Program Plan 2013 - 2016

Future Forests

Summary

Mission and vision

The mission of *Future Forests* is to provide a scientifically robust knowledge base for economically, socially and ecologically sustainable management of forests in a future characterized by change.

Our vision is that knowledge produced by *Future Forests* will make possible an increased and yet sustainable provision of ecosystem services from forest landscapes in Sweden and elsewhere. Regardless of the level of provision, forests will always constitute a limited resource and priorities concerning its use will have to be made. Hence, we envision that knowledge produced by *Future Forests* will contribute to informing societal processes aimed at reconciling current conflicting demands for biodiversity conservation, water protection, recreational needs, climate change mitigation and biomass production. Additionally, we aim to ensure a continued researcher – stakeholder interactive process in shaping the future of forests beyond the program period, by permanenting our interdisciplinary research platform for analysis and synthesis of forest futures.

Outcomes - scientific value and value to stakeholders and society at large

Future Forests contributes to the scientific development of forest governance and management supporting sustainable delivery of forest ecosystem services. In the program's second phase our interdisciplinary research team will target the theoretical framework of an ecosystem-based approach integrating ecological, social and economical forest management goals. Multiple stakeholders will be engaged in scenario analyses and round tables to define problems and find solutions. Adaptive forest management will be developed as a key tool to handle ecological risk and uncertainty, and to increase our understanding of how forests respond to landscape level applications of different silvicultural systems.

Specifically, *Future Forests* will deliver:

- A permanent Centre for Forest Systems Analysis and Synthesis (ForSA) that serves as a interdisciplinary hub for collaboration between science and society.
- A generation of young researchers addressing forest management with a novel interdisciplinary approach.
- An analysis of the Swedish Forestry Model (presented as a peer-reviewed book as well as a popularized version of it aimed for educational purposes) set in context of current international and European trends, particularly targeting the Model's ecosystem-based approach, and envisioning possible ways forward.
- Conceptual development and a model for implementation of adaptive forest management.
- Foresight studies, including scenario analyses and systemic economic analyses addressing national, European and global consequences of alternative future forest management strategies.
- Engagement of stakeholders and scientists in mutually benefitting dialogues and collaborative research processes.
- Scientific contributions within the fields of forest management, forest ecosystem ecology and biogeochemistry and forest policy, economy and governance.
- Communication of new scientific findings to the general public via the *Future Forests* web and newsletters, and twice a year via the magazine *Skog & Framtid.*
- Operationalization of science based decision support tools that will lead the way towards novel approaches to long-term sustainability of forest management.
- In 2016, international scientific and stakeholder conferences.

To the society at large *Future Forests* is a strategic investment to broaden the traditional approach to forestry research. The interaction among individual researchers from different, but complementary, backgrounds forms a novel approach to forest science and a new generation of researchers that will benefit academia, industry and society.

Programme structure and components

The program structure will consist of the Centre for Forests Systems Analysis and Synthesis (ForSA) and four component projects. In *Future Forests* first program period there were ten disciplinary component projects. Over time, four central themes emerged as important research frontiers: (i) *silvicultural systems for novel demands on forests*, (ii) *implications of forestry for the biogeochemistry of forest landscapes*, (iii) *climate change adaption and mitigation*, and (iv) *the need to govern conflicting demands*. The strengthened focus on these four themes was the result of input from stakeholder groups and program researchers working jointly during phase 1. Consequently, several of the most interesting and highly acclaimed results from phase 1 are within these themes. In the second program period, four program components (PCs) will be organised interdisciplinary into these four major themes:

- *Future silviculture* will focus on traditional silvicultural practices for biomass yield regulation in combination with novel practices for enhancing biodiversity conservation, recreational needs, water protection and climate change mitigation.
- *Forest soils and waters* will investigate the effects of different silvicultural practices on nutrient cycling and water quality, as well as on analysis of the governance systems involved.
- *Climate change mitigation and adaptation* will analyse direct and indirect effects of climate change and focus on adaptation strategies in relation to pests and diseases and catastrophic weather events, and climate change mitigation strategies from both forestry and governance perspectives.
- Governing conflicting demands will study policy and management options from ecological, economic as well as social aspects, identifying synergies, trade-offs, and conflicts and assess governance tools designed to manage multiple objectives in forested landscapes.

ForSA is the interdisciplinary hub of *Future Forests*. The capacity of ForSA emerges from researchers both within and outside the program, joining together in the creative environment of ForSA. During the upcoming program period ForSA will host the Senior Management Group, leading the four program components, as well as a number of overarching program-level projects. These projects will target 1) scenario analyses of desired futures of main stakeholder categories, 2) systemic economic analyses of potential Swedish forest management strategies in an international context, 3) analyses of long-term effects of different landscape-level strategies for biodiversity conservation, and 4) principles for and consequences of landscape level application of different silvicultural systems. Additionally, ForSA will continue to develop the successful *ad hoc* thematic working group approach that was initiated in *Future Forests'* first program period.

Communication

Future Forests' communication will include researcher – stakeholder dialogues in collaborative learning processes as well as dissemination of popularized scientific results to a broader public. Forest excursions will be an important communication tool, both for collaborative learning processes and for the dissemination of research results to the broader public.

The *Future Forests* web will continue to be a communication hub for both scientists and stakeholders involved or interested in the program. A quarterly newsletter will inform about on-going and upcoming activities. The magazine *Skog & Framtid* distributed to private and industrial forest owners will be a printed complement to the web, and an alternative for those not using it.

Budget
The program is a joint research effort of the Swedish University of Agricultural Sciences, Umeå University, and the Forestry Research Institute of Sweden (Skogforsk). It is organized under the Vice Chancellorship of the Swedish University of Agricultural Sciences and is led by a Program Board, a Program Director and a Senior Management Group.

The funding applied for by the *Future Forests* program for the period 2013 – 2016 is 126 million SEK. The funding applied for is distributed on the following partners: Mistra (56 MSEK), SLU (32 MSEK), Umeå University (8 MSEK), Skogforsk (6 MSEK), the forest industry (Sveaskog (4 MSEK), Bergvik (4 MSEK), SCA (4 MSEK), Holmen (4 MSEK), Skogssällskapet (4 MSEK)) and the forest owners association (LRF) (4 MSEK). Additionally, SLU provides 3,7 full-time positions of existing personnel as an in kind contribution.

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Part A

1. Significance of Future Forests

1.1. Vision and objectives

The vision of the *Future Forests* program is to:

- Provide knowledge needed to enable an increased and sustainable provision of ecosystem services, i.e. tree biomass, biodiversity conservation, recreation, water resources, and climate change mitigation, from boreal forest landscapes in Sweden and elsewhere.
- Develop models for science-based decisions that are useful for societal processes aimed at reconciling goal conflicts in multiple uses of forest landscapes.
- Improve the capacity of the forest sector to adapt to global changes driven by climate change, the energy transition process and altered markets for forest goods and services.
- Set up a framework for the discussion of forest futures in Sweden for the coming generation and make that discussion an inspiration for other countries.

We will realize our vision through the following objectives:

- Evaluate strengths and weaknesses of the current Swedish Forestry Model, in comparison to Forestry Models in other countries, and in consideration of the increased demands placed on forests by national as well as international societies.
- Develop a robust basis for adaptive forest management to cope with uncertainty within the framework of the Swedish Forestry Model.
- Set up a model framework for systemic analyses of forest management strategies in a context of global changes.
- Clarify economical, social and ecological consequences of trade-offs, aiming to resolve goal conflicts in forest land use.
- Permanenting an interdisciplinary research platform engaging stakeholders in analyses and syntheses of key knowledge needed to shape the future of forests.

1.2. Research rationale

In *Future Forests'* first program period we assumed and verified that forest ecosystems and the services they deliver are subject to a wide range of effects due to numerous global changes including climate change, energy transition processes and demographically driven alterations of markets for forest goods and services. In Europe one important example is the strategy recently adopted by the European Commission to shift the European economy towards greater and more sustainable use of renewable resources. The Commission's action plan, "Innovating for sustainable growth: a bio economy for Europe" (http://ec.europa.eu/research/bioeconomy/pdf/201202_innovating_sustainable_growth.pdf), outlines a coherent, cross-sectorial and interdisciplinary approach. The goal is a more innovative and lower-emission economy, which reconciles demands for sustainable use of renewable resources for food, energy and industrial purposes, while simultaneously protecting biodiversity and other environmental values. The adopted strategy underpins a continuing trend of placing increasing societal demands on forests for a diversity of ecosystem services. It is clear that increased societal pressure on forest resources already causes structural changes in the European forest sector (UNECE/FAO 2009). The European Commission Roadmap for moving to a low-carbon economy by 2050 points out that production of bio-energy must more than triple in the period 2010 to 2050 to enable the envisioned 80-95 % reduction in CO_2 emissions (http://ec.europa.eu/clima/policies/roadmap/faq_en.htm). In Sweden the parliament in 2009 adopted a vision of Sweden without greenhouse gas emissions in 2050. Sweden's Roadmap 2050 (https://www.naturvardsverket.se/sv/Start/Klimat/Klimatpolitik/Sveriges-klimatpolitik/Fardplan-2050) notes that more intensive forestry that bind CO_2 while providing society with bioenergy and renewable products can be a way to achieve that vision.

In the Swedish Forestry Model the Forestry Act stipulates equal importance for production- and environmental goals. Hence, all forest owners are obliged to sustain wood production while at the same time conserving biodiversity, enhancing recreational needs, protecting waters and soils and mitigating climate change. Multiple-use forest landscapes that take into account all these different user values are confronted with conflicting aims, some of which are far from being resolved at present. The increased demands placed on forests require decision-makers to take responsibility to manage an increasingly complex forest sector.

Although provision of ecosystem services from forests may increase in response to the increasing demands, forests will always constitute a limiting resource and priorities concerning its use will have to be made. Appreciating trade-offs among ecosystem services is key to solving problems related to sustainable use of natural resources. Understanding conflicting demands on the forest system was a focus in *Future Forests'* phase 1. In phase 2, we will further elaborate on these issues, but also acknowledge that society's overall claims and expectations on forests are increasing. In particular we aim at understanding how society within the framework of the Swedish Forestry Model can combine increasing demands for bioenergy and raw material for novel wood-based products with the already existing demand for raw material to the sawmill-, pulp- and paper industries, while at the same time improving biodiversity, maintaining the quality of waters, the fertility of soils and enhancing the social values of forests.

1.3. Significance of the program in terms of solving major environmental problems

A key deliverable from the program is a permanent centre for analyses and syntheses of complex forest problems. The centre will be located at the Faculty of Forest Sciences in Umeå and meet SLU's vision to strengthen interdisciplinary research and synthesis activities. The overall vision for the centre is to become a vibrant and dynamic arena on Umeå Campus where high quality and policy relevant research and extension is carried out. The centre will foster and facilitate the integration of data, ideas, theories and methods from a broad range of disciplines, and thereby synthesize existing knowledge and create new insights into forest-related issues. Pivotal is also close connections with stakeholders, decision-makers and interest groups to ensure that the research produced is relevant and applicable to society, and that dissemination of results is efficient and accessible.

Another important task of *Future Forests* is the further development of the team of young researchers established during the first program period. These researchers have been fostered in a creative interdisciplinary environment that addressed complex environmental issues related to forest management. In phase 2, a continued career development of the most successful individuals will be ensured. Following the *Future Forests* program period, these researchers will continue their contribution to science and society, with comprehensive analyses of forest-related problems, and the development of decision-support tools and models.

Finally, by combining state-of-the-art tools and training of young researchers in interdisciplinary interactions and research, *Future Forests* will set the stage for a new approach to the study of natural resource management in general, and forest management in particular.

1.4. Significance of the program in terms of promoting Sweden's competitiveness

In January 2012, the European Commission adopted a strategy to shift the European economy towards greater and more sustainable use of renewable resources. The Commission's action plan, "Innovating for sustainable growth: a bio economy for Europe", outlines a coherent, cross-sectorial, and interdisciplinary approach. The goal is a more innovative and lower-emission economy, which reconciles demands for sustainable use of renewable resources for food, energy, and industrial purposes, while simultaneously protecting biodiversity and other environmental values. The adopted strategy underpins a continuing trend of placing increasing societal demands on forests for a diversity of ecosystem services. The concept of bio economy holds huge potential for the forest sector, and *Future Forests'* research will contribute to open up a wide range of possibilities for the sector to refine forests into highly valuable forest products and services such as bioenergy, biodiversity, recreation and other welfare services.

Moreover, the on-going globalization of the forest sector is manifested in the increasing levels of international political interaction concerning forests, and in widespread social and cultural interchange. Globalization is challenging to the Swedish forest sector as it increases the demands placed on forests. Increased attention has resulted in that the Swedish Forestry Model has been internationally debated and challenged. *Future Forests'* research will play a pivotal role in shaping the national and international forest agenda.

1.5. Significance of the program in terms of creating strong research environments

Future Forests is the first large-scale attempt to integrate the different research disciplines that fall under the broad umbrella of 'forest research'. Scientists involved in phase 1 developed their disciplinary research fields in the humanities, social and natural sciences while at the same time contributing to a multi- and interdisciplinary research process. We foresee that in phase 2 the science will take a step further into formulating questions that can only be addressed by combining insights across disciplines. By joining various competences we will form a generation of scientists that can successfully address the complex issues of tomorrow's forest management. The permanent ForSA centre will ensure its continuation as a unique research resource in Sweden, as well as for the international community of researchers and practitioners.

2. Scientific value

The management of forest ecosystems is a formidable challenge. Societal demands to simultaneously extract resources for economic wealth and wellbeing while at the same time sustainably preserve forest environments and biodiversity, clean water, productive soils, recreation values, and cultural heritages is a difficult task. The overall scientific value of *Future Forests* is to yield scientific knowledge and tools that give decision makers new insights into how forests can be managed sustainably.

2.1. Future Forests in phase 1

Future Forests in phase 1 focused on multiple competing uses, globalization trends, and climate change as key departure points for analysing the future of Swedish forests. We argued that these international drivers would lead to increased pressure on our forest resources. One policy option to meet this increased demand is of course to modify forestry to produce more tree biomass. However, the ensuing effects on other ecosystem services, not least the balancing of production and environmental values are many and complex. Decision will thus need to be informed by good science, and we argue that this is the role for *Future Forests*, in both phase 1 and 2.

In the analyses of forest futures during phase 1, we worked with global, European, and national trends and drivers that affect the Swedish forest sector. For instance, we explored possible futures for Swedish forests in our own scenario analyses, and from a European perspective by taking part in a EU COST action project. We modelled shifting supply and demand within Europe in relation to different policy options that prioritize bioenergy, carbon sequestration, or biodiversity conservation (in collaboration with FAO and UNECE), and we interviewed key forestry actors in Europe so as to understand where the most important forest discourses lie. Furthermore, we examined possible consequences of the EU Renewable Energy Directive, and the role that forests can play in climate change mitigation and the Kyoto protocol. In addition we analysed the historical and contemporary roots of several forestry related conflicts and assessed various solutions to these conflicts. Finally, we also studied the perception on various forest issues held by different interest groups, and the scientific foundation of several multiple-use strategies and paradigms.

None of the results from these efforts contradict our initial view that demands on forests are increasing and difficult trade-offs between competing interests must be made. In fact, we are even more convinced now of the importance of understanding the consequences of different policy choices and the urgent need to address trade-offs associated with these choices. Several facts have become clear: (i) the demands placed on forests for different ecosystem services are increasing, (ii) Europe lacks sufficient forest resources and efficient policy mechanisms to implement the Renewable Energy Directive in all countries, (iii) the challenging trade-off between the production of timber and the protection of biodiversity has become even more complex with policies towards climate mitigation and biofuels, (iv) tensions between forest owners and conservation NGOs are increasing, and (v) globalisation means that the Swedish forest will be increasingly subject to influences from outside national borders.

We strongly believe that these issues can only be adequately addressed with an approach, where the dynamics of the full social-ecological system are studied (see below). Forest issues span many sectors, diverse scales, and include many different ecosystem services. Informed, legitimate, and transparent decisions on trade-offs require the best available scientific knowledge. *Future Forests* will thus strive to produce science of the highest quality and make that science available to society and decision-makers. Our theoretical framework for doing so will be an ecosystem-based approach with a multiple-use perspective in the context of the Swedish Forestry Model.

2.2. Theory and research design

2.2.1. Forests as social-ecological systems

Sustainable forest management is both a biological and socioeconomic concept, where the understanding and implementing of management requires an integration of social and natural systems. Continuing uncertainty over what is socially and economically desirable, as well as ecologically sustainable, combined with new challenges such as climate change will make future successful forest management much more challenging than in the past. Consequently, *Future Forests* takes a social-ecological perspective in its activities. Social-ecological systems are linked systems of people and nature (Berkes and Folke 1998), and this perspective emphasizes that humans must be considered as a part of, not apart from, nature and that any delineation between social and ecological systems is artificial and arbitrary.

In phase 1, we attempted to place our theoretical framework within the concepts of resilience, vulnerability, and adaptive capacity – key components of the social-ecological paradigm. While researchers within the program made important progress in understanding consequences of various management options, it soon became clear, however, that the traditional way of applying the framework (i.e. on local communities and on natural ecosystems) has short-comings when considering both larger scales, such as the forest land of an entire nation, and when applied to production systems, such as forestry. On-going collaboration during phase 1 with Stockholm Resilience Centre is currently addressing and developing new theory for applying resilience concepts to production systems, such as the Swedish forests. This work will continue in phase 2.

As well as being social-ecological systems, forests are also complex systems. These systems can be defined as large aggregations of many smaller, interacting actors or components, and where the actions of these components create emergent patterns and behaviours that are difficult to predict. Other examples of such systems in real life are the stock market, social insect communities, and the Internet. Developments in complex systems theory (e.g. Johnson 2010) have shown that these types of systems are common all around us and that they are inherently difficult to predict and control. This has also been the case with natural resource management, including forestry (Puettmann et al. 2008), i.e. the complexity of these systems includes uncertainties that can never be fully reduced. The long temporal scale of forest management makes outcomes of management decisions even harder to predict and control.

The social-ecological and complex systems frameworks raise important topics for natural resource management, including:

- The impact of social, economic and environmental factors on resilience and sustainability of forests and forestry.
- The incorporation of human values and beliefs into decision making.
- The management of forests for both economic and ecological sustainability under uncertainty.

As is the case for all ecosystems, the long-term functioning of northern forests depends on certain system states and key processes. A sustainable, natural forest ecosystem can be described as a system that, over the normal cycle of disturbance events, maintains a characteristic diversity of functional groups, soil fertility, levels of productivity, and rates of biogeochemical cycling. For the most part, Swedish forests are not “natural”, but are socio-ecological systems that have been managed to various degrees over hundreds of years. Successful management options in the future need to include an understanding of complex, social-ecological systems organized at large spatial scales. This, in turn, will bring issues of management in landscapes with a diverse ownership structure to the foreground. Further, uncertainties need to be addressed through adaptive and flexible management that keep options for the future open.

Future Forests in phase 2 will advance the understanding of complex social-ecological forest systems and generate new, deeper insights leading to the development of governance and management practices supporting ecosystem service delivery and long-term sustainability.

2.2.2. An ecosystem-based approach to forest governance and management

In theory and application, natural resource management is typically organized around a central paradigm, or norm, which formulates how the system under management is conceptualized, as well as the breadth of management objectives. Such paradigms differ in their ideas about system dynamics, in their perspectives on whether a more biocentric or anthropocentric interpretation of management is taken, as well as in indicative management characteristics, such as the scale of spatial delimitation. For example, early resource management focused on dominant uses, where maximum sustained biomass yield and economic feasibility were key principles (Sedjo 1996). More recently, the ecosystem-based approach has become a prominent concept with many agencies and policy processes adopting it as a guiding principle for managing resources, including forests (Chopra et al. 2005, Thomas 1996). Broadly, the ecosystem-based approach is an approach to natural resource management that focuses on sustaining ecosystems to meet current as well as future ecological and human needs (Figure 2.1). The ecosystem-based approach is adaptive to changing needs and new information. It promotes a shared vision of a desired future by integrating social, environmental and economic perspectives on the management of geographically defined natural ecological systems (UNEP 2012).

Key aspects of EBA include:

- Integration of ecological, social, and economic goals and recognition of humans as key components of the ecosystem, i.e. seeing the system as a multiple-use social-ecological system.
- Engaging multiple stakeholders in a collaborative process to define problems and find solutions.
- Accounting for the complexity of socioecological systems and using an adaptive management approach in the face of resulting uncertainties, i.e. seeing the system as a complex adaptive system with adaptive management as a key tool.
- Incorporating understanding of ecosystem processes and how ecosystems respond to environmental perturbations.

These four aspects, further elaborated on below, will form the point of departure for Future forest phase 2 (see figure 2.1).

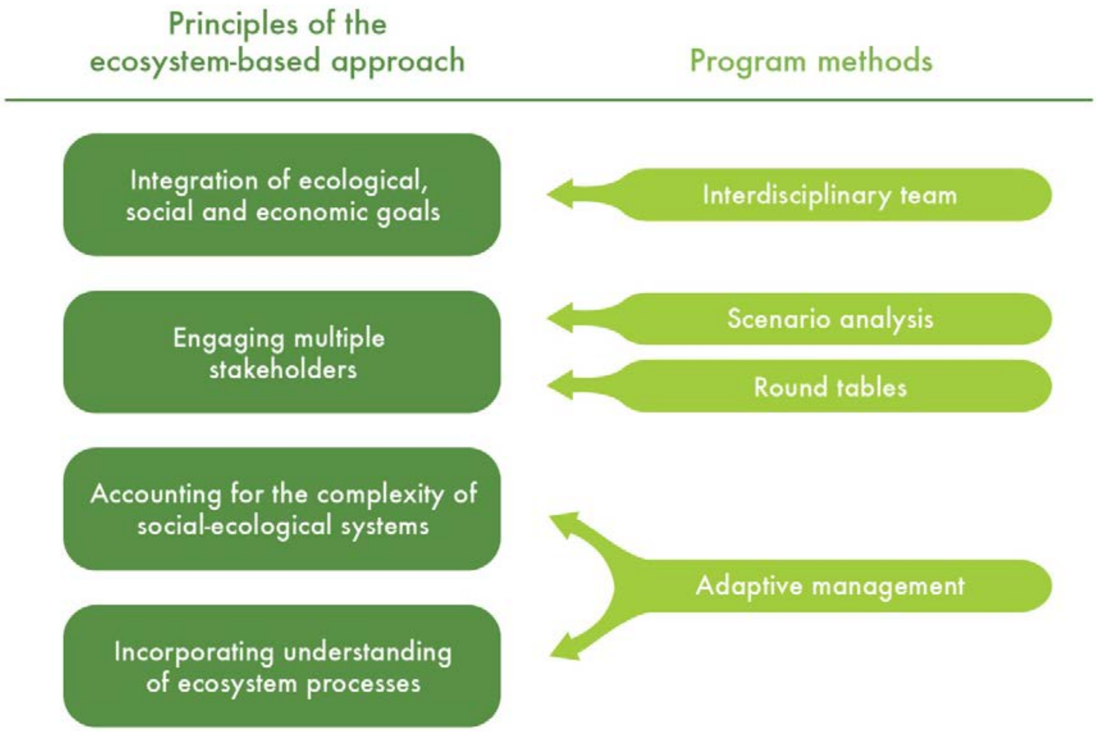

Figure 2.1. *Connections between the four principles of the ecosystem based approach and the program methods.*

2.2.3. Developing the Swedish Forestry Model with an ecosystem-based approach

A Forestry Model can be viewed as the general state-specific way of coping with forest related politico-economic issues (Lethinen, et al. 2004). The Swedish Forestry Model, as we know it today, came into being in the early 1900's when policy-makers recognized the need for sustainable forestry. At the time, Swedish forests were intensively used. The demand for forest products for industrial as well as domestic purposes had, at least in some regions, for many decades been higher than the supply, and harvests were not accompanied by measures to ensure effective regeneration. In 1903, policy makers launched the first Forestry Act; a "re-growth legislation" prescribing that the person who cut forest was required to ensure new forest by seeding or planting. In the following century the Forestry Act was re-formulated several times. The last time in 1993 when the former very detailed regulations were criticized, particularly by conservationists pointing out that the Forestry Act did not take into account the environmental values of forests. The main difference in the Forestry Act from 1993 from the previous law is that the production goals and environmental goals are set equal: preservation of natural and environmental values is just as important as the forest's production values. The current law is also less detailed in its regulations: freedom is given to forest owners to use alternative methods for forest management. The current forestry legislation can largely be summed up as "freedom under responsibility". The Forestry Act applies to all forest owners and the Swedish Forest Agency monitors forest owners' compliance to the Act, and support forest owners with education and counselling.

Exogenous as well as endogenous processes heavily influence the progress of the Swedish Forestry Model (Appelstrand 2007). Exogenously the model is affected by norms, rules, standards and procedures, for instance as expressed in international agreements, directives and certification schemes, but also due to the globalisation of e.g. wood and energy markets. Endogenously, national actors are shaping the policy and its model, under the concept of “freedom under responsibility”. To be able to analyse the Swedish Forestry Model it is thus necessary to put the model in its context and take into consideration global as well as national policy levels as well as market economy aspects.

As described above the model has also developed in terms of scope, from a specific focus on timber production, to the incorporation of other values such as biodiversity and social aspects of forest use. The focus has thus shifted with the aim to “sustain forest ecosystems in a healthy, productive and resilient condition so that they can provide the functions, goods and services that enrich and sustain human well-being”. This places the Swedish Forestry Model within the realm of the ecosystem-based approach, with the need to further develop the model to incorporate biological, physical and human components, including social and economic aspects with a particular focus on adaptive management.

If we connect the key aspects of EBA (section 2.2.2.) with the research on the Swedish Forestry Model and the research in phase 1 of *Future Forests*, we see that a central focus in phase 1 was to integrate ecological, social, and economic goals and the recognition of humans as key components of the interdisciplinary research, i.e. collaborations across and between disciplines was needed. This will be further developed in phase two. The ecosystem-based approach also point to the importance of engaging multiple stakeholders in a collaborative process to define problems and find solutions. In phase 1, several methods were tested with various results. In phase two, the engagement of stakeholders will be done more systematically by involving them in scenario analyses and round table discussions across the different program components (see figure 2.1).

Adaptive management is one of the important tools to implement the ecosystem-based approach. In phase one, we have begun the process of defining and developing an adaptive management approach for Swedish forestry, especially in a hypothetical case of introducing exotic tree species as a climate adaptation (see section 2.3.3.). During phase 2, we will develop models for adaptive forest management in the context of the Swedish Forestry Model and also discuss approaches to actual management issues, such as more intense fertilization regimes and continuous cover forestry. Part of this work will be done in collaboration with the Swedish Forest Agency.

2.3. Program methods

In *Future Forests* phase 2 we will integrate the research activities in a common framework. As in phase 1, futures studies will involve both researchers and stakeholders. Further, *Future Forests'* research focuses on complex problems that do not have simple optimal solutions. To address these questions, interdisciplinary research will be a guiding principle. Finally, we will involve actors in several collaborative learning processes.

2.3.1. Interdisciplinarity

Most, if not all, of the research issues addressed by *Future Forests* can be seen as complex problems, or what is sometimes known as ‘wicked problems’. Wicked problems can occur in any domain that involves actors and stakeholders with differing perspectives. In short, wicked problems can be characterised by situations in which (Conklin 2005, Ritchey 2007):

- The solution depends on how the problem is framed (how and by whom is the question phrased).

- Stakeholders and other actors have radically different worldviews and thus different frames for understanding the problem.
- The constraints that the problem is subject to and the resources needed to solve it change over time.
- The problem is never solved definitely (since drivers, constraints, and attitudes change over time).
- Solutions are not right or wrong, only better or worse from a certain perspective.

Given these characteristics, there is no single optimal solution for most management issues, but science can inform decision-making processes with knowledge. This is the overall mission for the *Future Forests* program.

An interdisciplinary approach is necessary to provide stakeholders and other actors with information that is relevant to these wicked problems. There are many definitions of interdisciplinarity, but we adhere to the definition by Repko (2008): "Interdisciplinary studies is a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline and draws on disciplinary perspectives and integrates their insights to produce a more comprehensive understanding or cognitive advancement". However, even with this definition in mind, interdisciplinary research needs to be discussed, planned and executed in a reflexive process.

Interdisciplinary research in its basic form means collaborations across and between disciplines. That may sound trivial, but it opens the question of what a discipline is. This question can be approached from at least three different perspectives. An epistemological perspective emphasizes differences in theories, approaches, methods, and concepts between different research areas, i.e. that knowledge is produced in different ways in different disciplines. An organisational perspective would discuss how universities are organised into departments and faculties, each with its own research area and knowledge-production system. Finally, a sociological perspective could analyse research as expressions of social control and acceptance, where, for instance, researchers within a particular discipline agree on how knowledge should be produced and how the research processes and results are to be judged. Interdisciplinary research can thus be seen as a research process that breaks or transcends these different perspectives on disciplines. This is not always easy in a conservative university context.

Interdisciplinary research can be classified into three different types of collaborations that differ in levels of integration: multidisciplinary, interdisciplinary, and transdisciplinary research (Mobjörk 2004). Multidisciplinary research has a low level of integration, the approach is additive, and integration is achieved through synthesis of the results. A typical example is an edited book with a synthesis chapter. Interdisciplinary research *sensu stricto* has a higher degree of integration where questions are formed and analyses and syntheses are all done in collaboration. This is a form of knowledge pluralism where different disciplines bring their specific knowledge to the table to answer a question in a more holistic way. A typical example could be a paper co-authored by several authors from several disciplines. Transdisciplinarity, on the other hand, has two different meanings in the scientific literature. It can mean both a research process that is aimed at developing new theories and methods that go beyond traditional disciplines, i.e. a new form of knowledge production, or it can specifically mean research approaches that include stakeholders (and thus including a knowledge system that is outside of academia). *Future Forests* uses all of these different forms of interdisciplinarity, and we also acknowledge that the level of integration in a particular research project may vary over time and that there are thus intermediate forms. However, it is not important for the program to correctly classify different collaborations. The important aspect is to develop the appropriate level of integration in relation to a particular research question. Throughout the program plan we will use interdisciplinary research to cover all of these forms without defining the level of integration in each case.

Any collaboration, disciplinary or otherwise, requires two or more researchers to sit down and apply their respective knowledge to the issue at hand. Interdisciplinary collaboration is thus not fundamentally different from disciplinary collaboration. However, the epistemological difference that exists between disciplines introduces a higher complexity, and this complexity increases with increasing difference in approaches. It is probably easier for two natural scientists, such as an ecologist and a chemist, to collaborate than for a natural scientist and a social scientist. The closer the disciplines, the more likely it is that the knowledge systems are similar. The increased complexity in interdisciplinary collaborations has some consequences. As more effort is needed to bridge the differences, projects tend to take longer resulting in slower publication rates (at least initially, a well-established interdisciplinary team should have the same publication rate as a disciplinary team). The extra time is required for building trust and respect between researchers, for instance to get away from commonly held stereotypes such as ”rigid natural scientists” and ”vague social scientists”. An essential component in this process is learning. For a collaboration to be fruitful, each researcher has to develop a certain level of knowledge in the other’s field, for instance by reading key literature or discussing assumptions for analyses. This also takes time. Developing a successful interdisciplinary research team is no trivial task, and may not suit everyone.

In *Future Forests* phase 1, we started out with ten different research groups ranging from the natural to the social sciences and the humanities. Many of the research groups had not collaborated before, and several of the groups came from research areas outside of forest management. We thus needed to find an approach that could develop our interdisciplinary skills in the program while still allowing the research groups to produce excellent disciplinary research. The scientific literature on interdisciplinarity agrees on the value of regular meetings on shared problems as an efficient method (e.g. Naiman 1999, Pickett et al. 1999, Nicholson 2002, Campbell 2005, Repko 2008, Sievanen et al. 2012). We thus decided to develop the workshop form as our approach. By organising series of meetings throughout the program period, we tried to give the interdisciplinary process enough time and resources to mature. We began by developing and analysing futures scenarios with the project leaders during the first 18 months or so of phase 1 (Moen et al. 2012). As we hired new researchers to the program, we then initiated a number of integration projects to expose these colleagues to an interdisciplinary research environment. We also ran an interdisciplinary PhD-course that was developed by a political scientist, an historian, and two ecologists, all on postdoc or assistant professor levels. The build-up phase of this process is now over and it is time to capitalize on our interdisciplinary skills in phase 2.

We will increase integration on two levels in phase 2. We will organize the work in our Program Components (PC’s) so the researchers in each component represent different disciplines. This is an important change from phase 1 where most component projects had a disciplinary approach. Further, we will plan and conduct a series of program-level themes, that will run throughout phase 2 (section 6.1.). The researchers working in these themes will mainly come from the PC’s, and the work will be organized as a series of workshops in the manner that we have found extremely successful in our thematic working groups in phase 1. The work in these themes will be focused on producing syntheses on key forest issues for the future. This synthesis work could include reviewing existing knowledge, modelling consequences of different policy choices, involving stakeholders in the process, and producing knowledge that increase the policy options for decision makers.

2.3.2. Involving stakeholders and other actors

2.3.2.1. *Scenarios – exploring the future*

The future cannot be studied empirically. It is possible, however, to systematically explore, create, and test both possible and desirable futures so as to improve decision making. This process includes analyses of how forest conditions might change as a result of the implementation of policies and actions, and the broader consequences of those actions. The value of such an exercise lies in its usefulness in setting strategies and informing decisions today by emphasizing opportunities and threats and the manner in which they may be addressed.

One method of studying the future is through scenario analyses. Scenarios are logically developed storylines regarding developments towards a potential future (Börjeson et al. 2006, Fahey & Randall 1998, Alcamo 2008). One advantage of scenario analysis over other futures methodologies is its potential for combining qualitative (narrative) information with quantitative modelling (Fig. 2.2). Qualitative storylines provide an understandable way of communicating complex information, have considerable depth, describe comprehensive feedback effects, and incorporate a wide range of views on the future. Quantitative modelling may be used to check the consistency of the storylines, to provide relevant numerical information, and to enrich the qualitative stories by showing trends and dynamics not anticipated by the storylines alone.

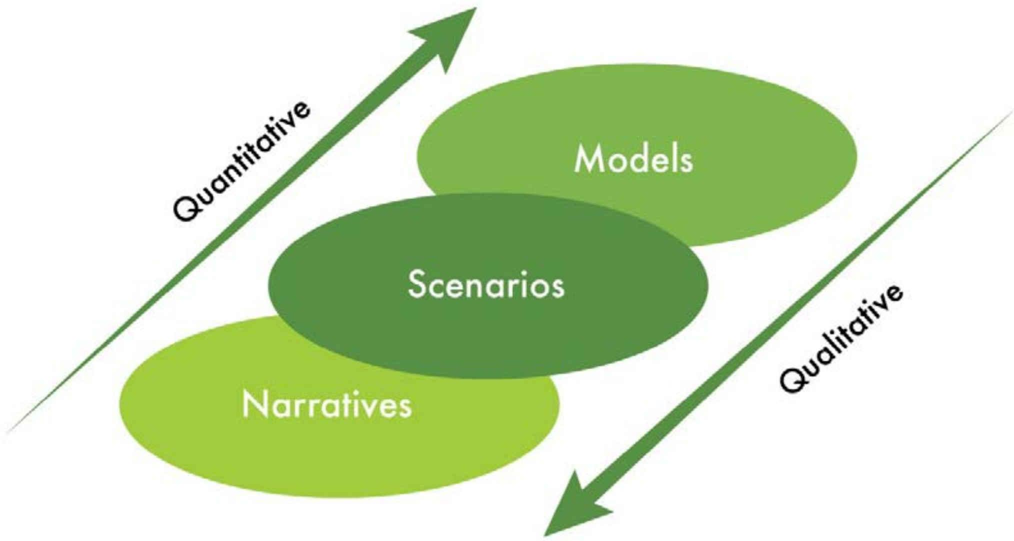

Figure 2.2. *Qualitative and quantitative information are preferentially combined when developing scenarios.*

Scenarios may be based on identified driving forces and an understanding of conflicting aims. The scenarios should be judged on their ability to help decision makers make policy now, and should be plausible (a rational route from here to there that makes causal processes and decisions explicit), internally consistent (alternative scenarios should address similar issues so they can be compared), and sufficiently interesting and exciting to make the future “real” enough to affect decision-making. Scenarios can be of different types that answer dissimilar questions. Predictive scenarios answer the question “what is most likely to happen?” and are most useful for short time ranges and in situations with low uncertainty about drivers. In phase 1, *Future Forests* used such scenarios in collaboration with FAO while generating and publishing the European Forest Sector Outlook Study II where the supply and demand consequences of different policy choices were studied. Explorative or descriptive scenarios answer the question "what may happen?", and can be useful in complex situations over the medium to long term. This was a focus for ForSA and the core team of researchers during the first half of phase 1, where four possible scenarios were developed: The Balance Act, The Carbon Sink, The Carbon Substitution, and The Free-for-all. The process of creating these scenarios was extremely important in forming the research team at the start of the program. The scenarios have also been discussed with our stakeholders, and are documented in a Foresight Brief at the European Foresight Platform. Finally, normative scenarios answer the question "what would we like to happen?", and are thus firmly based on attitudes and values.

In phase 2, *Future Forests* will focus on normative scenarios, or desired futures, identified by different stakeholder groups. Normative scenarios are constructed by identifying a desired future state (often about 50 years ahead), and then developing logical paths that would lead to these states. Possible stakeholder groups to involve in this exercise are conservation interest groups, representatives from large forest companies, private landowners, and the general public in the sense of recreational interests. We believe this will be an interesting and informative way of highlighting different views on forest use across different segments of society, and emphasizing the different trade-offs that would be needed to realize different futures.

2.3.2.2. *Round table discussions*

As a research program, we will not be directly involved in decision-making processes. However, our theoretical framework for interacting with stakeholders and other actors adheres to a large extent to the basis for Collaborative Learning, a conflict management framework (referring to decision conflicts, not confrontative conflicts; e.g. Daniels & Walker 2001). Collaborative learning seeks to help stakeholders and other actors generate a set of improvements in response to a mutual concern, based on a rich understanding of the complexity of the situation. It is in this rich understanding that the knowledge generated in *Future Forests* may be useful. Collaborative learning as a conflict management framework assumes that (i) conflict is inevitable, irresolvable, but manageable, (ii) the complex nature of managed systems makes decision making difficult, and (iii) that much of the value of a collaborative process comes from its value as a learning opportunity. Further, collaborative learning asserts that social learning is fundamental to good policy decisions, and that the complex, inter- and transdisciplinary nature of many public policy problems requires a systems learning approach. To employ collaborative-learning principles and techniques means designing and implementing a series of events that promotes creative thought and constructive debate. This is an important part of our communication strategy.

