important to recognize which spatial usages that are of highest importance for sustainability. First of all it is important that enough areas for the *nature* with its life-sustaining functions are secured for society’s continuous existence on the planet. Next, society needs sufficient areas to produce *food*, then areas for production of *energy and materials* also for other purposes of civilization than nature’s integrity and people’s food, and lastly areas for civilization’s *infrastructure* (Robèrt et al., 2017). Figure 9 explains these categories further and the order of prioritization in society. The role of forests and forestry follows from this same order of priorities, being key from the top (sustaining nature), through food, to being an essential contributor of materials. The following two perspectives, engineering and governance, will be all about understanding those priorities, understanding how to calculate the highest resource-potentials for different technical solutions within the boundary conditions of the SPs, and modeling to create as technically elegant solutions as possible e.g. through double-functions of various areal uses, and reducing the need for area-consuming infrastructures e.g. by public transport or an electrified traffic that needs no fuel-sector.
4.1.2. FSSD Level 2: Success in the Global Socio-ecological System

The following section presents conclusions in the global socio-ecological system from not violating the basic sustainability principles. This knowledge is important to have in mind when further exploring success for forestry.

SP1-3: ecological sustainability principles, designed from an understanding of three overriding mechanisms by which nature can be systematically degraded (Broman & Robèrt, 2017).

SP-1: A sustainable society is not contributing to systematically increasing concentrations in nature of substances extracted from the Earth’s crust (lithosphere principle)

The first SP addresses polluting use of lithospheric resources such as fossil fuels, metals and minerals. It is about a net input of elements to the biosphere from the lithosphere, such as heavy metals or phosphorus. Elements never degrade, and are typically returning only very slowly in geological processes to the Earth’s crust through sedimentation and mineralization. For instance increased concentrations of phosphorus derived from fertilizer use, leading to eutrophication and ocean and lake anoxia due to increased algae blooming and reduced sunlight deeper down in waters. Combustion of fossil fuels in power generation and in the industrial, residential and transport sectors is an example of very large emissions of something that is relatively abundant in the biosphere, natural CO₂ concentrations (Steffen et al., 2015). Increasing such concentrations affects the energy balance of the Earth system and, due to the large volumes, CO₂ is considered to be the dominating factor behind climate change. Increased CO₂-concentrations also causes ocean acidification with connecting adverse impacts on biodiversity through altered concentrations of H⁺ (ibid.). Use of minerals and metals outside of tight enough technical loops leads to increasing polluting concentrations (Broman & Robèrt, 2017), in particular for dissipative use of such materials that are normally scarce in natural systems or when emissions of more abundant metals and minerals are very large in relation to natural concentrations (Azar, Holmberg & Lindgren, 1996; Klee & Graedel, 2004).
Solutions to end violating the first SP’s are (Robèrt et al., 2002; Broman & Robèrt, 2017):

- Change from fossil energy sources to renewable sources and create energy-efficient societies. Use renewable energy sources with the highest energy-conservation ratio, e.g. use hydro-, sea-wave-, geothermal-, wind-solar-energy before biofuels.
- Halt inefficient resource use of minerals and metals by increasing re-use, recycling, reducing waste and modern business models such as various leasing-systems building on such possibilities.
- Develop new agricultural models where phosphates are recycled efficiently rather than running in linear flows from phosphate ores through farming to waste streams no longer available for crops.
- Change from using scarce metal resources, to metals that are more abundant in natural systems.
- Development of new materials that can substitute for metals.

SP-2: A sustainable society is not contributing to systematically increasing concentrations in nature of substances produced by society (chemical principle)

The second SP concerns all substances produced by society, such as different forms of chemicals. Today there are more than 100 000 chemicals and another additional amount of nanomaterial and plastic polymers in the global commerce (Egeghy et al., 2012; Steffen et al., 2015). The “cocktail effect”, arising from combined use of different substances, poses even greater threats to biosphere integrity, since the combination of two or more chemicals can lead to un-sustainability related impacts, even when the individual compounds at the same respective concentrations are not (Persson et al., 2013). According to Persson et al. (2013) a chemical or a mixture of chemicals pose a threat to the Earth system if: (i) the chemical has a disruptive effect on a vital Earth-system process; (ii) the disruptive effect is not discovered until it is a problem at the global scale; and (iii) the effect is not readily reversed. However according to the SPs any chemical will cause damage at some point, for as long as it is allowed to systematically increases in concentration in nature. This is no matter how toxic or bio-accumulative it is currently believed to be (Broman & Robèrt, 2017). An example from history is how CFCs were thought to be harmless precisely because they are relatively very non-toxic and non-bio-accumulative. From complexity reasons it would have been impossible from upfront to determine that large-scale use would eventually lead to adverse impacts on the stratospheric ozone layer (Broman & Robèrt, 2017; Steffen et al., 2015). From this reasoning follows the definition of the second SP.

Fertilizers with nitrogen (N) is a group of substances produced by society that leads to environmental concern despite that nitrogen, like CO₂, is an essential nutrient that naturally cycles in the biosphere. Increased concentrations of Nitrogen compounds to the Earth System occurs through (i) intended use of biological or artificially produced N-fertilizers; and (ii) unintended nitrogen emissions e.g. emissions of nitrogen oxides (NOx) from transport and industry (Steffen et al., 2015; Vries et al., 2013). Increased concentrations of nitrogen oxides leads to: acidification of soils and fresh waters, greenhouse gas formation (e.g. N₂O, also part of depleting stratospheric ozone), air pollution due to formation of close-to-land ozone from NOx induced photochemical reactions, and eutrophication in seas and lakes from contamination by nitrate (NO₃⁻) (Vries et al., 2013). All these effects have severe impacts on biodiversity and ecosystem functioning (Steffen et al., 2015) and the system will erode more and more from this for as long as further increases of NOx concentrations are not halted and NOx levels are returning to non-harmful levels.

In conclusion, solutions to sound management of chemicals and substances from societal production are connected to managing chemical use under great levels of uncertainty. Even though one chemical can be identified as relatively non-hazardous, there is always an eco-toxic threshold somewhere that must not be exceeded if destruction is to be avoided. Furthermore, the cocktail effect arising from various usages might cause damage already before such individual thresholds are exceeded (Collins,
2017; Persson et al., 2013). General solutions for sustainable development are (Robèrt et al., 2002; Broman & Robèrt, 2017):

- Use mass-balance calculations (degradability vs. emitted amounts in relation to natural concentrations) before new chemical uses are introduced to the market. When it comes to new chemicals, the first aspect (degradability in various conditions and temperatures) is of particular importance.
- Changed practices in agriculture and forestry so that the amounts of fertilizers, if used, are within the assimilation capacity of ecosystems.
- Tight enough technical cycles so that emissions or leakages from industrial processes, wastewater or sewage do not lead to increasing concentrations in nature.

SP-3: A sustainable society is not contributing to systematically increasing degradation of nature by physical means (displacement principle)

The third principle implies that “the area, thickness and quality of soils, the availability of fresh water, the biodiversity, and other aspects of biological productivity and resilience, are not systematically deteriorated by mismanagement, displacement or other forms of physical manipulation; e.g. over-harvesting of forests and over-fishing” (Broman & Robèrt, 2017). No further elaboration will be done here, since coming sections in this study will deal with land-use and physical displacement in more detail. However, general solutions connected to avoiding violation of the displacement principle are (Robèrt et al., 2002; Broman & Robèrt, 2017):

- Land surfaces are used efficiently in society,
- No methods, processes and management systems shall result in systematical displacement of nature.
- Renewable resources are not taken out faster than they are regenerated.

SP-4: A sustainable society is not contributing to systematically increasing structural obstacles to people's Health

This principle is about a societal design that respects people’s possibility to uphold health (Missimer, Robèrt & Broman, 2017b). Examples of violation of this principle may be structures and norms leading to harmful working conditions, salaries insufficient for sustaining individual health, or not having access to basic social systems or to safe products, services and living environments. Sustainable societies do make sure to secure all those needs, for instance by:

- Creating democratic societies that respect human rights, for instance by providing access to fair legal judgment.
- Setting up and monitor rules and policies that secure sound working conditions, e.g. by not allowing child labor or exploitation of people.
- Providing functioning institutions such as hospitals.
- Monitoring, e.g. through polls, how people perceive norms and use of power in this respect.
- Demonstrating and evaluating clear actions that follow from listening. Freedom to speech, polls and other ways of listening are of no help unless they lead to change when this is called for.