Just as interdisciplinarity is a process that takes time to develop, so do interactions with stakeholders. The transdisciplinary nature of collaborative learning requires that knowledge systems must meet, trust be built, and arenas developed where participants feel comfortable. During the last 1 – 1.5 years of phase 1, *Future Forests* have made great progress in this process. We have found that interactions get better when the groups are smaller, the subject focus is stronger, and the expected outcomes are more clearly voiced. We will continue to develop these processes in a key series of events under phase 2 which we call Round Table discussions. A number of Round Tables will be set up where researchers and actors/users can interact under the leadership of a professional facilitator. The Round Tables will have consultative as well as participatory roles. Consultative roles include: i) receiving first hand information and providing feedback throughout the research process, i.e. aiding in validating theoretical as well as empirical findings, and ii) helping to find suitable candidates for interviews/focus groups. Participatory roles include being part of a dialogue about alternative understandings of sustainable forest management and the options and limitations of the different management models analysed in the program. Specific methods will be chosen depending on the size of the groups and the stage in the process. Open Space Technology, World Café conversations and common facilitation tools such as Beehives, Rounds, and Focus groups will be used and combined in an adaptive and transparent way.

2.3.3. Adaptive forest management

Adaptive management (AM), as first formalised, is management conducted in a manner that explicitly aims to increase knowledge and reduce uncertainty (Holling 1978; Walters 1986). The AM process, a cycle of learning and evaluation, can be distilled into six stages (Figure 2.3.). Within AM, participation of stakeholders outside the management institution is also emphasised in order to manage conflicts and increase the pool of contributions to potential management solutions (Holling 1978; Walters 1986). We recognise AM as a tool that reduces ecological uncertainty via a formalized process of learning combined with deliberate experimentation in policy or practise.

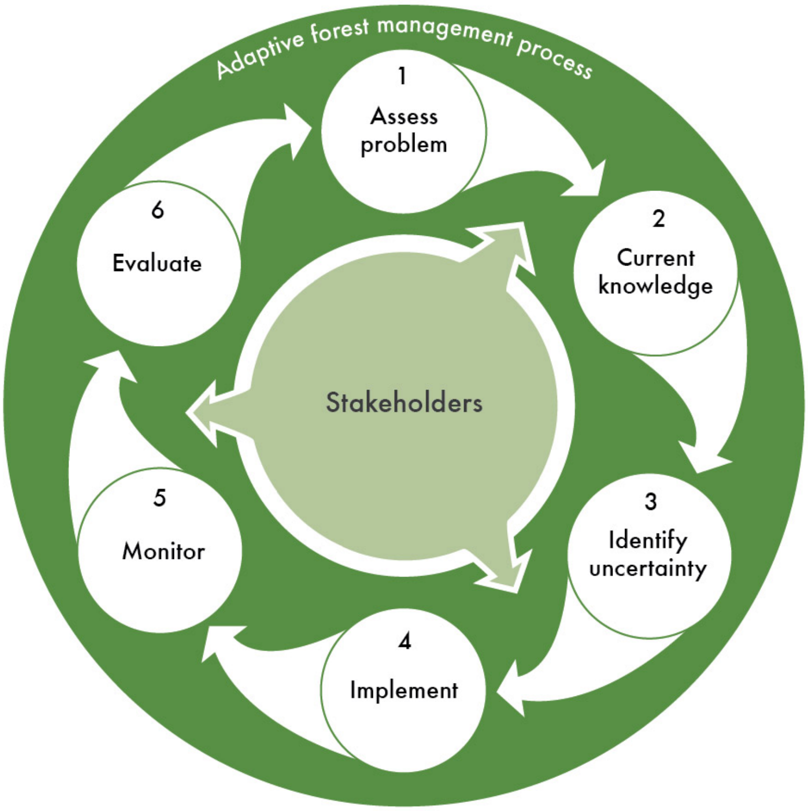

Figure 2.3. *The adaptive management process (based on Walters (1986, p. 9) and Holling (1978, p. 20)). Stakeholder participation is considered central to the process and achievement of successful natural resource management.*

Supporters and critics alike have identified many potential obstacles to AM implementation, including specific pathologies and reasons for failure. During that process, particular contexts have been suggested to be inappropriate for AM, e.g. in the presence of highly controversial risks, or where management problems are characterised by high complexity or extended scales. To overcome these perceived limitations in the applicability of AM, we suggest a strategy where questions are first separated into issues related to participation and governance, and secondly by refocusing and reconstructing the problem to those parts that are amenable to experimentation according to the AM principles. We provide a tentative decision tree, formulating a hierarchy of distinct questions to guide a manager to this end (Rist et al., submitted; Figure 2.4.). This will be a guiding principle for our continued research on AM in phase 2, where we will focus on developing theory and practice of adaptive forest management in the context of the Swedish Forestry Model (see section 6.1.4.).

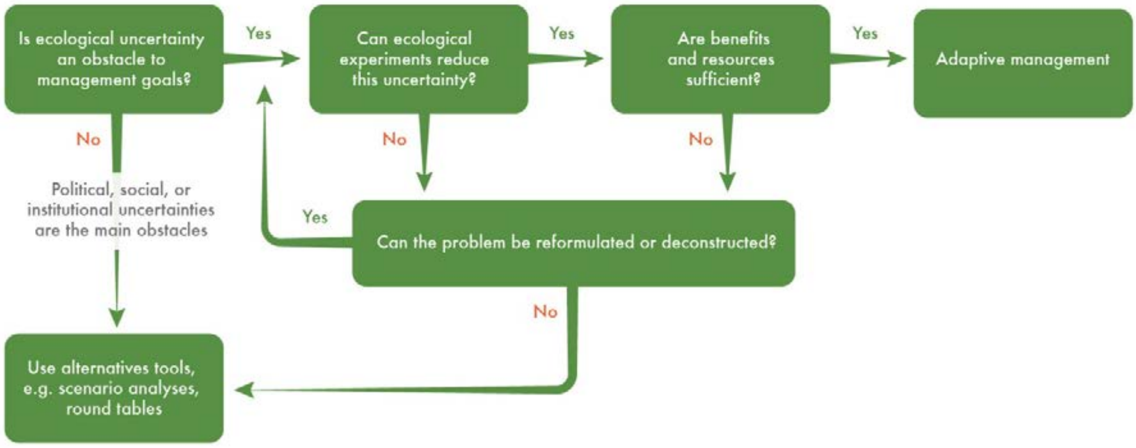

Figure 2.4. *Decision tree for assessing the appropriateness of adaptive management. The decision making begins on the left progressing towards the right in order to draw conclusions regarding the suitability of applying AM. In the cases where AM is not deemed suitable, e.g. where other than ecological uncertainties are the main obstacles or where there is not enough resources to experiment, alternative tools such as scenario analyses needs to be applied.*

2.4. Scientific program deliverables

Generally, we view *Future Forests* as a strategic investment in forest-related science. The science *Future Forests* develops broadens the traditional view of Swedish forest research.

Specifically, the following assets will come out from phase 2:

- A permanent Centre for Forest Systems Analysis and Synthesis that serves as an interdisciplinary hub for collaboration between science and society.
- A generation of young researchers addressing forest management with a novel interdisciplinary approach;
- An analysis of the Swedish Forestry Model (presented as a peer-reviewed book) set in context of current international and European trends, particularly targeting its ecosystem-based approach, and envisioning possible ways forward.
- Conceptual development and implementation of adaptive forest management.
- Foresight studies, including scenario analyses and systemic economic analyses addressing national, European and global consequences of alternative future forest management strategies.
- Engagement of stakeholders and scientists in mutually benefitting dialogues and collaborative research processes.
- Scientific contributions within the fields of forest management, forest ecosystem ecology and biogeochemistry and forest policy, economy and governance.
- In 2016, an international scientific end-conference displaying the results of *Future Forests*.

3. Value to users and other stakeholders

Future Forests ambition is to be recognized by actors and stakeholders in Sweden and worldwide for its novel research that can be used as science-based decision support for the long-term utilization of forest landscapes.

3.1. Actors and stakeholders involved in the program

The target groups of the research program are those who manage the forest, including industrial forest companies, non-industrial private forest owners, and forest owner associations. Other target groups are governmental authorities, such as the Swedish Forest Agency, the Swedish Environmental Protection Agency, County Administrative Boards, and other national and local authorities. We also target educational institutions, mainly university level, non-profit interest associations and NGO's, and the general public.

3.2. Program deliverables to actors and stakeholders

Generally, the science *Future Forests* develops is broadening the traditional view of Swedish forest research amongst actors and stakeholders and contributes to preparing the Swedish forest sector for the future.

Several of the scientific deliverables listed in 2.4. are also highly relevant to, and includes collaboration with, actors and stakeholders. In addition to those, we will produce a number of deliverables particularly targeted towards actors and stakeholders:

- Communication of new scientific findings to the general public via the *Future Forests* web and newsletter and twice a year via the magazine *Skog & Framtid*.
- A yearly report summarizing the activities each year.
- A popularized version of the peer-reviewed book analysing the Swedish Forestry Model aimed for educational purposes.
- Operationalization of science based decision support tools that will lead the way towards long-term sustainability of forest management.
- At the end of the program period, a stakeholder conference.

4. Program structure

The work in phase 2 will be organized with the Centre for Forest System Analyses and Syntheses (ForSA) as an integrating hub of four program components (Fig. 4.1.). Novel original multi- and interdisciplinary work will be done in the four thematic program components while work dominated by review, synthesis, meta-analyses and modelling mainly will be done at the program level within ForSA. ForSA will also host the Senior Management Group (SMG).

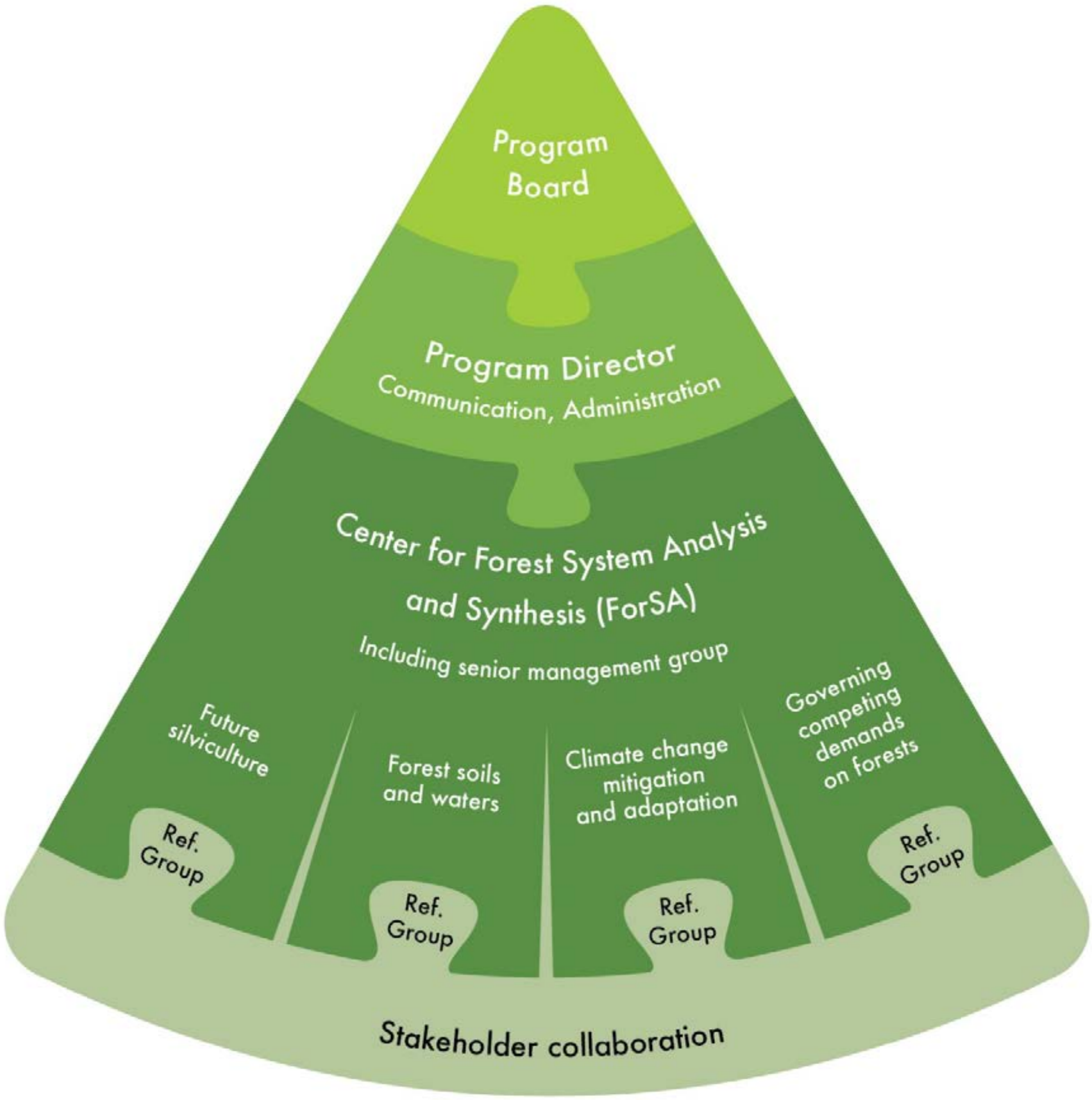

Figure 4.1. *Schematic illustration of the program structure in Future Forests phase 2 emphasizing the integration and coordination roles of ForSA, the thematic profiles of the component projects and the involvement of stakeholders.*

4.1. Leadership

SLU will be the official host of the program. The Vice Chancellor is appointing the Program Board in cooperation with MISTRA. The Board is responsible for the program, and thus for assuring that the program activities proceed according to plan, as well as for the fulfilment of the program's goals (see fig 4.1. for a schematics of the program structure).

Professor Annika Nordin will hold the leadership position of Program Director. The Program Director is responsible for the overall daily running of the program, i.e. leading the SMG. She is also responsible for presenting the agenda to the Board and for executing the Board's decisions. Annika Nordin is a professor in forest ecophysiology at SLU, Umeå.

The Senior Management Group will consist of all the persons who have leadership positions in the program, either as leaders of program-level projects in ForSA or as leaders of Program Components (PCs). This is a major change compared to the phase 1 organization as the research group leaders then was not part of the SMG. As in phase 1, also the Program Communicator will be part of the SMG. Thus, the following persons will be in the SMG in *Future Forests* phase 2: Annika Nordin (Program Director), Johan Bergh (PC leader), Hjalmar Laudon (PC leader), Tomas Lundmark (ForSA project leader), Jon Moen (ForSA project leader), Annika Mossing (Program Communicator), Urban Nilsson (PC leader) and Camilla Sandström (PC leader).

4.2. The Centre for Forest Systems Analysis and Synthesis (ForSA)

ForSA is the central hub of *Future Forests*. It is a unifying force promoting a creative and intellectually stimulating environment, where different scientific disciplines merge to address problem areas in a multi-faceted setting. According to the original plan ForSA will now be further strengthened to become a permanent platform for analysis and synthesis of forest- and forestry-related issues by the end of the second phase. Specifically, we will extend the role of ForSA to include the operational management of the interdisciplinary research efforts that will be the backbone of the program. ForSA will have two main types of activities in phase 2: (*i*) performing program-level research projects lead by members of the SMG and dominated by review, synthesis, meta-analyses and modelling, and (*ii*) running thematic working groups led by Prof. Jon Moen (section 6.2.).

4.3. Program Components

The Program Components (PCs) are responsible for producing novel original multi- and interdisciplinary research. Each PC will have a research leader who is part of the SMG and responsible for that the research within the PC is performed according to the program plan and according to the PC budget. The research leader will ensure that the competence and the results produced will be available to the program as a whole via the regular monthly SMG meetings.

4.4. Reference groups

During phase 1, one of the research groups, "Forest management" had its own reference group. Based on the positive experiences from how the research benefitted from the reference group, all PCs in phase 2 will have a reference group. These reference groups will consist of representatives from nature conservation organisations, forest industry, The Swedish Forestry Agency, and/or other governmental agencies and from outdoor recreation associations.

5. Skills and networks

5.1. The Consortium

The *Future Forests* program builds on formal cooperation between the Swedish University of Agricultural Sciences (SLU), Umeå University (UmU), and the Forestry Research Institute of Sweden (Skogforsk). The three are world leading Swedish academic institutions providing excellent research in the area of natural resources in forest landscapes. In *Future Forests,* the institutions are complementing each other in competences and research approaches: Umeå University adds a social-science perspective to the natural-science focus of SLU. Skogforsk has a close affiliation to the industrial forest sector and has developed a strong tradition in putting science into practice. It is clear that the *Future Forests* program has contributed to strengthening links, formally between the three institutions but perhaps mainly and most importantly between the researchers involved in the program.

Below follows a brief presentation of the three institutions:

SLU is the main academic institution in Sweden pursuing knowledge of biological natural resources and their sustainable utilization. The academic staff in subjects related to forests and forestry includes about 65 professors and over 160 PhD students, with an annual output of about 30 PhD degrees. Researchers in this field are among the universities most productive in terms of scientific publication and competition for external funding from both national and international sources. Available infrastructure includes a number of state-of-the-art specialist laboratories, as well as a wide range of experimental sites all over Sweden. SLU is responsible for several educational programs in, e.g., forestry and natural resource management. Collaboration with the forestry sector has a strong tradition at SLU and is regarded as a cornerstone for both research and education. SLU is the only Swedish university that acts as a national data host for environmental monitoring and assessment programs, such as the National Forest Inventory and the Forest Soil Inventory. Environmental monitoring contributes to the official Swedish statistics about changes in the environment and is the basis for evaluating progress towards national environmental quality goals.

At **UmU,** research on social aspects of natural resource management has a strong tradition at the Faculty of Social Sciences and the Faculty of Arts. The research includes climate- and environmental policy, resource conflicts and social change, as well as the effects of governance and awareness-raising mechanisms. Both broad and deep interdisciplinary research linkages exist, especially in areas such as resource conflict and governance, valuation and attitude shifts, rural development and resilience theory. Relevant research areas host more than 15 professors and over 40 PhD students engaged in environmental and natural resource research.

Skogforsk has a vital role in satisfying the industrial forest sector’s needs for operational research and efficient dissemination of new knowledge concerning the sustainable management of forests. Research areas span forest production including tree breeding, silviculture, conservation of nature and the environment, as well as forest operations including wood utilization, logging, logistics and forest bioenergy.

5.2. Research resources available to the Future Forests team

5.2.1. The Heureka model

The Heureka Forestry Decision Support System is a modelling tool for integrated analyses of multi-purpose forestry at different geographical scales, e.g., stands, forest holdings, landscapes, and regions. The core of the system is made up of models that provide detailed and long-term projections of tree growth and cover. By including models for other ecosystem services – depicting their relation to the tree cover development – possible outputs of different goods and services from the forest landscape can be analysed. Optimization techniques are typically used for forest-management planning at estate levels. Heureka can be used as a tool for identifying specific solutions, such as how to achieve the best economic turnover given restrictions based on nature conservation and environmental objectives. All Heureka analyses have a geographical context and GIS is used to convey results. Time sequences of maps, time graphs, and 3D visualization of forest landscapes can be used to enable stakeholders to interpret data provided by the analyses.

In *Future Forests* researchers have used, and will continue to use Herueka, for simulating forest growth, estimating ecosystem carbon sequestration of forest stands and regions under various silvicultural programs, calculating costs to forest owners caused by moose damages to forest plantations, and for analysing future forest landscapes where different alternative silvicultural programs and different strategies for biodiversity conservations are applied.

5.2.2. Environmental monitoring and assessment

A wealth of forest ecosystem data are provided by the National Forest Inventory (NFI), the Soil Survey, the Swedish Species Information Centre, and other environmental monitoring and assessment programs at SLU. In the first *Future Forests* phase 1 many of the component projects as well as several of the thematic working groups have made use of these unique national data assets. In *Future Forests* phase 2 we will continue to explore available data, and find novel ways of combining and analysing different data.

5.2.3. Field-based research infrastructure

In the task of building the knowledge base needed for adaptive ecosystem-based management of forests, the *Future Forests* program has been, and will continue to be, well served with long-term experiments, field stations, and institutional commitments to these facilities. The extensive records and on-going studies that address how different regions, stands, species, soils and waters respond to combinations of silviculture and climate turns the daunting spatial and temporal extent of the forest into a resource for achieving the goals of *Future Forests.*

The landscape scale perspective on different silvicultural systems that *Future Forests* is promoting is somewhat new for Scandinavian forestry research. To meet this challenge, SLU in collaboration with Sveaskog AB in 2009 and 2010 established two landscape-scale experimental parks (one in Västerbotten and one in Småland) to study landscape level responses to innovative silvicultural approaches for increased forest growth, while at the same time maintaining delivery of other ecosystem services. Some of the field-based research activities in *Future Forests'* first phase have been associated with these landscape-level experiments and in the program's second phase some of these activities will be continued.

5.3. Future Forests in the national network for forest research

The *Future Forests* program was launched in 2009 as a response to a knowledge gap arising from society's partly new and greatly increased demands on forests. At almost the same time several other major long-term research programs related to forest use were initiated by Swedish and European research grant agencies (VINNOVA, VR, FORMAS, EU FP7). *Future Forests* is the largest of these, having an interdisciplinary approach combined with high ambitions for interacting with stakeholders. To take advantage of possible synergies, *Future Forests* has already in its phase 1 established connection to the other major programs, both on the program and component project level. During phase 2 these connections will be further developed to take full advantage of positive synergies.

We believe it is particularly important to develop effective partnerships with the following programs:

- *Mistra Swedish research program on Climate, Impacts and Adaptations (Mistra-SWECIA) (2012-2015)*. The aim of the program is to provide scientific support for informing climate change adaptation processes with scenario-based integrated climate, impact and economic analysis. The focus will be on sectors in which land use decisions and management are key activities and the forest sector will be used as a starting point. Thus, there are obvious opportunities for positive synergies, both on the overall program level and on the program component level (in particular PC3). Collaborative activities between *Future Forests* and Mistra-SWECIA researchers occurred already during the first phases of respective program, and our continued partnership will be based both on already existing links in research interests, and on novel efforts to be planned in dialogue as soon as *Future Forests* phase 2 starts. Hence, the *Future Forests* SMG will initiate yearly meetings between the SMGs of the programs and the first one is planned for early spring 2013.
- *The UPSC Berzelii Centre for Forest Biotechnology* (2007-2016) financed by VINNOVA and VR is a joint research and innovation centre between Umeå Plant Science Centre (UPSC) and forest industrial partners. With an annual budget of more than 20 Mkr the project is the second largest forestry-related research project in Sweden, after *Future Forests*. The vision of the centre is to develop the research environment at UPSC into the world's most innovative milieu where top-class basic research in tree biology is translated into innovations with commercial potential. This will help the Swedish wood-based industries to stay competitive in the 21st century and enable the creation of new companies and industries based on the sustainable production and use of renewable wood-based raw materials with new and superior properties. This will allow the development of more efficient and advanced production of wood and wood-derived products for new materials and biofuels. There is a mutual interest in increasing the interactions to the *Future Forest* programs on adaptive silviculture for genetically enhanced trees (developed through breeding, somatic embryogenesis or genetic modification), but also in discussing the socioeconomic consequences of an increased use of such trees.
- *The Stockholm Resilience Centre (MISTRA)*. The centre focuses on research for the governance and management of social-ecological systems to secure ecosystem services for human wellbeing and resilience for long-term sustainability. Research during the first phase of *Future Forests* showed that resilience theory were poorly adapted for productions systems, such as forestry and agriculture. To develop and adapt theory further to these systems, collaboration with the centre on the resilience of production systems has been initiated and a working group has been formed. We envision that this collaboration will continue in phase 2, and that this will be of both theoretical and practical importance for both research programs.

With the following large-scale projects *Future Forests* will link via shared research-leaders and researchers:

- Future-oriented integrated management of European forest landscapes (INTEGRAL) (2011-2015). The INTEGRAL is an EU-FP7 program coordinated by SLU (Professor Ola Eriksson) aimed to reduce the differences between forest-related land-use policies and practices in Europe, as well as to examine the social conflicts regarding this subject. The European perspective of the program is complementary to the more national perspective of *Future Forests*. In particular *Future Forests* will gain from the European scale scenario-analyses work planned within INTEGRAL. Here, a common interest for collaborating with IIASA is manifested as *Future Forests* and INTEGRAL will share several researchers that will be involved in our collaboration with IIASA (see 6.1.2.).

- *Trees and crops for the future (TC4F) (2011-2015).* The aim of the research in TC4F is to develop knowledge for increased biomass production from forestry and agriculture. Research is within the following four fields; the impact of climate and nitrogen on carbon dynamics in forests; forest genetics and next generation of forest trees; sustainable and adaptive forest management; and biomass production from non-food crops. A main feature of the research program is to integrate research between major research programs. Thus, research within TC4F is connected to the research in *Future Forests*. Specifically, TC4F and *Future Forests* share research interests within the fields of forest management, nitrogen and carbon dynamics and forest genetics.
- *A state of the art modelling and decision support system for mitigating the role of forestry on water quality (2010-2015)* (ForWater). The program is a FORMAS strong research environment lead by Professor Hjalmar Laudon, SLU. The aim of ForWater is to understand and quantify how forestry affects the transport of nutrients, base cations and contaminants from soils to surface waters and to test what management strategies are available to minimize these negative environmental impacts in a changing climate. Several of the members of ForWater and the *Future Forest* program are shared which leads to a tight connection between the two programs.
- *Nitrogen and Carbon interactions in Forests* (2010-2015) (NiCAF) is a FORMAS strong research environment coordinated by SLU (Professor Torgny Näsholm). The aim of this project is to explore ecophysiological aspects of carbon – nitrogen interactions in boreal forest ecosystems to promote sustained forest productivity under a changing climate. Members of the *Future Forests* program are part of the NiCAF researcher team. Hence it will be ensured that relevant results from the project will benefit *Future Forests*.
- *Quantifying weathering rates for sustainable forestry (2011-2016)* (Qwarts) is a FORMAS strong research environment lead by Professor Kevin Bishop, SLU. The overall purpose of Qwarts is to provide scientifically based estimates of mineral weathering rates at the spatial and temporal scales relevant to the sustainable forest management with explicit representation of model uncertainty. The leader of this research program is part of the project component on forest soils and waters which ensures that the results from Qwarts can be incorporated into the synthesis work of *Future Forests*.
- *Smart Hänsyn* (2010-2013) is a FORMAS strategic research environment coordinated by SLU (Professor Lena Gustafsson). The aim of the project is to develop landscape level strategies for nature conservation in forestry, including aspects of societal values and attitudes towards conservation. The project has mutual interests with *Future Forests* in applying the Heureka decision support system to guide and evaluate nature conservation practices in forest management. The researchers that work in both projects will ensure that approaches and study objectives will be complementary and mutually benefitting.
- Governing sustainable rural development – for or by the local population? (2012-2016) is a part of the FORMAS grant to future research leaders in rural development and is led by

Camilla Sandström. The aim of the project is to explore the causes and consequences of the emerging governance arrangements in terms of public and private partnerships as a response to the challenge of sustainable rural development. This includes in particular Non Industrial Private Forest Owners and incentives structures to contribute to common goods such as biodiversity protection via e.g. the KOMET program. Relevant results from the project will benefit *Future Forests*.

5.4. International collaborations

In its first program period, *Future Forests* formalised two important international collaborations that will be continued and developed during the upcoming years: with the North European Regional Office of the European Forest Institute (EFINORD) and with the International Institute for Applied Systems Analysis (IIASA).

5.4.1. The North European Regional Office of the European Forest Institute (EFINORD)

EFINORD is a local branch of the European Forest Institute (EFI). EFI's mission is to carry out, strengthen, and mobilise forest research and expertise aimed at addressing policy-relevant needs with regard to forests and their governance. EFI is involved in key policy processes shaping the European forest sector. EFINORD was inaugurated in Copenhagen in late 2010 and already in 2011 Future Forests became involved in the institute's activities as we organized a foresight seminar to elaborate the EFINORD work plan on the topic "Biomass production and intensive forest management". The seminar activity resulted in a mutual project, which was later funded by SNS (Nordic Forest Research Co-operation Committee). The project investigates potentials for increased forest biomass production in the Baltic region. The point of departure for the study is the Selfoss declaration on sustainable forestry (http://www.norden.org/sv/publikationer/publikationer/2010-554), adopted by the Nordic ministers and secretaries of state responsible for forestry in 2008, which aims to further increase sustainable biomass production in the Nordic Region. The study reports data on forest resources, forest policy, forest industry and bioenergy sectors, and main silvicultural practices. In August this year a draft report from the study was completed, and it is expected to be finalized before the end of this year. The report will be used in PC4 in the international comparison of the Swedish Forestry Model (see section 6.3.4.). Moreover, as a spin off from the study, *Future Forests* will be involved in a project analysing the European market for forest bioenergy using the EFI global trade model (EFI-GTM). In addition a book project on bioenergy in Europe is planned. Moreover, EFINORD will be the platform for the planned activity within PC3 to discuss effects of the new climate scenarios (the Representative Concentration Pathways), implications and possible adaptation measures for forestry in the Baltic region (see section 6.3.3.).

5.4.2. The International Institute for Applied Systems Analysis (IIASA)

IIASA conducts policy-oriented research into problems that are too large or too complex to be solved by a single country. The institute provides practical and politically independent insights into today's most pressing global issues relating to the environment, society and technology. It has also been a leading contributor for 30 years to the development and refinement of assessment and decision-support methodologies, global databases, and analytical tools. Energy and climate change is one of IIASA's three core problem areas, which is of focal interest to *Future Forests*. Research at IIASA is designed to recognize the transformational nature of the globalized world. Work is being conducted in the context of what is driving the global transformation, how the methods of systems analysis can be improved to find the most effective solutions, and how policymakers at national and international levels can best implement those solutions. Systems analysis is based on quantitative models, databases, and analytical tools that allow researchers to look at complex problems in a holistic and integrated way. The goal of systems analysis is to highlight the impacts and trade-offs of different policy choices while preserving the complexity of the analysis. This approach is designed to meet the institute's mission of "developing solutions to global problems for the benefit of humankind".

Future Forests has initiated collaboration with IIASA's Ecosystems Services and Management Program to perform a pilot study during 2012 to test their models by evaluating the effects of Swedish strategies for forest use in the European forest sector. The collaboration will be developed during *Future Forests* phase 2 (see 6.1.2.).

5.5. International commitments and ambitions

During the first program period *Future Forests* committed to a number of international activities. Below follow a short summary of the most important ones. The fact that the program has been invited to the listed activities indicates our strong brand amongst international forest actors and organizations. During the second program period we will of course continue to be active in similar contexts. Some are already planned (listed at the end of this section), but many will appear "along the way" and we will maintain a continuous readiness to participate in activities as they appear.

Summaries of the most important international commitments during the first program period:

- Participation in an analysis of the future of boreal forests: co-authoring an IUFRO policy brief http://www.iufro.org/publications/view/article/2012/03/14/new-policy-brief-making-boreal-forests-work-for-/);
- Participation in an analysis of the European forest sector: co-authoring the UNECE European Forest Sector Outlook Study (http://www.unece.org/efsos2.html).
- Participation in an analysis of the future of European forests: COST-action; Foresight on Future Demand for Forest-based Products and Services. This was a network building activity where scenario techniques and existing forest scenarios, including *Future Forest,* where presented and discussed.
- Organization of side-event at the XXIII IUFRO (International Union of Forest Research Organizations) World Congress in Seoul August 2010: a number of *Future Forests'* researchers presented the scope of the program. Additionally, the program research was exposed in an exhibition boot and the present researchers gave presentations in various congress sessions.
- Participation in the 14th international conference of the International Boreal Forest Research Association (IBFRA): a number of *Future Forests'* researchers presented the scope of the program as well as original research originating from the program.
- Organization of exhibition and side-events at the UN conference on sustainable development Rio+20 in Rio de Janeiro June 2012: on commission of the Swedish government SLU and *Future Forests* were present on this UN conference with an exhibition in the Swedish pavilion presenting the Swedish Forestry Model. Additionally *Future Forests* organized three side-events, one for country delegates involved in the UN negotiations and two for conference visitors.
- Organization of side-events at the COP-meetings (under the UNFCCC and Kyoto processes) in Cancun 2010 and Durban 2011: *Future Forests* researcher participated, organized panels, and presented work being done in the context of the *Future Forests* project on LULUCF (Land

Use, Land Use Change and Forestry) carbon accounting. A similar side-event is planned for the upcoming COP18 meetings in Doha, Qatar later this year.

- Representation at the COFO meeting in Rome September 2012: The Committee on Forestry (COFO) is the highest FAO Forestry statutory body. COFO has biennial sessions and bring together heads of forest services and other senior government officials. The theme for this year's meeting was "Wood and the Green Economy: Forests Grow Solutions to Global Challenges". The objective was to feed into international platforms and initiatives for forests, forestry and forest products to be recognized as central to a green economy. *Future Forests* was represented at the boreal country's side-event and the aim was to communicate how sustainable forest management in the boreal zone and the resulting social, economic and environmental benefits can help address global issues of the 21st century.
- Organization of a conference symposium at EcoSummit 2012, Columbus Ohio October 2012: *Future Forests* used the conference as an opportunity to initiate collaboration with an international group of researchers on the role of the global boreal zone in mitigation of climate change. Researchers represented ecology, silviculture, and political science and came from Sweden, Finland, Australia, Canada, and the US. A pre-conference workshop was held outside of Umeå in June, and a dedicated session at the conference was held. Results from the workshop and the symposium are currently being reworked into several scientific papers.

Planned international activities in the second program period:

- Contribution to the book "*Forest bioenergy for Europe – What science can tell us"* The aim of this EFI initiative is to provide the research community with an opportunity to analyse the most important value chains related to forest bioenergy on the basis of scientific knowledge and information. The relevance of various chains will be assessed for offering to various stakeholders and decision makers an updated view to the strengths, weaknesses, opportunities and threats of the forest based bioenergy sector. A representative of Future Forests will be part of the drafting committee and Future Forests' researchers will be on the author list.
- Participation in the IBFRA conference in Edmonton, Canada, October 2013. Proposed title: "Boreal at risk: from boreal science to policy". Main focus will be on policy dimensions and we will present scientific findings within the field and share our experiences of developing the science- to- policy interface.
- Participation in the Resilience 2014 conference in Montpellier, France, May 2014. We will present and discuss our theoretical developments of resilience in production systems.
- Participation in the IUFRO World Congress in Salt Lake City, USA, October 2014. Congress title: "Sustaining forests, sustaining people – the role of research". The congress program will highlight how forest science is helping address significant environmental, social and economic challenges facing our world. Future Forests will apply to organize at least one side-event.

6. Research plan

6.1. Program-level research

6.1.1. Scenario analyses – back casting and desirable forest futures

Objective
The objective of this project is to use policy scenarios and back casting techniques to describe and understand how different stakeholder groups view their desired future of Swedish forests. The scenarios will also be used as input in the modelling activities planned in project 6.1.2.

Rationale
Actors differ in their attitudes and values concerning the future of forests. Democratic decision-making processes include actor´s values and attitudes through deliberation and systematic weighing of different options through interactions between the actors. This makes it important to understand how different actors view the future of Swedish forests. This is where the desired futures enter. We will not attempt to reach a consensus on the future, but rather use scenario techniques as a way of describing and comparing different visions of desirable futures.

We will use back casting techniques to address the issue of desired futures. Back casting can be defined as a method to generate a desirable future, followed by the development of agendas, strategies, and pathways that would be required to actually reach that future. This back casting step ensures that the desired futures will stay within the bounds of the possible, with alternative endpoints linked to distinct yet realistic combinations of agendas and strategies. A typical time horizon in back casting studies is 50 years. This means that it may be both realistic (encompassing the time frame of our grandchildren, and a significant fraction of a forest rotation period) and distant enough to allow for major changes in life styles, cultural norms, and values. An important difference between back casting and various other foresight techniques is that back casting does not rely on the extrapolation of trends, which is often, consciously or unconsciously, a part of any future study that takes today's situation as its starting point. Today's trends may also be responsible for problems that are not seen as sustainable or desirable, thus back casting may decouple futures from current trends if alternative pathways can be defined. Dreborg (1996) characterizes back casting as a favoured method of studying the future when:

- the problem to be studied is complex, affecting many sectors and levels of society;
- there is a need for major change, e.g., when marginal changes within the prevailing paradigm will not be sufficient;
- dominant trends are part of the problem;
- the problem to a great extent is a matter of externalities, which the market or sector cannot treat satisfactorily;
- the time horizon is long enough to allow considerable scope for deliberate choice.

Approach
A state-of-the-art approach for back casting studies is to involve various interest groups directly in the process of defining and evaluating the desirability of the scenarios that are developed. This approach to back casting has some important implications. It does not require the elements of a desired future to be known in advance. Instead, participants go through a process of learning and discovery, in which the desired future is a product of the process of trying to reach it. While any participant in the process may have specific goals in mind, the desirability of a given set of future conditions is not fully determined in advance but emerges as a result of a form of negotiation with the consequences of different choices. Participants may come to change their minds about what is desirable, based on seeing the outcomes of those choices. This qualitative method is based on

moderated group interviews. One of the strengths of this focus group methodology is that it enables researchers to learn from group participants, while they are communicating with each other. Distinct features of focus groups are that participants usually meet on one occasion, discussions are actively moderated by the researcher or interviewer, and that the individuals are asked to focus on a specific issue or question. Thus concepts, attitudes, and values related to a specific subject can be explored. Focus groups have gained acceptance in environmental studies since they are a means to ascertain the opinions and values held by stakeholders and other actors.

Typically, there are 6-8 participants in a focus group. We will gather four relatively homogeneous groups in different workshops with the aim of achieving far-reaching discussions without needing to spend too much time on participants first understanding each other's frames of reference. The groups will represent different interests in Swedish forest futures. We envision groups representing (i) conservation interests, (ii) large forest companies, (iii) non industrial forest owners, and (iv) the general public and recreation interests. Back casting takes its starting point from a future situation. In order to find flexible strategies to illuminate the way forward, it is important not to try to view the future situation in detail, but rather to find guiding principles, which can act as a frame for many possible futures. Even if the future cannot be foreseen, its desired qualities can be elaborated on.

We will document the discussion in each focus group, and describe the future scenarios and the steps required to reach those futures. We will then ask focus group members to validate our descriptions. The descriptions, rules, and future scenarios described in the workshops will be quantitatively modelled in Heureka. The scenarios will also, where appropriate, be linked with the IIASA modelling cluster to estimate European and global effects on different ecosystem services (see project 6.1.2.). In a later open workshop, we will use these different qualitative and quantitative scenarios as a basis for cross-group discussions on similarities and differences between the future scenarios as a way of identifying key trade-offs and choices that society will have to take.

Deliverables
Reports on analyses of desired futures by different stakeholder categories. A basis for model simulations of desired futures.

Personnel:
Jon Moen (project leader) is a Professor at Umeå University. He has been responsible for the scenario analyses in *Future Forests* in phase 1.

Karin Beland Lindahl is a postdoctoral research fellow at SLU. Her research is based in political science and focuses on politics of natural resource management, particularly forest conflicts.

Eva-Maria Nordström is a postdoctoral research fellow with IIASA. Her research is in forest planning and scenario modelling.

6.1.2. Economic consequences of alternative forest land-use strategies in Sweden – an analysis on national, European and global levels

Objective
This ForSA project is collaboration between *Future Forests* and scientists at the International Institute for Applied Systems Analysis (IIASA). We will apply the IIASA modelling cluster in order to analyse consequences of alternative Swedish forest use strategies on the Swedish forest sector's future position in Europe and globally. The modelling approach integrates detailed economic and biophysical components enabling an economic analysis of Swedish forestry competitiveness under different forest use strategies.

Rationale
In this ForSA project we will use economic modelling techniques to explore consequences of alternative Swedish forest use strategies. The alternative forest use strategies will be depicted from

the scenario analyses in 6.1.1. Economic modelling is an indispensable component of the outlined analysis, ensuring that model output is feasible, desirable and achievable given prevailing economic contexts and incentives. Economic modelling also enables qualified judgements of the effects of policy on chosen strategies. Furthermore, the IIASA model cluster enables analysis of economic as well as biophysical trade-offs not only on the national level, but also on the global level. Thus, it is possible to consider important systems effects arising due to Swedish forest use strategies from e.g. international trade such as indirect Land Use Change (iLUC), where land use changes are triggered in other sectors or other countries in response to strategies, policy goals and choices in Sweden. This ensures that the analysis will include sustainability of chosen strategies beyond local impacts.

Approach
The IIASA integrated modelling cluster contains two models of particular interest for this project: G4M (Global Forest Model) (Kindermann, 2008) and GLOBIOM (Havlík et al., 2011). The models are used in an integrated framework: G4M provides the economic partial-equilibrium model GLOBIOM with information on forestry (for example on mean annual increment, on maximum share biomass usable as saw logs in the mean annual increment, and on regeneration and harvesting costs). G4M also supplies GLOBIOM with consistent accounts of carbon stocks in forests, which are then used to assess greenhouse gas emissions related to forestry activities. In forward-looking scenarios, G4M can use in return GLOBIOM projections on wood and land prices, as well as wood demand quantities, to estimate future forest dynamics on high spatial resolution. Additionally, GLOBIOM is sometimes linked to the Joint Research Centre of the European Commission (JRC) global energy model POLES through information on macroeconomic indicators and bioenergy demand. Bioenergy demand is split in first generation biofuels, second-generation biofuels, bioenergy plants and direct biomass use for energy. Population and GDP projections from the POLES model are also used as exogenous drivers for the G4M baseline. However, alternative population, GDP and bioenergy projections from other sources are also often used.

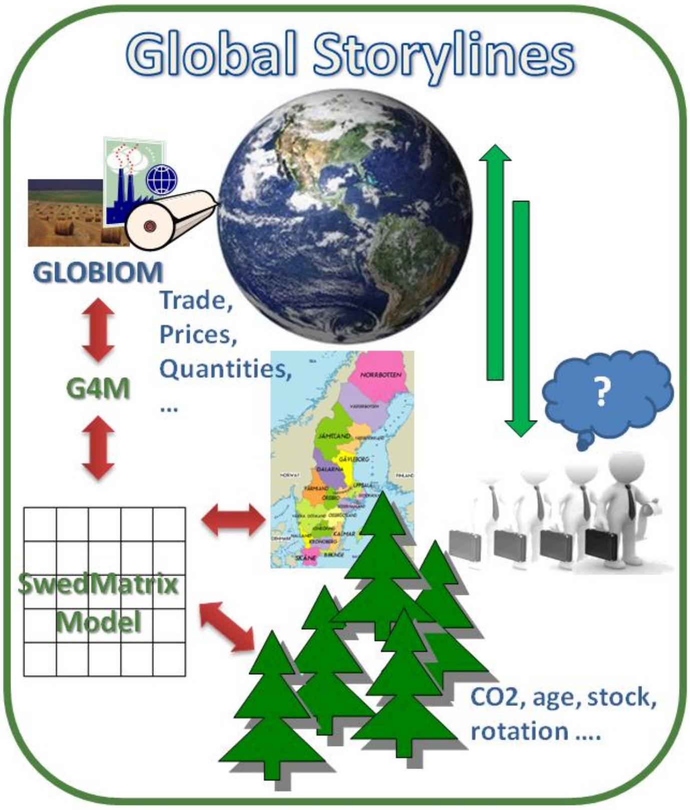

Figure 6.2. *Conceptual illustration of the Future Forests – IIASA modelling approach linking biophysical information into economic assessment. The SwedMatrix Model represents a model, e.g., Heureka, that will provide the IIASA modelling cluster (G4M and GLOBIOM) with reliable and detailed information in terms of forest data.*

The starting point in Fig. 6.2. are the trees, representing the Swedish forest. The state and development of the forest will be modelled using the Heureka system, represented by the SwedMatrix Model in the figure, The Heureka system is a forest decision support system for analysis and planning of the forest landscape which provides a range of models and tools for forest planning on different levels – stand, landscape up to national level. It supports the planning process by predictive modelling and optimization and is also linked to the National Forest Inventory, meaning that detailed and reliable analyses of Swedish forestry can be made. The Heureka model will consequently help calibrating the IIASA forest modelling cluster for Swedish conditions in a next step.

After the calibration of Heureka and the IIASA models, Heureka and G4M will provide GLOBIOM with the relevant forest data and GLOBIOM can subsequently produce forest sector scenarios at various scales from the economic perspective. GLOBIOM output covers a number of relevant variables including trade, prices, environmental change, (indirect) land use change, where land use changes are triggered in other sectors or other countries in response to e.g. bioenergy policies in Sweden, etc. which can be used either - after downscaling - to adjust for country level or even regional level resolution for Sweden.

The modelling approach as displayed in Fig. 6.2. provides for utmost flexibility with respect to the potential research questions and level of spatial resolution (local, regional, European, global) for the analysis. Modelling output covers a number of interesting variables including for example trade, prices, environmental change, and (indirect) land-use change (where land use changes are triggered in other sectors or other countries in response to forest use strategies in Sweden). Efforts to operationalize results for supporting decision-making in Sweden will be accompanied by illustrations of how to find robust strategies when facing uncertainty about future developments. Hence our analyses will not offer the optimal strategy for each scenario, but will delineate the scope of potential outcomes.

Summarizing this approach, it can be stated that in order to generate a globally consistent Swedish scenario analysis at the national level, the following steps need to be accommodated:

1. Model linkage establishment (between the IIASA models and Heureka) and validation with Swedish data.
2. Scenario translation into forest use strategies encompassing "hard data" as input to the economic modelling analysis.
3. Economic analysis of the forest use strategies using GLOBIOM.
4. Output analysis (assessment stage): can for example include effects of the Swedish strategies on global markets (trade) and global environmental issues (iLUC, GHG emissions), i.e. economic assessment of the Swedish forest sector.
5. Potential creation of an economic model specialized on the forest sector and land use, e.g. GLOBIOM-Sweden.

Deliverables
Scientific report on outcomes of the economic analysis: competitiveness assessment of the forestry sector in Sweden under different policy scenarios in European and global contexts (i.e. including implications for trade and environmental impacts such as indirect Land Use Change).

Personnel:
Johan Bergh (project leader) is associate professor at SLU and specialized in climate change and forestry.

Florian Kraxner is a research scholar at IIASA and will be the IIASA contact point for the project. His research is in sustainable forestry and bioenergy assessments.

Sabine Fuss is a research scholar at IIASA. Her research is in economics, integrated modelling and policy assessment.

Petr Havlik is a research scholar at IIASA. His research is in economic land use modelling using GLOBIOM.

Georg Kindermann is a research scholar at IIASA. His research is in forestry modelling using G4M.

Eva-Maria Nordström is a postdoctoral research fellow with IIASA. Her research is in forest planning and scenario modelling.

Michael Obersteiner is a research scholar at IIASA. His research is in economics, integrated modelling, and policy assessment.

6.1.3. Strategies promoting biodiversity in managed forest landscapes

Objective
This project will simulate and analyse long-term effects of different landscape-level strategies for biodiversity conservation.

Rationale
Today there are two main types of forest land use in boreal and hemi boreal Sweden: the largest part is subjected to even-aged management including biodiversity consideration measures as

prescribed by the current Swedish Forestry Act from 1993, while some areas are set aside for conservation or other reasons. Alternative landscape models have been proposed which involve higher degrees of differentiation in land-use intensity (Seymour & Hunter 1999, Côté et al. 2010), e.g. by also establishing zones dedicated to more intensive even-aged silviculture within a broader mosaic of other stands dedicated to less production-oriented silvicultural programs, which could be based on even-aged or uneven-aged approaches.

The effects of the current Forestry Act on biodiversity are not yet fully apparent. Firstly, the ecological delivery times for many of the measures stipulated in the Forestry Act from 1993 are much longer than the than the 20 years that have elapsed since the Act's implementation. Secondly, at this point only c. ~20% of the productive forestland has been regenerated according to the principles that were laid in 1993. Hence, simulations are necessary to assess the long-term potential of current and alternative landscape strategies from a biodiversity conservation perspective.

Approach
We will use simulations to explore the long-term effects of various scenarios at the landscape level on (1) the amounts and spatial distribution of forest attributes of special importance to biodiversity and (2) prospects for conserving viable populations of naturally occurring species as prescribed by Swedish environmental policy.

The first step will consist in designing a range of landscape scenarios involving different silvicultural systems (based on definitions from project 6.1.4.), different forestry intensification measures relating to the MINT-report (Larsson et al. 2009) (e.g. biofuel harvest, shorter rotations, non-native tree species), and small- and large-scale conservation actions corresponding to a range of ambition levels, from minimum levels to e.g. the Nagoya target. Knowledge about desirable futures obtained in project 6.1.1. will provide important input for the construction of those scenarios. The second step will consist in simulating the future development of the forest landscapes under the different scenarios. Here we will use and further develop the Heureka software, building on the work initiated as part of a thematic working group on future biodiversity initiated in *Future Forests* phase I and on the results from the "Smart Tree Retention" ("Smart Hänsyn") project. Third, we will analyse the effects of different landscape models on biodiversity, using metapopulation viability analyses in combination with knowledge about how the availability of forest structures influences the composition of species assemblages. We will collaborate with a large-scale project recently initiated in Finland (led by Prof. Mikko Mönkkönen and collaborators) studying the efficiency of different conservation measures in maintaining biodiversity in managed landscapes. This collaboration will both strengthen the work through exchange of experiences and also broaden the scope of applicability of the results.

A key aspect of this project is to understand the effects of emerging silvicultural systems and practices from a holistic landscape perspective. To this end, this project will be performed in collaboration with the parts of PC1 ("Future silviculture") addressing the conservation implications of emerging silvicultural practices, e.g. modified rotation lengths, intensive fertilization, and uneven-aged management. Data from empirical biodiversity-related projects performed – among others – as part of *Future Forests* phase 1 will also be used, together with data on the effects of historic land use on today's biodiversity from PC1 (RT5).

This project will also link directly to PC4 RT4, which will address the cost-efficiency of different biodiversity conservation strategies at the landscape scale. This collaboration will result in a dual approach combining conservation ecology and economics, constituting an important step in the development of a decision support tool for ecosystem based management. Moreover, landscape scenarios simulated in this project will be used as a basis for analysing stakeholders' perceptions of different management alternatives as well as their governance in PC4 (RT5).

The above described modelling will focus on predicting effects on land, capitalizing on the large body of past research addressing effects of forest management on terrestrial biodiversity. In comparison, far less effort has been put into addressing the effects of forest management on the biodiversity of streams and rivers in the Swedish landscape. To fill this knowledge gap, we will compile existing data on stream invertebrate community composition from forested lands, and evaluate the extent to which aquatic biodiversity shifts in response to landscape-scale forest management. This work will involve interaction with scientists in the WATERS program that are seeking to develop improved biological assessment criteria for freshwater and marine habitats in Sweden, including woodland streams.

Deliverables
In addition to scientific articles addressing specific ecological questions related to forest landscape management, this project will produce a comparative summary of the effects of different landscape strategies on the long-term maintenance of biodiversity in a Swedish context.

Personnel:
Annika Nordin (project leader) is a professor at SLU. Her research is on nitrogen fertilization effects on forest biodiversity.

Adam Felton is a researcher at SLU. His research is on forest biodiversity conservation.

Tomas Lämås is a researcher at SLU. His research is in forest planning and modelling.

Thomas Ranius, is professor at SLU. His research deals with the effects of conservation efforts and future environmental changes on biodiversity.

Jean-Michel Roberge, is a postdoctoral research fellow SLU. His research focuses on conservation and restoration ecology, landscape ecology and forest biodiversity.

Ryan Sponseller is an associate professor at SLU. His research focuses mainly on aquatic biodiversity and nutrient retention in streams.

6.1.4. Ecosystem-based forest management: analysing silvicultural systems in a landscape perspective and implementing a concept for adaptive forest management

Objective
This ForSA project will have an integrative role in the program, developing a broad interdisciplinary approach to analyse alternative silvicultural systems that can be applied in the context of ecosystem-based forest management. We will also develop theory and applications of adaptive forest management in relation to the silvicultural systems.

Rationale
Silviculture is the art and science of controlling the establishment, growth, composition, and quality of forest vegetation for the full range of forest resource use. Within a silvicultural system, a planned program of treatments during the whole life of a stand can be applied in order to achieve specific stand structural objectives. This program of treatments integrates specific harvesting, regeneration, and stand-tending methods to achieve a predictable stand yield.

In principle, there are only two silvicultural systems for yield regulation: even-aged and uneven-aged management. These two systems are fundamentally different and have specific limitations and requirements if sustained yields are to be attained. Whereas even-aged management focuses on forest stands with uniformly aged trees as the management unit, uneven-aged management is based on individual trees embedded within heterogeneously aged forests. For the even-aged system, the landscape should be organized into multiple stands, each with an even age-class distribution. Ideally, for a landscape unit to sustain an even annual yield, it should contain at least the same number of stands as the length of the rotation period. Thus, for a stand size of one hectare and a rotation length of 100 years, a landscape of 100 hectares will be needed to obtain uniform yield. The uneven-aged system relies on selection cutting to maintain a certain diameter distribution throughout each area under management. For that reason, the size of the landscape to be managed is determined by other criteria than the minimum area needed to obtain uniform yield.

In the late 1800s, and well into the 1900s, there was a lively debate in the forest sector concerning which of the two silvicultural systems was best suited to the Swedish forest management goal of delivering a high, consistent and valuable timber yield and a secure wood supply. Uneven-aged management was initially seen as advantageous as mainly large trees were cut. Large trees were in demand by the sawmill industry, and there was very little industrial demand for small trees as the pulp and paper industries were yet to expand. Even-aged management, on the other hand, was promoted as being more efficient than uneven-aged management. Because of a focus on economics and timber production, even-aged management came to become increasingly advocated as it in many ways offered a more rational management and harvesting of the forest. Since the early 1950s, even-aged management, generally referred to as clear-cut forestry, has totally dominated Swedish forestry, and innovations have mainly occurred along established technological trajectories and modes of thinking within this system. It is only recently that more serious attempts to discuss uneven-aged management have been put forward. As a result of the limited interest, research on uneven-aged management has been relatively limited in Sweden whereas it has long been an important component of forest management research elsewhere in continental Europe. The limited knowledge that exists from Swedish forestry research, and which is directly applicable, is about selective logging in all-sized uneven-aged forest stands (“blädningsskogsbruk”).

The silvicultural system *per se* does not necessarily take into account future generations’ resource needs because it only refers to a particular stand, or smaller parts of the landscape. For that reason, the Swedish Forestry Model has been developed to ensure that rates of cutting and stand replacement are managed for sustainable yield and other defined values over a longer time period.

Approach

In this project, silvicultural systems based on even-aged and uneven-aged management will be defined in the context of the Swedish Forestry Model. The starting point for the project will be to define and describe the two silvicultural systems in an interdisciplinary setting involving researcher from the four PCs and stakeholders. The project will direct relevant activities within the four PCs to facilitate common syntheses and analyses comparing the two silvicultural systems. Meaningful comparison of these two silvicultural systems requires explicit consideration of spatial and temporal scales. Therefore, a major objective of the project is to compare various aspects of the systems when they meet the conditions for uniform and sustainable yield. We will examine whether or not one of the systems is better suited to deliver a particular ecosystem service. However, to successfully execute relevant comparisons between the two systems, so often asked for by decision makers, individuals and NGOs, we need to assume a situation where the two systems are defined based on a common currency, in this project biomass production. The goal of the project is to contrast these silvicultural systems and to determine whether one or the other promises to be the best choice, given particular management goals. Interactions with stakeholders in a carefully structured “dialogue process”, similar to that in phase 1 in the Thematic Working Group on introductions of exotic tree species, will be an important step in analysing the results. This part of the project will be based on both existing and new knowledge produced in project 6.1.3. and in the four PCs.

Additionally we will adopt a societal perspective on the analysis of the two silvicultural systems. As analytic starting points, we will use ideas, actors, and practices connected to the two silvicultural systems. However, the ambition is not only to investigate these two silvicultural systems, but also to think “beyond” these systems in order to consider alternatives, which can meet future challenges for the forests and forestry. This is inspired by the economist Roger Martin’s “integrative thinking” (Martin 2007) which means “the ability to face constructively the tension of opposing ideas and, instead of choosing one at the expense of the other, generate a creative resolution of the tension in the form of a new idea that contains elements of the opposing ideas but is superior to both." According to Martin, integrative thinking is a way to broaden perspectives and expand the boundaries of what is possible to do. Martin's research is written in the management genre, but should be transferable to other areas where difficult decisions and trade-offs must be made. When choosing a silvicultural system or a combination of them, different social interests and values and ecosystem services delivered by forests must be considered. The work will mainly be done by literature studies, where everything from textbooks on forest management, scientific articles, media debate and governmental investigations over the last 20-30 years will be examined. Furthermore, interviews with key individuals will be made to deepen our understanding. Salient ideas and arguments, and proponents, institutions and networks connected to the two systems will be identified and charted during this analysis.

Conceptual development and implementation of adaptive forest management will be a third major task of this project. We anticipate that already the early analyses will show many knowledge gaps in both silvicultural systems. Some of these will involve effects of different silvicultural options on tree growth, biodiversity, and other ecosystem services. This could, for instance, include effects of thinning, fertilization, harvest techniques, considerations of the protection of biodiversity, etc. We will continue to develop principal approaches to reducing some of these ecological uncertainties, using adaptive forest management as a tool and based on the research we have done in phase 1 (see also section 2.3.3.). We will also develop implementation plans for actual cases in collaboration with forest companies and the National Forest Agency. A four-year program period is too short to allow for full-scale implementations of adaptive management processes. However, we are confident that we can develop guidelines for when, where, and how adaptive forest management can be applied, and also collaborate with stakeholders on initiating these processes.

Deliverables

The project will in collaboration with stakeholders define the baseline structure of the two silvicultural systems, i.e., the spatial and temporal configuration of even-aged and uneven-aged systems under otherwise identical ecological conditions, economy, and ownership. The project will thereafter report a comparison of ecosystem services provision of i.e. biomass production, economic revenue, biodiversity conservation, climate benefits and clean water from the two silvicultural systems. Additionally the project will report an analysis of societal aspects on silvicultural systems shifts, i.e. the history of ideas related to the transition from uneven-aged to even-aged forest management in Sweden in the 1930 – 1950s in Sweden. In parallel, the project will produce guidelines for implementing a model for adaptive forest management to reduce ecological uncertainties related to large-scale application of silvicultural systems and programs.

Personnel:

Tomas Lundmark (project leader) is a professor at SLU. His research is in forest management.

Petter Axelsson is a post-doctoral research fellow at SLU. His research is in ecophysiological aspects on re-generation in uneven-aged management of forests.

Anders Lundström is a researcher at SLU. His research is in forest planning and modelling.

Lars Lundqvist is a researcher at SLU. His research is on silvicultural practices in uneven-aged forests.

Tomas Lämås is a researcher at SLU. His research is in forest planning and modelling.

Erland Mårald is a professor at Umeå University. His research is in the history of ideas of land-use.

Lucy Rist is a post-doctoral research fellow at SLU. Her research is in ecological and social aspects of sustainable forest management.

6.2. Thematic working groups

When we began phase 1, we realized that we were not able to plan for all questions that would emerge during the program period. Thus, we assigned some resources to *ad hoc* Thematic Working Groups (TWG) with the ultimate purpose of maintaining flexibility in the program This meant that researchers within *Future Forests* can collaborate with other experts from outside the program to analyse and synthesize complex research questions. These research questions have been initiated by the program management, and by researchers both within and outside of the program. Usually these TWGs have engaged 5–15 persons, and most of the work has been done in workshop form. We have started 10 TWGs since the start of the program.

The establishment of TWGs led to successful integration within the program, and also allowed for addressing research questions that required skills and competences that were not covered by the staff appointed to the program. We intend to allow for this type of TWG in phase 2. Approximately two to five new TWGs will be supported annually after approval by the SMG. If a proposal is approved, the project will be given a total budget, where support will mainly include reimbursement for actual travel and lodging costs. Proposals may involve activities with partial support from matching funds or from one or more outside institutions or agencies. Each approved TWG will have its own research plan, including a detailed budget, time plan, and deliverables before commencing work. Prof. Jon Moen will have a special responsibility for the identification of urgent questions, knowledge gaps, and appropriate issues to analyse in TWGs.

6.3. Program Components

Each of the PCs hosts both disciplinary and interdisciplinary research related to the overarching theme of ecosystem-based management as interpreted in the Swedish Forestry Model (Fig. 6.3). Whereas the ForSA projects prioritize synthesis, program components also include original research. Moreover, the ForSA projects will act as coordinating hubs, and thus assist in prioritizing and structuring the work within the PCs.

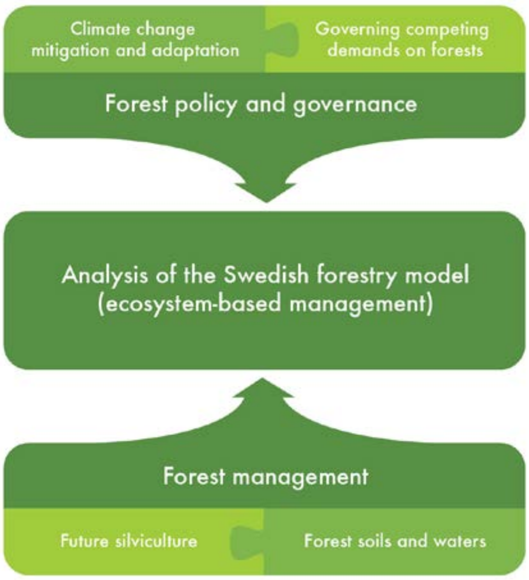

Figure 6.3. *A schematic illustration of how the four program components feeds into the overarching objective of analysing the Swedish Forestry Model.*

6.3.1. Future silviculture (PC1)

Objectives
PC1 will ensure state-of-the-art development of silviculture for the needs of forest owners and society. Results from empirical research on stand-level silvicultural practices will be assessed in relation to principles for sustainable forest management considering economic, social and ecological aspects. To achieve this we will combine empirical research and systematic reviews with advanced modelling

Rationale
Silviculture is about controlling the establishment, growth, composition, health, and quality of forests. The Swedish Forestry Model with multi-use forest landscapes, that considers the interests of many different actors and stakeholders, require new science-based silvicultural tools for forest managers to meet increasing, new and often conflicting demands imposed on forests by society. In addition, climate change poses a challenge to many traditional silvicultural practices, and calls for advanced approaches to the identification and development of silvicultural practices capable of dealing with climatically induced uncertainty and risk.

Introduction
In the first phase of *Future Forests,* it was acknowledged that society's claims and expectations for forests are increasing. This is manifested in the growing international framework of conventions and EU directives that are regulating forest use. For example, it is clear that the EU-directive promoting the use of renewable energy to mitigate climate change will result in an increasing demand for forest biomass to be used for energy production. At the same time, the Aichi Biodiversity Targets (agreed upon in October 2010) under the Convention on Biological Diversity will result in an update of the National Biodiversity Strategy and Action Plan. This has raised expectations from environmental NGOs that there will be an increase in the area of forestland set aside for conservation purposes. In addition, the EU Water Framework Directive (WFD) has raised concerns regarding the impact of silvicultural practices on water quality. A major challenge for future silviculture is thus to balance these conflicting demands on forests, i.e., to assess the potential for increasing forest growth while at the same time ensuring that the biodiversity of forestlands is substantially improved and high standards of water quality are preserved.

In this PC we will continue the research we started during *Future Forests* phase 1 on the development of stand-level silvicultural practices under even-aged management to increase both tree growth and the proportion of tree biomass that can be harvested. In addition to this, we will analyse alternatives to even-aged monocultures that can be used to create stand structures beneficial to biodiversity conservation and recreation. Alternatives that will be analysed are altered rotation lengths, uneven aged management and management of mixed forests.

Research questions and topics to be explored
The research in PC1 will be divided into five research topics (RTs). In summary, the research within the RTs will be aimed to answer the following questions:

- RT1. How will silvicultural practices for increased forest productivity and intensified harvesting affect different ecosystem services in even-aged managed stands?

- RT2. What are the consequences of varying rotation length on stand structure, productivity, biodiversity and economy in even-aged managed stands?

- RT3. What is required to maintain sustainable returns of forest products and other ecosystem services in uneven-aged managed stands?

- RT4. Is there a need to adapt forest management in stands where conifers are mixed with deciduous trees?

- RT5. Can the use of forest history data be used to evaluate effects on biodiversity of previous (historic) forest management?

RT1. Stand level silvicultural practices for increased forest yield in even-aged management
Background: Numerous field experiments have shown that the choice of silvicultural method can significantly affect forest yield and profitability in even-aged management. Classical Swedish silvicultural practices intended to increase forest yield include increased intensity in regenerations, choice of tree species, genetic improvement of regeneration material and forest fertilization. Greater intensity of tree species selection and regeneration efforts is suggested to be the most effective ways to increase production of forest stands. The choice of tree species often has a major effect on future yield (Nilsson et al. 2011). In northern Sweden, lodge pole pine out-competes Scots pine by more than 40 % in volume growth under similar site conditions. It has been shown that this result may be halved in the interior of northern Sweden if Norway spruce is planted instead of Scots pine. Forest fertilization is the most cost-effective silvicultural practice and can be applied in already existing forest stands. More knowledge and development is needed of the described practices concerning 1) yield return and 2) effects on forest biodiversity.

Approach: Existing long-term field experiments offer unique possibilities to collect empirical data to expand our knowledge concerning yield return of the described stand-level silvicultural practices. In particular we will investigate the long term effects on stand structure of increased intensity in stand establishment efforts, different tree species (lodge pole pine, Scots pine, Norway spruce and Douglas fir), varying harvest intensity and the effects of various forest fertilization regimes. The stand-level economics from the silvicultural practices described above will be analysed and described using the Heureka system and effects of fertilization on biodiversity will be described in a systematic review to synthesize the global knowledge base regarding this treatment. In collaboration with the other PCs and ForSA activities, consequences of these varied practices for other ecosystem services including biological diversity, recreational values, water quality, and carbon sequestration will be analysed.

RT2. Consequences of varying rotation length in even-aged forest management
Background: When simulating forest production in even-aged stands, the length of the rotation period is often decided so that the mean volume of annual increment is maximized. However, in practical forestry the rotation length is often set by other factors. Several economic parameters and the risk of damage associated with prolonged rotation length are important. In phase 1, we demonstrated that the risk of damage by storms, root-rot and bark beetles may be substantially reduced by shortening the rotation length to a minimum and drastically reducing the number of thinnings (Bergh et al 2012). It was also shown that the economic return for forest owners are unaffected or even improved with this silvicultural program; whereas provision of raw material to the forest industry decreased only marginally. An alternative strategy - increasing rotation length - has been proposed as a means of increasing the sequestration of carbon in standing biomass, and to create a stand structure more beneficial to biodiversity and recreation. At present, however, there is a lack of growth and yield models that can handle prolonged rotation lengths.

Approach: We will investigate the effects of different silvicultural treatments (e.g., selection of tree species, pre-commercial thinning, fertilization, and thinning) and altered rotation lengths on biomass production, economy, stand structure, biodiversity and risk for damages. The analysis will be based on existing data from fertilization and thinning experiments, and on simulation studies conducted with the Heureka planning system. The analysis will focus on stand level dynamics and effects on biodiversity, which will be assessed by modelling structures of high importance for biodiversity. However, in order to conduct the above-mentioned analysis, new functions for mortality in managed forests with long rotation lengths need to be developed. The results will be useful for the analyses of strategies promoting biodiversity and of alternative silvicultural systems (6.1.3. and 6.1.4).

RT3. Uneven-aged management – stand level yield, structure and economy

Background: In order to make reliable simulations of the sustainability of uneven-aged management, better models of ingrowth of the regeneration and models describing individual tree growth in heterogeneous stands need to be constructed.

Approach: Field data from existing experiments and relevant literature data will be used for parameterization of these models. Production of uneven-aged management will be analysed based on data from existing experiments and by retrospective studies in existing heterogeneous stands. To get a picture of the possible extent of implementation of uneven-aged management, short-term data from the National Forest Inventory will be used to estimate the existing area of forests with a heterogeneous structure, where the preconditions for uneven-aged management can be met. Data and models from the above projects will be incorporated into the Heureka planning system to make it possible to estimate forest growth and carbon stock in vegetation and soil at the stand-level for this silvicultural system. In addition to the production oriented research, we will conduct a global systematic review of the scientific and grey literature to synthesize current understanding regarding the potential biodiversity costs and benefits of even versus uneven-aged forest management, of direct relevance in the Swedish context. This will be an important contribution to the landscape-level analysis of different silvicultural systems in project 6.1.4.

RT4. Management of broadleaves in mixed species stands.

Background: Approximately 20 % of Sweden's forests are composed of broadleaves, with this number varying somewhat between regions (Riksskogstaxeringen 2011). Notably, the vast majority of the broadleaved proportion occurs in mixtures with other tree species. The prevailing silvicultural system of even-aged management used in Sweden has mostly been developed for relatively homogeneous stands that are dominated by Norway spruce or Scots pine. Very often, these silvicultural prescriptions are likewise referred to when discussing the management of mixed stands with a broadleaved component. To respond to the aim of maintaining or increasing the broadleaved proportion in the forest landscape, we here intend to improve management of the existing broadleaves.

Approach: We will challenge the idea that mixed species stands can be managed in similar ways to monocultures. We will use existing field experiments as the source for starting values in modelling studies and continue such experiments to further investigate the targeted management of a wider range of valuable trees in production forests. Analysis of existing experiments on establishment and the pre-commercial thinning of mixed young forest stands will be made and new experiments targeting knowledge gaps will be established. With this data, new models for the development of young trees will be constructed. Field studies of different tree species compositions, percentage mixtures, and placement (clustered, dispersed), and their associated impacts on biodiversity (birds) will be conducted with relevance for both the stand and regional level. Lastly, a global systematic review of monoculture versus mixed forest plantations impacts on production, economy and biodiversity will be completed.

RT5. The significance of land-use history for biodiversity

Background: The intensity of historical land-use varies across Scandinavia, from complete and permanent deforestation in the very southern parts, to recent and often marginal impact by modern forestry in the northernmost parts. Between these extremes, most areas have been subjected to a complex range of early forest utilization, pre-industrial and industrial forest exploitation, and modern forest management. As a consequence, today's forest landscapes contain areas which have been used with varying intensity and which carry legacies of past land-use as well as past natural qualities. In a pilot project in *Future Forests* phase 1, we investigated past land-use in an iron-ore smelter area close to Finspång, south Sweden, and showed that several stands with high conservation values today were characterized by an intensive use in earlier times. This challenges our current understanding of the connection between high conservation values today and anthropogenic disturbance, or the lack of such disturbance, in the past. Historical forest data are the key to understanding these legacies, and thus inform on potential effects on future biodiversity from current forest management. We will continue to use the data gathered in phase 1, but also expand and include new study areas, to address the following questions:

1. How much do historical data contribute to our understanding of the current state of ecological qualities in forest landscapes?
2. How can analysis of historical data be used to better understand the future effects of today´s tree and stand retention measures?

Approach: Our study sites will comprise a number of areas in central Sweden which are linked by two factors: varying and complex forest history including pre-industrial forest use and availability of reliable forest inventory data from the early 19th century and onwards. We are particularly interested in areas where different forestry methods have been applied such as early (pre-20th century) uneven-aged forestry, early clear-cutting, and low intensity agricultural forest use. The analysis will thus provide a temporal perspective on specific structures, address their value for biodiversity, and assess their role in different forest landscapes. The resulting knowledge about the historical, present, and future role of key forest structures for biodiversity will be crucial for evaluating the usefulness of current biodiversity conservation practices and will feed into project 6.1.3.

Deliverables

- Analysis of the effect of short vs. long rotation on production, economy, biodiversity and recreation.

- New knowledge on intensified forest management that can be used in adaptive forest management including new models that can be incorporated in Heureka.

- **Stand**-level economic analysis of different silvicultural programs.

- Systematic review of the biodiversity implications from applying even vs. uneven-aged silviculture.

- Development of a tree growth models for uneven-aged stands.

- Field studies on management of individual broadleaved trees in conifer dominated forest stands and on the impact of mixed tree species composition on biodiversity.

- Review of monocultures vs. mixed-forest plantations impacts on production, economy and biodiversity.

- Investigation on the relation between historical land-use and today’s biodiversity in forest landscapes.

Personnel:

Urban Nilsson will lead the work in PC 1. He is professor of forest production at SLU.

Nils Fahlvik is a researcher at SLU. His main research interests are forest modelling and management of mixed species stands.

Adam Felton is an assistant professor at SLU. His research focuses on the maintenance of biodiversity in production forests.

Emma Holmström is a PhD-student at SLU studying the establishment and early development of mixed species stands.

Johan Sonesson is a researcher at Skogforsk. His research interests include stand level economy of different silvicultural programs.

Kristina Wallertz is a researcher at SLU. Her expertize is in the field of regeneration practices resulting in mixed species stands.

Lars Lundqvist is a researcher at SLU. His expertise is in silviculture, especially forest growth and yield in managed uneven-aged forests.

Olle Sjölin is a PhD-student at SLU studying nutrient dynamics in newly planted Norway spruce and Scots pine seedlings.

Lars Östlund is a professor in forest history at SLU.

6.3.2. Forest soils and waters (PC2)

Objective
In PC2 we will develop a state-of-the-art understanding of land-water interactions and landscape scale processes with the primary goal to improve and guide future management strategies towards long-term sustainable use of forest soils and waters.

Rationale
Developing management strategies to ensure sustainable use of forest soils and waters in the face of increasing societal and environmental pressures is a major challenge. Decision-making must be based on a solid scientific understanding. Inadequate knowledge and unacceptable levels of uncertainty will likely weaken policy outcomes and increase the likelihood of unintended and perhaps unwanted consequences for forest soils and water. Instead successfully achieving societal goals is dependent on the clear communication of sound natural science, which can be used to inform the development of regulatory and voluntary governance tools. Hence, we will place state-of-the-art understanding land-water interaction, and landscape scale processes into the public's awareness by showing how different forest management strategies affect forest soils and waters.

Introduction
Phase 1 of *Future Forests* highlighted the consequences of an incomplete understanding of ecosystem processes and policy implications affecting the sustainable use of soils and water in the forested landscape. In Phase 2 we plan to mine and integrate the wealth of biophysical and social science findings so as to create improved knowledge, which can strengthen forest governance and policy. For example, in phase 1 we showed that inadequate understanding of forest biogeochemistry can lead to nutrient management strategies which are unsustainable (Klaminder et al. 2011, Laudon et al. 2011), problems implementing the EU Water Framework Directive (WFD; RDV, 2000/60/EG; Futter et al. 2011), and challenges in meeting Sweden's commitment to the Baltic Sea Action Plan (SEPA, 2009; Futter et al. 2010). Furthermore, we demonstrated that an inadequate conceptual understanding of the forest ecosystem can result in unsustainable management strategies that can harm both the Swedish environment and economy (Ellison et al. 2012).

We will use our improved understanding to develop new approaches for balancing potential trade-offs between forest yield and environmental quality. For example, possible negative effects of both even-aged and uneven-aged management can be minimized if credible scientific understanding is used to inform flexible strategies that protect parts of the landscape where local conditions make the soil-water system particularly vulnerable to different forestry activities. Maintaining or even increasing biomass production in Swedish forests does not necessarily mean other ecosystem services such as biodiversity, recreation, or reindeer husbandry will be unduly impacted, or that we will jeopardize long-term sustainability of soils and cause unacceptable deterioration of water quality. Instead, by developing management-support tools that incorporate process-based understanding of ecosystem functioning, landscape heterogeneity, and the regulatory and voluntary policy environments, we seek to simultaneously improve forest landscape sustainability and maintain or even increase the potential for biomass production.