SP-5: A sustainable society is not contributing to systematically increasing structural obstacles to people's Influence

Violations to the possibility to influence are taken place in suppressing regimes, for instance by limited freedom of speech, corruption, deception and lies and limited participation rights (Missimer, Robèrt & Broman, 2017b). Sustainable societies are societies that for instance

- Make sure no misuse of political or civil rights occurs, e.g. by allowing sovereign leaders.
• Make sure suppressing regimes are not supported by the rest of the world.
• Provide people the freedom of speech by not censoring media or putting people with different opinions in jail.
• Provide arenas for communication and discussions in society, e.g. by arranging local hearings or information meetings.
• Monitoring, e.g. through polls, how people perceive norms and use of power in this respect.
• Undertaking and evaluating clear actions that follow from listening. Freedom to speech, polls and other ways of listening are of no help unless they lead to change when this is called for.

SP-6: A sustainable society is not contributing to systematically increasing structural obstacles to people’s Competence
Constant learning is necessary in order to be able to respond and adapt to changes fast enough (Missimer, Robèrt & Broman, 2017b). Learning is important for society as well as individual organizations in order to foster flexibility. In order to make sure no structural obstacles to learning exists the following parameters are examples of what must be secured:
• Access to education, for instance by giving children possibilities to go to school or by providing possibilities for common and individual learning at workplaces.
• Fostering the right to know, e.g. by not hiding information from people who have the right to be informed.
• Possibilities for personal development, e.g. by removing systems and approaches that do not support innovation and continuous development.
• Monitoring, e.g. through polls, how people perceive norms and use of power in this respect
• Undertaking and evaluating clear actions that follow from listening. Freedom to speech, polls and other ways of listening are of no help unless they lead to change when this is called for.

SP-7: A sustainable society is not contributing to systematically increasing structural obstacles to people’s Impartiality
Unequal societies are created by partial treatment (Missimer, Robèrt & Broman, 2017b). In sustainable societies:
• Policies and works aren’t discriminative, e.g. by not allowing diversity in opinions and believes.
• Production and consumption patterns aren’t unfair, e.g. regarding food availability, energy consumption and environmental impact.
• Public and private steering institutions take responsibility for their actions, e.g. by acting as “good examples” for impartial treatment.
• Decisions are taken with respect to people’s different needs and interests, e.g. by including public participation in decision-making.
• Monitoring, e.g. through polls, how people perceive norms and use of power in this respect.
• Undertaking and evaluating clear actions that follow from listening. Freedom to speech, polls and other ways of listening are of no help unless they lead to change when this is called for.

SP-8: A sustainable society is not contributing to systematically increasing structural obstacles to people’s Meaning-making
Human are species that constantly seek for purpose and meaning in life. Nevertheless people are often exposed to obstacles to meaning making, such as limited possibilities to perform meaningful work and by societal or organizational ignorance of personal, religious or civic values (Missimer, Robèrt & Broman, 2017b). Sustainable societies hence take actions such as:
• Providing workplaces and methods that foster meaningfulness, e.g. by recognizing the meaning of people’s performance.
• Provide organizations and living environments that accept all, despite of religious background, gender, age, differences in talents and competences.
• Monitoring, e.g. through polls, how people perceive norms and use of power in this respect.
• Undertaking and evaluating clear actions that follow from listening. Freedom to speech, polls and other ways of listening are of no help unless they lead to change when this is called for.

4.2. System 2: Applying the FSSD on the Swedish Forest Sector

After an exploration of the large socio-ecological system, the Swedish forest sector and its use of forestland are analyzed on the first and second levels of FSSD and to a limited extent also on the three remaining levels.

4.2.1. FSSD Level 1: System

Given the above outlined spatial prioritization dilemma the use of forestland must be prioritized to produce certain ecosystem services before others. Nature functions are first and foremost intermediate ecosystem services, such as air quality maintenance, climate regulation, erosion control, regulation of diseases, water purification, primary production, production of oxygen, and soil formation, whereas it is the final ecosystem services that supply society with food, wood and energy sources (Alcamo et al., 2003; Guerry et al., 2015).

The Planetary Boundary (Steffen et al., 2015) calculations point out that 85 percent of the potential forest land in boreal areas must be covered by forests and that 75 percent of this area should have its original cover left in order not to exceed the capacity for the bio-geophysical processes in land systems that directly regulate climate (exchange of energy, water, and momentum between the land surface and the atmosphere). Sweden is according to Steffen et al. (2015) in the zone of uncertainty, where the risk for crossing the planetary boundary is high. A forestry that strives to sustain such functions rather than disrupting them, will obviously allow for more forestry within the sustainability constraints set by the SPs. However, due to the complexity of natural functions, the precautionary principle must also be applied. An example of this is the biosphere 2 project where an attempt to mimic natural functions failed (Winerip, 2013). It is therefore likely to believe that substantial land-areas in the future needs to be reserved for only providing nature functions (Robèrt et al., 2017). However, the better society succeeds to manage forests as non-disruptively as possible, and to effectively provide as many ecosystem services as possible, the less land has to be protected to only provide nature functions (see further in Chapter 5). Figure 10 pictures this.

![Figure 10](image.png)

Figure 10: Depending on how society succeeds to sustain nature functions within the managed forest (forestland for materials), more or less forest area needs to be protected to provide only such functions. The intersecting area of the two green circles symbolizes the forest area that can provide both nature functions and materials.

Society must stop “enhancing short-term production and consumption of marketed commodities at the expense of stewardship of natural capital necessary for human well-being in the long term” (Guerry at al., 2015). To ‘stop enhancing short-term production’ connects to society’s use of forest ecosystem
services. Products with long-term uses should be prioritized before products with short life cycles. An example is timber, or polymers produced from forestry-feedstock, providing societal value for many decades in the construction sector. This is to be compared with the same amount of carbon passing through the one-time use in a combustion process of bio-alcohol propelled traffic (Robèrt et al., 2017). It is likely that wood fiber will be used even more than today as construction material for such uses where it can replace other materials in functions where those are more costly to use and safeguard within sustainability constraints, e.g. cement and concrete. Residues and wood waste from such forestry is likely to be increasingly used as feedstock for the chemical industry (to replace fossil raw-material in this sector). Forestry systems should enable flexibility when it comes to delivering materials to society (over and above sustaining the nature’s integrity and planning for its indirect and direct role for food production when we have stopped using fossil fuels). It is impossible to know at the level of detail what forest products that will be requested in the future and since trees grow slowly it is dangerous to “bet everything on one card” both when it comes to the selection of plants and the structure of forests. Today’s market requests should only have limited weight in deciding what may be needed from forests in the future. Those aspects should be modeled together in order to approach what sustainable Swedish forestry should be like. The next section examines what the sustainability principles can tell about the sustainability performance of the Swedish forest sector.

4.2.2. FSSD Level 2: Success in the Swedish Forest Sector
The sustainability principles are used to evaluate the sustainability performance of the Swedish forest sector. The results follow from the above outline of success in the global socio-ecological system. As mentioned in the Methodology chapter, the ABCD planning procedure (on the third strategic level of FSSD) with examples of concrete measures and actions (on the fourth level of FSSD) has been used to structure the findings in this section.

SP-1: lithosphere principle and forestry
In the future forestry machines and transports are driven on fossil free energy such as renewable fuels or electricity and management routines are highly efficient regarding energy and other resources. Nitrogen fertilizers, when sometimes used, are not manufactured by use of fossil fuels. This is in contrast to today’s situation in which the energy consumption is dependent on the number and intensity of management activities (González-García et al., 2009; 2013). Certain continuous cover forestry has great potential to minimize energy need, such as close-to-nature forestry, since (Karlsson7, 2016):

- It enhances natural vegetation, natural succession and regeneration requiring lower external energy-support.
- More manual felling is done.
- Scarification, fertilization and application of pesticides are not performed.
- Final felling and several clearing and thinning-sessions are replaced by regular selective cutting sessions.

Machines and other equipment are produced, used and recycled without contributing to increased concentrations of metal pollution in nature. Today large machines are used in forestry, such as forwarders and timber trucks. The need for large machinery and equipment will most likely continue to exist alongside more manual work in the forest. The presence of large trees will increase in close-to-nature forestry (Karlsson8, 2016) and these are very difficult to handle without technical assistance. Solving the issue to get out of fossil dependency and non-sustainable sourcing and handling of metals requires cooperation across sector boundaries. When doing so it will also become clear that the forest won’t be the solution to getting out of society’s fossil dependency since, as discussed before, using biofuels is not what the forest resource is best used for (Robèrt et al., 2017). It will be difficult to produce as much bioenergy as needed and in the same time deliver all the other requested forest services such as those needed for nature’s integrity, protecting cropland, and on top of this sourcing of materials to society. This is not the least since forests are highly efficient when it comes to producing materials to society.

7 Personal communication with Mikael Karlsson, forestry practitioner, entrepreneur and Director of Silvaskog AB.

8 Karlsson, 2016.
materials. The opposite is true when we compare biofuels and other forms of energy production from forests with photovoltaic, wind-power, hydropower etc.; bioenergy is relatively inefficient from a systems perspective (Borén et al., 2017; Robert et al., 2017). When using wood it must also be secured that carbon is captured in the long term, not the least in soils of forestlands.

**SP-2: chemical principle**

Large-scale use of pesticides and use of relatively persistent pesticides are not used in a sustainable forest sector. Historically the use of pesticides has been a problem in forestry (Enander, 2007; Lagerqvist & Lindqvist, 1999). Nowadays other solutions are available for handling invasive species and pathogens, such as use of degradable pesticides or natural bio control of pests by e.g. by adopting natural forest design (Klapwijk et al., 2016). Improved forest growth is obtained by optimal planning of forest design and composition, e.g. by fostering multi-species forests (Gamfeldt et al., 2013).

In a sustainable society fertilizing with nitrogen does not contribute to letting out more nitrogen oxides in the biosphere. Amounts allowed within the SP-2 constraint depend on whether or not the ground possesses an excess of nitrogen or not. Nowadays fertilizing is carried out at about 33 000 ha forestland yearly, which corresponds to about 0.15 percent of the total area of forestland (Skogstyrselsen, 2016). In total about 10 percent of the forestland have been subjected to nitrogen fertilization at some occasion (Noehrstedt, 2001). Even though fertilization occurs to a relatively small extent in forestry, the global and local risks with applying nitrogen fertilizers at all are still high. The sustainability principles are about “not contributing to…”, and in many regions there is no marginal room for any further nitrogen-emissions at all since other sources are in play at the same time (e.g. agriculture, industry and traffic). Finally, SP-2 is also violated indirectly from physically destructive forestry causing material leakages, which will be discussed at the end of the next section about SP-3.

**SP-3: the displacement principle**

Very few natural forests exist in Sweden today and with the modern clear-cut forestry society moves further away from the natural forest design reducing, for instance, biodiversity (Eide et al., 2014). Historically, when people had little impact on nature and only small take outs of wood were done, there was great room for species movement in forests (as visualized in Figure 11a). With increased human population and intensified forestry the opposite scenario turned out: “nature’s integrity” has been diminished to small, fragmented and isolated areas (as seen in Figure 11b). According to the spatial planning perspective the future sustainable scenario relies on our preparedness to, very fast, begin to prioritize nature’s integrity with its life-sustaining functions for the path ahead. The difference from history however is that it is currently not only forestry that conquers for forestland. Pressures also comes from food production, as well as fracking and tar-sands and other means of fossil-fuel extraction, infrastructure, housing, etc. as visualized in the third box (Figure 11c). Maintenance of sustainably managed green areas for ecological reasons and biodiversity is crucial in order to secure biosphere integrity. Forests should either be nature reserves or forests managed with continuous cover forestry and other researched means to comply with the third sustainability principle. Multi-species and multilayered forests have a more diverse structure and thus room for more biotic life (Felton et al., 2016; Gamfeldt et al., 2013). Favoring natural regeneration and local plant materials are also beneficial as natural pest control, since natural adapted solutions are more resilient (Klapwijk et al., 2016a). With global trade and climate change the risk for invasive species establishment increases; solutions to the latter are discussed to be found on a political level (Klapwijk et al, 2016b) but even so – a proactive private forestry acting as role models may be essential for such policies to be implemented in time (Robèrt & Broman, 2017).
Figure 11: The historical forest landscape (a) was dominated by large natural capital assets in contrast to today’s situation (b) in which areas for natural capital assets are limited. The future use of forestland (c) does not only hold natural capital, but also limited areas for tree plantations (clear-cut forestry), food production, energy and material sourcing and production, as well as different kinds of infrastructure.

The future areas with tree plantations, managed by forestry, are consequently limited in size. These could be managed as “closed-systems”, meaning that the activities taking place within these areas shall not have an impact on the surrounding areas. For instance no introduction of species shall take place that pose a risk to surrounding biodiversity. An example from history is how the lodgepole pine in some areas has replaced many local occurring tree species in Sweden (Andersson et al., 1999). Research shows that introduced tree species might have lower resistance to pests (Wallertz, Nordenhem & Nordlander, 2014). If outtakes of roots and branches are done within the clear-cut plantations, then solutions for mitigating nutrient loss or impact on water quality must be taken as well as other measures for not violating the sustainability principles.

Assessing different forestall activities’ impact on water quality in and downstream a watershed is complex, since there are cumulative effects resulting from multiple management activities occurring at different times (Alexander et al., 2007; Schelker et al., 2014). Deforestation for other land uses should be minimized also for other than direct physical damage to biotopes and nature’s integrity, since it indirectly results in violation of the first and second sustainability principles as well. First, over time it contributes to increased CO₂ levels in the atmosphere due to that more carbon is captured in biomass of trees and in forest soils than is stored in other land systems such as grasslands (Pleijel, 2013). Second, forestry activities - such as clear-cutting, outtakes of roots and branches, thinning, scarification, forwarding, timber transport and ditching/water drainage – does not only physically disturb water tables and water flows. It also increases the risk for material leakage (Bishop et al., 2009; From, Stengblom & Nordin, 2015). For instance, runoff from clear-cuts is documented to increase transport of nitrogen, dissolved organic carbon (DOC) and sludge into water bodies (Schelker et al., 2014). DOC is an important “transporter” of toxins, metals (such as mercury and arsenic) and persistent organic pollutants and it also affects how much light that is available on depth since DOC makes water turbid (ibid.). When nutrients and metals are in dissolved forms, they become accessible for flora and fauna and thereby affect biodiversity. For instance toxic levels of mercury in fish, due to a violation in society of SP-1, has raised major concern (Eklöf, Lidskog & Bishop, 2016). Solutions to lowering the impact from forestry activities on water quality and ecosystems are also connected to
better planning of log transports to fixed road systems, to specific seasons (such as when the ground is frozen), and to the use of machines with lower ground pressure (Bishop et al., 2009; Karlsson, 2016). In small numbers we have also begun to see a re-incarnation of horses in forestry to comply with SP3, followed by interesting economic perspectives regarding comparison of life-cycle costs (e.g. heavy machines vs. horses, biodiversity and resilience in the face of climate change) and life-cycle income (e.g. growth-rate of high-quality timber) (Skeare, 2016). In highly sensitive areas (e.g. highly biodiversity rich areas) buffer zones, such as small swamps, wetlands and tree-covered zones can be created next to water bodies in order to trap nutrients, sludge and heavy metals (ibid.).

**SP-4: Health**

Human rights and respect for the individual are part of sustainable forestry. An example of misuse of human rights from today’s forest sector is how low-paid immigrant workers are hired as berry pickers to the Swedish forests and forced to work without having access to sound working conditions (Wingborg, 2012). Solutions to overcome the problems with exploitation of human rights are on an education level for all people in the forestry sector. This includes the political level, for instance by looking over how the Swedish right of commons is used for commercial use.

In the future forestry working conditions are sound and safe. Manual forest work is a high-risk job that historically and today has put people’s health and life at risk. Today, for instance, it is necessary to have a license for using a chainsaw (Säker skog, n.d.). Continuous measures must always be taken to inform and educate forest workers about how to mitigate the health risks in forests. Meanwhile manual forest work can also be beneficial for people that today have sedentary jobs.

**SP-5: Influence**

Rain-deer headers, as well as other people living in sparsely populated areas, often feel that they are overlooked in forestall decisions (Sandström & Öhman, 2013). From a discussion with a forest owner in the Swedish region Dalarna it was clear that locals are angry on agencies who sit at a distance and create nature reserves without giving economic compensation for the income loss the forest owner experiences. In some areas the forest is more important as an income than others. Taking this in consideration when assessing how to manage, or not to manage, a forest is crucial. Sometimes potential nature reserves could continue to be managed if done so in ways that do not violate the SPs at any scale. If forest consultants would be better informed about alternatives and of how to present the importance of forests as providers of nature functions, then the potential for finding suitable solutions where both nature concern and individual meaning would increase. Wallin, Carlsson and Hansen (2016) also highlights the importance of bringing national and regional policy makers to the local arena and landscape level in order to increase individual’s sense of having influence.

**SP-6: Competence**

The research arena on forestry is mainly focused on clear-cut forestry, since it has been the dominant practice since the middle of 20th century (Klapwijk et al., 2016a). Due to this, the acquired knowledge on continuous cover forestry is generally quite limited. Carl Appelqvist, project leader of the Swedish Forest Agency’s project about continuous cover forestry systems, explains that the Forest Agency’s policy is that continuous cover forestry shall coexist besides clear-cut forestry. Furthermore that a fear may exist in the sector that continuous cover forestry systems will be misused, i.e. that the individual forest owner fails to succeed with afforestation if planting isn’t done, or that too intensive cutting make forests more storm sensitive. Continuous cover forestry-systems systems are moreover often grouped into one unit (see for instance the Forest Agency: Skogsstyrelsen, n.d.) and compared to the type of selective cutting occurring in the beginning of the 20th century. There is a fear of doing the same mistakes as before the breakthrough of the clear-cut forestry during the period 1950-1970: “the

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8 Personal communication with Mikael Karlsson, forestry practitioner, entrepreneur and Director of Silvaskog AB
9 Personal communication with Mattias Skeare, forest owner and forestry practitioner
10 Personal communication with anonymous forest owner and agriculturalist from Älvdalen in Dalarna, Sweden
11 Personal communication with Carl Appelqvist, project leader for the Swedish Forest Agency’s project about continuous cover forestry
ones who now argue for going back to earlier forestry systems shall consider the condition of the forest fifty to sixty years ago. It was not a forestry that favored a sustainable yield. Especially in Norrland it was devastating for the ground condition in some areas due to the low litter production, something that hardly favored biodiversity. ” (translated from Enander, 2007, pp. 206).