Research questions and topics to be explored

To reach the goals set up in PC 2, research will be divided into five research topics (RTs). These RTs will be organized to answer the following over-arching questions:

- RT1. Carbon sequestration in forests soils: is it increased or decreased by different forest management strategies?
- RT2. How does forest management affect nutrient dynamics in soils, leakage to surface waters, and eventual export to the Baltic Sea?
- RT3. Is the long-term sustainability of base cations threatened by biomass removal and how does this affect surface water acidification?
- RT4. What is the contribution of forest cover to water quantity and quality, and how do different types of silvicultural systems affect the overall health of surface waters?
- RT5. How can landscape approaches be used to improve the sustainability of forests and forestry?

RT1. Carbon sequestration in forests soils: is it increased or decreased by different forest management strategies?

Background: Knowledge gaps related to carbon (carbon) sequestration in forest soils and waters could have implications for climate change- and management-related policies. It has been suggested that preserving forests in reserves may be the best way to promote forest soil carbon sequestration (Jonsson and Wardle, 2010). In contrast, Berg et al. (2009) showed higher average soil carbon accumulation in managed stands compared to soils in undisturbed, old growth forests during periods with no human or fire disturbance. Resolving these different perspectives, and understanding the effect of different silvicultural programs applied in even- and uneven-aged forests on above- and belowground carbon sequestration are critical for quantifying the importance of forests and forestry to the regional carbon balance. This question must also include carbon losses via hydrologic transport, which is important to the carbon balance of forest landscapes (Cole et al. 2007) and is sensitive to silvicultural activities (Schelker et al. 2012).

Approach: To quantitatively assess the amount of carbon sequestered using different forest management strategies we will collaborate with the Swedish Forest and Soil Inventories. Using the unique monitoring data from the national forest and soil inventory, we will investigate how different forest age classes and silvicultural measures influence the rates and magnitude of soil carbon accumulation and loss to surface waters. This analysis will also include the large amount of existing monitoring data from across Sweden on stream runoff of organic and inorganic dissolved carbon, which will allow a quantitative investigation of the effects of different silvicultural activities on carbon losses via the aquatic conduit. The results will feed into the work on governance as a tool for carbon management and mitigation in RT4, PC3.

RT2. How does forest management affect nutrient dynamics in soils, leakage to surface waters, and consequences for the Baltic Sea?

Background: By virtue of their vast area, forest-covered areas are the largest source of nutrient reaching the Baltic Sea from Sweden. Strategies for nutrient management have traditionally focused on inorganic nitrogen (N), a bio reactive, yet typically minor component of the total N in forest soils and surface waters (Kortelainen et al. 2006). A holistic understanding of nutrient dynamics in the forest landscape must include consideration of 1) organic, inorganic and gaseous forms of nutrients, 2) both terrestrial and aquatic processes, and 3) the synergistic effects of changes in climate and forest management. Holistic understanding is clearly needed for the development of sustainable management strategies for Swedish forests and the Baltic. For example, silvicultural programs that reduce aquatic N leakage while increasing gaseous fluxes of NO_x may benefit the Baltic at the expense of the global climate. We will focus on analysing and synthesizing on-going research and available monitoring data, and will integrate small-scale, mechanistic research on nutrient cycling in forests and streams from the Formas-funded strong research constellation NiCAF (*Nitrogen and Carbon in Forests*) into a sustainability and management perspective.

Approach: The research addressing how N fertilization affects soil functionality, and leaching received considerable research interest during phase 1 because of the important implications for the future of forestry in Sweden. We will continue to work with these questions in the next phase in close collaboration with NiCAF, with the goal of providing synthesis on N use, retention, and loss from Swedish forests.

Another pressing issue to resolve is the degree to which biological processing and retention in streams and rivers reduces the downstream losses of N from forest landscapes (Futter et al. 2010). Despite widespread concern over nutrient loading to the Baltic Sea, very little is known about how N is used, transformed, and retained within the network of streams, rivers, and lakes that serve to connect Sweden's forests and coastal ecosystems. Our group is uniquely poised to provide a better understanding of this vital ecosystem service, as well as insight into how different silvicultural programs applied in even-aged and uneven-aged managed forests (see 6.1.4.) can affect the nutrient load to the Baltic Sea. Landscape- and regional-scale processes will be assessed using modelling of long-term monitoring data so as to quantify the role of different silvicultural programs for N retention, leakage to surface waters, and the possible consequences for how to fulfil the Baltic Sea Action plan. Smaller scale, mechanistic insight into the controls over N retention in riparian soils and within aquatic networks will be derived from a combination of existing monitoring data and ecosystem-level experiments that are currently supported through ForWater and NiCAF.

RT3. Is the long-term sustainability of base cations threatened by biomass removal and how does this affect surface water acidification?

Background: There are credible concerns that both conventional and whole-tree harvesting are removing base cations (BC) from Swedish forests more rapidly than they can be replaced through mineral weathering. Recent modelling results suggest forest growth will be negatively affected by deficiencies in soil BC supply following both conventional and whole-tree harvesting, and that these deficiencies will result in surface water acidification (Akselsson et al. 2007). Furthermore these models predict that forest soils will take decades or centuries to recover from such losses. However, in a study carried out in phase 1 of *Future Forests*, Klaminder et al. (2011) showed that different weathering models produced contrasting results with a precision far from what is needed to predict any forestry related effects on the BC pool. Taken together, these results demonstrate the urgent need for further investigation as the potential pitfalls associated with over-reliance on individual models can result in poor policy decisions.

Approach: The concern about previous results demonstrates that the high uncertainty in weathering models lead to a potential for confusion in the policy arena. To come to grips with this in phase 2 we will work in cooperation with the Formas-funded strong research constellation Qwarts (Quantifying Weathering Rates for Sustainability). The purpose of Qwarts is to provide better mineral weathering estimates, whereas our specific goal in phase 2 is to use the new insights to better understand and quantify the implications of different silvicultural programs and knowledge gaps for the long-term sustainability of BC in forest soils and surface waters.

RT4. What is the contribution of forest cover to freshwater resources and how do different types of natural forests and silvicultural systems affect surface waters?

Background: Healthy forests generally promote good water quality (Neary et al. 2009). However, forest management can have unintended consequences on both water quality and quantity. In this work, we continue research we initiated in phase 1 that addressed basic relationships between forest cover, hydrology and landscape water balances (Ellison et al. 2012). This effort touches on many areas of current interest to forestry and water resource management, including the Water Footprint initiative, and the maintenance of flow regimes that ensure the ecological integrity of aquatic habitats.

Approach: In this work we will investigate how different silvicultural practices affect soil-water availability and hydrology, and whether these affects are different from natural forest cover. To do this will address pertinent issues related to the Water Footprint initiative, the WFD and the potential for Payment for Ecosystem Services (PES) systems, and the real 'water impact' of bioenergy forestry.

RT5. Can landscape approaches be used to improve the sustainability of forests and forestry?

Background: Forest stands cannot be seen in isolation but must be managed as part of a landscape mosaic supporting a complex interaction between different state factors and actors. A recent management approach that is promising from a water quality perspective involves organizing landscapes into areas that are sensitive to disturbances caused by different silvicultural measures and those that are not (Ågren et al. 2010). By applying this 'landscape sensitivity' approach greater care can be devoted to protecting certain areas because of their importance for biodiversity, water quality and/or sensitivity. For example, areas at the interface of mineral and organic soils are hotspots of methyl mercury production (Bishop et al. 2009). When these areas are close to streams, rutting by forest machinery could cause both increased methylation and provide connectivity and hence more rapid flushing to adjacent surface waters. This general management approach will require more input from scientists related to how intrinsic properties of forest ecosystems (e.g. landscape position, slope, underlying geology, soil texture etc.) influence the degree of sensitivity to various harvesting practices. Another way forward will include the use of planning tools such as Heureka designed to help managers develop strategies for maximizing forest yield in the long term, while maintaining particular water quality parameters below specific thresholds (Öhman et al. 2009).

Approach: By developing a "landscape sensitivity" approach in conjunction with new laser scanned data available for the entire country we will develop models that can be applied to direct different silvicultural management measures to landscape areas that are best suited for those activities. This work will be carried out in close collaboration with the strong research constellation ForWater (*Modelling forest production and climate change impacts on water quality*), an interdisciplinary platform for water quality modelling. Examples of approaches we will test include: minimizing the effect of mercury leaching to surface waters by avoiding sensitive areas, optimizing use of fertilizers by avoiding areas with high leaching potentials, differential management of sensitive forest stands and a better understanding of the functionality of riparian areas. This work will be carried out in collaboration with PC1.

Deliverables

- A quantitative analyses of the amount of carbon sequestered in managed vs. unmanaged forest soils.
- Examination of how nitrogen fertilization affects tree growth, soil functionality and leaching to surface waters.
- Assessment of how different silvicultural systems affect the N export to the Baltic Sea.
- Syntheses of the current knowledge of base cation release rates through weathering, long-term BC cycling, and effects of different silvicultural systems.
- Examination of how different silvicultural systems will affect soil-water availability and hydrology, and its implication for the Water Framework Directive and Payment for Ecosystem Services System.
- A development of landscape sensitivity tools to direct different silvicultural practices to different landscape areas, including minimizing mercury leaching to surface waters.

Personnel:
Hjalmar Laudon will lead the work in PC2. He is a professor in forest landscape biogeochemistry at SLU. His work is focused around soil, stream and landscape effects of natural and human impact on carbon, nitrogen and metals.

Kevin Bishop is professor in environmental assessment at SLU. Much of his research deals with the role of human perturbation on stream water quality.

Peter Högberg is a professor in forest soils at SLU. His work is mainly focused on the interplay between soils and trees for the carbon and nitrogen cycle.

Gustaf Egnell is a soil scientist at SLU. He is specialized on bioenergy and carbon sequestration in relation to forestry.

David Ellison is a researcher at the Institute of World Economics in Hungary. His work focuses on the policy and science of the water footprint, WFD, and payment for ecosystem services, PES, in relation to forestry.

Martyn Futter is an associate professor at SLU. His research focus is on modelling the effects of forestry and climate change on surface water quality.

Eva Ring is a researcher at the Forestry Research Institute of Sweden (Skogforsk). She studies the effects of different forestry operations on soils and water quality.

Ryan Sponseller is an associate professor at SLU. His research focuses on aquatic biodiversity, nutrient retention and leakage of nitrogen to downstream ecosystems.

Anneli Ågren is an assistant professor at SLU. Her research focuses on landscape sensibility and effects on surface water quality from forestry and climate change.

6.3.3. Climate change mitigation and adaptation (PC3)

Objectives
In PC3 we will 1) evaluate the effects of climate change on Swedish forests using new climate scenarios and state of the art modelling, 2) compare different silvicultural strategies and use of forest products in terms of carbon balance and mitigation benefits, 3) evaluate the potential in adapting silviculture to expected climate change in relation to risk and/or benefits expressed in economical terms, 4) analyse the associated institutional framework and assess its capacities to support various forest related strategies to mitigate and adapt to climate change as a part of

multiple stresses, in order to enable policy development facilitating climate change mitigation and adaptation on national level as well as on EU level, and 5) investigate how actors position themselves in relation to emerging forest related carbon mitigation strategies and identify conflicts, synergies and needs for trade-offs and choice.

During *Future Forests'* phase 1 we established collaboration with Mistra-Swecia that we intend to develop further. Results of this PC will hence be shared, synthesized and analysed together with researchers from Mistra-Swecia. Additionally, we will take an active role in setting up collaboration within EFI-Nord (see 5.4.1.) aimed at analysing potential impacts of the new climate scenarios on forest production and management in the Nordic countries, and at defining adaptation to climate change in forest management as a part of the IUFRO working group on this subject (see below).

Rationale
Climate change will cause fundamental changes to the current conditions for ecosystem-based management of the boreal forests. Consequently, we envision the arrival of new opportunities as well as of new challenges and threats. Adapting silviculture has the possibility of not only mitigating risks but also to utilize improved growing conditions of the future climate. These new conditions, both opportunities and potential threats and their effects on economy, need to be evaluated, in the context of climate change within a multiple stresses framework, both, for different silvicultural systems, as well as for alternative ways of managing the forest. The basis for such an approach should be the new set of climate scenarios that has recently been developed by four independent modelling groups worldwide (van Vuuren et al. 2011). There is also a EU directive promoting the use of renewable energy to mitigate climate change that will increase demand for forest biomass. As a consequence there is a need to assess the capacity of the institutional framework to support various forest related strategies to mitigate and adapt to climate change as well as to understand how actors position themselves in relation to emerging forest related carbon mitigation strategies.

Introduction
The observed increase of atmospheric greenhouse gas (GHG) concentration has led to an increased mean surface temperature during the 20^{th} century. The temperature increase is expected to continue during this century, and be more pronounced at higher latitudes. Changed climate conditions in Sweden have been suggested to improve growing conditions (Bergh et al. 2011), but also to increase risk of damage to forests from storms, pests and pathogens (Blennow and Eriksson 2006).

There are a number of political initiatives to promote the production and use of bioenergy. European Commission Roadmap for moving to a low-carbon economy until 2050 points out that production of bio-energy must more than triple in the period 2010 to 2050 to enable the envisioned 80-95 % reduction in CO_2 emissions. In Sweden the parliament in 2009 adopted a vision of Sweden without greenhouse gas emissions in 2050. Sweden's Roadmap 2050 notes that more intensive forestry that binds CO_2 while providing society with bioenergy and renewable products can be a way to achieve that vision. It is, therefore, important to identify and understand how socioeconomic and political factors act and interplay with respect to climate change mitigation.

Research questions and topics to be explored
The research in PC3 will be divided into five research topics (RTs). In summary, the research within the RTs will be aimed to answer the following questions:

- RT1. How will the Swedish forests respond to new climate scenarios in terms of forest production and risk for damages?

- RT2. What is most effective way to use forest for climate change mitigation: to use forests as carbon storage or to manage forests for high yields and utilise forest products for substitution?
- RT3. How can silviculture be adapted to utilise future climate conditions while at the same time minimising the risk of damages in an economically feasible way?
- RT4. How do crucial international and national forest-related policies and broader adaptation policies impact forest management, and what integration and trade-offs are needed to support long term adaptation to climate change within a multiple stresses framework?
- RT5. How do key actors position themselves in relation to the emerging forest related carbon mitigation strategies?

RT1. Effects of climate change on forest

Background: A new set of climate scenarios has recently been developed and are projections of radiative forcing instead of different emissions scenarios, "Representative Concentration Pathways". They are intended to be used as a framework for further analyses within the global scientific community, i.e. for climate modelling, mitigation analyses and impact assessments (van Vuuren et al. 2011). This RT will analyse how these new future climate scenarios will affect forest production, risk of pests and pathogens. The RT will consider different silvicultural strategies in context of the new scenarios. The RT will also evaluate effects of climate change on wood supply to industry and society.

Approach: We will analyse how new future climate scenarios will affect the production for our main tree species in Sweden by using a number of processes-based growth models and link them with empirical growth models and models for pest and pathogen dynamics. *Future Forests* has initiated a Nordic collaboration with EFI-Nord and leading scientists in the Nordic countries within this area of research. This PC will initiate a joint venture where we will run models from the different Nordic countries to try to agree on the likely effects on the Nordic forest due to a changing climate. Socioeconomic consequences for the Swedish forest sector will be analysed and synthesized in collaboration with the Mistra-Swecia research program. Results from this RT will feed in to the analyses of different silvicultural systems in project 6.1.4.

RT2. Efficiency of different strategies to mitigate climate change

Background: There are heated debates on-going worldwide as to whether it is better for the global carbon balance to store more carbon in the forest or to use forest products to replace carbon-intensive fossil fuels and construction material (cement and metal). The International Union of Forest Research Organizations (IUFRO) has pointed out the immense potential for the forest sector to mitigate climate change at low cost. In Sweden, where forests cover more than 60% of the land area, silviculture and use of forest products by industry and society will play a crucial role for the national carbon balance. The scientific challenge is to understand how different forest management strategies can contribute to mitigation benefits (cf. Canadell & Raupach 2008). It is debated whether or not carbon sequestration in forests is the most effective way of mitigating climate change, and therefore, if forest management should be optimised to increase carbon stocks. However, wood product substitutions, where forest products replace CO_2-intensive materials and fuels, have been suggested to be an even more important element of a long-term strategy for mitigating climate change (Sathre & O´Conner 2010). When balancing the different components, the time perspective is of crucial importance because different forest management strategies yield benefits at different time scales, and substitution effects are typically cumulative.

Approach: Within this RT we will analyse what is most effective in short- and long-term perspective, to store carbon or utilise forest products for substitution. We will also analyse different use of forest products to optimise the substitution effect and how different energy-use systems influence the substitution effects. Another focus in this RT is to adapt silvicultural programs to maximise overall carbon benefits. Analysis will rely on biometric forest inventory data and on models. We will account for carbon uptake and storage as well as variable residence times of the different carbon pools in a forest ecosystem. Substitution effects of harvested products in society will be dealt with in a life cycle perspective considering all relevant emissions of GHGs.

RT3. Adaptation of forest management to climate change: models for risk assessments

Background: The RT will focus on adaption of silvicultural systems to utilise future climate conditions while at the same time minimising the risk of damages. This RT focuses on how to handle different climate variables in a risk perspective, and when is it worthwhile to adapt silvicultural strategies to future climate. By proper selection of forest regeneration material (by developing robust genotypes in breeding programs and improving deployment recommendations of existing forest regeneration material) it is possible not only to mitigate risks but also to utilize improved growing conditions of the future climate.

Forest pests and pathogens – both novel and longstanding – will continue to be a threat to forests. Climate change and changes in forest management will affect the risk for damage (Björkman et al. 2011, Stenlid et al. 2011, Klapwijk et al. 2012). Our ability to control and foresee pests and pathogens depend partly on monitoring, including reporting of observations, and partly on how well we understand the mechanisms behind changes in damage.

Approach: There will be a special focus on economical effects of risk management, where cost of risks and adaption of different silvicultural strategies will be evaluated and compared. In order to develop future regeneration material for Norway spruce, new response models will be developed including varying environmental conditions, climatic indices and genotypes. The project will also develop models of potential risks in a future climate to analyse effects on forest vitality, mortality, wood quality and production. The models will be implemented in Heureka to make analyses on different geographical scales possible. Additionally we aim to develop activities that will facilitate decision making in collaboration with Environmental Assessment (FOMA) at SLU, the Swedish Forestry Agency, forest companies, and other governing bodies. For example, we aspire to work toward unifying the knowledge on ecological risk, legislation, and governance needed to improve the regulations related to moving products, which have a high risk of carrying pests and pathogens. To reach our objectives we will continue the work started in *Future Forests* phase 1 (Björkman et al. 2011) and combine descriptions of observed patterns and mechanistic understanding with modelling so as to generate improved predictive tools that can be used in forest management, governance and planning.

Results from this RT will feed in to the analyses of different silvicultural systems in project 6.1.4. and in to RT3 in PC4.

RT4. Governance for forest management: how climate and forest policies affect the Swedish forest sector

Background: It is increasingly recognized that the effects of climate change on forest systems will impact most forest functions, including growth, hydrological and storm regimes, pest outbreaks and impacts from potential invasive species, all of which changes will impact the productivity of forest. Decisions on management of forest to adapt to and improve management to secure production of forest goods and protection of biodiversity under climate change, however, place large requirements on integration of different forest-relevant policies on EU and national levels, as well as on implementation on regional and local forest management. While no strong European adaptation policies yet exist, national policies on adaptation have recently started to be developed. These national policies stress an increasing integration with coping strategies developed in policy or legislation (e.g., frameworks for crisis response, including storm or fire hazard) to be able to support future adaptation. Integration is also needed with large-scale frameworks (such as the EU Habitats directive and Natura 2000 regulation) that will impact adaptation in forests.

Approach: This RT reviews crucial forest-relevant policies on international, EU and national level with regard to integration in relation to adaptation aims and the requirements of a future climate. The RT thereby reviews how legislation, policy, and implementation of adaptation and mitigation-relevant frameworks from international to local levels impact Swedish forest use and competitiveness. The RT subsequently aims to identify and explore the requirements for efficient adaptation placed on national, regional and local forest management systems within this broader governance system, as well as relate these requirements to potential needs for improvement in forest decision making chains within companies, for instance in relation to overall quality management or e.g. certification systems. Methodologically, the study will utilize policy and legal analysis including qualitative studies, extending upon earlier work reviewing the different legislative and policy elements on international, EU and Swedish levels that may impact adaptation to climate change in forests. These include changes in resource management frameworks (e.g., biodiversity, water) and risk response frameworks, e.g., pests and invasive species, drought, storm and potentially even fire. Background data on climate change as well as on impacts of changing pest regimes will be drawn from other RTs in this WP. When possible, this RT will also seek comparisons between Swedish cases and other European states, for instance through the recently established IUFRO working group on adaptation and e.g. from the outset drawing upon international cases developed within an existing EU Cost Action on adaptation and mitigation to climate change in forests. The understanding of an international context of forest management and change in other countries will provide a better understanding of the role of governance and management context, as well as potential possibilities to learn from other cases as well as contribute to the developing international adaptation research field on forest.

RT5. The politics of forest related carbon– actors' perceptions and strategies

Background: Carbon-related arguments and strategies have become part of actors' visions and strategies. Research carried out during phase 1 show that the question of forest related carbon and its role in climate mitigation is contested. The aim of this RT is to investigate how actors position themselves in relation to emerging forest related carbon mitigation strategies, and thus enable an identification of possible conflicts, synergies and needs for trade-offs and choice. How actors' visions and strategies interlink with emerging institutions and governance processes will shape the conditions for Swedish policymaking, forest management and climate mitigation strategies. This study aims at exploring an expanding political field: the politics of forest carbon. Existing legislation and policy from the international to the national and local levels, i.e. 'the rules of the game', are analysed in RT 4.

Approach: In this RT, we investigate how actors respond to this institutional framework and how carbon related arguments shape their strategies and practices. We start by identifying a number of empirical examples illustrating efforts to implement forest related carbon accounting, offsetting or mitigation strategies/schemes. One such example is the Landvetter Airport Carbon Accreditation project in which the airport plans to invest in forest management activities in order to compensate for its air traffic related carbon emissions. Various attempts by forest owners and forest owner associations to sell carbon credits to carbon emitting industries also exist. In a next step, we explore relevant actors' responses to the identified initiatives with the aim of identifying potential conflicts as well as preconditions for co-operation and synergies. Key actors include businesses, industries and forest owners involved in the identified initiatives, other affected businesses, civil society organizations, authorities and relevant political institutions. In PC 4 (see RT4) a set of general methods and approaches will be developed to 1) qualitatively explore actor's response pathways, i.e. their perceptions and strategies, and 2) involve actors in the research process. These methods/approaches will be applied in this RT to address actors' and user's responses to different kinds of forest related carbon accounting, offsetting and mitigation strategies. Potential conflicts, synergies and needs for trade-offs will thus be identified.

Deliverables

- Analysis of the effects of new climate scenarios on forest growth:
- Evaluation of the effectiveness for climate change mitigation of different silvicultural systems.
- The develop of an integrated framework modelling tool for total forest carbon balance, where use of forest products and substitution are considered.
- An analysis of risks of pests and pathogens in a changed climate and adaptation of silviculture to minimize these risks.
- A contribution to the development of future regeneration material for Norway spruce;
- An analysis of how political processes (EU and Sweden) associated with pests and pathogens impact possibilities to govern outbreaks.
- An analysis of how forest-relevant policies at national and international level (state systems and risk management) integrate and influence adaptation to climate change in forest management.
- An exploration of perceptions and key actors responses to different kinds of forest related carbon accounting, offsetting and mitigation strategies and identify potential conflicts, synergies and needs for trade-offs.

Main personnel in PC3:
Johan Bergh will lead the work in PC3. He is associate professor and specialized in climate change and forestry.

Karin Beland Lindahl is a post-doctoral research fellow at SLU. Her research is based in political science and focuses on politics of natural resource management, particularly forest conflicts.

Mats Berlin is a researcher at Skogforsk focusing on tree breeding.

Christer Björkman is professor in forest entomology at SLU. He is a specialist in plant-insect interactions, plant resistance, biological control, population biology, insect outbreaks and climate change.

Johanna Boberg is a post-doctoral research fellow at SLU. Her research focuses on fungal communities, invasive pathogens and distribution patterns of fungal pathogens in relation to climate change.

Peichen Gong is professor in forest economics at SLU. His research focuses on developing tools for economical evaluation of risks and different silvicultural strategies available for the forest owner.

Anna Gunulf is a PhD-student at SLU. Her area of research is pathogens (root-rot) distribution in forest stands.

Ragnar Jonsson is a post-doctoral research fellow at SLU. His research is on forest-products market analysis and wood use in the context of future studies.

Carina Keskitalo is professor at Umeå University. Her research focuses on institutional factors relevant to adaptation to climate change with examples from multi-level cases and forest systems.

Maartje Klapwijk is a post-doctoral research fellow at SLU. Her area of expertise is community ecology, species interactions and population dynamics. In this context she works on insect outbreaks and outbreak species in the context of climate change.

Jan Stenlid is professor in Forest Pathology at SLU. He has a broad spectrum of interests, e.g. invasive fungal species, infection biology of forest pathogens, fungal ecology and genomics of fungi.

6.3.4. Governing competing demands on forests (PC4)

Objectives
Given the global drivers affecting forestry the purpose of PC4 is threefold;

- To put the Swedish forestry model in an international perspective comparing the potentials of various forestry models to govern competing demands in forested landscapes, with a specific focus on forest production and biodiversity protection.
- To analyse alternative policy and management options from ecological, economic as well as social aspects, identifying synergies, trade-offs, and conflicts.
- In close collaboration with stakeholders – assess and develop governance mechanisms, in particular adaptive management and decision support models designed to manage multiple objectives in forested landscapes.

Rationale
Despite the fact that the Swedish forestry model, or the general state-specific ways of coping with forest related politico-economic issues - with its objective to balance forest production and biodiversity protection, has been in place for almost 20 years, it has not been able to fully reconcile these different competing demands for forest resources. On the contrary, there are signs of increasing conflicts and intensifying competitive behaviour among forest actors in Sweden. As mentioned in the introduction the robustness of the Swedish forestry model is thus challenged by exogenous factors such as changing global and European rules and regulations, focusing on multiple functions of forests, in combination with the prospect of significantly increasing demands for forest raw materials, and endogenous factors such as an increased level of conflict and competition. Consequently, there is a call for improved capacity to govern these competing demands.

The rationale of this PC is thus based on the need to scrutinize the past, present and future potential of the Swedish forestry model to meet these challenges. This is done by identifying deficiencies that may undermine the robustness of the model and subsequently to suggest solutions, policy tools and decision support systems to govern competing demands. Given the two equal objectives of the Swedish forestry model, a specific focus will be paid to the potentials to balance forest production and biodiversity protection thus comparing the Swedish forestry model with forestry models in other countries. Since this balance is challenged by other demands such as carbon mitigation and various social aspects of forests, these needs will however also be considered.

The research will be based on the ecosystem-based approach in order to be able to consider the potentials to govern competing demands at various policy levels and ecosystem scales.

Introduction
In the light of global development (Beland Lindahl and Westholm, 2011a) –basic conditions for the Swedish forest sector are being altered. Future forest governance in Sweden will to a greater extent be affected by global actors and policies aiming for sustainable forestry management (e.g. the Intergovernmental Panel on Forests, (IPF), the Intergovernmental Forum on Forests (IFF), the United Nations Forum on Forests (UNFF), and the expanded program of work on the biological diversity of forests under the Convention on Biological Diversity (CBD),but also by European actors and policy initiatives (e.g. the Ministerial Conference on the Protection of Forests in Europe (MCPFE), Forest Europe and the EU Forest Strategy and Forest Action Plan, and the EU Green Paper on Forest Protection and Information) and market based strategies such as various forest certification schemes. In addition to these forest policy initiatives numerous initiatives focusing on e.g. climate and climate change mitigation (e.g. the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto protocol and the EU directive on Electricity Production from Renewable Energy Sources the European level (RES) will directly or indirectly have an effect on forest governance and

management. Furthermore, analysis of forest market development points at an increasing demand for forest resources to meet expected demographic changes.

As a consequence forest will have to provide many more functions in parallel such as the provision of natural heritage, economic assets and sustenance for the global environment, but also to provide a wide range of goods, such as food, fuel, fibre and bio products, and ecosystem services, e.g. climate regulation, clean water, and aesthetic enjoyment.

Although many of these initiatives mainly classify as “soft law”, providing political rather than legally binding commitments, they have, 20 years after the Rio Conference, contributed to the establishment of a new institutional landscape with a strong impact on forest governance and management and other issues related to forest use in Sweden. This new institutional landscape in combination with the prospect of significantly increased demands for raw materials from the forest imposes new challenges on the Swedish forestry model. Questions such as whether or not we should continue to pursue a multi-functional forestry with the same ambitions for production and conservation of biodiversity on all forest land, or whether we should set aside certain limited areas of lower conservation value for more intensive forest production, have increasingly come to the forefront during recent years. In addition, the question of the need for a European forest policy is hovering over this entire discussion.

Given these new challenges, this PC explores from a comparative perspective the potentials of forestry models in different countries to respond to the range of challenges driven by global change by exploring governance mechanisms, policy tools and decision support systems designed to manage conflicts, synergies and trade-offs on this changing forest political arena. As an outset, the research will use the ecosystem-based approach as an overarching theoretical framework. The ecosystem-based approach, in general, emphasizes ecosystem integrity and stresses the need for holistic and integrated decision-making. Accordingly, this approach calls for an expansion of the spatial and temporal scale of planning and management, with managers taking into account ecologically relevant boundaries or landscape units (Conrad et al. 2011). This approach, however, may represent a departure from traditional governance and legal traditions – in particular strong private property rights - in most Western European countries. It is thus a research issue of utmost importance to examine various management models, identify their compatibility with ecosystem-based management and clarify choices and consequences that may shape the Swedish forestry model.

A complicated factor related to the ecosystem-based approach is how to make decisions when the available knowledge is limited or uncertain. Scientific knowledge is inherently uncertain because implicit assumptions are associated with the interpretation of empirical data and measurement errors are ubiquitous. Furthermore, new data are continuously created and scientists accept or reject them in a process that – sometimes – makes yesterday’s view on scientific truth obsolete. Thus, natural resource managers are faced with ’wicked’ challenges when transforming scientific knowledge into policy. Decision making is often further complicated because of lack of time, great economic values at stake, competing interests, and the long-term consequences of the decision (or non-decision) made. These issues will also be dealt with in PC4, and are highly significant for the guiding themes in phase 2, viz. the Swedish forestry model and the science-based decisions made within this context.

Research questions and topics to be explored
To reach the objectives set up in PC 4, research will be divided into five research topics (RTs). These RTs will be organized to answer the following over-arching questions:

- RT1. What comparable forestry models exist in other European countries, USA and Canada and how do they respond to the challenges outlined above?

- RT2. How have different stakeholders, perceptions and ideas in society (nationally and internationally) influenced Swedish forest policies and management systems over the last century?
- RT3. How do regulatory agencies deal with conflicting demands in managing natural resources under conditions of great uncertainty both in day-to-day management and in extreme cases?
- RT4. How to manage forest landscapes for cost-efficient biodiversity conservation?
- RT5. What are the roles of different actors in the current shaping of the future Swedish forestry model and what are their responses to the forest management models identified above and finally, how can an ecosystem based management approach contribute to a future Swedish forest model capable of balancing increasing and conflicting demands?

RT1. Global drivers, national responses – comparative perspectives on the Swedish forestry model
Background: The overarching objective of this RT is to analyse the Swedish forestry model from a comparative perspective. Particularly we will focus on core institutional aspects of forestry models, e.g., property and access rights, governing principles, and economic and social organization of the forestry sector. We will analyse how these aspects influence the possibilities of different forestry models to govern increased and competing demands. Specifically the RT will bring answers to questions on comparable forestry models in other European countries, USA and Canada and how they respond to the challenges outlined above. The RT will thus, through an initial scoping phase of forestry models, set the overarching framework for further comparisons in this PC. This will include all the researchers in PC4 and be done in close collaboration with researches in PC1 to review the impact of various forestry models and policy instruments on e.g. biodiversity protection.

Approach: A systematic comparison of different forestry models in different countries or states based on these core institutional aspects will identify relative strengths and weaknesses of the Swedish forestry model, and thus put the model in an international perspective with a specific focus on the influence of international norms such as an ecosystem-based approach through the CBD and the European Landscape Convention. The RT will attempt to understand to what extent it is possible to incorporate key features of the ecosystem-based approach such as stakeholder participation and adaptive management and what the scientific basis is for introducing these principles. The study will be based on policy analysis; interview data combined with ecosystem analysis and will link to research in PC1 and PC2.

RT2. Historicizing and contextualizing the Swedish forestry model
Background: The overarching objective of this RT is to achieve further understanding of the current forestry model and its future, by analysing why it was developed, which stakeholders were active in the process, and how it has been perceived over time. To be able to understand the background of the current model it will be necessary to go further back in time to see how different views and other policies and management systems have been discussed and practiced over the years. Hence, this RT will: i) Conduct a longitudinal study over the evolvement of forest policies and their practical implications on forest management since the early 20th century, ii) analyse how different stakeholders, perceptions and ideas in society (nationally and internationally) have influenced Swedish forest policies and management systems over the last century

Approach: RT 2 will problematize notions commonly reproduced by the forestry sector where the "Swedish forestry model" is viewed as something quite static and unique, which has evolved during the 20th century as a logical outcome of particular Swedish values, institutions and natural conditions. It will also scrutinize the notion of consensus and deliberation imbedded in the concept of the Swedish forestry model, by highlighting influential debates, conflicts and power relations that have been crucial to the development of forest policy and management over the years (cf.

Andersson 2009). Focus will thus be set on the dynamics of forest governance and forestry models and open up for discussing not only the existence of one single Swedish forestry model but possibly multiple, both past and future models.

The analyses will be based on policy documents produced by governmental as well as private stakeholders and on interviews with experts involved in past and present governmental policy processes. RT2 will be conducted in collaboration with PC1 (RT5) (Analyses of societal aspects on silvicultural shifts) and provide theoretical input to the other subprojects RT3 and RT4 and deliver new knowledge to the current scientific and popular forest policy debate.

RT3. Coping with uncertainty: regulation, decision making and learning in natural resource management

Background: It is more the rule than the exception that governmental agencies make decisions based on insufficient or uncertain knowledge. In most cases, organizations have developed strategies to deal with cognitive, strategic, institutional and normative uncertainty. However, when the economic stakes are high and there are demands for fast and firm decisions, cognitive uncertainty creates problems. Regulatory agencies commonly solicit expert knowledge so as to develop relevant and efficient regulation and recommendations. Conflicting pressures are put on experts, who are asked to rapidly give advice that is relevant, transparent and scientifically valid.

This RT will analyse how actors deal with uncertainty with regard to biodiversity. In particular, we will investigate how cognitive uncertainties are interpreted and transformed into recommendations to and action by forest managers. The role of uncertainty in decision making related to i) regular decision-making in forestry operation; ii) the major insect outbreaks following the storm Gudrun that hit south Sweden in 2005. By investigating both regular decision-making and an extreme case, the study will produce knowledge about decision-making under uncertainty with regard to biodiversity.

Approach: The theoretical framework includes (i) governance and regulation, (ii) path dependency, and (iii) social learning i.e. the organisational capacity to deal with complexity. These perspectives are strongly related in the sense that new forms of governance are historically contingent, and that new path creation depends on both social learning and on changes in policy and governance structures at different levels. The empirical material will consist of interviews and written materials. In the Gudrun study individual interviews will be conducted with persons involved in the process of mitigating damage after the storm felling, viz. key actors in the Swedish Forestry Agency, the forest company SÖDRA, land owners, and experts on predicting future risk of damage. The written material will mainly be policy documents, public records, and media reporting. A similar study will be conducted on decision making as related to biodiversity conservation at forestry operations. Although similar in approach, the biodiversity issue is very different; as it rests on empirical data that are even more uncertain due to their complex nature and long response time.

RT4. Analysing attitudes and cost-efficiency of strategies promoting forest landscape biodiversity

Background: The need to establish a resource efficient economy, including the role of biodiversity and other ecosystem services is widely acknowledged. It is thus necessary to develop cost-efficient strategies to guide decision-makers and landowners in developing plans to meet budget constraints as well as conservation objectives. The strategies need to be based on cost-effective solutions, taking into account the monetary aspects due to conservation. These types of strategies are being developed in Finland. However, every country is different why there is a need to specifically design a system of cost efficient policy and management tools to protect biodiversity and other ecosystem services in response to the Swedish context. While the focus in 6.1.3. is to simulate and analyse long-term effects of different landscape-level strategies for biodiversity conservation the purpose of this RT is to analyse the cost efficiency of alternative measures to conserve biodiversity in managed boreal forest landscapes but also to assess the attitudes of various strategies and conservation measures among land owners.

Approach: Given different scenarios for future forest management and conservation efforts at a landscape scale (constructed in the ForSA project 6.1.3.), we will here analyse long-term effects on the economic aspects of forest production. Different scenarios will be compared either by keeping the biodiversity value constant and comparing the financial costs or by keeping the financial costs constant and comparing the biodiversity value. In some studies we will only compare a limited number of relevant scenarios, while in others we may use mathematical optimisation to compare a large range of scenarios. The financial cost will be estimated as the decrease in net present value. For biodiversity value of alternative landscape strategies we will use various proxies derived from ForSA project 6.1.3. For the modelling we will use Heureka combined with models that reflect current knowledge of the biology of target species and models predicting the economic outcome current and emerging forestry practices. To this end, we plan to collaborate with Professor Artti Juutinen who is the leader of the project "Valuing and marketing forest externalities" in the Finnish Forest Research Institute with specific expertise about the cost-effectiveness of conservation actions in forest (e.g. Mönkkönen et al. 2011, Juutinen 2008). In addition we will, through surveys, analyse the attitudes of various strategies and conservation actions among stakeholders, e.g. single forest owners (non-industrial private forest owners or forest companies) as well as forest organisations (such as forest owners associations) to understand the potential problems and prospects of implementing different strategies and conservation actions.

RT5. Identifying conflicts and the need for choice and trade-offs

Background: Given the new political and institutional landscape described above, we will explore how actors on the Swedish forest political arena position themselves in relation to emerging issues and trends with a specific focus on biodiversity issues. The aim of this RT is to investigate actors' perceptions of future opportunities and challenges; their perceptions of the capacity of alternative policy/management options identified to respond to these; and thus to identify possible synergies, trade-offs, and conflicts. For example, what are actors' views on alternative landscape configurations and forestry models identified and analysed in RT1, RT2 and RT3?

Traditionally, the forest sector in most parts of the world include landowners, various users of forest land, loggers, transporters, and a range of industries producing pulp, paper, and wood products. The state and its agencies as well as social and environmental NGOs are also typically represented in the group (Gane 2007). Environmental, and sometimes social, arguments for greater forest conservation have historically stood against the forest industry´s interests of increasing wood production, in Sweden as well as in many other wood-producing regions (Lisberg Jensen 2002; Beland Lindahl 2008).

Research carried out during FF1 showed that this situation may now be about to change. Changing activities and outputs bring new actors into the sector while others may exit. The "rules of the game" are changing. Knowledge about key actors' response pathways, i.e. their perceptions and strategies are now needed to identify future conflicts, need for trade-offs, possible synergies, etc. How they position themselves in this transition process will shape Swedish forest politics and future management models.

Approach: In this RT we will develop a set of general methods and approaches to i) qualitatively explore actor's response pathways, i.e. their perceptions and strategies, and ii) involve actors in the research process to ensure a wide variety of views on forests and the Swedish forestry model, to get feed back on our research results but also to contribute to the capacity-building with regard to stakeholder participation in management activities, business enterprises, the forming of participatory structures and other related activities. These methods/approaches will be applied in PC 3 (RT 6), PC 4 (RT 4) and ForSA to address actors' responses to various contested questions and contexts. A combination of frame analysis (Perri 2005; Schön and Rien 1994; Beland Lindahl 2008) and institutional analysis (Leach et al. 2010; Raitio 2008) will be used to explore actors' response pathways and how they interlink with dominant institutions and governance processes. By mapping actors' interactions and networks, the conditions for coalition building will be investigated. Qualitative interviews and document analysis will be the main sources of empirical information. A number of Round Tables will be set up where researcher and actors/users can interact under the leadership of a professional facilitator. The setup of these Round Tables is described in 2.3.2.2.

Deliverables

- A comparative analysis of the Swedish forestry model with a specific focus on the potentials to govern increasing and competing demands on forested landscapes, envisioning possible ways forward.
- An historic analysis of how different stakeholders, perceptions and ideas in society (nationally and internationally) have shaped the Swedish forest policies and management systems and their practical implications on contemporary forest management.
- An assessment of potential governance mechanisms, in particular adaptive management and decision support models designed to manage multiple objectives in forested landscapes.
- An analysis of regulatory agencies potential to deal with conflicting demands in the management of in particular biodiversity conservation under conditions of great uncertainty.
- Ranking of the cost-efficiency of various biodiversity conservation measures at the landscape scale, to be used for decision making by forest landscape managers.
- An assessment of the attitudes among land-owners of the potential to implement various biodiversity conservation measures at the landscape scale.
- An overview of relevant actors' responses (perceptions and strategies) to the forestry models explored in RT1-RT4 it will identify competing demands, conflicts and synergies and thus highlight choices and trade-offs that decision makers, practitioners and stakeholders will be faced with.
- Participatory methods and processes that can help decision makers develop the policy tools that are needed to tackle trade offs and conflicts in efficient and democratic ways.

Personnel

Camilla Sandström will lead the work in PC4. She is senior lecturer and associate professor in political science, Umeå University. She is also associated to the Department of Fish, Wildlife and Environmental Studies at the Swedish University of Agricultural Sciences.

Karin Beland Lindahl is a post-doctoral research fellow at the Department of Urban and Rural Development, at the Swedish University of Agricultural Sciences. Her research deals with the politics of natural resource management and future studies of Swedish forest use in light of e.g. climate change.

Artti Juttinen is a professor and affiliated to the Department of Economics and Thule Institute, University of Oulu and the Finnish Forest Research Institute. His research primarily focuses on cost-effective forest conservation. He is currently leading the projects "Valuing and marketing forest externalities" and "Assessing recreation benefits of commercial state owned forest in Finland" in the Finnish Forest Research Institute.

Rolf Lidskog is a professor in sociology at the Centre for Urban and Regional Studies, at the Örebro University. His research focuses on environmental regulation, environmental sociology and risk communication.

Thomas Ranius is a professor at the Department of Ecology at the Swedish University of Agricultural Sciences. Much of his research deals with the effects of conservation efforts and future environmental changes on biodiversity.

Jean-Michel Roberge is a postdoctoral research fellow at the Department of Wildlife, Fish and Environmental Studies at the Swedish University of Agricultural Sciences. His research mainly focuses on conservation and restoration ecology, landscape ecology and forest biodiversity.

Daniel Sjödin has a PhD in sociology (2011) and will be postdoctoral fellow at Centre for Urban and Regional Studies, Örebro University. His research concerns social learning in organizations.

Anna Sténs is a postdoctoral fellow at the Department of Historical, Philosophical and Religious Studies, Umeå University. Much of her research deals with how historic and contemporary perceptions and ideas affect forest policy development.

Camilla Widmark is assistant professor at the Department of Forest Economics at the Swedish University of Agricultural Sciences. Her research interest is in forest policy and natural resource economics, in particular the valuation of ecosystem services.

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Part B

8. Deliverables

Below we present deliverables representing major milestones for Future Forests 2013 – 2016, and we have also included a coarse timetable indicating the time plan of the activities. The table is a summary of the deliverables mentioned in chapter 6. Detailed deliverable lists followed by similarly detailed timetables will be submitted yearly to Mistra in accordance to the Mistra principles for program management. It has been agreed that the 2013 plan for deliverables will be submitted to Mistra in late January 2013.

ForSA (including program communication)		
	Section	***Time***
ForSA as a permanent interdisciplinary stand-alone centre	4.2.	January 2017
Scientific book analysing the Swedish Forestry Model in a global context	9.5.	December 2016
A conceptual model for implementation of adaptive forest management in Sweden	6.1.4.	June 2014
Reports on scenario-analyses and back-casting of desired forest futures of various stakeholder categories	6.1.1.	January 2015
Reports on economic analyses of alternative Swedish forest futures in a global context	6.1.2.	December 2015
Reports on results of modelling study on strategies promoting forest landscape biodiversity	6.1.3.	December 2014
Comparative synthesis on landscape-level effects of alternative strategies for the application of silvicultural systems (even-aged vs. uneven-aged silviculture)	6.1.4.	December 2014
Operationalization of science-based decision support tools based on findings from 6.1.1., 6.1.2., 6.1.3.and 6.1.4.		December 2016
Establishment and reporting from thematic working groups	6.2.	Continuously
Communication of syntheses in "Future Forests Syntes"	9.5.	2-4 a year
Communication of popular science in the magazine Skog & Framtid	9.5.	Twice a year
Communication of short notices and announcements of meetings and forest excursions in "Future Forests Newsletters"	9.5.	4-6 times a year
Annual reports	9.5.	Yearly
Organization of Future Forests scientific meetings (round tables)	9.5.	2-4 times a year
Organization of Future Forests excursions;	9.5.	2-4 times a year
Future Forests Final Conferences	9.5.	December 2016
Program components		
Future silviculture	***Research topic, RT***	***Time***
Reports on new knowledge on intensified forest management that can be used in adaptive forest management	RT1	December 2014
Stand-level economic analysis of different silvicultural programs	RT1	December 2014
Analysis of the effect of short vs. long rotation on stand-	RT2	December 2015

level production, economy and biodiversity		
Systematic review of the biodiversity implications from applying even vs. uneven-aged silviculture.	RT3	June 2014
Development of a tree growth model for uneven-aged stands.	RT3	December 2013
Field studies on management of individual broadleaved trees in conifer dominated forest stands and on the impact of mixed tree species composition on biodiversity.	RT4	May-Sept 2013
Review of monocultures vs. mixed-forest plantations impacts on production, economy and biodiversity.	RT4	December 2014
Reports of investigation on the relation between historical land-use and today's biodiversity in forest landscapes.	RT5	December 2014
Forest soils and waters	***Research topic, RT***	***Time***
A quantitative meta-analysis of the amount of carbon sequestered in managed vs. unmanaged forest soils.	RT1	December 2013
Examination of how nitrogen fertilization affects soil functionality and leaching to surface waters.	RT2	June 2014
Assessment of how different silvicultural systems affect the nitrogen export to the Baltic Sea.	RT2	December 2014
Syntheses of the current knowledge of base cation release rates through weathering, long-term BC cycling, and effects of different silvicultural systems.	RT3	June 2015
Examination of how different silvicultural systems will affect soil-water availability and hydrology, and its implication for the Water Framework Directive and Payment for Ecosystem Services System.	RT4	December 2015
A development of landscape sensitivity tools to direct different silvicultural practices to different landscape areas, including minimizing mercury leaching to surface waters.	RT5	December 2015
Climate change adaptation and mitigation	***Research topic, RT***	***Time***
Analysis of the effects of new climate scenarios on forest growth.	RT1	December 2013
Evaluation of the effectiveness for climate change mitigation of different silvicultural systems.	RT2	December 2013
The develop of an integrated framework modelling tool for total forest carbon balance, where use of forest products and substitution are considered.	RT2	June 2014
An economical analysis of adaptation measures (to climate change) in forest management.	RT3	December 2014
An analysis of risks of pests and pathogens in a changed climate and adaptation of silviculture to minimize these risks.	RT3	June 2015
A contribution to the development of future regeneration material for Norway spruce.	RT3	December 2014
An analysis of how political processes (EU and Sweden) associated with pests and pathogens impact possibilities to govern outbreaks.	RT4	June 2014

An analysis of how forest-relevant policies at national and international level (state systems and risk management) integrate and influence adaptation to climate change in forest management.	RT4	December 2014
An exploration of perceptions and key actors responses to different kinds of forest related carbon accounting, offsetting and mitigation strategies and identify potential conflicts, synergies and needs for trade-offs.	RT5	June 2015
Governing increasing and competing demands on forests	***Research topic, RT***	***Time***
A comparative analysis of the Swedish forestry model with a specific focus on the potentials to govern increasing and competing demands on forested landscapes, envisioning possible ways forward.	RT1	December 2015
An historic analysis of how different stakeholders, perceptions and ideas in society (nationally and internationally) have shaped the Swedish forest policies and management systems and their practical implications on contemporary forest management.	RT2	June 2014
An assessment of potential governance mechanisms, in particular adaptive management and decision support models designed to manage multiple objectives in forested landscapes.	RT 1,2 & 5	December 2015
An analysis of regulatory agencies potential to deal with conflicting demands in the management of in particular biodiversity conservation under conditions of great uncertainty.	RT3	June 2014
Ranking of the cost-efficiency of various biodiversity conservation measures at the landscape scale, to be used for decision making by forest landscape managers.	RT4	December 2014
An assessment of the attitudes among land-owners of the potential to implement various biodiversity conservation measures at the landscape scale.	RT4	June 2015
An overview of relevant actors' responses (perceptions and strategies) to the forestry models explored in RT1-RT4 it will identify competing demands, conflicts and synergies and thus highlight choices and trade-offs that decision makers, practitioners and stakeholders will be faced with.	RT5	June 2015
Participatory methods and processes that can help decision makers develop the policy tools that are needed to tackle trade offs and conflicts in efficient and democratic ways.	RT5	December 2015

9. Communication strategy

It is stated that a Mistra program is successful when research of high scientific quality is put to practical use. We acknowledge that if the purpose is to initiate a process where actions are taken based on the scientific knowledge generated, the research process must be continuous, iterative, and include reciprocal exchange between science and practice.

The key message for our communication strategy is: *Future Forests* generates knowledge to enable science-based decisions for the future management of forests.

The overarching communication objective is to optimize the learning potential of the individuals and interest groups involved, to create constructive relations, and build capacities. The knowledge generated by *Future Forests* should be perceived as reliable and socially robust, i.e. understandable, acceptable, and applicable.

9.1. Target groups

Target groups for *Future Forests* communication are both internal within the program and external.

Internal:

- The Board
- *Future Forests* researchers

External:

- Forest sector officials
- Forest owners
- Politicians and Ministry officials (national and EU)
- Authorities (The Swedish Forest Agency, the Swedish Environmental Protection Agency, The Water Boards, the Swedish National Heritage Board)
- NGO’s with an interest in forest issues
- Energy sector officials
- The general public
- The international research community

9.2. Organization

The program director is ultimately responsible for communication activities in the program.

A communicator – Annika Mossing – leads the operative work, and develops and executes the communication plan.

The communication work is done in collaboration with information personnel at SLU, Umeå University, and Skogforsk. In addition, we have the ambition to create synergies with our collaborative partners’ on-going outreach and communication activities.

The communication plan is to be revised every year, and approved by the Board.

9.3. Chosen strategies

The communications strategy of *Future Forests* includes three levels of communication: **1) information measures,** which are mainly based on one-way communication, including printed information, regular newsletter and the website, but also forest excursions and seminars in which *Future Forests* researchers provide information about the program and the research that is conducted; **2) dialog meetings,** where representatives of the various target groups contribute with perspectives and views valuable to the researchers, who thereby receive feedback on how results are received, and **3)**

collaborative learning, where part of the research task involves collaboration between stakeholders and researchers, and the stakeholders are involved in development of research issues and analyses.

Strategy for stakeholder participation
From the activities during phase 1 we have learned that stakeholder commitments in most cases have to as little time-consuming as possible. In order to offer many opportunities to interact with *Future Forests*, the participation of stakeholders will be organized in a way that allows different degrees of commitment.

We will organize events, dialogue meetings and excursions that focus on issues that are relevant to both policy and science and that stakeholders and the scientific community recognize as urgent to discuss. The events can be arranged as workshops or seminars depending on the art of the issue at hand. The aim is to continue to invite a wide representation of stakeholders to collaborate with *Future Forests*. In order to make the expectations clear, we will formulate how we intend to make the results from each meeting play a part in the scientific work. The events will be an opportunity for stakeholders to be involved in an early stage of the scientific process, and raise questions and ideas that they regard as important.

Strategy for channels and activities
The choice of channels and activities to be used depends on the complexity of the issue and the intended audience. There is no 'one size fits all' formula, but there are a number of tools and techniques that can be applied to suit a given situation. We recognize timing as crucial and have the ambition to schedule activities, when possible, to coincide with important national and international meetings and events to raise interest and increase chances of an impact on decisions.

The core group of stakeholders from the forest industry and forest-related authorities, and to some extent NGO's often participate in events, such as excursions and meetings, for instance those arranged by SKOGEN and KSLA, and can therefore be reached by continuing to co-operate over such events.

By organizing "Round tables" on "hot topics" with a clear purpose to open a dialogue and ask for input on research at the planning stage, we hope to also reach NGO's and ministry officials, and target groups that have limited time/and or resources to take part in activites. The *Future Forests* Syntes is also an initiative aimed to communicate research from *Future Forests* on policy related topics.

Our ambition is to connect different communication activities and channels in order to create synergies. Examples of channels and activities are scientific and popular science publications, presentations, and information and marketing materials. Our web page (www.futureforests.se) is an important hub in our communication structure.

9.4. The magazine *Skog & Framtid* (Forest & Future)

The magazine *Skog & Framtid* (with two issues per year and a circulation of approx. 250.000) is the best channel for reaching forest owners, a big and diverse target group, that only rarely participates in organized events. After three issues, the magazine has established itself as a popular and easily accessible source for information about current forest research.

The key to the success of the magazine is the collaboration with the skilled and experienced editor Lars Klingström. With Lars Klingströms' solid background within the forest sector and his capacity to quickly and to the point translate scientific results into popular science and put them into the context of society and on-going debate, it is possible to produce a high quality magazine to a reasonable cost.

As a bonus, the magazine is distributed to stakeholders at excursions, conferences and other events. It is also offered for free to Swedish high schools with a natural resource management profile.

9.5. Future Forests education

During *Future Forests* phase 1, an interdisciplinary Ph.D. course was organized with the title "Forests in a changing world integrating values, interests and trade-offs". In phase 2, we will continue this activity and offer Ph.D.courses on a yearly basis.

9.6. The Future Forests book project

In *Future Forests* phase 2, the Swedish Forestry Model will be the focus of a number of analyses aimed at clarifying and scrutinizing the conceptual framework for today's management of Swedish forests. These will be presented in a peer-review book at the end of the program period. Professor Stig Larsson, the former assistant program director of Future Forests, will edit the book and the lead authors will be *Future Forests* researchers.

The basis for the book is an interdisciplinary scientific approach to experiences from two decades of decision-making and actions under the current framework of the Swedish Forestry Model. With the analyses carried out in *Future Forests* we expect to foresee, and further develop, the potential for its use in the future. Many different aspects of the Swedish Forestry Model will be researched and hence featured in the book. These are described in detail in the program plan.

9.7. Communication plan

Target group	**Activities/channel**	**Responsible**	**Date**
Board	Website "*Future Forests* Syntes" (scientific results in short) "*Future Forests* Nyhetsbrev" (newsletter)	Annika M Annika M Annika M	Cont. 8-10/yr 4-6/yr
Program researchers	Program conferences and meetings Website "*Future Forests* Syntes" "*Future Forests* Nyhetsbrev"	FF SMG Annika M Annika M Annika M	Yearly Cont. 8-10/yr 4-6/yr
Future Forest network	Stakeholder conference Stakeholder workshops Stakeholder excursions Website "*Future Forests* Syntes" "*Future Forests* Nyhetsbrev" Basic information material	FF SMG FF SMG FF SMG Annika M Annika M Annika M Annika M	2016 2-4/yr 1-2/yr Ongoing 8-10/yr 4-6/yr Yearly
External target groups; Representatives from the forestry sector, including NGO:s, authorities, and politicians.	Stakeholder conference Stakeholder workshops Stakeholder excursions Website "*Future Forests* Syntes" "*Future Forests* Nyhetsbrev" Basic information material Media through press releases	FF SMG FF SMG FF SMG Annika M Annika M Annika M Annika M Annika M	2016 2-4/yr 1-2/yr Cont. 8-10/yr 4-6/yr Yearly On occasion

Forestry owners	"Skog & Framtid" (popular magazine) Media through press releases	Annika M Annika M	2/yr On occasion
The general public	Popular book to summarize the conclusions of *Future Forests* Media through press releases Website (in Swedish)	FF SMG Annika M Annika M	2016 On occasion Cont.
The international research community	Website (in English) Scientific workshops	Annika M Researchers	Cont. On occasion

10. Budget

Below is the budget for 2013 - 2016. It is noteworthy that part of SLU's funding has been assigned to cover over-head costs. Overhead cost has been calculated as 35 % of salary costs. Costs in the first three years exceed the average annual contributions of financiers. As a consequence program costs will be less in the last year than the first three years. This reduces the risk of unspent funds remaining at the end of the program period.

Program researchers will be contracted for three years, 2013 - 2015. The last year of the program a main focus will be on communication and finalizing research projects. The personnel will be contracted accordingly, and will besides communication personnel consist of program researchers with skills and interests to take part in the process of finalizing the program. The communication budget is twice as high in the last year compared to the previous years.

Detailed budgets will be submitted yearly to Mistra in accordance to the Mistra principles for program management.

INCOMES	**Annual**	**Total**
Mistra	14 000 000	56 000 000
Forest Enterprises	6 000 000	24 000 000
Skogforsk	1 500 000	6 000 000
Umeå University	2 000 000	8 000 000
SLU	4 500 000	18 000 000
SLU ”cash” contribution to OH	3 500 000	14 000 000
Sum of incomes	**31 500 000**	**126 000 000**

COSTS	**2013**	**Total**
Personnel	17 984 000	63 546 619
Travel expenses	1 325 000	4 902 500
Supplies	1 290 000	4 773 000
Other expenses	1 875 000	7 937 500
OH incl. rent	6 294 000	22 139 881
Services	5 865 000	22 700 500
Sum of costs	**33 933 000**	**126 000 000**

Program management

COSTS	2013	Total
Travel expenses	200000	740000
Supplies	50000	185000
Other expenses	200000	740000
Services	200000	740000
Sum of costs	**650000**	**2405000**

Program board

COSTS	2013	Total
Travel expenses	25000	92500
Supplies	0	0
Other expenses	75000	277500
Services	150000	550000
Sum of costs	**250000**	**925000**

Communication

COSTS	2013	Total
Travel expenses	75000	277500
Supplies	25000	92500
Other expenses	350000	2295000
Services	1900000	8030000
Sum of costs	**2350000**	**10695000**

ForSA 6.1.1.

COSTS	2013	Total
Travel expenses	75000	277500
Supplies	50000	185000
Other expenses	50000	185000
Services	150000	555000
Sum of costs	**325000**	**1202000**

ForSA 6.1.2.

COSTS	2013	Total
Travel expenses	75000	277500
Supplies	25000	92500
Other expenses	50000	185000
Services	1200000	4440000
Sum of costs	**1350000**	**4884000**

ForSA 6.1.3.

COSTS	2013	Total
Travel expenses	75000	277500
Supplies	25000	92500
Other expenses	200000	740000
Services	400000	1480000
Sum of costs	**700000**	**2590000**

ForSA 6.1.4.

COSTS	2013	Total
Travel expenses	100000	370000
Supplies	100000	370000
Other expenses	200000	740000
Services	400000	1480000
Sum of costs	**800000**	**2960000**

ForSA 6.2.

COSTS	2013	Total
Travel expenses	200000	740000
Supplies	50000	185000
Other expenses	50000	185000
Services	400000	1480000
Sum of costs	**700000**	**2590000**

PC 1

COSTS	2013	Total
Travel expenses	100000	370000
Supplies	600000	2220000
Other expenses	200000	740000
Services	300000	1110000
Sum of costs	**1200000**	**4440000**

PC 2

COSTS	2013	Total
Travel expenses	150000	555000
Supplies	100000	370000
Other expenses	200000	740000
Services	400000	1480000
Sum of costs	**850000**	**3145000**

PC 3

COSTS	2013	Total
Travel expenses	100000	370000
Supplies	100000	370000
Other expenses	200000	740000
Services	215000	795500
Sum of costs	**615000**	**2275500**

PC 4

COSTS	2013	Total
Travel expenses	150000	555000
Supplies	165000	610500
Other expenses	100000	370000
Services	150000	555000

10.1. Staff list

Program researchers will be contracted for not more than three years, 2013 - 2015. PhD-students will only be contracted until they dissertate. According to university employment regulations, post-doctoral research fellows cannot be contracted for more than two years. Obviously the staff list below applies primarily to 2013 and is to some extent indicative, as it is the hosting universities/institute that takes final decisions on employment.

Personnel	% of full time financed by Future Forests	% of full time as in kind contribution from SLU
Axelsson Petter, SLU	100	
Beland-Lindal Karin, SLU	80	
Bergh Johan, SLU	50	
Berlin Mats, Skogforsk	50	
Bishop Kevin, SLU/Uppsala Univ		20
Björkman Christer, SLU		20
Boberg Johanna, SLU	50	
Egnell Gustaf, SLU		80
Ellison David, Consultant	50	
Fahlvik Nils, SLU	50	
Felton Adam, SLU	50	
Futter Martyn, SLU	60	
Gong Peichen, SLU	20	
Gunulf Anna, SLU	40	
Holmström Emma, SLU	50	
Högberg Peter, SLU		20
Jonsson, Ragnar, SLU		20
Keskitalo Carina, Umeå Univ	20	
Klapwijk Maartje, SLU	50	
Laudon Hjalmar, SLU		50
Lidskog Rolf, Örebro Univ	10	
Lundmark Tomas, SLU		50
Lundström Anders, SLU	20	
Lundqvist Lars, SLU	10	
Lämås Tomas, SLU	30	
Moen Jon, Umeå Univ	100	
Mossing Annika, SLU	100	
Mårald Erland, Umeå Univ	30	
Nilsson Urban, SLU		50
Nordin Annika, SLU	100	
Nordmark Jan-Peter, SLU	50	
Nordström Eva-Maria, SLU	50	
Ranius Thomas, SLU	50	
Ring Eva, Skogforsk	50	
Rist Lucy, Umeå Univ	80	
Roberge J-M, SLU	50	

Sandström Camilla, Umeå Univ	50	
Sjödin Daniel, Örebro Univ	50	
Sjölin Olle, Skogforsk	50	
Sonesson Johan, Skogforsk	50	
Sponseller Ryan, SLU	50	
Stenlid Jan, SLU		20
Wallertz Kristina, SLU	40	
Sténs Anna, Umeå Univ	80	
Widmark Camilla, SLU		20
Ågren Anneli, SLU	30	
Östlund Lars, SLU		20
Post doc NN/PhD NN/Technical	480	
Total	**2330**	**370**

In total, salary costs amount to 17 984 000 kr in 2013. In kind contribution of salary costs for chairs and staff with other funding has not been included in the budget but the extent is indicated in the staff list above.

Appendix 1. Curriculum vitaes of senior management group

CV/ANNIKA NORDIN

Degree:	Ph.D. in Forest Plant Physiology	**Current appointment:**	Professor
Affiliation:	Umeå Plant Science Centre, Swedish University of Agricultural Sciences (SLU)	**Birth year:**	1968
		Sex:	Female

Interests in relation to Future Forests:
Annika Nordin has served as *Future Forests*' Program Director since 2010. Her previous merits of academic leadership includes leading positions at the Faculty of Forest Sciences, SLU: Vice dean responsible for PhD education 2007 – 2009 and Prodean responsible for leading the *Future Forests* program, and for faculty extension 2010 – 2012. Additionally Nordin has since 2000 led a research group in the field of forest ecophysiology focusing on nitrogen fertilization effects on forest plant biodiversity.

The most relevant publications:
Strengbom, J., **Nordin, A.** 2012. Physical disturbance determines effects from nitrogen addition on ground vegetation in boreal coniferous forest. Journal of Vegetation Science 23: 361-371.

Nordin, A., Larsson, S., Moen, J., Linder, S. 2011. Science for trade-offs in *Future Forests*. Forests 2: 631-636.

Gundale, M., DeLuca, T., Nordin, A. 2011. Bryophytes attenuate anthoprogenic nitrogen inputs in boreal forests. Global Change Biology doi: 10.1111/j.1365-2486.2011.02407.x

Johansson, O., **Nordin, A**., Olofsson, J., Palmqvist, K. 2010. Responses of epiphytic lichens to an experimental whole-tree nitrogen-deposition gradient. New Phytologist 188: 1075-1084.

Hedwall, P-O., **Nordin, A**., Brunet, J., Bergh, J. 2010. Compositional changes of forest-floor vegetation in young stands of Norway spruce as an effect of repeated fertilization. Forest, Ecology & Management 259: 2418-2525.

Bobbink, R., Hicks, K., Galloway, J., Spranger, T., Alkemade, R., Ashmore, M., Bustamante, M., Cinderby, S., Davidson, E., Dentener, F., Emmett, B., Erisman, J-W., Fenn, M., Gilliam, F., **Nordin, A**., Pardo, L. & de Vries, W. 2010. Global Assessment of Nitrogen Deposition Effects on Terrestrial Plant Diversity: a synthesis. Ecological Applications 20: 30-59.

Ishida, T. A., **Nordin, A.** 2010. No evidence that nitrogen enrichment affect fungal communities of Vaccinium roots in two contrasting boreal forest types. Soil, Biology & Biochemistry 42: 234 - 243.

Nordin, A., Strengbom, J., Forsum, Å., Ericson, L. 2009. Complex biotic interactions drive long-term vegetation change in a nitrogen enriched boreal forest. Ecosystems 12: 1204-1211.

Wiedermann, M. M., Gunnarsson, U., Nilsson, M. B., **Nordin, A**. & Ericson, L. 2009. Can small scale experiments predict ecosystem responses? An example from peatlands. Oikos 118: 449-456.

Wiedermann, M. M., **Nordin, A**., Gunnarsson, U., Nilsson, M. B. & Ericson, L. 2007. Global change shifts vegetation and plant-parasite interactions in boreal mire. Ecology 88: 454-464.

CV/JOHAN BERGH

Degree:	Associate professor, SLU Appointed professor, MIUN	**Current appointment:**	Senior extension officer research leader
Affiliation:	Southern Swedish Forest Research Centre SLU	**Birth year:**	1965
		Sex:	Male

Research interests in relation to Future Forests:
My area of expertise is ecophysiology, forest production and forest management, all linked together by the effects of climate change. My interests mainly concerns how nutrient dynamics and climate change may affect boreal forest ecosystems, including risks related to climate change. Adapted forest management is one way to take advantage of the new situation, to handle potential risks and to minimize damage. My interests also include how to manage the forest to mitigate effects of climate change through uptake/storage of carbon dioxide and through an optimal usage of the forest raw material. Collaboration with the Swedish forest industry and society constitutes a big part of my work. I also work internationally to give advice on plantation forestry.

The most relevant publications:

Bergh, J., et al. 2003. Modelling the short-term effects of climate change on the productivity of selected tree species in Nordic countries. Forest Ecology and Management 183: 327-340.

Bergh, J., Linder, S. and Bergström, J. 2005. The potential production for Norway spruce in Sweden. Forest Ecology and Manangement 204: 1-10.

Bergh, J., Freeman, M., Kellomäki, S. and Linder, S. 2006. Impact of climate change on the forest growth and the production potentials of bio-fuels in forestry. In: Impacts of climate change on renewable energy sources and their role in Nordic and Baltic energy systems: case of bio-fuels. Research notes 170: 19-37.

Bergh, J., Nilsson, U., Kjartansson, B. & Karlsson, M. 2010. Impact of climate change on the productivity of Silver birch, Norway spruce and Scots pine stands in Sweden with economic implications for timber production. Ecological Bulletins, 53(15), 2010: pp. 185-195.

Sathre, R., Gustavsson, L. & and **Bergh, J**. 2010. Greenhouse gas implications of increased biomass production from optimised forest fertilization. Biomass and Bioenergy (34): 572-581.

Poudel, B.C., Sathre, R., Gustavsson, L., **Bergh, J**., Lundström, A. and Hyvönen. R. 2011. Effects of climate change on biomass production and substitution in north-central Sweden. Biomass & Bioenergy, vol 35, 4340-4355.

Poudel C.B., Sathre R., **Bergh J.**, Gustafsson L., Lundström A., Hyvönen R. 2012. Potential effects of intensive forestry on biomass production and total carbon balance in north-central Sweden. Environmental Science & Policy, vol 15, 106-124.

Bergh, J., Johansson, U., Nilsson, U., Sallnäs, O. and Lundström, A. 2012. Är anpassning av skogsskötseln nödvändigt i dagsläget för att minska skogsskador i ett förändrat klimat? Analyser på beståndsnivå och landskaosnivå. Institutionsrapport nr 43 vid Institutionen för Sydsvensk Skogsvetenskap (76 sidor).

CV/HJALMAR LAUDON

Degree:	Ph.D. in Soil Science	**Current appointment:**	Professor (Chair) in forest landscape biogeochemistry
Affiliation:	Forest Ecology and Management Swedish University of Agriculture	**Birth year:**	1966
		Sex:	Male

Research interests in relation to Future Forests:
Hjalmar Laudon is a professor, and holds the chair, in forest landscape biogeochemistry at SLU. His research is focused on process based understanding of how forestry and climate induced changes in biogeochemistry and hydrology affect the sustainability of the boreal landscape. The main focus of his research is on the transition zone between soils and surface waters and how catchment scale affects the dominating processes in the forested landscape. He has several years experience from research in USA and Canada and has the last 10 years been the director of the multi-disciplinary Krycklan catchment study. He is involved in several synthesis projects around the world. Laudon is also the PI for the ForWater strong research program on improving the modeling and prediction capability of how forestry affects water quality in a changing climate. He has published over 120 peer-reviewed papers of which half are from the last five years.

The most relevant publications:

Laudon, H., Buttle, J., Carey, S.K., McDonnell, J., McGuire, K., Seibert, J., Shanley, J., Soulsby, C., and Tetzlaff, D., (2012). Cross-regional prediction of long-term trajectory of stream water DOC response to climate change. Geophysical Research Letters, 39, L18404.

Schelker, J., Eklöf, K., Bishop, K. and **Laudon. H** (2012). Effects of forestry operations on dissolved organic carbon (DOC) concentrations and export in boreal first-order streams, Journal of Geophysical Research-Biogeoscience, JG001827.

Laudon, H., Berggren, M., Ågren, A., Buffam, I., Bishop, K., Grabs, T., Jansson, M., Köhler, S. (2011). Patterns and Dynamics of Dissolved Organic Carbon (DOC) in Boreal Streams: The Role of Processes, Connectivity, and Scaling Ecosystems, 14, 880-893.

Laudon, H., Sponseller, R.A., Lucas, R.W., Futter, M.N., Egnell, G., Bishop, K., Ågren, A., Ring, E., and Högberg, P. (2011). Consequences of More Intensive Forestry for the Sustainable Management of Forest Soils and Waters, Forests, 2, 243-260.

Klaminder, J., Lucas, R.W., Futter, M.N., Bishop, K., Köhler, S.J., Egnell, G. and **Laudon, H.** (2011). Silicate mineral weathering rate estimates: Are they precise enough to be useful when predicting the recovery of nutrient pools after harvesting? Forest Ecology and Management, 261, 1-9.

Laudon, H., Hedtjärn, J. Schelker, J., Bishop, K., Sørensen, R., and Ågren, A. (2009). Response of dissolved organic carbon (DOC) following forest harvesting in a boreal forest. Ambio, 7, 381-386.

Laudon, H. and Buffam, I. (2008). Impact of changing DOC concentrations on the potential distribution of acid sensitive biota in a boreal stream network, Hydrology and Earth System Science, 12, 425-435.

Laudon, H., Sjöblom, V., Buffam, I., Seibert, J. and Mörth, CM. (2007). The role of catchment scale and landscape characteristics for runoff generation of boreal streams. Journal of Hydrology, 344, 198-209.

CV/TOMAS LUNDMARK

Degree:	Professor in Forest Management	**Current appointment:**	Professor
Affiliation:	Department of Forest Ecology and Management, Swedish University of Agricultural Sciences	**Birth year:**	1955
		Sex:	Male

Research interests in relation to Future Forests:
Tomas Lundmark is the dean of the Faculty of Forest Sciences at the Swedish University of Agricultural Sciences (term of office expires 20121231). He has extensive experience from managing field based forest research infrastructure and was appointed director of SLUs Unit of Field-based Forest Research 2004-2009. Since 2009 he holds the faculty chair in forest management. Lundmark's research has been in the boundary between ecophysiology and applied silviculture. The empirical field studies have mainly focused on plant responses to environmental stresses, effects of nitrogen fertilization, yield studies in even-aged and uneven-aged stands and management for biodiversity. He has also carried out studies on forest carbon balances in relation to different management strategies. Lundmark has an extensive network throughout the forestry sector and a strong commitment to outreach.

The most relevant publications:
Hyvönen, R., Ågren, G., Linder, S., Persson, T., Cotrufo, F.M., Ekblad, A., Freeman, M., Grelle, A., Janssens, I., Jarvis, P.G., Kellomäki, S., Lindroth, A., Loustau, D., **Lundmark, T**., Norby, R., Oren, R., Pilegaard, K., Ryan, M., Sigurdsson, B., Strömgren, M., Oijen, M. & Wallin, G. 2007. The likely impact of elevated [CO_2], nitrogen deposition, increased temperature, and management on carbon sequestration in temperate and boreal forest ecosystems. A literature review. New Phytologist 173: 463-480.

Bergh, J., Grip, H, Nilsson, U and **Lundmark, T**. 2008. Effects of frequency of fertilisation on production, foliar chemistry and nutrient leaching in young Norway spruce stands in Sweden. Silva Fennica, 42(5) 721-733.

Högberg, P., Högberg, M.N., Göttlicher, S.G., Betson, N.R., Keel, S.G., Metcalfe, D.B., Campbell, C., Schindlbacher, A., Hurry, V., **Lundmark, T.**, Linder, S., Näsholm, T. 2008: High temporal resolution tracing of photosynthate carbon from the tree canopy to forest soil microorganisms. New Phytologist, 177, 220-228.

Lidén, M., Jonsson Cabrajic, A., Palmqvist, K., Ottosson-Löfvenius, M. and **Lundmark, T.** 2010. Species-specific activation time lags can explain habitat restrictions in hydrophilic lichens. Plant Cell and Environment 33: 851-862.

Nilsson, U., Agestam, E., Ekö, P-M., Elfving, B., Fahlvik, N., Johansson, U., Karlsson, K., **Lundmark, T**., and Wallentin, C. 2010. Thinning of Scots pine and Norway spruce monocultures in Sweden. Studia forestalia Suecica; 219.

CV/JON MOEN

Degree: Ph.D. in Ecology

Current appointment: Professor

Affiliation: Dept. of Ecology and Environmental Science
Umeå University

Birth year: 1960

Sex: Male

Research interests in relation to Future Forests:
Jon Moen is an ecologist with expertise in natural resource ecology and management.. His research ranges from plant ecology and plant-herbivore interactions, to analyses of land use and ecosystem services in landscapes. He has worked extensively with land use issues from conservation to reindeer husbandry and forestry. His current research is predominantly interdisciplinary, where collaborations with political scientists, human geographers, and historians are especially prominent. He has special interests in facilitating and organising interdisciplinary research, and is also interested in the interactions between science and society. Professor Moen is the author of over 90 peer-reviewed and popular-press articles.

The most relevant publications:

Rist, L. & **Moen, J.** 2012. Does resilience offer a new model for sustainable forest management? Ecology and Society (accepted)

Setten, G., Stenseke, M. & **Moen, J.** 2012. Ecosystem services and landscape management: three challenges and one plea. International Journal of Biodiversity Science, Ecosystem Services & Management Early view

Kivinen, S., Berg, A., **Moen, J.**, Östlund, L. & Olofsson, J. 2012. Forest fragmentation and landscape transformation in a reindeer husbandry area in Sweden. Environmental Management 49: 295-304.

Horstkotte, T., **Moen, J.**, Lämås, T. & Helle, T. 2011. The legacy of logging - estimating arboreal lichen occurrence in a Boreal multiple-use landscape on a two century scale. PLoS ONE 6(12): e28779.

Moen, J. & Keskitalo, C. 2010. Interlocking panarchies in multi-use boreal forests in Sweden. Ecology & Society 15(3): 17 [online]

Olofsson, J., **Moen, J**. & Östlund, L. 2010. Effects of reindeer on boreal forest floor vegetation: do grazing cause vegetation state transitions? Basic and Applied Ecology 11: 550-557

Kivinen, S., **Moen, J**., Berg, A. & Eriksson, Å. 2010. Effects of modern forestry on winter grazing resources for reindeer in Sweden. Ambio 39: 269-278.