Mikael Karlsson\textsuperscript{12}, entrepreneur and practitioner, states that much has happened regarding the types of continuous cover forestry practices available. Close-to-nature forestry, as practiced in Lübeck (European Forest Institute, n.d.), is rather an approach than a single system. One of the core principles of the model is “minimum interference”, which highlights that an activity should not be done if it puts the natural ecosystem at environmental risk. This is decided on by doing research on comparing managed areas with unmanaged reference areas, in which the nature can freely evolve. According to Karlsson the risk is not associated with the use of continuous cover forestry per se, but from sub-optimized design in combination with overuse of biomass. In order to manage the forest successfully with close-to-nature forestry a great deal of tactfulness as well as more research is necessary. More planning and knowledge about site conditions are required than in clear-cut forestry, which is much more based on templates for how to plant and when to perform different management activities such as thinning and clearings. For continuous cover forestry to gain importance and influence compared to clear-cut forestry, the following measures are needed:

- Visualizing and communicating good examples of continuous cover forestry- systems, both regarding environmental improvement and yield.
- Establishing better competence about continuous cover forestry- systems by improved research and “outside the box thinking”, for instance gained from including other research disciplines such as biology, ecology and social science.
- More diverse education systems. Today’s forest education and research is mainly concentrated to two places in Sweden (Umeå and Skinnskatteberg).

It is often assumed that a forest can be seen as a carbon sink only for as long as trees grow on the height and that old forests have reached a carbon balance, i.e. they are believed to take up about the same amount of CO\textsubscript{2} through photosynthesis as it releases through respiration in decomposition (Hjorth, 2003; Pleijel, 2013). Nonetheless just because a tree has stopped growing on the height doesn’t mean it has stopped increasing in volume. At the extreme a single large tree can fix as much carbon to the forest within a year as is contained in an entire mid-sized tree (Stephenson et al., 2014). Tree volume is therefore something that needs to be analyzied further within Swedish forestry, since trees could potentially stand longer in the forests than is the case today. Favoring larger trees is done within close-to-nature forestry, but as discussed above there is little research about continuous cover forestry methods in comparison with clear-cut forestry. Moreover when stand growth and environmental impacts between continuous cover forestry and clear-cut forestry are compared, for instance by using life cycle assessments, it is commonly two monocultures that are assessed (e.g. Lundmark et al., 2016) and not mixed stands. Ambiguities still exists regarding whether or not volume production is better with multiple species systems and conclusions are dependent on the design of experiments and measurements (Felton et al., 2016). For life cycle assessments factors such as indirect land use change, albedo, impact on biodiversity, as well as carbon stock changes are often difficult to predict and quantify and therefore handled differently in assessments and comparisons (Brandão\textsuperscript{13}, 2016). Finally, soil-composition is very important when growth is considered, partly because potential growth into the future is relying on robust soils, partly because forest soils probably provide as important carbon sinks as the trees themselves (Goodale et al., 2002; Fontaine et al., 2007; Wieder et al., 2015).

There are many short-term interests in the forest resource and the forest sector is not always competently considering how to best prioritize the forest for future societal needs. There are many

\textsuperscript{12} Personal communication with Mikael Karlsson, forestry practitioner, entrepreneur, Director of Silvaskog AB

\textsuperscript{13} Personal communication with Miguel Brandão, Associate Professor in Industrial Ecology and Life Cycle Assessment at KTH.
examples of this from the history. For instance oak was planted on Visingsö in the 1820s to provide the fleet with good timber, already mentioned under the history section 2.3.1 (Ekvall & Bostedt, 2009). When the fleet then stopped to build its ships from timber it was suggested that the oak would be used for parquet floors instead. Today the oaks are about 200 years old (not too old for being an oak) and protected, since they are seen as key habitats for biodiversity. This is an example of difficult-to-foresee societal changes over time. Therefore it is crucial that today’s system enable enough flexibility when it comes to being open to a change of future needs of ecosystem services as well as resources for societal production, and that forests are planned and managed wisely in this regard. For instance today’s society puts a large pressure on the forest sector to produce raw material for bioenergy. This wood usage might not be the most wise from a future spatial planning perspective since: (1) bioenergy systems require very large areas compared to other renewable energy systems e.g. hydro, photovoltaic, waves, wind etc. (Borèn et al.; Dijkman & Benders, 2010); (2) this conquers with the functions of natural forests as well as with much more resource efficient use of forestry for timber and material production from the chemical sector, where the life spans of utility are so much longer (Robèrt et al., 2017) and; (3) carbon is not removed from the atmosphere in a long time perspective (Chadwick et al., 2014). Continuous cover forestry systems, such as close-to-nature forestry that tries to mimic nature’s own structure by not favoring monoculture plantations, should have larger potential than clear-cut forestry to provide this flexibility.

**SP-7: Impartiality**

The literature studies and interviews in this thesis have provided numerous examples of how money often “speaks” so loud that those with less of it have little or no say. Below, under this paragraph, follows many examples of this.

The forest industry has a huge influence on today’s Swedish economy, based on the large export of sawn timber, pulp and paper (KSLA, 2009). Private companies own 23 percent of the productive forestland (SLU, 2016a) and often also parts of the value chain such as pulp-industries and sawmills. Consultation to private forest owners regarding forestry systems is also often given for free by large forestry companies, making it more difficult for independent consultants to operate on the market (Lidskog & Löfmark, 2016).

Impacts on “natural capital” are generally left out from forest profitability calculations as well as in most other cases regarding ecosystem services: “the appropriateness of discounting in cases affecting natural capital with potentially profound influences on future generations is controversial and entails ethical as well as economic considerations” (Guerry et al., 2015). This is an example of inter-generational inequtiy (Missimer, Robèrt & Broman, 2017b). The real costs for destroying natural capital and forest ecosystems must be put large enough for destruction to stop. Either by private forest owners thinking and planning like this, or by policy making, or even better – a dynamic combination of the two (Robèrt & Broman, 2017). A comparison could be done to climate change. It doesn’t matter if the exact planetary boundary for temperature increase is known for as long as burning of fossil fuels continues and we keep approaching this boundary wherever it is (Robèrt, Broman & Basile, 2013). Full sustainability is reached first when there is a complete halt to further violation of the SPs. The topic about “natural capital” will be further discussed under “Discussion” (Chapter 5).

Today’s profitability calculations in forest economy can give very different results depending on what is included in the calculation and if it is connected to maximum land value or cash inflow (Ekvall & Bostedt, 2009). Thereby it is always possible to put up calculations that are beneficial to specific interests - something which is important to consider when the return of investment is compared between different forestry systems. Depending on set-up assumptions certain forestry systems can receive partial treatment, not at least from the many taxation rules that have been constructed under an era of clear-cut forestry dominance. Moreover, the direct ecosystem services that are given a current value on the market (wood) are of course included but, given the change that our un-sustainably designed society will bring about sooner or later, certainly not all values are included. We are facing growing economic uncertainties and risks from un-sustainable designs of forestry as well as society at large, and the costs for this will inevitably increase systematically for as long as society and forestry...
keep violating the SPs. Profitability calculations are already today a bad measure for drawing general economic conclusions about various forestry methods, and increasingly so if we include the future aspects of resilience and flexibility on more and more sustainability driven markets. More focus should be put on modeling various scenarios within the constraints of the SPs, combined with the development of such step-wise paths towards attractive sustainable scenarios that can be strategically motivated on the private sector. And only then consider politically determined policies to increase the pace towards sustainable forestry, putting costs high enough to gradually discourage the remaining unsustainable practices more and more (Robèrt & Broman, 2017).