Nilsson, C., Jansson, R., Keskitalo, E.C.H., Vlassova, T., Sutinen, M.-L-. **Moen, J**. & Chapin, F.S.III. 2010. Challenges to adaptation in northernmost Europe as a result of global climate change. Ambio 39: 81-84.

Berg, A., Östlund, L., **Moen, J**. & Olofsson, J. 2008. A century of logging and forestry in a reindeer herding area in northern Sweden. Forest Ecology and Management 256: 1009-1020

Moen, J. 2008. Climate change: effects on the ecological basis for reindeer husbandry in Sweden. Ambio 37: 304-311.

Sandström, C., **Moen, J**., Widmark, C. & Danell, Ö. 2006. Progressing toward co-management through collaborative learning – forestry and reindeer husbandry in dialogue. International Journal of Biodiversity Science and Management 2: 326-333.

CV/ANNIKA MOSSING

Degree:	M.Sc. in Earth Science	**Current appointment:**	Communications Officer
Affiliation:	Department of Communication Swedish University of Agricultural Sciences	**Birth year:**	1972
		Sex:	Female

Background:
Annika Mossing is a former journalist with a career at the national Swedish television company *Sveriges Television*. Annika Mossing has worked with a number of popular prime-time television series, such as Uppdrag Granskning (investigative journalism), Mitt i naturen (a wildlife show) and PLUS (consumer report) in the positions of researcher and editor. She has also been involved in television and documentary series concerning environmental issues, such as climate adaptation in Sweden, the effect of climate change on indigenous people in the Arctic and environmental innovation. Annika Mossing has a university degree including physical geography, chemistry, political science and economical history, and has also studied journalism.

CV/URBAN NILSSON

Degree:	Docent in Silviculture	**Current appointment:**	Professor
Affiliation:	Southern Swedish Forest Research Centre SLU	**Birth year:**	1959
		Sex:	Male

Research interests in relation to Future Forests:
Urban Nilsson is a forest researcher whose research focuses on management of planted Norway spruce and Scots pine. During the 1990:s, his research focused on regeneration of these two species. During the recent years, he has changed focus and is now more interested in stand management and modeling of forest stands. Prof. Nilsson is currently involved in a number of research projects dealing with e.g. thinning in Norway spruce and Scots pine, modeling growth of genetically improved trees, investigations on the effect of climate change on tree phenology and growth and management of forest stands to reduce the risk of wind-throw. Prof. Nilsson is currently main supervisor of five PhD-students and assistant supervisor for another two PhD-students. He is also engaged in teaching undergraduate-courses at basic and advanced level and he has been involved in the organization of numerous excursions and educations for forest managers in practical forestry. Prof. Nilsson has published 57 peer-reviewed scientific articles

The most relevant publications:

Nilsson, U., Elfving, B., Karlsson, K. 2012. Productivity of Norway spruce compared to Scots pine in the interior of northern Sweden. Silva Fennica, 46, 197-209.

Wallentin, C. & **Nilsson, U**. 2011. Initial effect of thinning on stand gross stem-volume production in a 33-year-old Norway spruce (Picea abies (L.) Karst.) stand in southern Sweden. Scand. J. For Res. 26: 21-35.

Nilsson, U., Fahlvik, N., Johansson, U., Lundström, A., Rosvall, O. 2011. Simulation of the effect of intensive forest management on forest production in Sweden. Forests 2: 373-393.

Nilsson, U., Luoranen, J., Kolström, T., Örlander, G. & Puttonen, P. 2010. Reforestation with planting in northern Europe. Scandinavian Journal of Forest research 25: 283-294.

Nilsson, U., Agestam, E., Ekö, P-M., Elfving, B., Fahlvik, N., Johansson, U., Karlsson, K., Lundmark, T., Wallentin, C. 2010. Thinning of Scots pine and Norway spruce monocultures in Sweden – Effects of different thinning programmes on stand level gross- and net stem volume production. Studia Forestalis Suecica 219: 1-46.

Nilsson, U. & Gemmel, P. 2007. Growth in supplementarily planted Picea abies regenerations. Scandinavian Journal of Forest Research 22, 160-167.

Johansson, K., **Nilsson, U**. & Allen, H.L. 2007. Interactions between soil scarification and Norway spruce seedling types. New Forests 33, 13-27.

Nordborg, F., **Nilsson, U**., Gemmel, P. & Örlander, G. 2006. Carbon and nitrogen stocks in soil, trees and field vegetation in conifer plantations 10 years after deep soil cultivation and patch scarification. Scandinavian Journal of Forest Research 21, 356-363.

Nilsson, U., Örlander, G. & Karlsson, M. 2006. Establishing mixed forests in Sweden by combining planting and natural regeneration - effects of shelterwoods and scarification. Forest Ecology and Management 237, 301-311.

Fahlvik, F., Agestam, E., **Nilsson, U**. & Nyström, K. 2005. Simulating the influence of initial stand structure on the development of young mixtures of Norway spruce and birch. Forest Ecology and Management 213, 297-31.

CV/CAMILLA SANDSTRÖM

Degree:	Ph.D. in Political Science	**Current appointment:**	Senior lecturer/ Associated professor
Affiliation:	Dept. of Political Science Umeå University	**Birthyear:**	1967
		Sex:	Female

Research interests in relation to Future Forests:
Camilla Sandström is a political scientist with an expertise in the governance and management of natural resources and rural development. Her research ranges from how institutional aspects (rules and norms), influence the incentives to sustainably govern natural resources, through studies in close collaboration with stakeholders on how to manage common pool resources such as forests, fish and game, to quantitative studies on wildlife and biodiversity conservation values. Sandström was recently awarded with FORMAS research grant: Future research leaders in rural development. She has ten years of interdisciplinary research experience and has co-edited one book, published 25 peer-reviewed articles, 8 book chapters and 20 technical reports in Swedish to provide the Swedish audience with research results.

The most relevant publications:

Sandström, C & Sténs, A., (Accepted). Dilemmas in forest policy development – "the Swedish forestry model" under pressure. Book chapter in Forest Futures: re-thinking global trends - implications for boreal regions (eds. Karin Beland Lindahl/Erik Westholm).

Widmark, C., Bostedt, G., Andersson, M., & **Sandström, C.** (2013). Measuring transaction costs incurred by landowners in multiple land-use situations. Land Use Policy, 30(1), 677-684.

Sténs, A., & **Sandström, C**. In press. Divergent interests and ideas around property rights: The case of berry harvesting in Sweden. Forest Policy and Economics.

Sandström, P., **Sandström, C**., Svensson, J., Jougda, L., Baer, K. 2012. Participatory GIS to mitigate conflicts between reindeer husbandry and forestry in Vilhelmina Model Forest, Sweden. Forestry Chronicle. Vol. 88: 3pp. 254-260.

Fischer, A., **Sandström, C**., Delibes-Mateos, M., Arroyo, B., Tadie, D., Randall, D., . . . Majić, A. (2012). On the multifunctionality of hunting – an institutional analysis of eight cases from Europe and Africa. Journal of Environmental Planning and Management, 1-22.

Ezebilo, E. E., **Sandström, C.**, & Ericsson, G. (2012). Browsing damage by moose in Swedish forests: assessments by hunters and foresters. Scandinavian Journal of Forest Research, 27(7).

Sandström, C. (2012). Managing Large Ungulates in Europe: The Need to Address Institutional Challenges of Wildlife Management. Human Dimensions of Wildlife, 17(5), 320-332.

Sandström, C., Lindkvist, A., Öhman, K., Nordström, E-M. 2011. "Governing Competing Demands for Forest Resources in Sweden." Forests 2, no. 1: 218-242.

Keskitalo, E. H., **C. Sandström**, M. Tysiachniouk and J. Johansson. 2009. Local Consequences of Applying International Norms: Differences in the Application of Forest Certification in Northern Sweden, Northern Finland, and Northwest Russia. Ecology and Society 14 (2): 1.

Sandström, C. 2009.'Institutional Dimensions of Comanagement: Participation, Power, and Process', Society & Natural Resources, 22: 3, 230-244.

Appendix 2. Curriculum vitaes of program researchers

CV/PETTER AXELSSON

Degree:	Ph.D. in Ecology	**Current appointment:**	Post-doc
Affiliation:	Department of Forest Ecology and Management, Swedish University of Agriculture Sciences	**Birth year:**	1973
		Sex:	Male

Research interests in relation to Future Forests:
PAs research is currently focusing on developing the ecophysiological base of forest regeneration and growth of forest trees under canopies to provide knowledge of importance for implementing an uneven aged management in boreal forests. This basic knowledge includes an understanding of mechanisms of competition (below and above ground) in such stands and its importance for regeneration and productivity.

The most relevant publications:

Axelsson EP and Andersson J. (Accepted) A case study of termite mound occurrence in relation to forest edges and canopy cover within the Barandabhar Forest Corridor in Nepal. International Journal of Biodiversity and Conservation.

Axelsson EP and Stenberg JA. (In press) Associational resistance in a multiple herbivore system: differential effects of mammal vs. insect herbivores. Ecological Research.

Axelsson EP and Hjältén J. (2012) Tolerance and growth responses of populus hybrids and their genetically modified varieties to simulated leaf damage and harvest. Forest Ecology and Management 276, 217-223.

Hjältén J, **Axelsson EP** et. al. (2012) Increased resistance of Bt aspens to Phratora vitellinae (Coleoptera) leads to increased plant growth under experimental conditions. PLoS ONE

Axelsson EP et. al. (2012) Performance of insect-resistant Bacillus thuringiensis (Bt)-expressing aspens under semi-natural field conditions including natural herbivory in Sweden. Forest Ecology and Management 264 (15): 167-171.

Axelsson EP et. al. (2011) Leaf litter from insect-resistant transgenic trees cause changes in aquatic insect community composition. Journal of Applied Ecology 48: 1472-1479.

Axelsson EP et. al. (2011) Leaf ontogeny interacts with Bt-modification to affect innate resistance in GM aspens. Chemoecology, 21(3): 161-169.

Axelsson EP et. al. (2010). Can leaf litter from genetically modified trees affect aquatic ecosystems? Ecosystems 13(7):1049-1059.

Stenberg JA and **Axelsson EP**. (2008). Host race formation in the meadowsweet and strawberry feeding leaf beetle Galerucella tenella. Basic and Applied Ecology, 9 (5): 560-567.

CV/KARIN BELAND LINDAHL

Degree: Ph.D. in Rural Developement **Current appointment:** Post Doctoral Researcher

Affiliation: Dept. of Urban and Rural Development, Swedish University of Agricultural Sciences **Birth year:** 1964

Sex: Female

Research interests:
Karin Beland Lindahl has more than 25 years experience from working with national as well as international forest issues in a range of different capacities. Her research primarily focuses on politics of natural resource management and a central theme is forest related controversies. Studies cover local forest controversies and the roles of place perceptions, participation and collaboration, multi level forest governance as well as future Swedish forest use in light of global change, e.g. climate change and energy transition. She is currently co-editing a book about global trends and the future of Nordic Forestry. Her research is based in political science and a tradition of interpretive policy analysis. She made her first post doctoral period at the Institute for Future Studies in Stockholm and is familiar with different kinds of futures study methodologies and transdisciplinary research approaches. Pedagogical experiences include teaching at undergraduate level, organisation of PhD courses, and various kinds of communication with stakeholders and end users including a large number of popular science presentations.

The most relevant publications:

Beland Lindahl, K. & Westholm, E. 2011. Food, Paper, Wood or Energy: Global Trends and Future Swedish Forest Use. Forests, 2, 51-65.

Beland Lindahl, K. & Westholm. E. 2011. *Future Forests*: Perceptions and Strategies of Key Actors. Scandinavian Journal of Forest Research, DOI: 10.1080/02827581.2011.635073.

Westholm, E. and **Beland Lindahl, K**. 2012. The Nordic welfare model providing energy transition? A political geography approach to the EU RES Directive. Energy Policy, doi.org/10.1016/j.enpol.2012.07.027

Beland Lindahl, K. 2008. Frame Analysis, Place Perceptions and the Politics of Natural Resource Management: Exploring a forest policy controversy in Sweden. Doctoral Thesis. Acta Universitatis Agriculturae Sueciae No. 2008:60 Swedish University of Agricultural Sciences, Uppsala.

Beland Lindahl, K. 2009. Politik och Plats: Om platsrelaterade föreställningar och deras betydelse i skogspolitiken. In: Tunón, H. (ed). Kunskap, föreställningar, natursyn, hållbar utveckling: Om mötet mellan myndigheter, lokalsamhällen och traditionella värderingar. CBM:s skriftserie 32. Centrum för Biologisk Mångfald, Uppsala.

Beland Lindahl, K. 2009. Skogens kontroverser: En studie om plats och politik i norra Sverige. Institutet för Framtidsstudier, Forskningsrapport 2009/3, Stockholm 2009.

Accepted publications in progress:

Zachrisson, A. and **Beland Lindahl, K**. Conflict resolution through collaboration: preconditions and limitations in forest and nature conservation controversies. Accepted by Forest Policy and Economics.

Beland Lindahl, K. Actors' perceptions and strategies: forests and pathways of sustainability. In: Westholm, E., **Beland Lindahl, K**. and Kraxner, F. (Eds), Global Trends and the Future of Nordic Forestry (in progress).

CV/MATS BERLIN

Degree:	PhD in Biology	**Current appointment:**	Researcher
Affiliation:	Skogforsk The Forestry Research Institute of Sweden	**Birth year:**	1976
		Sex:	Male

Research interests in relation to Future Forests:
Mats Berlin is a researcher at Skogforsk with expertise in quantitative genetics, statistics and forest tree breeding. His main responsibility is the forest tree breeding of Norway spruce in central Sweden and he is also the editor of the public web tool "Plantval", which is a decision support for choosing suitable forest regeneration material. He has also been working with the development of new transfer/production functions for Scots pine in Sweden and Finland including the effects of climate change. This work has mainly been performed within the NOVELTREE EU-project in collaboration with METLA and SMHI.

The most relevant publications:

Norin, L., S. M. Grach, T. B. Leyser, B. Thidé, E. N. Sergeev, and **M. Berlin.** 2008. Ionospheric plasma density irregularities measured by stimulated electromagnetic emission, J. Geophys Res., 113, A09314, doi: 10.1029/2008JA013338.

Berlin, M., Danell, Ö., Jansson, G., Andersson, B., Elfving, B. and Ericsson, T. 2009. A model to estimate economic weight of tree survival relative to volume production taking patchiness into account. Scand. J. For. Res. 24(4): 278-287.

Berlin, M., Jansson, G., Danell, Ö., Andersson, B., Elfving, B. and Ericsson, T. 2009. Economic weight of tree survival relative to volume production in tree breeding: A case study with Pinus sylvestris in northern Sweden. Scand. J. For. Res. 24(4): 288-297.

Berlin, M., Lönnstedt, L., Jansson, G., Danell, Ö. & Ericsson, T. 2010. Developing a Scots pine breeding objective: A case study involving a Swedish sawmill. Silva Fennica 44(4): 643-656.

Berlin, M., Sonesson, J., Bergh, J. and Jansson, G. 2012. The effect of fertilization on genetic parameters in Picea abies clones in central Sweden and consequences for breeding and deployment. For. Ecol. Man. 270: 239-246.

Berlin, M., Jansson, G., Lönnstedt, L., Danell, Ö. and Ericsson, T. 2012. Development of economic forest tree breeding objectives: review of existing methodology and discussion of its application in Swedish conditions. Scand. J. For. Res. 27(7): 681-691 DOI:10.1080/02827581.2012.672586

CV/KEVIN BISHOP

Degree:	Ph.D. in Geography	**Current appointment:**	Professor
Affiliation:	Aquatic Sciences and Assessment Swedish Univ. of Agricultural Sci. & Earth Sciences, Uppsala Univ.	**Birth year:** **Sex:**	1960 Male

Research interests in relation to Future Forests:
Kevin Bishop is a professor, and holds two chairs, one at SLU in Environmental Assessment and the other at Uppsala University in Aquatic Climatology. His research is focused on discerning human influence in running waters from a catchment perspective that uses hydrological flow paths and residence times as the starting point for untangling the effects of climatic variation from those created by land use change and atmospheric deposition. Mercury, acidity and organic carbon have been issues in the boreal zone where the function of the riparian zone has been a central feature of his work. In subtropical Africa, his work has focused on the influence of forests on the hydrological cycle. He has also worked on policies to manage surface waters, and the search for reference conditions against which to measure human influence. Kevin has supervised a dozen PhD’s and led numerous projects, including a new strong research environment on quantifying weathering to help establish the sustainability of forestry. He has published over 150 peer-reviewed papers and has an H-index of 30.

The most relevant publications:

Ellison, D., M. Futter and **K. Bishop.** 2012. On the Forest Cover - Water Yield Debate: From Demand- to Supply-side Thinking. Global Change Biology. 18:806–820, doi: 10.1111/j.1365-2486.2011.02589.x

Erlandsson, M., N. Cory, J. Fölster, S. Köhler, H. Laudon, G. Weyhenmeyer and **K. Bishop**. (2011). Increasing Dissolved Organic Carbon Redefines the Extent of Surface Water Acidification and Helps Resolve a Classic Controversy. Bioscience 61(8): 614-618.

Bishop, K., J. Seibert, L. Nyberg and A. Rodhe. (2011) Water storage in a till catchment II: Implications for flow paths, turnover times and transmissivity feedback. Hydrological Processes, 25(25), 3950-3959

Wallin, M., Öquist, M., Buffam, I., Billett, M.F., Nisell, J., and **Bishop, K**. (2011), Spatiotemporal variability in the gas transfer coefficient (KCO2) of boreal streams; implications for large scale estimates of CO2 evasion. Global Biogeochemical Cycles, 25.

Gebrehiwot, S. G., U. Ilstedt, A. I. Gardenas, and **K. Bishop** (2011), Hydrological characterization of watersheds in the Blue Nile Basin, Ethiopia, Hydrology and Earth System Sciences, 15(1), 11-20.

Bishop, K., Allan, C., Bringmark, L., Garcia, E., Hellsten, S., Högbom, L., Johansson, K., Meili, M., Munthe, J., Nilsson, M., Porvari, P., Skyllberg, U., Sorensen, R., Zetterberg, T. And Åkerblom, S. (2009) Bioaccumulation of Hg in boreal freshwaters – an assessment of contribution by forestry based on available data and current recommendations for good silvicultural practice. Ambio. 38(7): 373-380.

CV/CHRISTER BJÖRKMAN

Degree:	Ph.D. Forest Entomology	**Current appointment:**	Professor
Affiliation:	Dept. of Ecology Swedish Univ. of Agricultural Sci.	**Birth year:**	1959
		Sex:	Male

Research interests in relations to Future Forests:
Christer Björkman is a forest entomologist with a broad expertise in insect ecology. The main research focus has been on the causes behind insect outbreaks. To reach mechanistic understanding of observed patterns of insect damage a natural ingredient has been experiments on interactions. In addition, prof. Björkman has analysed time series data and studied the effects the landscape on insect pests and their natural enemies. The effect of variation in tree quality and resistance, genetically and environmentally induced, on insects has been a theme throughout his career. Most of prof. Björkman's research is done in collaboration with other researchers and the questions asked are developed in communi-cation with stakeholders. He has a well developed international network. Large effort is devoted to communicate science to stakeholders and the public. Prof. Björkman is the author of over 65peer-reviewed articles, book chapters and popular articles, and has recently accepted to be the editor of a book on "Climate Change and Insect Pests".

The most relevant publications:

Koricheva, J., Klapwijk, M.J. & **Björkman, C.** 2012. Life history traits and host plant use in defoliators and bark beetles: implications for population dynamics. In: Insect Outbreaks Revisited ed. by Barbosa, P., Schultz, J.C. & Letourneau, D., Blackwell Publishing Ltd., Oxford.

Björkman, C., Bylund, H., Klapwijk, M.K., Kollberg, I. & Schroeder, M. 2011. Insect pests in *Future Forests*: More severe problems? Forests 4: 474-485.

Björkman, C., Bylund, H. & Berggren, Å. 2011. Insekter och klimatförändringar – vad vi vet, tror oss veta och inte vet. Fakta Skog Nr. 6.

Björkman, C., Kindvall, O., Höglund, S., Lilja, A., Bärring, L. & Eklund, K. 2011. High Temperature Triggers Latent Variation among Individuals. PLoS ONE 6(1): e16590.

Björkman, C., Berggren, Å. & Bylund, H. 2011. Causes behind insect folivory patterns in latitudinal gradients. Journal of Ecology 99: 367-369.

Dalin, P., Demoly, T., Kabir, Md. F. & **Björkman, C**. 2011. Global land-use change and the importance of zoophytophagous bugs in biological control: coppicing willows as a timely example. Biological Control 59: 6-12.

Berggren, Å., **Björkman, C.**, Bylund, H. & Ayres, M. 2009. The distribution and abundance of animal populations in a climate of uncertainty. Oikos 118: 1121-1126.

Dalin, P., Kindvall, O. & **Björkman, C.** 2009. Reduced Population Control of an Insect Pest in Managed Willow Monocultures. PLoS ONE 4(5): e5487. Doi: 10.1371/journal.pone.0005487.

CV/JOHANNA BOBERG

Degree:	Ph.D. in Biology	**Current appointment:**	Researcher
Affiliation:	Dept. of Forest Mycology & Plant Pathology, Swedish University of Agricultural Sciences	**Birth year:**	1976
		Sex:	Female

Research interests in relation to Future Forests:
Johanna Boberg is a mycologist with expertise in fungal ecology and forest pathology. She is currently involved in research projects studying shifts in the geographical distribution of forest pathogens in relation to predicted changes in climate using the bioclimatic niche model CLIMEX. Included is also a specific focus on the risk posed by invasive pathogens, how introduction of new species relate to climate and trade and the development of efficient methods to monitor their spread, e.g. spore traps and molecular detection. Within Future forest, she has been part of organizing an interdisciplinary project and a workshop 'Invasive pests and pathogens –a future threat to our forests?', which not only focused on the biological specifics, but also included approaches in society to handle these problems. She is also involved in the EU-projects BACCARA and FunDivEurope where the function and ecosystems services of forest ecosystems in Europe are studied. Specific projects involve changes in communities of foliar pathogenic and endophytic fungi in relation to climate change (BACCARA) and the tree species diversity (FunDivEurope). Here, fungal community analysis is done using state of the art molecular methods. She is also studying pathogen risks associated with potential introduction of non-native tree species in Sweden as part of a Future forest project.

The most relevant publications:
Oliva, J., **Boberg, J.B.**, Ammunét, T., Desprez-Loustau, M-L., Niemela, P., Slippers, B., Simberloff, D., Stenlid, J., Björkman, C., Linking biology and policy measures in a conceptual framework for controlling invasive forest pests and pathogens. In prep.

Oliva, J., **Boberg, J.B.**, Hopkins, A.J.M., Stenlid, J., Concepts of Epidemiology of Forest Diseases. In: Paolo Gonthier (Ed) Infectious forest diseases. CABI International. UK. In press.

Boberg, J. 2012. Simulering av potentiell etablering av skadesvampar i svensk skog. Bilaga 6 till rapport 2012: 10. Vässa växtskyddet för framtidens klimat -Hur vi förebygger och hanterar ökade problemi ett förändrat klimat (Jordbruksverket).

Hopkins, A.J.M., **Boberg, J.B**., 2012. Risk assessment and establishment of a system to adress potential pathogens in Nordic and Baltic forestry as a result of climate change. SNS Research Project Report within the Selfoss declaration on sustainable forestry, www.nordicforestresearch.org/sns-research/research-projects/risk-assessment-and-establishment/

Stenlid, J., Oliva, J., **Boberg, J.B.,** Hopkins, A.J.M., 2011. Emerging diseases in European forest ecosystems and responses in society. Forests 2(2): 486-504.

CV/DAVID ELLISON

Degree:	Ph.D. Political Science	**Current appointment:**	Senior Researcher
Affiliation:	Institute of World Economics Hungarian Academy of Sciences	**Birth year:**	1958
		Sex:	Male

Research interests in relation to Future Forests:
David Ellison is a Senior Researcher at the Institute of World Economics in Budapest, Hungary. His work focuses broadly on the science, politics and policy of climate. David works closely together with Swedish colleagues at the Swedish University of Agricultural Sciences (Umea and Uppsala, Sweden). His work focuses primarily on carbon accounting practices in Land Use, Land Use Change and Forestry (LULUCF) in the UNFCCC and Kyoto frameworks, and on Forest-Water Dynamics, in particular how these impact moisture vapor transport and water availability across terrestrial space, and the potential role of forests in Climate Change mitigation and adaptation.

The most relevant publications:

Ellison, David, Hans Petersson, Mattias Lundblad and Per-Erik Wikberg (forthcoming). “The Incentive Gap: LULUCF and the Kyoto Mechanism Before and After Durban” Global Change Biology – Bioenergy.

Ellison, David, Martyn Futter, Kevin Bishop (2012). “On Hydrology, Forests and Precipitation Recycling”, Global Change Biology, 18, 3272-3274.

Ellison, David, Martyn Futter and Kevin Bishop (2012). “On the Forest Cover – Water Yield Debate: From Demand to Supply-Side Thinking”, Global Change Biology, 18, 806-820.

Ellison, David (2011). “Should the EU Climate Policy Framework be Reformed?” Eastern Journal of European Studies, 2, 133-167.

Ellison, David, Mattias Lundblad and Hans Petersson (2011). “Carbon Accounting and the Climate Politics of Forestry”, Environmental Science & Policy. 14, 1062-1078.

Futter, M., E.C.H. Keskitalo, **D. Ellison**, M. Petersson, A. Strom, E. Andersson, J. Nordin, S. Löfgren, K. Bishop and H. Laudon (2011). “Forests, Forestry and the Water Framework Directive in Sweden: A trans-disciplinary commentary”, Forests, 2, 261-282.

Altmann M., J. Michalski, A. Brenninkmeijer, J.C. Lanoix, P. Tisserand, C. Egenhofer, A. Behrens, N. Fujiwara and **D. Ellison** (2010). “EU Energy Efficiency Policy – Achievements and Outlook”, report commissioned by the European Parliament.

Ellison, David (2010). “Addressing Adaptation in the EU Policy Framework”, in Keskitalo, E. C. H. (ed.), Developing Adaptation Policy and Practice in Europe: Multi-Level Governance of Climate Change, Berlin: Springer: Ch. 2.

Westerhoff, Lisa M., E.C.H. Keskitalo, Heather McKay, Johanna Wolf, **David Ellison**, Iosif Botetzagias (2010). “The development of adaptation to climate change in Europe and beyond: an overview”, in Keskitalo, E. C. H. (ed.), Developing Adaptation Policy and Practice in Europe: Multi-Level Governance of Climate Change, Berlin: Springer.

Altmann, M., A. Brenninkmeijer, J.C. Lanoix, **D. Ellison**, A. Crisan, A. Hugyecz, G. Koreneff and S. Hänninen (2010). “Decentralized Energy Systems”, report commissioned by the European Parliament.

CV/GUSTAF EGNELL

Degree:	Ph.D. in Silviculture	**Current appointment:**	Researcher in Forest Production
Affiliation:	Forest Ecology and Management Swedish Univ Agriculture Sciences	**Birth year:**	1961
		Sex:	Male

Research interests in relation to Future Forests:
Gustaf Egnell is a researcher primarily financed by the Swedish Energy Agency. His research focuses on long-term site productivity and carbon balance following increased harvest intensities driven by the growing market for bioenergy. I.e. harvest of branches, tops, and stumps for energy purposes, where a limited increase in biomass removal is done at the expense of a substantial increase in nutrient removal. Concerns about long-term site productivity were raised already following the oil crises in the 1970s, when forest biomass was discussed as a possible energy option. Due to this concern a number of long-term field experiments were established to study the effect of whole-tree harvest on future site and stand productivity. These long-term experiments constitute an important infrastructure for his current research. He is also engaged in extension through IEA Bioenergy task 43, *Biomass Feedstocks for Energy Markets*, and through standardisation as an expert in the European CEN standard, *"Biodiversity and environmental issues on sustainable biofuels within EU"* and in the global standard within ISO, *"Sustainability Criteria for Bioenergy".*

The most relevant publications:

Lattimore B, Smith CT, Titus BD, Stupak I & **Egnell G**, 2012. Woodfuel Harvesting: a Review of Environmental Risks, Criteria and Indicators and Certification Standards for Environmental Sustainability. Journal of Sustainable Forestry, Accepted for publication. DOI: 10.1080/10549811.2011.651785

Egnell G & Björheden R, 2012. Options for increasing biomass output from long-rotation forestry. WIREs Interdisciplinary Reviews - Energy and Environment, Accepted for publication. DOI: 10.1002/wene.25

Egnell G, 2011. Is the productivity decline in Norway spruce following whole-tree harvesting in the final felling in boreal Sweden permanent or temporary? Forest Ecology and Management 261: 148-153.

Egnell G, Laudon H & Rosvall O, 2011. Perspectives on the Potential Contribution of Swedish Forests to Renewable Energy Targets in Europe. Forests 2: 578-589.

Klaminder J, Lucas RW, Futter MN, Bishop KH, Kohler SJ, **Egnell G** & Laudon H, 2011. Silicate mineral weathering rate estimates: are they precise enough to be useful when predicting the recovery of nutrient pools after harvesting? Forest Ecology and Management 261: 1-9.

Melin Y, Petersson H & **Egnell G**, 2010. Assessing carbon balance trade-offs between bioenergy and carbon sequestration of stumps at varying time scales and harvest intensities. Forest Ecology and Management 260: 536-542.

Egnell G & Valinger E, 2003. Survival, growth, and growth allocation of planted Scots pine trees after different levels of biomass removal in clear-felling. Forest Ecology and Management 177: 65-74.

Egnell G & Leijon B, 1999. Survival and growth of planted seedlings of Pinus sylvestris and Picea abies after different levels of biomass removal in clear-felling. Scandinavian Journal of Forest Research 14: 303-311.

CV/NILS FAHLVIK

Degree:	M.Sc. in Forestry, Dr. of Forestry	**Current appointment:**	Assistant professor
Affiliation:	Southern Swedish Forest Research Centre Swedish University of Agriculture	**Birth year:**	1974
		Sex:	Male

Research interests in relation to Future Forests:
Nils Fahlvik has been working with silviculture as well as within the field of growth and yield, with expertise in mixed species stands. A main area of his research has been the development of young stands and the evaluation of thinning treatments, with special emphasis to the management of mixtures. Simulations have been an important tool to study the influence of silvicultural actions on stand development. Nils has been working with the development of growth models and the construction of such growth simulators. A part-time work at the Department of Silviculture and Forest Protection, Technische Univeristät Dresden (TUD), Germany during the last three years has given a profound experience of forestry and forest research in Central Europe. Nils is currently responsible for a project within the research program "Lövskogsprogrammet" in which ecological effects of an admixture of birch in spruce dominated stands are studied.

The most relevant publications:

Fahlvik, N., Elfving, B. & Wikström, P. Evaluation of growth functions used in the Heureka Forest Planning System. Submitted.

Fahlvik, N., Agestam, E., Ekö, P.M. & Lindén, M. 2011. Development of single-storied mixtures of Norway spruce and birch in southern Sweden. Scandinavian Journal of Forest Research 26, 1-10.

Nilsson, U., **Fahlvik, N.**, Johansson, U., Lundström, A. & Rosvall, O. 2011. Simulation of the Effect of Intensive Forest Management on Forest Production in Sweden. Forests 2(1), 373-393.

Nilsson, U., Agestam, E., Ekö, P.-M., Elfing, B., **Fahlvik, N.**, Johansson, U., Karlsson, K., Lundmark, T. & Wallentin, C. 2010. Thinning of Scots pine and Norway spruce monocultures in Sweden: effects of different thinning programmes on stand level gross- and net stem volume production. Studia forestalia Suecica, 219.

Fahlvik, N., Johansson, U. & Nilsson, U. 2009. Skogsskötsel för ökad tillväxt. Swedish University of Agricultural Sciences. Report. 401 pp.

Fahlvik, N. & Nyström, K. 2006. Models for predicting individual tree height increment and tree diameter in young stands in southern Sweden. Scandinavian journal of forest research 21, 16-28.

Fahlvik, N. 2005. Aspects of precommercial thinning in heterogeneous forests in southern Sweden. Acta Universitatis Agriculturae Sueciae, 2005: 68. Doctor´s dissertation.

Fahlvik, N., Ekö, P.M. & Pettersson, N. 2005. Influence of precommercial thinning grade on branch diameter and crown ratio in Pinus sylvestris in southern Sweden. Scandinavian journal of forest research 20, 243-251.

CV/ADAM FELTON

Degree:	Ph.D. in Natural Resource Management	**Current appointment:**	Assistant Professor
Affiliation:	Southern Swedish Forest Research Centre SLU	**Birth year:**	1970
		Sex:	Male

Research interests in relation to Future Forests:
Dr. Adam Felton is an ecologist whose research focuses on the maintenance of biodiversity in production forests. To effectively conserve forest biodiversity requires that conservation is not relegated to limited protected forest areas, but integrated with production forestry at the stand and landscape scale. Dr. Felton is in an excellent position to conduct policy relevant science on such issues as he has conducted research in a diverse array of forest types, from tropical rainforests to temperate woodlands; on issues ranging from the capacity of FSC certified forestry to maintain bird, mammalian, and plant communities; deciphering the likely biodiversity cost and benefits from converting conifer monocultures to mixed-species stands; and the biodiversity implications of converting pasture lands to forestry plantations. Dr. Felton has published over 38 peer-reviewed scientific articles, and is currently examining the potential implications for forest-dependent biodiversity from intensifying production forestry in Sweden.

The most relevant publications:

Felton, A., Andersson, E., Ventorp, D., Lindsbladh, M. 2011 Avian biodiversity responses to retaining birch (Betula spp.) in Norway spruce (Picea abies) stands: An assessment from southern Sweden. Silva Fennica 45(5): 1143–1150.

Brunet, J., K. Valtinat, M. L. Mayr, **Felton, A**., M. Lindbladh, and H. H. Bruun. 2011. Understory succession in post-agricultural oak forests: Habitat fragmentation affects forest specialists and generalists differently. Forest Ecology and Management 262: 1863-1871.

Lindbladh, M., **A. Felton**, R. Trubins, and O. Sallnas. 2011. A landscape and policy perspective on forest conversion: Long-tailed tit (Aegithalos caudatus) and the allocation of deciduous forests in southern Sweden. European Journal of Forest Research 130: 861-869.

Felton, A., E. Knight, J. Wood, C. Zammit, and D. Lindenmayer. 2010. A meta-analysis of fauna and flora species richness and abundance in plantations and pasture lands. Biological Conservation 143: 545-554.

Felton, A., M. Lindbladh, J. Brunet, and O. Fritz. 2010. Replacing coniferous monocultures with mixed-species production stands: An assessment of the potential benefits for forest biodiversity in northern Europe. Forest Ecology and Management 260: 939-947.

Felton, A., L. Ellingson, E. Andersson, L. Drossler and K. Blennow. 2010. Adapting production forests in southern Sweden to climate change: Constraints and opportunities for risk spreading. International Journal of Climate Change Strategies and Management 2: 84-97.

Lindenmayer, D.B., Cunningham, R.B., MacGregor, C., Crane, M., Michael, D., Fischer, J., Montague-Drake, R., **Felton, A**., et al. 2008 Temporal changes in vertebrates during landscape transformation: A large-scale “natural experiment”. Ecol. Mono. 78(4): 567-590.

Felton, A., et al. 2008 Bird community responses to reduced-impact logging in a certified forestry concession in lowland Bolivia, Biol. Con., 141: 545-555.

CV/SABINE FUSS

Degree:	Ph.D. in Economics	**Current appointment:**	Research Scholar
Affiliation:	International Institute for Applied Systems Analysis	**Birth year:**	1979
		Sex:	Female

Research interests in relation to Future Forests:
S.F. is a Research Scholar at the International Institute for Applied Systems Analysis (IIASA). She conducts applied research and economic modeling with emphasis on stochastic optimization methods, risk assessment and decision-making under uncertainty in EU funded research projects. Dr. Fuss graduated from the Faculty of Economics at the University of Maastricht in 2003 and completed her PhD at the same university and UNU-MERIT from 2003 to 2007. Her research interests include: decision-making under uncertainty (portfolio selection, real options theory, stochastic optimization, robustness), energy and agricultural economics (especially in the field bioenergy), integrated assessment with focus on climate change mitigation and adaptation (also the role of negative emission options), and socio-economic benefit assessment of Earth Observation (e.g. value of information). S.F. has more than 25 peer-reviewed publications and is currently Principle Investigator of 8 projects.

The most relevant publications:

Fuss S, Szolgayova J, Khabarov N, Obersteiner M (2012). Renewables and climate change mitigation: Irreversible energy investment under uncertainty and portfolio effects. Energy Policy, 40: 59-68.

Lemoine DM, **Fuss S**, Szolgayova J, Obersteiner M, Kammen DM (2012). The influence of negative emission technologies and technology policies on the optimal climate mitigation portfolio. Climatic Change, 113(2): 141-162.

Reuter WH, **Fuss S**, Szolgayova J, Obersteiner M (2012). Investment in wind power and pumped storage in a real options model. Renewable and Sustainable Energy Reviews, 16(4): 2242-2248.

Szolgayova J, **Fuss S,** Khabarov N, Obersteiner M (2012). Robust energy portfolios under climate policy and socioeconomic uncertainty. Environmental Modeling and Assessment, 17(1-2): 39-49.

Fuss S, Szolgayova J, Golub A, Obersteiner M (2011). Options on low-cost abatement and investment in the energy sector: New perspectives on REDD. Environment and Development Economics, 16(4): 507-525.

Fuss S, Szolgayova J (2010). Fuel price and technological uncertainty in a real options model for electricity planning. Applied Energy, 87(9): 2938-2944.

Fuss S, Johansson DJA, Szolgayova J, Obersteiner M (2009). Impact of climate policy uncertainty on the adoption of electricity generating technologies. Energy Policy, 37(2): 733-743.

Fuss S, Szolgayova J, Obersteiner M, Gusti M (2008). Investment under market and climate policy uncertainty. Applied Energy, 85(8): 708-721.