**SP-8: Meaning-making**

Obstacles to meaning making in the Swedish forest sector can for instance be found in the discourse between Sami people and other land-users. The Sami way of living and culture must be respected, as well as Sami have to respect others. Equally people who try different forms of continuous cover forestry must be welcomed and respected for their beliefs and not forced away due to that they do not follow the conventional way of doing forestry. Actors who may believe that horse driving is irrational in an era of machine use must respect the person who uses his or her horse in the forest to bring meaningfulness and provide opportunities for innovations. Finally, another example of putting meaning-making in jeopardy has already been provided under the SP 5 Influence (see Sandström & Öhman above): The anger from tensions between people on the countryside vs. policy-makers in cities is probably not about the former not being listened to per se, but also about concrete changes that may come from this. Many people on the countryside suffer from a deeper sense of losing a whole culture through urbanization. A lack of true constructive dialogues between policy makers and cultures on the country side, with a reduced influence from the cultures towards policy makers, may lead to very concrete changes that really deteriorate the opportunities for the cultures to be sustained. It is a vicious cycle, not the least in context of the increased need to understand the spatial perspective for the future. We all rely on areas and spatial planning for the future, when we have stopped using concentrated and inherently unsustainable energy. Fossil-free management of ecosystems is relatively more labor- and area-dependent (Robèrt et al., 2017). Who are going to take care of all those areas, managing them, if urbanization and shrinking rural cultures are allowed to just go on?

4.2.3. Contribution to Programs for Sustainable Forestry

The following section presents how the SDGs, the SEOs and the Swedish NFP both have contributed with information to the above analysis, as well as how the protocols have missed out some important points that the above analysis managed to discover. The ABCD-procedure has again been used to structure the findings in this section.

**SDGs relation to Sustainable Forestry**

Agenda 2030 contains 17 SDGs and 169 targets to be accomplished by the year 2030 (UN, 2015). The full list with all the SDGs is included in Appendix B. The SDGs are on a very general level and in practice especially directed towards sustainability problems in developing countries. Therefore the SDGs leave room for individual interpretations, in particular since they are not operationally structured. However, even though the SDGs are not operationally structured by design-principles, it doesn’t mean that they won’t be of use for sustainable development. They are narratives of important sustainability domains, described in a convincing and attractive way, and may certainly help politics to raise awareness and create a sense of cooperation across regions and nations. They can potentially also be used as a data-collection, for cross reading of FSSD informed transition plans (see further in Section 5.1 for how discussion about how the SDGs relate to FSSD). An example is that the SDGs helped us in this study to identify the following social sustainability problems within the forest sector, that were not identified in the earlier analysis in Section 4.1.2 (but they are easy to put into this structure):

- Goal number 5 highlights the importance of gender equality and Target 10.2 highlights the importance to “empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status” (UN, 2015). The forest sector is dominated by the traditional Swedish man
(Andersson, 2015), hence has a lot to work with when it comes to the highlighted target (mainly SP 5, 6 and 7).

- Target 11.4 points out the importance of protecting and safeguarding the world’s cultural and natural heritage. This is worthwhile to consider with regards to forestry’s impact on landscape structures and cultural heritage (mainly SP-8).
- Target 11.a enhances the need to strengthen the links between urban, peri-urban and rural areas. There are most likely many prerequisites about forestry and forests among people living in cities. A parallel could be drawn to the child who says that “milk comes from the supermarket” instead of the cow. The same is perhaps true when it comes to production of wood based products (mainly SP-s -5 and -6).

Nonetheless, as discussed above, for operational purposes in individual organizations and sectors and regions, definitions of sustainability and a framework for how to step-wise approach such definitions are needed for systematic re-design. In the case of sustainable forestry it is clear that measures to deal with one impact without assessing it by basic sustainability principles, may miss upstream-causes of the problem, and/or lead to more problems from violation of SPs in other sectors. For instance target number 6.6 highlights the importance of restoring water-related ecosystems such as forests. Into that target could be interpreted that an FSSD analysis should be done, leading to conclusions as regards reduction of clear-cutting and soil destruction from driving too heavy forestry machines along poorly planned cutting patterns, which leads to decreasing risks for reduced water quality. However, target 6.6 could also be interpreted such that it would be okay for forestry to continue with all those activities for as long as some temporal and down-stream solutions for ameliorating water quality would be put in place. Such measures may serve as potential mitigating stepping stones towards less impact on ecosystems, but not instead of looking upstream to find causes and real solutions, calling for a use of operational re-design principles. Moreover it is not certain that individual measures for meeting one target will comply with the full sustainability picture, since many of the harmful activities in forestry violate several SPs. The measures taken must, all together, comply with the full sustainability picture for all sectors as discussed in this report.

The following sustainability points from the above analysis of the forest sector in Section 4.1.2 are worth to highlight as “missing points” in Agenda 2030:

- There is no definition of sustainability that can be used for strategic planning of the forestry-sector.
- No link has been drawn between forestry practice, energy consumption and an outline of the ecosystem services that need to be prioritized for future sustainability of the biosphere.
- Land-use change from natural forestland to monoculture plantation and its impact on biodiversity is not addressed.
- No coupling between the economic system and dominant forestry practices has been identified, let alone the lack of the dynamic changes of such coupling that is bound to happen on more and more sustainability driven markets.

**SEOs relation to Sustainable Forestry**

The Swedish system of environmental objectives includes a generational goal, 16 environmental quality objectives, and specifications for each of the environmental quality objectives, and 24 milestone targets (Naturvårdsverket, 2016b). The generational goal is the overall goal of Swedish environmental policy that “defines the direction of the changes in society that need to occur within one generation if the country’s environmental quality objectives are to be achieved” (Naturvårdsverket, 2016a). The full list with all the SEOs are included in Appendix C.

Each SEO contains a number of detailed specifications/precisions that are more hands-on than the SDGs. They are even simpler to put into a FSSD analysis and planning structure, than the SDGs (see further in Section 5.1 for how the SEOs relate to FSSD). The following points from the SEOs are examples of this:
• Precision “Sustained natural and cultural assets” under the goal “Sustainable forests” highlights the importance of sustaining cultural assets. They are a part of human history and culture and therefore relates to the social SPs. According to the SEO follow-up (Naturvårdsverket, 2016b) 40 percent of the assets are negatively affected by left branches, planting, driving damages and scarification. This added an essential element to the study.
• Precision “Outdoor life” under “Sustainable forests” denotes the importance of forests for outdoor activities. The point can be connected to the social SPs perhaps especially as a solution to stress related health problems.

The SEOs are explored to only cover a sample of environmental problems. For instance the challenge about how economic rules steer prioritization of certain ecosystem services belongs under the domain of social sustainability and is hence not included in the SEOs. Such gaps seriously hamper the possibility to effectively model sustainable futures. Effective solutions and innovations that many disciplines and sectors can agree on, happen in the creative tension field between the full scope of ecological problems on the one hand, and social problems on the other: What is an attractive sustainable society, where the social system is strong and vital within ecological constraints?

The following sustainability points for the Swedish forestry (see Section 4.1.2) have been identified as missing in the goals and precisions of the SEOs:
• There is no definition of sustainability that can be used for strategic planning of the forestry-sector. The goal “Sustainable forests” is defined as: “The value of forests and forest land for biological production must be protected, at the same time as biological diversity and cultural heritage and recreational assets are safeguarded” (Naturvårdsverket, 2016b). Just like regarding the SDGs, this definition opens up for much interpretation and it is not sufficient for strategic planning.
• No identification have been done regarding how energy and resource intensive today’s forestry is.
• Outtakes of roots and branches (GROT) have not been identified as unsustainable, even though such harvesting will lead in the wrong direction with regards to SPs.
• The systematic change of forestland that takes place could be emphasized further. The precision “favorable conservation status and genetic variation” under Sustainable forests could somewhat be interpreted to include this, but then the precision should rather be “No systematic change of nature types should take place that threat the genetic variation and biodiversity”. Again, without SPs that are robust for re-design, it is difficult to draw operational conclusions from such general statements.
• Notion is not made to the social conditions under which the ecological changes are supposed to take place. For complex goals in complex systems, it is a mistake to analyze and plan ahead from one set of success-criteria at a time (Senge, 2003; Broman & Robèrt 2017).

**NFPs relation to Sustainable Forestry**

In contrast to SDGs and SEOs the National Forest Program (NFP) is going to be a program of actions, meaning it is not supposed to only consist of goals and targets. Right now the NFP consists of four background reports, developed by four different interest groups (Regeringskansliet, 2016). The groups have worked separately to find pressures and challenges, as well as strengths and weaknesses within the sector. Based from the findings, visions for the future forest sector have been pictured and strategic recommendations have been created. A parallel could be drawn to the FSSD-methodology, besides that NFP doesn’t base their vision from any basic understanding of what sustainability entails (see further in Section 5.1 for discussion about how the NFP relates to FSSD).

The strategic recommendations of NFP have contributed to identify the following sustainability aspects for the forest sector that this far have been missing in the analysis of this study (but easy to put in this structure):
• The attractiveness for forestry work among people, as well as the progress potential of the sector, is dependent on the prerequisites on the countryside, such as availability to good
infrastructure and communications. These issues can be seen as institutional hinders, belonging to the social SPs e.g. SP 5 and 7, and thus adding to the presented FSSD analysis.

- There are problems connected to commercial use of the right of commons that must be solved in order to promote more sustainable multi-use of forests. These institutional hinders also belong to the structural obstacles under the social SPs e.g. SP 5 and 7. The need for a more widespread and eminent educational system is high in order to improve the competitiveness of the Swedish forest sector on the global market and to get more students attracted to forestry, mainly belonging under the SP 6.

By looking through the strategic recommendations, the following sustainability aspects have been identified as missing in the NFP in relation to what has been discovered in Section 4.1.2:

- There is no definition of sustainability that can be used for strategic planning of the forestry-sector.
- There is no recommendation for lowering the energy and resource use of today’s forestry.
- The risks of negative sustainability impacts from more intensified forestry have been left out, e.g. measures like fertilization and deprivation of nutrients and enhanced acidification through outtakes of roots and branches. Those risks have not been put in relation to a thorough enough modeling of what full forest sustainability would entail.
- No strategic recommendation is there to halt the increasing risks from systematic change of forestland through clear-cuts and monoculture plantations.
- The need of increased competence within alternative forestry methods vs. clear-cut forestry has been left out. Given the source of expanding hands-on experiences from the emerging field of continuous cover forestry-systems, it is not sufficient to write; “strengthened and broadened knowledge about sustainable management of all the forest’s ecosystem services” (Bodegård & Kårén, 2016).
- No identification has been given to the spatial prioritization dilemma and how and why certain uses of the forest are not strategically wise from a sustainability perspective.
5. Discussion

5.1. SDGs, SEOs and NFP’s Compliance with FSSD

None of the three analyzed frameworks include the full FSSD-derived sustainability picture (A of ABCD). In SEO a unifying operational definition of sustainability based on principles is missing, leading to such overlaps of the addressed aspects that it is likely to obscure the potential of arriving at clear re-design solutions. Examples are that the objective “no eutrophication” is dependent on a fulfillment of the objective “sustainable forests” as well as “a varied agricultural landscape”. Another example is how “a rich diversity of plant and animal life” is dependent on the fulfillment of for instance the objectives “sustainable forests” and “thriving wetlands”. Nevertheless the responsibilities for these different objectives are divided between different authorities (Naturvårdsverket, 2016b). If a unifying and common principled goal would be set in order to solve the core problems, authorities could more effectively cooperate to model possible scenarios within such constraints (Robèrt et al., 2017). There are inherently, for instance, different design solutions for avoiding eutrophication from too much fertilization, vs. too heavy machinery causing micro-erosion and eutrophication that way. To just state “an end to eutrophication” says less than to systematically, sustainability principle by principle, exploring how this problem could be avoided. Even the social principles are intimately in play to avoid technical problems of this kind; after all it is people, and trust between people in functional communities, that we rely on for powerful enough concrete change to happen.

In the same way, Agenda 2030, which uses the Brundtland definition of sustainable development (UN, 2015), suffers from the same deficiency but this time from a higher systems perspective. It is not possible to use this philosophical high-level definition for concrete and operational re-design (Broman & Robèrt, 2017). Consequently the outlined goals and target’s contribution to full sustainability have not been analyzed by the Agenda 2030-working group, nor how the ideas and goals put forward could assist a strategic plan towards sustainability. For instance a conflict may arise between the second and seventh SDGs (“zero hunger” and “affordable and clean energy”) due to that an investment in renewable energy may conquer with agricultural land for food production. The sustainability potential of the SDGs is discussed by Nilsson and Costanza (2015): “To be effective in communicating the SDGs it is necessary to have a compelling narrative to describe how the world could look when the SDGs are fully achieved. This narrative needs to consider more explicitly the ends-means continuum of sustainable development. Articulating this narrative would enhance the capacity to deal with trade-offs and synergies among the 17 goals since it must describe a world where the trade-offs and synergies have been resolved.”

Just like with SDGs and SEOs, the strategic recommendations of NFPs are not framed within sustainability constraints. Only two of the working groups have found a definition of sustainable forest management, the definition taken by FAO14. But just like the Brundtland definition of sustainability, FAO’s definition of sustainable forest management is philosophical at such a high systems level that it is not operational and cannot be effectively used for informed cross-sector modeling and redesign towards social and ecological sustainability.

When the SEOs and SDGs are placed within FSSD (see Figure 13) it is clear that the SEOs and SDGs are rather to be regarded as helpful narratives with samples of ideas that may contribute to well-structured FSSD and ABCD analyses and planning. The SDGs are formulated to include both descriptions of current problems (B), and solutions (C). E.g. the first goal “end poverty in all its forms everywhere” both tell us that poverty is a current problem, but also that we need to end it. However just like discussed before regarding the design of the SEOs, this type of phrasing says very little about the mechanisms behind poverty (A), and how an understanding of this may trigger concrete analyses of concrete problems (B) to serve brainstorming for the derivation of possible solutions and

14 “Managing forests sustainably means increasing their benefits, including timber and food, to meet society’s needs in a way that conserves and maintains forest ecosystems for the benefit of present and future generations.” (FAO, 2015)
innovations (C) to be put into an actual solution path (D). Somewhat more concrete solutions (C) towards sustainability (A) can be seen in “the means of implementation” that are presented in goal number 17 and as targets under each of the other goals. These include suggestions of more concrete actions to be taken. One such example is the identified need for qualified teachers when it comes to solving goal number 4 about “qualified education for all”. In the SEOs an example of information about the current situation (B) can be achieved by looking at the specifications and indicators under each objective. E.g. in the case of the objective “sustainable forests” one specification is “threatened species and restored habitats”. This specification is connected to the indicator “older deciduous forests” (Naturvårdsverket, 2016c), which follows up the share and volume of deciduous trees in the forest. The indicators and the connected follow-up on those give important ideas that can be used to understand and solve the current challenges under each environmental SP.

The relation between the works of NFP in relation to the ABCD-planning process of FSSD is visible in Figure 13. Some strategic suggestions by the working groups may lead in the right direction (green arrow), others may not (red arrow). For instance suggestions to improve and expand the educational system (all working groups) and to expand urban wood constructions (group 3: Larsson & Rogestedt, 2016) have a potential to lead in the direction towards sustainability. The same goes for many overlaps and free-for-interpretation statements in the suggestions, such as the “need for increased competence”. All of those examples would benefit from being based on education that expands the scope as suggested in this study, including the proposed methodology of iterative cross-sector learning (Robèrt et al., 2017). In the lack of iterative learning from a sufficiently large scope i.e. no sustainability evaluation of the current forestry has been carried out, the NFP suggestions to fostering a more intensified forestry pose a high risk of even leading in the wrong direction.

Figure 12: the relation of the Swedish Environmental Objectives (SEOs), the UN Sustainability Goals (SDGs) and the ABCD-process of the Framework for Strategic Sustainable Development (FSSD). (D) holds prioritizations of the solutions derived in (C) in order to close the gap between the current situation (B) and the sustainable vision in (A) where the sustainability principles (SPs) have been secured.

The relation between the works of NFP in relation to the ABCD-planning process of FSSD is visible in Figure 13. Some strategic suggestions by the working groups may lead in the right direction (green arrow), others may not (red arrow). For instance suggestions to improve and expand the educational system (all working groups) and to expand urban wood constructions (group 3: Larsson & Rogestedt, 2016) have a potential to lead in the direction towards sustainability. The same goes for many overlaps and free-for-interpretation statements in the suggestions, such as the “need for increased competence”. All of those examples would benefit from being based on education that expands the scope as suggested in this study, including the proposed methodology of iterative cross-sector learning (Robèrt et al., 2017). In the lack of iterative learning from a sufficiently large scope i.e. no sustainability evaluation of the current forestry has been carried out, the NFP suggestions to fostering a more intensified forestry pose a high risk of even leading in the wrong direction.

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15 see references Bodegård & Kårén, 2016; Bruce & Samuelsson, 2016; Larsson & Rogestedt, 2016; Salander-Björklund & Westman, 2016
Figure 13: the relation between the Swedish National Forest Program (NFP) and the ABCD-process of the Framework for Strategic Sustainable Development (FSSD). The task of the four working groups have been: (1) Growth, multiple use and value creation of the forest as a resource; (2) Timber production, other ecosystem services and nature's boundaries; (3) Promotion of bio-based products and energy, smart mobility, a forest of excellence and increased exports; and (4) International forestry issues. (D) holds prioritizations of the solutions derived in (C) in order to close the gap between the current situation (B) and the sustainable vision in (A) where the sustainability principles (SPs) have been secured.