Szolgayova J, **Fuss S**, Obersteiner M (2008). Assessing the effects of CO2 price caps on electricity investments - A real options analysis. Energy Policy, 36(10):3974-3981.

Fortin I, **Fuss S**, Hlouskova J, Khabarov N, Obersteiner M, Szolgayova J (2008). An integrated CVaR and real options approach to investments in the energy sector. The Journal of Energy Markets, 1(2): 61-85.

CV/MARTYN FUTTER

Degree:	Ph.D. Watershed Ecosystems in forest water quality	**Current appointment:**	Assistant Professor
Affiliation:	Aquatic Science and Assessment Swedish Univ Agriculture Sciences	**Birth year:**	1965
		Sex:	Male

Research interests in relation to Future Forests:
Martyn Futter is an assistant professor with a focus on water quality in the boreal forest. His research is focused on the development, application and interpretation of process based models of surface water biogeochemistry and hydrology. He also has a strong interest in water policy and environmental communication. The main focus of his research is on understanding and predicting the effects of climate and land management change on water quality in the boreal forest landscape. He has considerable research experience from the boreal forests of Canada, Finland, Norway and Sweden. During the last 8 years, he has developed new landscape-scale, process-based models of dissolved organic carbon, suspended sediments and mercury in soils and surface waters. Has published close to 50 peer-reviewed papers of which half are from the last five years.

The most relevant publications:

Futter, M.N., Klaminder, J., Lucas, R., Laudon, H., Köhler, S.J. (2012). Uncertainty in silicate mineral weathering **rate** estimates. Environmental Research Letters, 7 024025 doi:10.1088/1748-9326/7/2/024025.

Futter, M.N., Poste, A.E., Dillon, P.J., Butterfield, D., Lean, D.R.S., Dastoor, A.P., Whitehead, P.G. (2012). Using the INCA-Hg model of mercury cycling to simulate total and methyl mercury concentrations in forest streams and catchments. Science of the Total Environment, doi:10.1016/j.scitotenv.2012.02.048

Futter, M.N., Löfgren, S., Köhler, S.J., Lundin, L., Moldan, F., Bringmark, L. (2011). Simulating dissolved organic carbon dynamics at the Swedish Integrated Monitoring sites with the Integrated Catchments Model for Carbon, INCA-C. Ambio, 40: 906-919.

Futter, M.N., Keskitalo, E.C.H., Ellison, D., Pettersson, M., Strom, A., Andersson, E., Nordin, J., Löfgren, S., Bishop, K., Laudon, H. (2011). Forests, Forestry and the Water Framework Directive in Sweden: A Trans-Disciplinary Commentary. Forests, 2: 261-282; doi: 10.3390/f2010261

Futter M.N., Ring, E., Högbom, L., Entenmann, S., Bishop, K. (2010). Consequences of nitrate leaching following conventional harvesting of Swedish forests are dependent on spatial scale. Environmental Pollution, 158: 3552-3559.

Futter, M.N., Forsius, M., Holmberg, M., Starr, M. (2009). Modelling the impact of European emission and climate change scenarios on dissolved organic carbon concentrations the surface waters of a boreal catchment. Hydrology Research, 40: 291-305.

Futter, M.N., Skeffington, R.A., Whitehead, P.G., Moldan, F. (2009). Modelling stream and soil water nitrate dynamics during experimentally increased nitrogen deposition in a coniferous forest catchment at Gårdsjön, Sweden. Hydrology Research, 40: 187-197.

Futter, M.N., de Wit, H.A. (2008). What controls dissolved organic carbon concentrations in streams: a comparison of empirical and process-based models. Science of the Total Environment, 407: 698-707.

Futter M.N., Butterfield, D., Cosby, B.J., Dillon, P.J., Wade, A.J., Whitehead, P.G. (2007). Modelling the mechanisms that control in-stream dissolved organic carbon dynamics in upland and forested catchments. Water Resources Research 43, W02424, doi: 10.1029/2006WR004960.

CV/PEICHEN GONG

Degree:	Ph.D. in Forest Economics	**Current appointment:**	Professor
Affiliation:	Dept. of Forest Economics Swedish Univ Agriculture Sciences	**Birth year:**	1965
		Sex:	Male

Research interests in relation to Future Forests:
Peichen Gong is an economist with expertise in management of forest and related natural resources. His research covers various theoretical, methodological and empirical topics in the field of forest and natural resource management, ranging from optimization of silvicultural programs and timber harvest decisions to analysis of private forest owners' preferences and forest policy evaluation. One of the focal issues of his research has been how to determine the optimal silvicultural program and timber harvest plan under conditions of uncertainty and risks from different sources and when land owners manage their forests with a multitude of objectives.
Another is the development and application of partial equilibrium timber market models to simulate the consequences and assess the welfare impacts of institutional, technological and policy changes related to the forest sector. His recent research focuses on economic incentives for forest conservation and the use of forests to mitigate climate change.

The most relevant publications:

Gong, P., K.-G. Löfgren, and Rosvall, O. (2012) Economic Evaluation of Biotechnological Progress: The effect of changing management behavior. Natural Resource Modeling, doi: 10.1111_j.1939-7445.2012.00118.

Andersson, M. and **P. Gong**. (2010) Risk Preferences, Risk Perceptions and Timber Harvest Decisions – An Empirical Study of NIPF Owners in Northern Sweden. Forest Policy and Economics 12: 330-339.

Simonsen, R., Rosvall, O., **Gong, P**., and Wibe, S. (2010) Profitability of measures to increase forest growth. Forest Policy and Economics 12: 473-482.

Wibe, S. and **Gong, P**. (2010) Can forests save the world? Journal of Forest Economics 16: 177-178.

Brännlund, R., A. Sidibe, and **P. Gong**. (2009) Participation to forest conservation in National Kabore Tambi Park in Southern Burkina Faso, Forest Policy Economics 11: 468-474.

Gong, P. and K.-G. Löfgren (2009) Modeling Forest Harvest Decisions: Advances and challenges. International Review of Environmental and Resource Economics, 3: 195-216.

Gong, P. and K.-G. Löfgren (2009) Did Pressler fully understand how to use the indicator per cent? Journal of Forest Economics 16: 195-203.

Xie, Y., Wen Y., and **Gong, P**. (2009) Reasonableness of Farmers' Transfer Benefits in the Reform of Collective Forest Property Rights System. Scientia Silvae Sinicae, 45(10): 134-140.

Gong, P., and K.-G. Löfgren. 2008. Impact of risk aversion on the optimal rotation with stochastic price. Natural Resource Modeling 21: 385-415.

Gong, P., and K.-G. Löfgren. 2007. Market and welfare implications of adaptive harvest strategy. Journal of Forest Economics, 13: 217-243.

CV/PETR HAVLIK

Degree:	PhD in Agricultural Economics	**Current appointment:**	Research Scholar
Affiliation:	International Institute for Applied Systems Analysis	**Birth year:**	1978
		Sex:	Male

Research interests in relation to Future Forests:

Petr Havlik joined IIASA's Forestry Program as a Research Scholar in July 2007. After studies in the Czech Republic and in France, Dr. Havlik received an M.Sc. degree in economics and management (2001), and in economics of agriculture, agri-business, and rural development (2002), from the Mendel University of Agriculture and Forestry in Brno (Czech Republic) and the University of Montpellier 1 (France), respectively. Before joining IIASA, Dr. Havlik shortly worked as a post-doc at INRA Grignon (France), where he set up a spatially explicit optimization model for the design of biodiversity compatible landscape pattern policies. Dr. Havlik's current research interests include the use and development of forest and agricultural sector optimization models at the European and global level.

The most relevant publications:

Frank S, Bottcher H, **Havlik P**, Valin H, Mosnier A, Obersteiner M, Schmid E, Elbersen B (2012). How effective are the sustainability criteria accompanying the European Union 2020 biofuel targets? Global Change Biology Bioenergy, Article in press (Publshed online 9 July 2012).

Fritz S, Fuss S, **Havlik P**, Szolgayova J, McCallum I, Obersteiner M, See L (2012). The value of determining global land cover for assessing climate change mitigation options. In: The Value of Information, R. Laxminarayan and M.K. Mcauley (eds), Springer, Dordrecht, The Netherlands pp.193-230 (2012).

Reisinger A, **Havlik P**, Riahi K, van Vliet O, Obersteiner M, Herrero M (2012). Implications of alternative metrics for global mitigation costs and greenhouse gas emissions from agriculture. Climatic Change, Article in press (Published online 6 October 2012).

Bamiere L, **Havlik P**, Jacquet F, Lherm M, Millet G, Bretagnolle V (2011). Farming system modelling for agri-environmental policy design: The case of a spatially non-aggregated allocation of conservation measures. Ecological Economics, 70(5): 891-899 (15 March 2011) (Published online 8 February 2011).

Fritz S, See L, McCallum I, Schill C, Obersteiner M, van der Velde M, Bottcher H, **Havlik P**, Achard F (2011). Highlighting continued uncertainty in global land cover maps for the user community. Environmental Research Letters, 6(4): 044005 (October-December 2011) (Published online 21 October 2011).

Havlik P, Schneider UA, Schmid E, Bottcher H, Fritz S, Skalsky R, Aoki K, De Cara S, Kindermann G, Kraxner F, Leduc S, McCallum I, Mosnier A, Sauer T, Obersteiner M (2011). Global land-use implications of first and second generation biofuel targets. Energy Policy, 39(10): 5690-5702 (October 2011) (Published online 7 April 2010).

Schneider UA, **Havlik P**, Schmid E, Valin H, Mosnier A, Obersteiner M, Bottcher H, Skalsky R, Balkovic J, Sauer T, Fritz S (2011). Impacts of population growth, economic development, and technical change on global food production and consumption. Agricultural Systems, 104920: 204-215 (February 2011) (Published online 24 December 2010).

CV/PETER HÖGBERG

Degree:	Ph.D. in Soil Science	**Current appointment:**	Professor (Chair) in forest soils
Affiliation:	Forest Ecology and Management Swedish Univ Agriculture Sciences	**Birth year:**	1955
		Sex:	Male

Research interests in relation to Future Forests:
Prof. Peter Högberg holds the chair in forest soils at SLU. He explores interactions between the carbon and nitrogen cycles in forest ecosystems. A focal point is the role of the carbon supply from the tree canopies to mycorrhizal fungi as a regulator of the ecosystem nitrogen dynamics. This research has important implications for our views on forests as sinks for nitrogen added as fertilizer or by atmospheric deposition, for predictions of the effect of nitrogen on the forest carbon balance, and for the development of silvicultural systems. Högberg has been involved in many international collaborative projects, notably six major European projects and the International Biosphere Geosphere project. He has published over 115 peer-reviewed papers, which altogether have been cited more than 7400 times.

The most relevant publications:

Vicca, S. et al. (2012). Fertile forests produce biomass more efficiently. Ecology Letters, 15, 520-526.

Högberg, M.N. et al. (2010). Quantification of effects of season and nitrogen supply on tree below-ground carbon transfer to ectomycorrhizal fungi and other soil organisms in a boreal pine forest. New Phytologist, 187, 485-493.

Högberg, P. (2007). Nitrogen impacts on forest carbon. Nature, 474, 781-782.

Högberg, P. et al., (2006). Tree growth and soil acidification in response to 30 years of experimental nitrogen loading on boreal forest. Global Change Biology, 12, 489-499.

Högberg, M.N. & **Högberg, P.** (2002). Extramatrical ectomycorrhizal mycelium contributes one third of microbial biomass and produces, together with associated roots, half the extractable dissolved organic carbon in a forest soil. New Phytologist, 154, 791-796.

Högberg, P. et al. (2001). Large-scale forest girdling shows that current photosynthesis drives soil respiration. Nature, 411, 789-792.

Falkowski, P. et al. (2000). The global carbon cycle: a test of our knowledge of earth as a system. Science, 290, 291-296.

Näsholm, T. et al. (1998). Boreal forest plants take up organic nitrogen. Nature, 392, 914-916.

Högberg, P. (1997). 15N natural abundance in soil-plant systems. Tansley Review No. 95. New Phytologist, 137, 179-203.

Binkley, D. & **Högberg, P.** (1997). Does atmospheric deposition of nitrogen threaten Swedish forests? Forest Ecology and Management, 92, 119-152.

CV/RAGNAR JONSSON

Degree: D.Tech **Current appointment:** Post-doctoral researcher

Affiliation: Southern Swedish For. Res. Centre, Swedish Univ. of Agric. Sciences **Birth year:** 1964

Sex: Male

Research interests:
Ragnar Jonsson has a master's degree in forestry from the Swedish University of Agricultural Sciences, a master's degree in social sciences from Lund University, and a PhD from Växjö University. His main research area is forest-products market analysis within the context of future studies. Ragnar Jonsson has a post-doc position within the research program *Future Forests*, where he previously was in charge of the component project The Swedish forest sector in a global context. The objective of the project, which was finalized by the end of 2011, was to analyze the implications for the Swedish forest sector of different possible future developments in international forest-product markets. The project was based on international cooperation in the context of the European Forest Sector Outlook Study (EFSOS). In addition, he has been involved in the scenario analysis of the Swedish forest sector undertaken in the *Future Forests*. At the moment Ragnar Jonsson is working part-time in a study within *Future Forests* concerning possible wood-product market implications of REDD (reduced emissions from deforestation and forest degradation). The rest of his work time Mr. Jonsson spends at the EFI regional office EFINORD in Copenhagen, where he is currently engaged in a project assessing the potential for intensified forest management within Northern Europe.

The most relevant publications:

Jonsson, R., 2006. Increasing the competitiveness of wood in material substitution: a method for assessing and prioritizing customer needs. Journal of Wood Science 52(2): 154-162.

Jonsson, R., 2011. Trends and Possible Future Developments in Global Forest-Product Markets—Implications for the Swedish Forest Sector. Forests 2: 147-167.

Jonsson, R., Mbongo, W., Felton, A., Boman, M., 2012. Leakage Implications for European Timber Markets from Reducing Deforestation in Developing Countries. Forests 3: 736-744.

Jonsson, R., Egnell, G., Baudin, A., 2011. The Swedish Forest Sector Outlook Study. Geneva Timber and Forest Discussion Paper no. 58, ECE/TIM/DP/58. UNECE, Geneva, Switzerland.

Jonsson, R., 2012. Econometric Modelling and Projections of Wood Products Demand, Supply and Trade in Europe. Geneva Timber and Forest Discussion Paper no. 59, ECE/TIM/DP/59. UNECE, Geneva, Switzerland.

Jonsson, R., 2012. How to cope with changing demand conditions –The Swedish forest sector as a case study. An analysis of major drivers of change in the use of wood resources. Canadian Journal of Forest Research (accepted for publication).

CV/ARTTI JUUTINEN

Degree:	Ph.D. in Economics	**Current appointment:** Professor	
Affiliation:	Finnish Forest Research Institute; Department of Economics and Thule Institute, University of Oulu	**Birth year:** 1965 **Sex:** Male	

Research interests in relation to Future Forests:
Artti Juutinen is an environmental and resource economist with expertise in economics of multiple-use forestry. His research is largely focused on cost-effective forest conservation covering topics such as the effectiveness of distance-based diversity index in selecting protected areas and how various ecological criteria used in conservation decisions affect the cost-effective choice of reserves. He has also investigated the effectiveness of voluntary conservation measures. In addition, he has looked on economic valuation of forest recreation services and biodiversity. Ongoing studies focus on efficiency of different forest conservation practices in dynamic and spatial context. Prof Juutinen is the leader of projects "Valuing and marketing forest externalities " and " Assessing recreation benefits of commercial state owned forest in Finland" in the Finnish Forest Research Institute. Juutinen is the author of over 50 publications including peer-reviewed and popular-press articles, and an edited book on the environmental and resource economics.

The most relevant publications:

Tikkanen, O.-P., Matero, J., Mönkkönen, M., **Juutinen, A**., Kouki, J., 2012. To thin or not to thin - bio-economic analysis of two alternative practices to increase amount of coarse woody debris in managed forests. European Journal of Forest Research 131: 1411-1422.

Juutinen, A., Reunanen, P., Mönkkönen, M. Tikkanen, O.-P., Kouki, J., 2012. Conservation of forest biodiversity using temporal conservation contracts. Ecological Economics 81:121-129.

Juutinen, A., Mitani, Y., Mäntymaa, E., Shoji, Y., Siikamäki, P., Svento, R., 2011. Combining ecological and recreational aspects in national park management: a choice experiment application. Ecological Economics 70: 1231-1239.

Mönkkönen, M., Reunanen, P., Kotiaho, J., **Juutinen, A**., Tikkanen, O-P., Kouki, J., 2011. Cost-effective strategies to conserve boreal forest biodiversity and long-term landscape-level maintenance of habitats. European Journal of Forest Research 130: 717-727.

Juutinen, A, Luque, S., Mönkkönen, M., Vainikainen, N., and Tomppo, E., 2008. Cost-effective forest conservation and criteria for potential conservation targets: A Finnish case study. Environmental Science & Policy 11: 613-626.

Juutinen, A., Mönkkönen, M. and Ollikainen, M., 2008. Do environmental diversity approaches lead to improved site selection? A comparison with the multi-species approach. Forest Ecology and Management 255: 3750-3757.

Juutinen, A., Mäntymaa, E., Mönkkönen, M and Svento, R., 2008. Voluntary agreements in protecting privately owned forests in Finland - To buy or to lease? Forest Policy and Economics 10: 230-239.

Juutinen, A. Mönkkönen, M., Sippola, A.L., 2006. Cost-efficiency of decaying wood as a surrogate for overall species richness in boreal forests. Conservation Biology 20:74-84.

Juutinen, A., Mäntymaa, E., Mönkkönen, M. & Salmi, J., 2004. A Cost-Efficient Approach to Selecting Forest Stands for Conserving Species: A Case Study from Northern Fennoscandia. Forest Science 50: 527-539.

Juutinen, A. and Mönkkönen, M., 2004. Testing alternative indicators for biodiversity conservation in old-growth boreal forests: ecology and economics. Ecological Economics 50: 35-48.

CV/CARINA KESKITALO

Degree:	Ph.D. in International Relations	**Current appointment:**	Professor of Political Science
Affiliation:	Departement of Geography and Economic History Umeå University	**Birth year:**	1974
		Sex:	Female

Research interests in relation to Future Forests:
E. Carina H. Keskitalo is a political scientist with expertise in adaptation to climate change and environmental policy development in multi-level governance systems. Her studies include multi-level studies of the development of adaptation policy at local to national levels in selected European countries including the UK and Sweden, studies of adaptation to climate change in forestry and water management, international comparative studies of adaptation in multi-use forest sectors (including forestry, reindeer husbandry and tourism) and implementation of EU directives at national, regional and local level in Sweden. She leads multiple national projects and is also the leader of a large-scale FORMAS-funded research environment on the role of forest in rural areas. At 20 % of her time, Keskitalo is employed as a strategic research resource at the Forest in Rural Studies Unit, Department of Forest Resource Management, Swedish University of Agricultural Sciences, Umeå. Professor Keskitalo is the author, editor or co-editor of four books broadly in the environmental policy field, and the author of over 40 peer-reviewed book chapters or articles, popular-press articles or reports.

The most relevant publications:

Keskitalo, E. C. H. (2013 [scheduled], ed) *Climate Change and Flood Risk Management: Adaptation and Extreme Events at Local Level.* Edward Elgar, Cheltenham.

Keskitalo, E. C. H. (2010, ed). *The Development of Adaptation Policy and Practice in Europe: Multi-level Governance of Climate Change.* Springer, Dordrecht. 379p.

Koivurova, T., **E. C. H. Keskitalo,** and N. Bankes (2009, eds) *Climate Governance in the Arctic.* Springer, Dordrecht. 450 p.

Keskitalo, E. C. H. (2008) *Climate Change and Globalization in the Arctic: An Integrated Approach to Vulnerability Assessment.* Earthscan, London. 257 p.

Keskitalo, E. C. H. and M. Pettersson (2012) “Implementing multi-level governance? The legal basis and implementation of the EU Water Framework Directive for forestry in Sweden”. *Environmental Policy and Governance* 22 (2): 90-103.

Keskitalo, E. C. H., S. Juhola and L. Westerhoff (2012) "Climate Change Adaptation as Governmentality: Technologies of Government in the Development of Adaptation Policy in Four Countries". *J. Environmental Planning and Management* 55(4): 1-18

Keskitalo, E. C. H. (2011) “How Can Forest Management Systems Adapt to Climate Change? Possibilities in Different Forestry Systems”. *Forests* 2(1): 415-430.

Keskitalo, E. C. H. (2008) ”Vulnerability and adaptive capacity in forestry in northern Europe: a Swedish case study”. *Climatic Change* 87: 219-234.

CV/GEORG KINDERMANN

Degree:	Ph.D. in Forestry	**Current appointment:**	Research Scholar
Affiliation:	International Institute for Applied Systems Analysis	**Birth year:**	1973
		Sex:	Male

Research interests in relation to Future Forests:
G.K. is a Research Scholar in the Forestry Program at the International Institute for Applied Systems Analysis (IIASA). He holds a PhD in forestry, with particular focus on forest growth and yield modeling. He has experience in forest measurement and sample plot design, data storage (SQL), statistics (R) and programming (C++, Perl). He has developed a model estimating forest growth for any point on the globe (G4M) which allows simulation of the amount of biomass for bioenergy and stored carbon in forests. In combination with economic estimates like the wood price it is possible to calculate the competition over land between different land uses and to find regions which have a high pressure on deforestation. For regions with deforestation pressure it is possible to calculate incentives which will make forestry competitive with alternative land uses and will prevent further forest degradation and deforestation.

The most relevant publications:
Wetterlund E, Leduc S, Dotzauer E, **Kindermann G** (2012). Optimal use of forest residues in Europe under different policies-second generation biofuels versus combined heat and power. Biomass Conversion and Biorefinery, Article in press (Published online 12 July 2012).
Gusti M, **Kindermann G** (2011). An approach to modeling landuse change and forest management on a global scale. Proceedings, 1st International Conference on Simulation and Modeling Methodologies, Technologies and Applications (SIMULTECH 2011), 29-31 July 2011, Noordwijkerhout, Netherlands.
Huang J, Abt B, **Kindermann G**, Ghosh S (2011). Empirical analysis of climate change impact on loblolly pine plantations in the southern United States. Natural Resource Modeling, 24(4): 445-476.
Riahi K, Rao S, Krey V, Cho C, Chirkov V, Fischer G, **Kindermann G**, Nakicenovic N, Rafaj P (2011). RCP 8.5 - A scenario of comparatively high greenhouse gas emissions. Climatic Change, 109(1-2): 33-57.
Gusti M, Bottcher H, **Kindermann G**, Obersteiner M (2009). Integrated assessment of global mitigation options in the forestry sector (Abstract). In: 8th International Carbon Dioxide Conference, 13-19 September 2009, Jena, Germany.
Kindermann G, McCallum I, Fritz S, Obersteiner M (2008). A global forest growing stock, biomass and carbon map based on FAO statistics. Silva Fennica, 42(3): 387-396
Kindermann G, Obersteiner M, Sohngen B, Sathaye J, Andrasko K, Rametsteiner E, Schlamadinger B, Wunder S, Beach R (2008). Global cost estimates of reducing carbon emissions through avoided deforestation. PNAS, 105(30): 10302-10307.
Kindermann G, Obersteiner M, Rametsteiner E, McCallum I (2006). Predicting the deforestation-trend under different carbon-prices. Carbon Balance and Management, 1: 15.

CV/MAARTJE J. KLAPWIJK

Degree:	Ph.D. in Community Ecology	**Current appointment:**	Researcher
Affiliation:	Inst. for Ecology, Swedish University of Agriculture	**Birth year:**	1977
		Sex:	Female

Research interests:
Maartje Klapwijk is an ecologist with an expertise in community ecology and species interactions. Her long term research focuses on anthropogenic effects on species interactions and their consequences. Her work ranges from the effects of habitat fragmentation on species persistence and interactions at a spatial scale to the effects of climate change on phenology of host – natural enemy interactions. The main subject of her recent research is the effect of climate change on insect outbreaks through direct and indirect effects. Her research also involves the effect of forest stand composition on insect herbivore densities and their parasitism rates, moving towards investigating food web structures under different stand management regimes. In general, the dynamics of insect outbreaks and the mechanism behind these fluctuations and potential methods of mitigating the potential threats for increased damage under climatic change are part of the driving force in her research interests. Recently, she took part in organizing a workshop on the effect of invasive insect species in Europe, with special attention to Sweden. Maartje Klapwijk is currently working on several papers connected the above mentioned research and is developing collaborations with established experts on forest insect dynamics as well as collaborating with colleagues within SLU to develop a solid foundation for future research.

The most relevant publications:

Björkman, C., Bylund, H., **Klapwijk, M.J**., Kollberg, I., & Schroeder, M. (2011) Insect Pests in *Future Forests*: More Severe Problems? Forests, 2, 474-485.

Klapwijk, M.J., Battisti, A., Ayres, M.P., & Larsson, S. (2012). Assessing the impact of climate change on outbreak potential. In Insect Outbreaks Revisited (ed. by P. Barbosa, D. Letourneau & A.A. Agrawal). Blackwell Publishing Ltd, Oxford.

Klapwijk, M.J., Grobler, B.C., Ward, K., Wheeler, D., & Lewis, O.T. (2010) Influence of experimental warming and shading on host-parasitoid synchrony. Global Change Biology, 16, 102-112.

Klapwijk, M.J. & Lewis, O.T. (2008) Effects of Climate change and Habitat Fragmentation on Trophic Interactions. In Encyclopedia of Life Support Systems (EOLSS) (ed. by A. Bonet & G. Carrion-Villarnovo), Vol. Tropical Biology and Conservation. UNESCO Eolss Publishers, Oxford, UK.

Klapwijk, M.J. & Lewis, O.T. (2011) Spatial ecology of multiple parasitoids of a patchily-distributed host: implications for species coexistence. Ecological Entomology, 36, 212-220.

Klapwijk, M.J. & Lewis, O.T. (2012) Host-parasitoid dynamics in a fragmented landscape: Holly trees, holly leaf miners and their parasitoids. Basic and Applied Ecology, 13, 94-105.

Koricheva, J., **Klapwijk, M.J**., & Björkman, C. (in print). Implications of life history traits and host plant characteristics for insect herbivore population dynamics. In Insect Outbreaks Revisited (ed. by P. Barbosa, D. Letourneau, & A.A. Agrwal). Blackwell Publishing Ltd, Oxford.

CV/FLORIAN KRAXNER

Degree:	DI in forestry/mountain risk eng.	**Current appointment:**	Research Scholar
Affiliation:	International Institute for Applied Systems Analysis	**Birth year:**	1973
		Sex:	Male

Research interests in relation to Future Forests:
Florian Kraxner has been Deputy Program Leader of IIASA's Ecosystems Services and Management (ESM) Program since 2011, following a period as Acting Deputy Leader of the former Forestry Program (FOR) since July 2009. Since 2006 he has also been a visiting researcher at the National Institute for Environmental Studies (NIES) in Japan, where he is working on integrated biomass for bioenergy projects in various Japanese Eco-Model Cities. He graduated in forestry with a specialization in mountain risk engineering and watershed management from BOKU-University in Vienna, where he was employed from 2000 to 2004. His research activities comprise socio-economics in forestry, forest policy, REDD+, bioenergy, and BECCS. He is author of over 50 peer-reviewed and popular press articles and book chapters.

The most relevant publications:

Kraxner, F., Aoki, K., Albrecht F., Kindermann, Yang, J., Yamagata Y. (2012), Urban Ecosystem Management – Geospatial Bioenergy Modeling for Vienna, Applied Energy Journal (submitted).

Kraxner, F., Aoki, K., Leduc, S., Kindermann, G., Fuss, S., Yang, J., Yamagata, Y., Il Tak, K. and Obersteiner, M. (in press), BECCS in South Korea - An analysis of negative emissions potential for bioenergy as a mitigation tool. Renewable Energy (issue forthcoming).

Kraxner, F., Nordström, E.-M., Obersteiner, M., Havlík, P., Gusti, M., Mosnier, A., Frank, S., Valin, H., Fritz, S., McCallum, I., Kindermann, G., See, L., Fuss, S., Khabarov, N., Böttcher, H., Aoki, K. and Máthé, L. (2012), Global bioenergy scenarios - Future forest development, land-use implications and trade-offs. Biomass and Bioenergy (issue forthcoming).

Franklin O, Moltchanova E, **Kraxner F,** Seidl R, Bottcher H, Rokityiansky D, Obersteiner M (2012). Large-scale forest modeling: Deducing stand density from inventory data. International Journal of Forestry Research, 2012: 934974 (2012).

Kraxner F., Aoki K., Fuss S., Obersteiner M., Yang J., Yamagata Y. (2011): Assessing the Sustainability of Bioenergy Diffusion in Austria. Paper presented at the International Conference for Applied Energy, ICAE 2011. Proceedings, ICAE 2011; submitted to the ICAE 2011 Special Edition of the Applied Energy Journal.

Kraxner, F., Yang, J., Yamagata, Y. (2009): Attitudes towards forest, biomass and certification – A case study approach to integrate public opinion in Japan. Bioresource Technology, 100 (2009): 4058-4061.

Kraxner F. and Y. Yamagata (2007): Biomass for Bioenergy – An Austrian Real Case Compared to the Biomass for Bioenergy Environment in Japan. (In Japanese Language). The Japanese Quarterly Journal for Bioenergy. 32 (4): 12-15.

Obersteiner M., G. Alexandrov, Pablo C. Benítez, I. McCallum, **F. Kraxne**r, K. Riahi, D. Rokityanskiy, Y. Yamagata (2006): Global Supply of Biomass for Energy and Carbon Sequestration from Afforestation/Reforestation Activities, Mitigation and Adaptation Strategies for Global Change, 11(5-6): 1003-1021.

CV/ROLF LIDSKOG

Degree:	Ph.D. in Sociology Ph.D. in Ethics	**Current appointment:**	Professor
Affiliation:	Centre for Urban and Regional Studies, Örebro University	**Birth year:**	1961
		Sex:	Male

Research interests in relation to Future Forests:
Rolf Lidskog is a sociologist with expertise in environmental regulation, environmental sociology and risk communication. A central issue of his research concerns how actors perceive, evaluate and manage risks, where there are high demands on safety, while science and technology often cannot guarantee it in a satisfactory manner for all. To answer this question, he has studied a variety of environmental areas: climate change, air pollution policy, nuclear waste management, hazardous waste management, biodiversity and urban transport. Professor Lidskog is the author or co-author of seven books and editor or co-editor of six books. He has published more than 50 peer-reviewed articles and 30 chapters in books.

The most relevant publications:

Lidskog, R. & Elander, I. (2013) “Ecological modernisation in practice? The case of sustainable development in Sweden”, forthcoming in Journal of Environment Policy & Planning

Gustafsson, K. & **Lidskog, R**. (2013) “Boundary work, hybrid practices and portable representations: an analysis of global and national co-productions of Red Lists”, forthcoming in Nature and Culture.

Engdahl, E & **Lidskog, R (**2013) “Risk, communication and trust. Towards an emotional understanding of trust”, forthcoming Public Understanding of Science

Lidskog, R. & Sundqvist, G. (2012) “The sociology of risk”, pp 1001-1028 in Roeser, S, Hillerbrand, R, Sandin, P & Peterson, M (eds) Handbook of Risk Theory. Epistemology, Decision Theory, Ethics and Social Implications of Risk. New York: Springer.

Lidskog, R. (2011) “Regulating Nature: Public Understanding and Moral Reasoning”, Nature and Culture 6(2): 149-167.

Lidskog, R, Uggla, Y & Soneryd, L (2011) “Making Transboundary Risks Governable: Reducing Complexity, Constructing Identities and Ascribing Capabilities”, Ambio, 40(2): 111-120.

Lidskog, R, Soneryd, L & Uggla, Y (2009) Transboundary Risk Governance. London: Earthscan.

Granberg, M, **Lidskog, R** & Larsson, S (2008) “Dealing with Uncertainty. A Case Study of Controlling Insect Populations in Natural Ecosystems” Local Environment 13(7): 641-652

Lidskog, R (2008) “Scientised Citizens and Democratised Science. Re-assessing the Expert-lay Divide”, Journal of Risk Research 11(1-2): 69-86.

Gouldson, A, **Lidskog, R** & Wester-Herber, M (2007) “The Battle for Hearts and Minds. Evolutions in Corporate Approaches to Environmental Risk Communication”, Environment and Planning C: Government and Policy, 25(1): 56-72.

CV/LARS LUNDQVIST

Degree:	Docent in Silviculture	**Current appointment:**	Researcher
Affiliation:	Dept of Forest Ecology and Management, Swedish University of Agricultural Sciences	**Birth year:**	1972
		Sex:	Male

Research interests in relation to Future Forests:
Lars Lundqvist is a senior researcher with expertise in silviculture, especially forest growth and yield. The research is based both on experimental studies, often in the form of long-term field experiments, on survey studies in different stand types, and on simulations.
The current research follows two main lines: stand dynamics of uneven-aged Norway spruce forests managed with single-tree selection and other continuous cover systems, and incorporating biomechanics in studies of tree growth. The studies of uneven-aged Norway spruce forests cover both stand and tree growth – e.g. how standing volume and harvest intensity influence annual volume increment, and how the stand structure affects this relation –and the ingrowth and recruitment process. A future line of research is to analyze stand development in heterogeneous pine stands, aiming at developing an uneven-aged system for pine forests.

The most relevant publications:

Modig, E., Magnusson, B., Valinger, E., Cedergren, J. & **Lundqvist, L**. 2012. Damage to residual stand caused by mechanized selection harvest in unevenaged Picea abies dominated stands. Silva Fenn. 46(2), 267-274.

Lundqvist, L. & Elfving, B. 2010. Influence of biomechanics and growing space on tree growth in young Pinus sylvestris stands. Forest Ecology and Management 260, 2143-2147.

Lundqvist, L. & Nilson, K. 2007. Regeneration dynamics in an uneven-aged virgin Norway Spruce forest in northern Sweden. Scandinavian Journal of Forest Research, 22, 304-309.

Lundqvist, L., Chrimes, D., Elfving, B., Mörling, T. & Valinger, E. 2007. Stand development after different thinnings in two uneven-aged Picea abies forests in Sweden. Forest Ecology and Management 238, 141-146.

Lundqvist, L. 2004. Stand development in uneven-aged sub-alpine Picea abies stands after partial harvest estimated from repeated surveys. Forestry 77, 119-129.

Chrimes, D. & **Lundqvist, L.** 2004. Simulated volume increment of managed uneven-aged Picea abies stands in central Sweden. In Crimes, D; 2004; Stand development and regeneration dynamics of managed uneven-aged Picea abies forests in boreal Sweden; Thesis, Acta Univ. Agriculturae Sueciae, Silvestria 304.

Nilsson, K. & **Lundqvist, L.** 2001. Effect of stand structure and density on development of natural regeneration in two Picea abies stands in northern Sweden. Scandinavian Journal of Forest Research 16, 253-259.

Lundqvist, L. & Fridman, E. 1996. Influence of local stand basal area on density and growth of regeneration in uneven-aged Picea abies stands. Scandinavian Journal of Forest Research 11, 364-369.

Lundqvist, L. 1995. Simulation of sapling population dynamics in uneven-aged Picea abies forests. Annals of Botany 76, 371-380.

Lundqvist, L. 1994. Growth and competition in partially cut sub-alpine Norway spruce forests in N Sweden. Forest Ecology and Management 65, 115-122.

CV/ANDERS LUNDSTRÖM

Degree:	B.Sc.	**Current appointment:**	Research leader
Affiliation:	Dep of Forest Resource Management Swedish University of Agricultural Sciences	**Birth year:**	1953
		Sex:	Male

Research interests in relation to Future Forests:
AL is working with production of long-term forecasts using NFI data. During the period 1996-2008 AL was leading the Section of Forest Statistics, leading and control of the main task of the section i.e. performing the Swedish NFI. AL also has been working with the development and use of systems for long-term forecasts in Sweden. The system used until today is Hugin, and AL has been responsible for the calculations for regional scenarios for forest utilizations in Sweden. The first use of Hugin for scenarios for the whole of Sweden was AVB 85, and since then AVB 92, SKA 99, SKA 03 and SKA-VB 08 has been carried out using the Hugin system.
AL's work today is concentrated in use and further development of the new system for long-term regional scenarios, Heureka RegWise.

The most relevant publications:

Poudel, B.C., Sathre, R., Gustavsson, L., Bergh, J., **Lundström, A**. and Hyvönen. R. 2012. Effects of climate change on biomass production and substitution in north-central Sweden. Biomass and Bioenergy.

Poudel, B.C., Sathre, R., Bergh, J., Gustavsson, L., **Lundström, A**. and Hyvönen R. 2011. Potential effects of intensive forestry on biomass production and substitution in north-central Sweden. Accepted in Forest Ecology and Management.

Lestander, T., **Lundström, A**. and Finell, M. 2011. Assessment of biomass functions for calculating bark proportions and ash contents of refined biomass fuels derived from major boreal tree species. Canadian Journal of Forest Research.

Nilsson, U., Fahlvik, N., Johansson, U., **Lundström, A**., Rosvall, O. 2011. Simulation of the Effect of Intensive Forest Management on Forest Production in Sweden. Forests 2011, 2, 373-393. ISSN 1999-4907

Rosvall, O. & **Lundström, A**. 2011. Förädlingseffekter i Sveriges skogar - kompletterande scenarier till SKA-VB 08. Skogforsk, Redogörelse nr 1, 2011

Lundström, A., Glimskär, A. 2009. Definitioner, tillgängliga arealer och konsekvensberäkningar. SLU, Rapport. ISBN 978-91-86197-42-1.

Athanassiadis, D., Melin, Y., **Lundström, A**., Nordfjäll, T. 2009. Marginalkostnader för skörd av grot och stubbar från föryngringsavverkningar i Sverige. SLU, Arbetsrapport 261, ISSN 1401-1204.

Claesson, S., **Lundström, A.**, m.fl. 2008. Skogliga konsekvensanalyser 2008, SKA-VB 08, (Forest Inpact Analyses 2008). Skogsstyrelsen, rapport 25.

Lundström, A. 2008. Regionala analyser om kontinuitetsskogar och hyggesfritt skogsbruk. Skogsstyrelsen Rapport 7. ISSN 1100-0295.