5.2. A Sustainable Forest Sector?

This study concludes that the existing “Swedish forestry model”, based on clear-cutting forestry and monoculture planting, violate basic principles of sustainability as expressed by FSSD. Even though there may exist possibilities to temporarily ameliorate some consequences from this type of forestry, when impacts are looked at one by one, it is first and foremost the combination of actions that are unsustainable. Sustainability is a binary matter, either society is sustainably designed (=1) and can continue to evolve ecologically, biologically, culturally and technically or else it is not (=0), i.e. ecological, biological, cultural and technical evolution will come to an end sooner or later depending on the magnitude of violations of the principles. Furthermore, that we cannot, due to complexity, foresee exact planetary boundaries and points of no return from further violations of the principles. This means that even though there are solutions within the clear-cut forestry for lowering impact on for instance physical displacement (e.g. biodiversity loss due to removal of tree continuity), these actions are not enough to lead us to sustainability. Leaving some deadwood on clear-cuts is not sufficient for securing biodiversity at large, i.e. the lowering of a sustainability related impact is not equal to sustainability. Lindahl et al. (2015) concludes their article about the Swedish forestry model by writing:

“Based on this analysis, we argue that the model still prioritizes wood production and the economic dimension of sustainability. Consequently, there is a need for a broad public debate, not only about the role of forests in future society but also about the understanding and operationalization of sustainable development.”

Based on the sustainability analysis of the current Swedish forestry model, this study has also pointed at an approach for sustainable forestry. It relates forestry to sustainability for the whole human civilization. Such a large systems perspective inherently calls for cross-sector and cross-disciplinary modeling within robust sustainability constraints. Furthermore, it is discussed that such modeling points at a need for a profound spatial planning perspective, one that respects the key role of bio-diverse forests for sustainability at large and the safe-guarding of sufficient areas for this. Civilization’s future relies on forests to protect nature’s integrity and sustain the biosphere on land as we know it, and it relies on an understanding of the need to protect areas also for sustainable food
production. Those top-priority areas are also interconnected, cropland is originally manipulated forest, and sustainable management of both relies on an understanding of the intricate relationship between the two. The study has also discussed how the importance of sufficient areas for productive and biodiverse forests, the spatial perspective for survival of civilization, will be even clearer further ahead when we have been forced, or consciously learnt, to stop using inherently un-sustainable energy sources. In turn, this underpins a need for technical innovations and more efficient cross-sector governance models to ensure that areas needed for other functions for civilization such as energy, materials, and infrastructure, are planned with respect for this spatial perspective, and prioritizations within it, as well.

Though the study’s analysis departs from a global perspective on forests and forestry, its main objective has been to focus Swedish/boreal forests and forestry. Examples of differences to forests in the south are related to aspects such as biodiversity, relationship of carbon-sinks in soils vs. trees etc. Other examples of differences relate to climate. For instance, the need for climate shelter does not look the same across the globe. It’s about planning for hurricanes, rain-periods and drafts being relatively more important in many areas in the south, and it is about protection from cold and snow in the north.

Effective developments along the proposed approach rely on more research going into evaluations of the wide diversity of norms and practices established on the proactive forestry arena. And effective developments rely on the evaluation of this variety in relation to differences in ecological and climate conditions on different sites. Further research also needs to go into how energy needs will differ depending on site locations, since factors such as elevation and terrain will affect how easily machines can drive in the forest. There will also be differences regarding how much manual work that will be needed. Specific research should also departure from exactly how forestry can look like without any use of fossil fuels at all. How should the machines be designed and what type of “fuel” should they operate on? Given that electricity has greater potential for sustainable traffic than fuel-based traffic (Borén et al, 2017): how would completely electrified forestry machines look like? It must also be examined how machinery should be designed in order not to destroy soils through compaction. And in contrast to machines there might be other solutions. There is already a minority of foresters who manage forests by using horses in order to minimize fossil dependency, make less ground damage, lowering the life-cycle costs from management activities and for increasing their own sense of meaning.

The growth economy is often highlighted as a major obstacle to sustainable development, not the least in the forest sector. A way to bridge the two perspectives into a more non-confrontational paradigm is an idea of referring to nature functions in terms of “capital”. Thus “natural capital” may coexist with other forms of capital assets in society, such as manufactured capital (buildings and machines), human capital (knowledge, skills, experience, and health), social capital (relationships and institutions), and financial capital (monetary wealth) (Guerry et al., 2015). This perspective refers to an awareness that the economic system has largely been designed under an era of human evolution when nature and its flows were still very large in relation to human activities. It was then all too easy to regard many of the life-sustaining services civilization gets from nature as “free”, and that we would continue to get them regardless how we chose to design our societies and organizations. Society has now entered the “Anthropocene” (Steffen et al., 2007), a time era in which the human civilization exerts a dominating influence on the biosphere with its evolution, much larger than nature itself regarding many material flows. Talking about nature in terms of “natural capital” has been suggested as a way to change this paradigm, since the decline of life-supporting services from nature is largely connected to “economic growth” but still not visible in macroeconomic terms.

There are however authors who are hesitant to lean too heavily on the term natural capital and other ways to begin analyses of societies’ sustainability imperative at the economic end. For as long as unsustainable development undermines the biosphere with its functions, the remaining healthy forests, farmland and fisheries will systematically increase in value. Consequently, any attempt to put a real value on nature and the life-sustaining-ecosystems cultured from it, inherently implies an understatement, increasingly so for as long as society is unsustainable. This is until we may have lost
it all, the loss of which can be put at infinity. An alternative economic approach is more closely aligned with the approach proposed in this study. It would suggest to model and design futures that comply with basic sustainability principles, and then develop pragmatic economic models and strategic routes to get there with as low as needed costs for, and/or highest incomes from, the transitions. Political-economic measures, when knowledge transfer and actions on the private sector do not suffice on its own, then ought to be chosen high enough to discourage and face out unsustainable behaviors, but not necessarily any higher than that (Robèrt & Broman, 2017).

The above economic discourse on sustainability on the one hand and “economic growth” on the other can be linked to a general disability in society to think strategically. This can in turn be envisioned by the absence of strategic thinking in existing sustainability policies and frameworks. What would be the result if a goal or target in any of the reviewed protocols had been “end use of fossil fuels”, (as a direct consequence of SP-1)? Probably this would have increased the chances for more creative and constructive outcomes for all SEOs and SDGs. For instance step-wise approaching “no use of fossil fuels” would contribute to the ending of poverty (SDG #1) e.g. by removing obstacles towards human health (providing jobs, improving working conditions through lower exposure to pollution) as well as reducing inequalities among countries (SDG #10) due to removal of many obstacles connected to the oil market and the vested interests there. Would it not also have helped the target “reduce climate impact” (SEO #1) and “clean air” (SEO #2)? The study has tried to show that design principles have this effect for forestry analysis and planning, i.e. seeing underlying causes clearer and thereby making it easier to find such solutions that tackle many problems upstream in cause-effect chains instead of one problem at a time with risks of solving one problem while causing another. It is only in the creative tension-field between all sustainability principles that sustainable scenarios can be effectively modeled and approached (Broman & Robèrt, 2017).

Similarly, what would have happened if one sustainability goal had been to “end all kinds of systematic physical displacement of nature” as a consequence of SP-3? Wouldn’t this have increased the understanding of how many SDGs are connected and thereby inspiring designs that tackle them all? Examples are “achieve food security” (goal #2), “conserve and sustainable use the oceans” (goal #14) and “promote, restore and promote sustainable use of terrestrial ecosystems…” (goal #15). In fact, the principled goal “ending all kinds of systematic physical displacement of nature” is likely to have positively influenced all existing SEOs, e.g. reduced “climate impact” (more trees take up more carbon), improvement on “clean air” (purifying function of forests), help towards only natural acidification (by not breaking the natural nutrient cycle in forests that otherwise has an acidifying effect), zero eutrophication (by not casing nutrient transport due to interference in soil systems), a good built environment (by providing green spaces to inhabitants), a rich diversity of animal and plant life (by securing habitats), etc.

If the working groups of the Swedish national forest program (NFP) had been using backcasting from sustainability principles as a shared mental model, they would most likely not have missed so many existing sustainability challenges in the current Swedish forestry model. Nor would they have missed to identify the great potential of forestry when it comes to delivering on the vast smorgasbord of solutions for the future society beyond what today’s dominant clear-cut forestry can deliver. Examples of remaining issues to be researched, all within a more systems-based Swedish NFP, would be to:

(i) Identify which areas in Sweden that should be protected from any kind of forestry,
(ii) Identify how much trees that can harvested if sustainable forestry methods are used,
(iii) Find out in what ways our common tree resource is best used in society at large,
(iv) Distinguish how large the need is for having some remaining monocultures and where those isolated plantations could be located.
(v) Try to foresee what kind of materials and resources from forests that are likely to increase in value on more and more sustainability driven markets.

An example of the latter point is biofuels that can be used for specific purposes, such as aircraft takeoffs where electric propelling of flights is more difficult than for cruising and landing. In cross-sector modeling this might call for some biomass plantations to solve this societal need. However
biomass for jet fuel production should not come from slowly growing trees like spruce and pine, since the carbon cycle is too slow for such species. In this context, planning for the future is already happening among airplane constructors where developments of electric propelling of future aircrafts is already on the drawing-board, even if the high energy-demands in the starting of air-flights may take longer times to solve (Masunaga, 2016). Moreover the planning of forest land-use and the formulation of a NFP should be done in cooperation with other sectors, such as the energy sector, which has relatively larger knowledge regarding what energy sources that have the highest energy efficiency in relation to area need. And, given its high priority for future planning, it should be done in cooperation with the food-sector.

5.3. Validity
The work has involved meetings and discussions with many experts and stakeholders and the author is aware about risks accompanying the subjectivity of interests. Moreover, it is a fact that there is only little academic research about different forms of continuous cover forestry in comparison with clear-cut forestry. Bias may have favored continuous cover forestry more than is the real case. The same may be true for the opposite, based on the norms of the more traditional Swedish forestry sector. The report has discussed that relatively more money is channeled into research there, which is largely behind the dominance of such articles in comparison to articles on continuous forestry. A bias also in this direction can therefore not be excluded.

Using basic sustainability principles as a checklist has most likely helped to overcome some biases, since the principles are designed at a generic level beyond norms, derived from our scientific knowledge about the socio-ecological system. Therefore the principles are non-prescriptive when it comes to various sustainable scenarios, transition-paths, and evaluations amongst those. Furthermore, within the limited time-scope of this thesis, the primary objective of the study has not been to find all the data needed for drawing safe concrete conclusions regarding the future development of Swedish forestry. It has rather been about finding an approach to iterative learning and research from a well-structured and large enough systems perspective. Furthermore to show how this may be helpful to model and discuss interrelated data and aspects for cross-sector inter-disciplinary cooperation towards sustainability. The study points at an approach that may be helpful to bring more meat to the bones in future research, as well as to discuss the validity of the primary conclusions presented in this study and further discussed in the final section below.
6. Conclusion

The author is careful when it comes to details, but believe it is safe to say that the study shows:

1. Sustainable development for forestry, in order to support the biosphere’s essential functions for higher forms of life (including the civilization), relies on a paradigm shift in civilization’s perception of forestry. It includes a shift from today’s practices where improvements are done by “solving known sustainability impacts” to a practices that are planned from “envisioning a future where forest-functions are safeguarded to continuously provide life-sustaining services to civilization”. It also includes a shift from the dominating clear-cut forestry in combination with monocultures, to forestry practices that allow for diversity both in terms of composition and age of trees, and species in general e.g. nitrogen fixing organisms and natural enemies to pests.

2. This in turn means that nature functions are prioritized before other usages of the forest, resulting in increased potential for gaining high resilience forests with higher-quality-timber productivities that can supply various kinds of resources on more and more sustainability driven markets. Furthermore, such development of society’s forest use increases the chances for civilization to be sustainable also with relatively smaller forest areas put aside for no forestry at all.

3. In such a situation, forestry and society prioritize forest products and usages with long life spans before such with short life spans, e.g. prioritizing high-quality timber and new types of materials at the cost of forests as providers of bio-fuels.

4. A future sustainable Swedish forest sector has recognized the above, and drawn an essential conclusion from it: the interdependency of forests with society’s overall sustainability performance calls for a cooperative approach. It’s about modeling visions, and strategic plans to get there, by use of robust sustainability principles that are shared across sectors and disciplines.

5. The SDGs, SEOs and the Swedish NFP all fail to take the above broad-systems perspective when it comes to proposing measures for the future, including how to advise further research to explore what sustainable Swedish forestry could entail.

The study arrives at pointing out an overall approach in those regards. To that end, the author believes to have shown that the FSSD with its basic SPs and ABCD process model have the capacity to help people from different competences and planning perspectives to find the core mechanisms behind disperse and complex sustainability-related impacts in forestry, thereby stimulating more creative, cost-efficient cross-sector designs and strategies. Likewise, the author believes to have shown how the big picture perspective brought about by the FSSD is helpful to identify areas and details that need to be researched more in detail. Consequently this study has hopefully contributed to a broadening of the forestry perspective for the Swedish forest sector. The overall recommendation is to apply the proposed approach for more “out-of-the-box” thinking and for integrating the full scope of sustainability on different levels (local, regional, national), among different stakeholders (owner, consultants, operators, industry, science, etc.) and between different disciplines (social and natural sciences at large).
References


Appendix A: Continuous-Cover Forestry Terminology

"Blädning"
The Swedish term Blädning can be seen as a thinning session in which trees are taken out from the forest leaving a multilayered tree composition. Two directions of blädning can be seen in Sweden: "stamvis blädning" where single trees are taken out from all diameter classes and "volymblädning" where only the largest trees are taken out. The interval between thinning sessions should not be more than 15-30 years, depending on the woodland’s site quality. This form of forestry has been the dominant practice in Sweden historically. (Rosell, 2012)

"Måldiameterhuggning" - target diameter felling
Felling by target diameter selection is a method, which has been little used in Sweden but the more in Europe. Different target diameters are set up for different tree species and only trees that are above a certain diameter are felled. (Rosell, 2012)

"Luckhuggning" -
In this type of forestry felling takes place in areas or gaps of 20-50 meters. With time the gaps are enlarged and after 20-30 years and 3-4 felling sessions the whole area has been cut. This management system is seen as a suitable method for tree species that require much light, such as deciduous trees and pine. (Rosell, 2012)

"Överbållen Skärm" - underplanting/shelterwood harvest
For species that require much light forestry with screens can be good practice. The screen is felled continuously and the permanent trees are left to provide shelter and seed for natural regeneration. (Rosell, 2012)

"Plockhuggning" - selective cutting
Widely used term that refers to the practice of creating gaps in the forest. (Rosell, 2012)

"Dimensionshuggning" -
A practice in which felling of all trees over a set diameter occurs without any concern about the remaining forest distribution. (Rosell, 2012)

Naturkultur
Naturkultur is rather an economic principle than a forest management system. The purpose with the method is to maximize the present value of trees that use the same resources for growth. Trees with low growth rate are felled in order to benefit stronger individuals (Rosell, 2012).

Naturnära Skogsbruk - Close-to-nature forestry
CNF is forestry approach that takes natural ecosystem conditions into account. One version of CNF is presented by ProSilva Europe, an organization founded in Slovenia 1989 constituting of 25 member countries (Prosilva Europe, n.d.). ProSilva consider that forests benefit society with four categories of services (ibid.):
1. production of timber and other products
2. protection of soil and climate
3. maintenance of ecosystems
4. recreation, amenity, and cultural aspects

The Ecoforest Institute is a non-governmental organization operating in the US and Canada that practice Ecoforestry, a practice similar to close-to-nature forestry (The Ecoforestry Institute, 2017). The organization recommends multi-species and multi-layered forests, just like ProSilva. In England close-to-nature forestry is often referred to as Continuous cover forestry (Continuous Cover Forestry Group, 2014) and in Lübeck a model developed by Lutz Fähser has been practiced since the mid 1990s (European Forest Institute (EFI), n.d.). The Lübeck version of close-to-nature forestry is
practiced in Sweden by Mikael Karlsson at Silvaskog (Karlsson, n.d.). Three basic principles are enhanced in the concept (EFI, n.d.):

1. Naturalness: lowest risk and highest productivity are achieved in natural forest communities.
2. Following natural yield levels: the forest ecosystem shall never be threatened in favor for overambitious performance and economic goals.
3. Principle of minimal intervention (MI): no interference shall be superior to maximum yield in both ecological and economic terms.
Appendix B - Swedish Environmental Objectives (SEOs)

These are the 16 Swedish Environmental Quality Objectives (Naturvårdsverket, 2016b):

1. Reduced Climate Impact
2. Clean Air
3. Natural Acidification Only
4. A Non-Toxic Environment
5. A Protective Ozone Layer
6. A Safe Radiation Environment
7. Zero Eutrophication
8. Flourishing Lakes and Streams
9. Good-Quality Groundwater
10. A Balanced Marine Environment, Flourishing Coastal Areas and Archipelagos
11. Thriving Wetlands
12. Sustainable Forests
13. A Varied Agricultural Landscape
14. A Magnificent Mountain Landscape
15. A Good Built Environment
16. A Rich Diversity of Plant and Animal Life
Appendix C - UN Sustainability Goals (SDGs)

During the United Nations Sustainable Development Summit on 25 September 2015 the new plan for sustainable development, Agenda 2030, was formed, containing 17 sustainable development goals and 169 target to be accomplished by the year 2030 (UN, 2015).

1. End poverty in all its forms everywhere.
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
3. Ensure healthy lives and promote well-being for all at all ages.
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
5. Achieve gender equality and empower all women and girls.
6. Ensure availability and sustainable management of water and sanitation for all.
7. Ensure access to affordable, reliable, sustainable and modern energy for all.
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
10. Reduce inequality within and among countries.
11. Make cities and human settlements inclusive, safe, resilient and sustainable.
12. Ensure sustainable consumption and production patterns.
13. Take urgent action to combat climate change and its impacts.
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.