Dolk Fröjd, C., **Lundström, A**., Sporrong, H., Tormalm, K., Öberg, A. 2006. Myllrande våtmarker - förslag till uppföljning av delmålet om byggande av skogsbilvägar över värdefulla våtmarker. Skogsstyrelsen, rapport 3.

CV/TOMAS LÄMÅS

Degree:	Ph.D. in Forestry	**Current appointment:**	Associate Professor
Affiliation:	Dept of Forest Resource Management, Swedish Univ. of Agricultural Sciences	**Birth year:**	1957
		Sex:	Male

Research interests in relation to Future Forests:
Tomas Lämås research area and interest is based on a broad view on forest resources and forest management planning. It includes data acquisition, analyses, planning procedures and decision support systems for multi-purpose forestry. As a former programme director of a large multi-disciplinary research programme, the Heureka research programme, Lämås has insight in most problem areas and disciplines related to multi-purpose forest management. The Heureka research programme ran in two main phases 2002-2009. In the research programme a versatile and comprehensive forest analysis and planning system was developed containing a set of decision support tools (software) for different users and problem areas. Lämås is now leading a recently started activity on Forest Sustainability Analyses (SHa, www.slu.se/SHa). The aim of SHa is to provide decision support tools and analyses related to forest resource development – including the production of goods and services – to policy developers, decision makers and managers within sectors like forestry, environment and energy. The Heureka analyses and planning system makes up central technical platform in the SHa activities and SHa is also responsible for further development and maintenance of the system. Lämås recent research concern, e.g., data quality, forest bio-energy and landscape analyses in national as well as EU funded projects.

The most relevant publications:

Duvemo, K., Eriksson, L.O., **Lämås, T**., and Wikström, P. 2012. Introducing cost plus loss analysis into a hierarchical forestry planning environment. Ann. of Oper. Res. Published on line DOI 10.1007/s10479-012-1139-9.

Horstkotte, T., Moen, J., **Lämås, T**. & Helle, T. 2011. The legacy of logging. Estimating arboreal lichen occurrence in a boreal multiple-use landscape on a two century scale. PLoS ONE 6(12) e28779.

Wikström, P., Edenius, L., Elfving, B., Eriksson, L.O., **Lämås, T**., Sonesson, J., Öhman, K., Wallerman, J., Waller, C., Klintebäck, F. 2011. The Heureka forestry decision support system: An overview. Mathematical and Computational Forestry & Natural-Resource Sciences 3(2): 87-94.

Backéus, S., Wikström, P., and **Lämås, T**. 2006. Modelling carbon sequestration and timber production in a regional case study. Silva Fennica 40(4): 615-629.

Duvemo, K. and **Lämås, T**. 2006. The influence of forest data quality on planning processes in forestry. Scandinavian Journal of Forest Research 21(4): 327-339. (Review article).

Backéus, S., Wikström, P., and **Lämås, T**. 2005. A model for regional analysis of carbon sequestration and timber production. Forest Ecology and Management 216: 28-40.

Ringvall, A., Petersson, H., Ståhl, G. and Lämås, T. 2005. Surveyor consistency in presence/absence sampling for monitoring vegetation in boreal forests. Forest Ecology and Management 212:109-117.

Ringvall, A., Petersson, H., Ståhl, G. and **Lämås, T**. 2005. Surveyor consistency in presence/absence sampling for monitoring vegetation in boreal forests. Forest Ecology and Management 212: 109-117.

CV/ERLAND MÅRALD

Degree:	Professor in History of science and ideas	**Current appointment:**	Professor
Affiliation:	Department of Historical, Philosophical and Religious studies, Umeå University	**Birth year:**	1970
		Sex:	Male

Research interests in relation to Future Forests:
Erland Mårald is a historian of science and ideas with expertise in the interdisciplinary field of environmental history. EM belongs to the interdisciplinary research group USSTE, Umeå University Studies in Science, Technology and Environment, consisting of internationally well-reputed researchers engaged in the environmental humanities. EM has analyzed the social role of forestry and agrarian sciences, notions of sustainability, environmental debate and legislation, energy issues and perspectives on the future from late 18th century until today. EM is currently, within Future Forests, involved in the integration project "How to balance knowledge and value in forest management – The case of introducing exotic tree species to southern Sweden". In the project EM, as historian of technology, science and environment, is working together with foresters, ecologists, entomologists, philosophers and political scientists, and ten different stakeholders, to examine values, attitudes and stakeholder positions concerning exotic trees.

The most relevant publications:

Eklöf, J., H. Ekerholm & **E. Mårald** (2012), "Promoting Ethanol in the Shadow of Oil Dependence: 100 years of Arguments and Frictions in Swedish Politics", Scandinavian Journal of History, forthcoming.

Mårald, E. & C. Nordlund (2012), "Modern Nature for a Modern Society: A History of Dissonances", in Nordic Nature Cultures, eds. C. Oscarson & C. Thomson (Seattle, WA: University of Washington Press, accepted).

Nordlund, C., **Mårald, E**. & O. Rosvall (2012) "Forests, Technoscience and the Future: Some Thoughts about Visions and Challenges", in Being and Acting in Times of (Un)certainty, ed. M. Nyström (Uppsala: Center for Environment and Development Studies).

Mårald, E. (2011),"Knowledge in the Service of Agriculture: Knowledge on the Borderline between Academe and Farming". In Agriculture and forestry in Sweden since 1900: Geographical and historical studies, H. Antonson & U. Jansson, eds. (Stockholm: Royal Swedish Academy of Agriculture and Forestry).

Mårald, E. (2010), "Methanol as Future Fuel: Efforts to Develop Alternative Fuels in Sweden after the Oil Crisis", History and Technology 26:4, pp. 335-357.

Mårald, E. (2008), "A Catalyst for Modern Agriculture: The Importance of Peatland Cultivation for the Adoption of Inorganic Fertilizers in Sweden, 1880–1920", The Agricultural History Review 56:1, pp. 48-65.

Mårald, E. (2006), "Our Finest Gold: Agrarian Perspectives on Urban Technology from the Mid-19th Century to Present-Day Ecocyclical Society", Progress in Industrial Ecol 3:4, pp. 393-407.

Mårald, E. & U. Jansson, eds. (2005), Bruka, odla, hävda: Odlingssystem och uthålligt jordbruk i Sverige under 400 år, eds. E. Mårald & U. Jansson (Stockholm: Royal Swedish Academy of Agriculture and Forestry), 323 p.

Mårald, E. (2002), "The BT Kemi Scandal and the Establishment of the Environmental Crime Concept", Scandinavian Journal for Studies in Criminology and Crime Prevention, vol. 2. pp. 149-170.

Mårald, E. (2002), "Everything Circulates: Agricultural Chemistry and Recycling Theories in the Second Half of the Nineteenth Century", Environment and History, 1, pp. 65-84.

CV/EVA-MARIA NORDSTRÖM

Degree:	Ph.D. in Forestry	**Current appointment:**	Postdoctoral Research scholar
Affiliation:	International Institute for Applied Systems Analysis (IIASA); Department of Forest Resource Management, SLU	**Birth year:**	1977
		Sex:	Female

Research interests in relation to Future Forests:
Eva-Maria Nodrströms' research focuses on planning for sustainable forest management. Her focus on forest planning aims to develop and test approaches for including stakeholders and multiple objectives in the planning. She has experience of using multiple criteria decision analysis (MCDA) as a tool for participatory forest planning and is currently working on integrating MCDA with other methodologies to widen the scope of analysis. For instance, she aims to investigate how future studies methodology, like scenario analysis and backcasting, can be used to generate innovative and socially acceptable strategies for forest management.

The most relevant publications:

Kraxner F., **Nordström E.-M.**, Havlík P., Gusti M., Mosnier A., Frank S., Valin H., Fritz S., McCallum I., Kindermann G., See L., Fuss S., Khabarov N., Böttcher H., Aoki K., Máthé L., and Obersteiner M. (accepted) Global bioenergy scenarios – Future forest development, land-use implications and trade-offs. *Biomass & Bioenergy.*

Nordström E.-M., Öhman K., and Eriksson Ljusk O. 2012. Approaches for aggregating preferences in participatory forest planning – An experimental study. *Open Forest Science Journal* 5: 23-32.

Menzel S., **Nordström E.-M.**, Buchecker M., Marques A., Saarikoski H., and Kangas A. 2012. Decision support systems in forest management - requirements from a participatory planning perspective. *European Journal of Forest Research* 131(5): 1367-1379.

Ångman E., Hallgren L., and **Nordström E.-M.** 2011. Managing impressions and forests: the importance of role confusion in co-creation of a natural resource conflict. *Society & Natural Resources* 24(12): 1335-1344.

Nordström E.-M., Eriksson Ljusk O., and Öhman K. 2011. Multiple criteria decision analysis with consideration to place-specific values in participatory forest planning. *Silva Fennica* 45(2): 253-265.

Sandström C., Lindkvist A., Öhman K. & **Nordström, E.-M.** 2011. Governing competing demands for forest resources in Sweden. *Forests* 2(1): 218-242.

Nordström E.-M., Eriksson Ljusk O., and Öhman K. 2010. Integrating multiple criteria decision analysis in participatory forest planning: Experience from a case study in northern Sweden. *Forest Policy and Economics* 12(8): 562-574.

Nordström E.-M., Romero C., Eriksson Ljusk O., and Öhman K. 2009. Aggregation of preferences in participatory forest planning with multiple criteria: an application to the urban forest in Lycksele, Sweden. *Canadian Journal of Forest Research* 39(10): 1979–1992.

CV/MICHAEL OBERSTEINER

Degree:	Ph.D. in Forestry	**Current appointment:**	Sen. Researcher
Affiliation:	International Institute for Applied Systems Analysis	**Birth year:**	1967
		Sex:	Male

Research interests in relation to Future Forests:
Michael Obersteiner is leader of the Ecosystems Services and Management (ESM) Program at the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria. Dr. Obersteiner's research experience stretches from plant physiology and biophysical modeling in the areas of ecosystems, forestry and agriculture to environmental economics, bioenergy engineering and climate change sciences as documented in his publications record. He is author of over 150 scientific papers and consultancy reports in the above mentioned fields.

The most relevant publications:

Lemoine DM, Fuss S, Szolgayova J, **Obersteiner M**, Kammen DM (2012). The influence of negative emission technologies and technology policies on the optimal climate mitigation portfolio. Climatic Change, 113(2): 141-162 (July 2012) (Published online 15 October 2011).

Frank S, Bottcher H, Havlik P, Valin H, Mosnier A, **Obersteiner M**, Schmid E, Elbersen B (2012). How effective are the sustainability criteria accompanying the European Union 2020 biofuel targets? Global Change Biology Bioenergy, Article in press (Publshed online 9 July 2012).

Liu J., L. You, M. Amini, M. **Obersteiner, M.** Herrero, A.J.B. Zehnder, and H. Yang, (2010) "A high-resolution assessment on global nitrogen flows in cropland," PNAS, Proceedings of the National Academy of Sciences, 2010.

Searchinger T.D., S.P. Hamburg, J. Melillo, W. Chameides, P. Havlik, D.M. Kammen, G.E. Likens, M. **Obersteiner, M.** Oppenheimer, G.P. Robertson, W.H. Schlesinger, G.D. Tilman, and R. Lubowski, "Response," SCIENCE, vol. 327, 2010, p. 781.

Obersteiner M. (2009) Storing carbon in forests. Book Review: Climate Change and Forests: Emerging Policy and Market Opportunities. Edited by Charlotte Streck, Robert O'Sullivan, Toby Janson-Smith and Richard G. Tarasofsky. NATURE 458, 151 (12 March 2009)

Kindermann G., **M. Obersteiner**, B. Sohngen, J. Sathaye, K. Andrasko, E. Rametsteiner, B. Schlamadinger, S. Wunder, and R. Beach (2008) Global cost estimates of reducing carbon emissions through avoided deforestation. PNAS, July 29, vol. 105, no. 30, pp. 10302-10307

Searchinger TD, Hamburg SP, Malillo J, Chameides W, Havlík P, Kammen DM, Likens GE, Lubowski RN, **Obersteiner M**, Oppenheimer M, Robertson PG, Schlesinger WH, Tilman DG (2009). Fixing a critical climate accounting error. SCIENCE 326(5952): 527-528.

Marland G., **M. Obersteine**r, B. Schlamadinger (2007) The Carbon Benefits of Fuels and Forests. SCIENCE, 16 Nov. 2007 VOL 318 p.1066

Brian O'Neill, Arnulf Grübler, Nebojsa Nakicenovic, **Michael Obersteiner**, Keywan Riahi, Leo Schrattenholzer, Ferenc Toth (2003) Planning for Future Energy Resources. SCIENCE. Vol. 300 25 APRIL 2003 p. 581.

Obersteiner M., Ch. Azar, P. Kauppi, K. Möllersten, J. Moreira, S. Nilsson, P. Read, K. Riahi, B. Schlamadinger, Y. Yamagata, J. Yan, and J.-P. van Ypersele (2001) Managing Climate Risk. SCIENCE; Volume 294, Number 5543, Issue of 26 Oct 2001, pp. 786-787.

CV/THOMAS RANIUS

Degree:	Professor in ecology	**Current appointment:**	Professor
Affiliation:	Department of Ecology, Swedish University of Agriculture	**Birth year:**	1971
		Sex:	Male

Research interests in relation to Future Forests:
The overall goal with TR's research is to evaluate the effect of human's use of natural resources on biodiversity, and developing cost-efficient measures to mitigate negative effects. To predict changes in biodiversity and individual populations, TR carry out simulation studies (population viability analyses and simulations of habitat dynamics at a landscape scale). These are based either on mathematical models developed from empirical data analyzed by frequentist or Bayesian statistics, or on theoretical/expert models. When analyzing which strategies for resource utilization and nature conservation that should be chosen, not only biodiversity, but also other aspects, especially financial costs, are important. For that reason, TR has collaborated with forest economists in several projects. TR's empirical studies have mainly focused on invertebrates in dead wood in boreal forest and in hollow trees in agricultural/mixed landscapes. TR has published 55 papers in international peer-review journals, and 16 popular papers in Swedish journals.

The most relevant publications:

Ranius, T. & Jansson, N. (2000) The influence of forest regrowth, original canopy cover and tree size on saproxylic beetles associated with old oaks. Biological Conservation 95: 85-94.

Ranius, T. & Hedin, J. (2001) The dispersal rate of a beetle, Osmoderma eremita, living in tree hollows. Oecologia 126: 363-370.

Ranius, T. & Kindvall, O. (2004) Modelling the amount of coarse woody debris produced by the new biodiversity-oriented silvicultural practices in Sweden. Biological Conservation 119: 51-59.

Ranius, T., Ekvall, H., Jonsson, M. & Bostedt, G. (2005) Cost efficiency of measures to increase the amount of coarse woody debris in managed Norway spruce forests. Forest Ecology and Management 206: 119-133.

Ranius, T. & Kindvall, O. (2006) Extinction risk of wood-living model species in forest landscapes as related to forest history and conservation strategy. Landscape Ecology 21: 687-698.

Schroeder, L.M., **Ranius, T**., Ekbom, B. & Larsson, S. (2006) Spatial occurrence in a habitat-tracking saproxylic beetle inhabiting a managed forest landscape. Ecol Appl 17: 900-909.

Ranius, T. (2007) Extinction risks in metapopulations of a beetle inhabiting hollow trees predicted from time series. Ecography 30: 716-726.

Ranius, T., Johansson, V. & Fahrig, L. (2010) A comparison of patch connectivity measures using data on invertebrates in hollow oaks. Ecography 33: 971-978.

Ranius, T., Roberge, J.-M. (2011) Effects of intensified forestry on the landscape-scale extinction risk of dead-wood dependent species. Biodiversity and Conservation 20: 2867-2882.

Johansson, V., **Ranius, T**., Snäll, T. (2012) Epiphyte metapopulation dynamics are explained by life-history, connectivity and patch dynamics. Ecology 93: 235-241.

CV/EVA RING

Degree:	Ph.D. in Soil Science	**Current appointment:**	Scientist
Affiliation:	Skogforsk The Forestry Research Institute of Sweden	**Birth year:** **Sex:**	1966 Female

Research interests in relation to Future Forests:
Eva Ring is a scientist at Skogforsk. She has been working with environmental effects of different forestry operations on water and soils since the early 1990´s. Her research has focused on effects of common forestry operations such as final felling, site preparation, nitrogen fertilization, wood-ash application, bio-fuel extraction and lately off-road traffic. In addition to scientific publication, she has been involved in producing various guidelines and reports on how negative impacts on soils and water can be reduced in operational forestry.

The most relevant publications:

Ring, E., von Brömssen, C., Losjö, K., Sikström, U. (2011). Water chemistry following wood-ash application to a Scots pine stand on a drained peatland in Sweden. Forestry Studies 54, 54-70.

Laudon, H., Sponseller, R.A., Lucas, R.W., Futter, M.N., Egnell, G., Bishop, K., Ågren, A., **Ring, E.**, Högberg, P. (2011). Consequences of More Intensive Forestry for the Sustainable Management of Forest Soils and Waters. Forests 2, 243-260.

Ring, E., Jacobson, S., Högbom, L. (2011). Long-term effects of nitrogen fertilization on soil chemistry in three Scots pine stands in Sweden. Canadian Journal of Forest Research 41, 279-288.

Futter, M.N., **Ring, E**., Högbom, L., Entenmann, S., Bishop, K. (2010). Consequences of nitrate leaching following stem-only harvesting of Swedish forests are dependent on spatial scale. Environmental Pollution 158, 3552-3559.

Berg, R., Bergkvist, I., Lindén, M., Lomander, A., **Ring, E**. & Simonsson, P. (2010). Förslag till en gemensam policy angående körskador på skogsmark för svenskt skogsbruk. Skogforsk Arbetsrapport 731, 18 pp.

Gundersen, P., Laurén, A., Finér, L., **Ring, E**., Koivusalo, H., Sætersdal, M., Weslien, J-O., Sigurdsson, B. D., Högbom, L., Laine, J., Hansen, K. (2010). Environmental Services provided from Riparian Forests in the Nordic Countries. AMBIO 39(8), 555-566.

Löfgren, S., **Ring, E.**, von Brömssen, C., Sørensen, R., Högbom, L. (2009). Short-term effects of clear-cutting on the water chemistry in two boreal streams in northern Sweden: A paired catchment study. AMBIO 38(7), 347-356.

Sørensen, R., **Ring, E**., Meili, M., Högbom, L., Seibert, J., Grabs, T., Laudon, H., Bishop, K. (2009). Forest harvest increases runoff most during low flows in two boreal streams. AMBIO 38(7), 357-363.

Ring, E., Löfgren, S., Sandin, L., Högbom, L., Goedkoop, W., Bergkvist, I. & Berg, S. (2008). Skogsbruk med hänsyn till vatten – en handledning från Skogforsk. Skogforsk, Handledning, 64 pp.

Ring, E., Jacobson, S. & Nohrstedt, H.-Ö. (2006). Soil-solution chemistry in a coniferous stand after adding wood ash and nitrogen. Canadian Journal of Forest Research 36: 153-163. With corrigendum in Canadian Journal of Forest Research 41, 902 2011.

CV/LUCY RIST

Degree:	Ph.D. in Forest Ecology and Management	**Current appointment:**	Forskare
Affiliation:	Ecology and Environmental Science, Umeå University	**Birth year:**	1980
		Sex:	Female

Research interests in relation to Future Forests:
Lucy´s research focuses on the sustainable use of natural resources integrating ecological, social and economic perspectives. Her focus on forest management aims to advance the application of concepts such as resilience and adaptive management in a practical context.
She is currently working to apply resilience theories in an operational way in the context of forests and forestry. Specifically aiming to understand the practical value of these ideas: are these concepts compatible with systems focused on resource production? Should enhanced resilience be an objective of management? If so, how does one manage 'for' resilience and what are the trade-offs associated with doing so? Similarly she is investigating the philosophy and methodology of adaptive management, drawing on interdisciplinary collaborations to assess the value of experimentation in forest resource management and conservation.

The most relevant publications:

Rist, L. and J. Moen. (accepted) Does resilience offer a new model for sustainable forest management? Ecology and Society.

Rist, L. B.M. Campbell and P. Frost. 2012. Adaptive management; where are we now? Environmental Conservation. Published online: 16 August 2012

Rist, L., Shanley, P., Sunderland, T., Sheil, D., Ndoye, O., Liswanti, N. and J. Tieguhong. 2012. The impacts of selective timber harvest on non-timber forest products of livelihood importance. Forest Ecology and Management. 268: 57-69

Lee, J.S.H., **Rist, L**., Obidzinski, K., Ghazoul, J. and Koh, L.P., 2011. No farmer left behind in sustainable biofuel production. Biological Conservation 144: 2512-2516.

Rist, L., Uma Shaanker, R., and Ghazoul, J. 2011. The spatial distribution of mistletoe in a tropical forest at multiple scales. Biotropica 43: 50-57.

Rist, L., Kaiser-Bunbury, C.N., Fleischer-Dogley, F., Edwards, P., Bunbury, N. and Ghazoul 2010. Sustainable Harvesting of Coco de Mer, Lodoicea maldivica, in the Vallée de Mai, Seychelles. Forest Ecology and Management. 260: 2224-2231

Rist, L., Feintrenie, L. A. and Levang, P. 2010. The livelihood impacts of oil palm: smallholders in Indonesia. Biodiversity and Conservation. 19: 1009-1024.

Rist, L., Uma Shaanker, R., Milner-Gulland E.J., and Ghazoul, J. 2010. Traditional Ecological Knowledge in Forest management, an example from India. Ecology and Society 15: 3.

Rist, L., Lee, J. and Koh, L.P. 2009. Biofuels: Social benefits. Science 326: 1344.

Rist, L., Uma Shaanker, R., Milner-Gulland E.J., and Ghazoul, J. 2008. Managing mistletoes: the value of local practices for a non-timber forest resource. Forest Ecology and Management 255: 1684-1691

CV/JEAN-MICHEL ROBERGE

Degree:	BA.Sc. Forestry, Ph.D. in Ecology	**Current appointment:**	Assistant professor
Affiliation:	Dept of Wildlife, Fish and Environmental Studies, SLU	**Birth year:**	1977
		Sex:	Male

Research interests in relation to Future Forests:

Jean-Michel Roberge is a conservation ecologist with special fondness for forest ecosystems. His research addresses basic mechanisms influencing the characteristics of forest-dwelling animal assemblages, the effects of forest management on biodiversity at various scales, the assessment of surrogate approaches for biodiversity conservation (e.g. indicator species), and the evaluation of the efficiency of alternative landscape approaches for biodiversity maintenance and restoration. Dr Roberge is the authors of 27 peer-reviewed scientific articles and book chapters and 14 popular-science articles, official reports and letters. He has co-edited a book on the conservation of forest biodiversity (published by Wiley-Blackwell) and is currently working on a new co-edited book on the ecology and conservation of forest birds.

The most relevant publications:

Elo M, **Roberge J-M**, Rajasärkkä A, Mönkkönen M. 2012. Energy density and its variation in space limit species richness of boreal forest birds. J Biogeogr 39: 1462-1472.

Ranius T, **Roberge J-M**. 2011. Effects of intensified forestry on the landscape-scale extinction risk of dead-wood dependent species. Biodivers Conserv 20: 2867-2882.

Roberge J-M, Bengtsson SBK, Wulff S, Snäll T. 2011. Edge creation and tree dieback influence the patch-tracking metapopulation dynamics of a red-listed epiphytic bryophyte. J Appl Ecol 48(3): 650-658.

Stighäll K, **Roberge J-M**, Andersson K, Angelstam P. 2011. Usefulness of biophysical proxy data for modelling habitat of an endangered forest species: the white-backed woodpecker Dendrocopos leucotos. Scand J Forest Res 26: 576-585.

Edman T, Angelstam P, Mikusiński M, **Roberge J-M**, Sikora A. 2011. Spatial planning for biodiversity conservation: assessment of forest landscapes' conservation value using umbrella species requirements in Poland. Landscape Urban Plan 102 16-23.

Honkanen M, **Roberge J-M**, Rajasärkkä A, Mönkkönen M. 2010. Disentangling the effects of area, energy and habitat heterogeneity on boreal forest bird species richness in protected areas. Global Ecol Biogeogr 19: 61-71.

Roberge J-M, Angelstam P. 2009. Selecting species to be used as tools in the development of forest conservation targets. Pp. 109-128 in: Villard M-A, Jonsson BG (Eds). Setting Conservation Targets for Managed Forest Landscapes. Cambridge U. Press, UK.

Roberge J-M, Angelstam P, Villard M-A. 2008. Specialised woodpeckers and naturalness in hemiboreal forests – deriving quantitative targets for conservation planning. Biol Conserv 141: 997-1012.

Roberge J-M, Angelstam P. 2006. Indicator species among resident forest birds – a cross-regional evaluation in northern Europe. Biol Conserv 130: 134-147.

Roberge J-M, Angelstam P. 2004. Usefulness of the umbrella species concept as a conservation tool. Conserv Biol 18: 76-85.

CV/DANIEL SJÖDIN

Degree:	Ph.D. in Sociology	**Current appointment:**	Senior Lecturer
Affiliation:	Centre for Urban and Regional Studies, Örebro University	**Birth year:**	1974
		Sex:	Male

Research interests in relation to Future Forests:
Daniel Sjödin has a PhD in sociology from Lund University (2011). His PhD-thesis identifies social mechanisms on the societal, organizational and individual levels that link commitments, membership and integration. His method competence is both in quantitative methods (especially multivariate analysis) and qualitative methods. Currently he works as senior lecturer in sociology and have started to conduct research on organizational learning with regard to environmental catastrophes.

The most relevant publications:

Sjödin, Daniel (2011). *Tryggare kan ingen vara: migration, religion och integration i en segregerad omgivning*. Diss. Lund: Lunds universitet.

Sjödin, Daniel (2009) ”Analys av tidsserier”, s. 149-194 i Djurfelt, G. & Barmark, M. (red.) *Statistisk verktygslåda – multivariat analys.* Lund: studentlitteratur

CV/JOHAN SONESSON

Degree:	Ph.D. Forest Genetics	**Current appointment:**	Researcher
Affiliation:	Skogforsk, Uppsala The Forestry Research Institute of Sweden	**Birth year:**	1960
		Sex:	Male

Research interests in relation to Future Forests:
Johan Sonesson made his PhD in the field of early genetic testing of tree seedlings in environments with different water availability and temperature. The results had implication on tree breeding and the possibilities for tree species to adapt to climate change. He has been responsible for operative tree breeding work in the Swedish breeding program for Norway Spruce, as well as project leader for the central Swedish clonal forestry program. Sonesson has also been involved in evaluations of the need for adaptation of forestry to climate change. He has been assistant program manager for the Heureka research program and project leader in projects aiming at developing decision support tools for forest management for non-industrial forest owners. At present he is working as project leader in a number of research and development projects in the field of forest management and forest management planning.

The most relevant publications:
Berlin, M., **Sonesson, J**., Bergh, J. & Jansson, G. 2012. The effect of fertilization on genetic parameters in Picea abies clones in central Sweden and consequences for breeding and deployment. For. Ecol. Man. 270 (2012) 239-247.

Sonesson, J. & Rosvall, O. 2011. Lönsamma åtgärder för ökad tillväxt på Sveaskogs marker. Skogforsk.

Wikström, P., Edenius, L., Elfving, B., Eriksson, L.O., Lämås, T., **Sonesson, J**., Öhman, K., Wallerman, J., Waller, C. & Klintebäck, F. 2011. The Heureka Forestry Decision Support System: An Overview. Mathematical and Computational Forestry & Natural-Resource Sciences 3(2) 87-95.

Sonesson, J. 2009. Skogsbruk och naturvård – målkonflikter I en föränderlig framtid. Book chapter in: L. J. Lundgren (ed), Naturvård bortom 2009. Kassandra, Kristianstad. ISBN: 978-91-631-6083-7

Sonesson, J., Swedjemark, G., Almqvist, C., Jansson, G., Hannrup, B., Rosvall, O. & Kroon, J. 2007. Genetic variation in responses of Pinus sylvestris trees to natural infection by Gremmeniella abietina. Scand J. For Res. 22:290-298.

Gustavsson, L., Rummukainen, M. & **Sonesson, J**. 2006. Klimatförändring – konsekvenser för skog och skogsbruk. I Sex Omvärldsanalyser för Framtidens skog – hållbara strategier under osäkerhet. Mistra 20 s

Sonesson, J. (ed), P. Barklund, J. Bergh, R. Bergström, C. Björkman, K. Blennow, L. Bärring, D. Chen, L. Hansson, T. Lämås, U. Nilsson, M. Ottosson-Löfvenius, J. Persson, M. Rummukainen, P. Samuelsson & B. Smith. 2006. Klimatet och skogen – underlag för nationell forskning. Kungl. Skogs- och Lantbruksakademiens Tidskrift 9:145.

Sonesson, J., Bradshaw, R., Lindgren, D., & Ståhl, P. 2001. Ecological evaluation of clonal forestry with cutting-propagated Norway spruce. SkogForsk. Report No. 1, 2001.

Sonesson J & Eriksson G. 2000. Genotypic stability and genetic parameters for growth and biomass traits in a water x temperature factorial experiment with Pinus sylvestris. For Sci. 46:487-495

CV/RYAN SPONSELLER

Degree:	Ph.D. in Life Sciences/Ecology	**Current appointment:**	Assistant Professor
Affiliation:	Forest Ecology and Management Swedish Univ of Agricultural Sciences	**Birth year:**	1975
		Sex:	Male

Research interests in relation to Future Forests:
Ryan Sponseller is an Assistant Professor in the Department of Forest Ecology and Management at SLU. His research focuses on the controls over community structure and ecosystem function in landscapes, with an emphasis on the ecology and biogeochemistry of streams, rivers, and wetlands. He has research experience in a diversity of regions, including North American deserts and Temperate, Humid, and Boreal forests. His current research addresses the relationships between forest management and stream ecosystem structure and function in the Boreal landscape, as well as the role of aquatic processes in regional biogeochemical cycles.

The most relevant publications:

Sponseller, R.A., J.B. Heffernan, and S.G. Fisher. Pending revision. On the multiple ecological roles of water in river networks. Ecosphere.

Sponseller, R.A., J. Temnerud, K. Bishop, and H. Laudon. Pending revision. Linking regional patterns of riverine carbon, nitrogen, and phosphorus to ecosystem state factor and anthropogenic gradients. Limnology and Oceanography.

Sponseller, R.A., S.J. Hall, N.B. Grimm, J.P Kaye, D. Huber, C. Clark, and S. Collins. 2012. Variation in monsoon precipitation drives spatial and temporal patterns of Larrea tridentata growth in the Sonoran Desert. Functional Ecology 26, 750–758.

Hall, S.J, **R.A. Sponseller**, N.B. Grimm, David Huber, Jason P. Kaye, Christopher Clark, and Scott Collins. 2011. Ecosystem response to nutrient enrichment in the Sonoran Desert. Ecological Applications 21: 640-660.

Laudon, H., **R.A. Sponseller**, R.W. Lucas, M.N. Futter, G. Egnell, K. Bishop, A. Ågren, E. Ring and P. Högberg. 2011. Consequences of More Intensive Forestry for the Sustainability of Forest Soils and Waters. Forests 2: 243-260.

Sponseller, R.A., N.B. Grimm, A.J. Boulton, and J.L. Sabo. 2010. Responses of macroinvertebrate communities to long-term flow variability in a Sonoran Desert stream. Global Change Biology 16: 2891-2900.

Sponseller, R.A. and S.G. Fisher. 2008. The influence of drainage networks on patterns of soil respiration in a desert catchment. Ecology 89: 1089-1100.

Sabo, J.L., **R.A. Sponseller**, M. Dixon, K. Gade, T. Harms, J. Heffernan A. Jani, G. Katz, C. Soykan, J. Watts, and J. Welter. 2005. Riparian zones increase regional species diversity by harboring different, not more species. Ecology 86: 56-62.

Fisher, S.G, **R.A. Sponseller**, and J.B. Heffernan. 2004. Horizons in stream biogeochemistry: flowpaths to progress. Ecology 85: 2369-2379.

Sponseller, R.A., E.F. Benfield, and H.M. Valett. 2001. Relationships between land use, spatial scale, and stream macroinvertebrate communities. Freshwater Biology 46: 1409-1424.

CV/JAN STENLID

Degree:	Ph.D. in Biology 1986	**Current appointment:**	Professor
Affiliation:	Dept Forest Mycology and Plant Pathology, Swedish University of Agricultural Sciences	**Birth year:**	1954
		Sex:	Male

Research interests include: infection biology of plant pathogens, resistance biology of conifers; biodiversity, succession and interactions of fungi; monitoring, control and management of forest diseases; forest and ecosystem management including invasive species; fungal genomics.

Stenlid leads a research group of approx 20 researchers. He has been the main supervisor for 22 PhD students that have defended their theses. Currently main supervisor for 5 PhD students. Stenlid is the main PI of a Strategic Stiftelse programme on Resistance against root rot, holds one Formas and three EU grants. He became a honorary member of American Mycological Society, 2007. He received the Alfred Toepfer prize for Agriculture, Forestry and Nature Protection, 2009. He has published over 200 papers in peer reviewed journals. Total citations in the ISI data base 3747, H-factor 30.

The most relevant publications:

Lindahl BD Ihrmark K Boberg J Trumbore SE Högberg P **Stenlid J** & Finlay RD. 2007. Spatial separation of litter decomposition and mycorrhizal nitrogen uptake in a boreal forest. New Phytologist 173: 611-620.

Bidartondo MI., **Stenlid, J.** et al. 2008. Preserving accuracy in GenBank. Science 319 (5870): 1616

Bakys, R. Vasaitis, R. Barklund, P, Thomsen IM & Stenlid, J. 2009. Occurrence and pathogenicity of fungi in necrotic and non-symptomatic shoots of declining Fraxinus excelsior in Sweden. European Journal of Forest Research 128:51-60

Oliva, J., Thor, M., **Stenlid, J**. 2010. Long term effects of mechanized stump treatment against Heterobasidion annosum s.l. root rot in Picea abies. Can. J. Forest Res. 40, 1020-1033.

Stenlid, J, Oliva, J, Boberg, J, Hopkins, A. 2011. Emerging diseases in European forest ecosystems and responses in society. Forests 2: 486-504.

Eastwood, DC, … **Stenlid J,** … & Watkinson, SC. 2011. The Plant Cell Wall-Decomposing Machinery Underlies the Functional Diversity of Forest Fungi. Science 333, 762-765.

Oliva J & **Stenlid, J**. 2011. Validation of the Rotstand model for simulating Heterobasidion annosum root rot in Picea abies stands. Forest Ecology and Management. 261:1841-1851.

Olson, Å, … & **Stenlid J**. 2012. Trade-off between wood decay and parasitism: Insights from the genome of a fungal forest pathogen. New Phytologist 194:1001-1013.

Floudas, D, ... **Stenlid, J**, ... & Hibbett, DS. 2012. The Paleozoic Origin of Enzymatic Lignin Decomposition Reconstructed from 31 Fungal Genomes. Science 336:1715-1719.

Santini A, ... & **Stenlid J**. 2012. Biogeographical patterns and determinants of invasion by forest pathogens in Europe. New Phytologist. doi/10.1111/j.1469-8137.2012.04364.x/pdf

CV/ANNA STÉNS (formerly Lindkvist)

Degree:	Ph.D. in History	**Current appointment:**	Postdoctoral Fellow
Affiliation:	Dept. of Historical, Philosofical And Religious Studies, Umeå University	**Birth year:**	1976
		Sex:	Female

Research interests in relation to Future Forests:
Anna Sténs, formerly Lindkvist, is a historian with expertise in contemporary social, political and agrarian history. She is currently doing research within the interdisciplinary field of environmental history, focusing on past, present and future utilization of forest resources and on controversies surrounding forests and forestry in Sweden. Sténs belongs to the interdisciplinary research group USSTE, Umeå University Studies in Science, Technology and Environment, consisting of internationally well-reputed researchers engaged in the environmental humanities. Thanks to her background as a museum curator working on land use issues, she has a broad network also including researchers and practitioners outside of the academy. Sténs has published a number of peer-reviewed papers in historical and social science journals, and, as a result of interdisciplinary cooperation, in journals oriented towards the natural sciences.

The most relevant publications:

Sandström, C & **Sténs, A**., (Accepted). Dilemmas in forest policy development – "the Swedish forestry model" under pressure. Book chapter in Forest Futures: re-thinking global trends - implications for boreal regions (eds. Karin Beland Lindahl/Erik Westholm).

Kardell, Ö. & **Sténs, A**., (Accepted), *Future Forests* in danger? The rise and fall of public attention to forest die-back in Sweden, 1970-2012, Environment and history.

Sténs, A. & Sandström C., (In press). Divergent interests and ideas around property rights: the case of berry harvesting in Sweden. Forest Policy and Economics, doi:10.1016/j.forpol.2012.05.004.

Lindkvist, A., Mineur, E., Nordlund, A., Nordlund, C., Olsson, O., Sandstrom, C., Westin, K., Keskitalo, C., (2012). Attitudes on intensive forestry. An investigation into perceptions of increased production requirements in Swedish forestry, Scandinavian Journal of Forest Research, 27, 1-11.

Lindkvist, A., Kardell, Ö., Nordlund, C., (2011). Intensive forestry as progress or decay? An analysis of the debate about forest fertilization in Sweden, 1960 - 2010, Forests, *2*, 112-146.

Sandström, C., **Lindkvist, A**., Öhman, K., Nordström, E-M., (2011). Governing competing demands for forest resources in Sweden, *Forests*, *2*, 218-242.

Lindkvist, A., (2007). Jorden åt folket: Nationalföreningen mot emigrationen 1907-1925 [Land for the people: The National Society Against Emigration, 1907-1925] (diss.), Umeå universitet, Umeå.

Lindkvist, A., (2003). Landskap och identitet [Landscape and identity], In: Värdefulla Landskap, Mårald, E. (ed.), Landskapet som arena: Umeå.

Lindkvist, A., (2003). 'Aa - her er ein herlig provins til lande lagt': från emigration till inre kolonisation i 1900-talets Norge och Sverige. Heimen 81, 105-118.

CV/KRISTINA WALLERTZ

Degree: PhD in Forest management **Current appointment:** Research assistant

Affiliation: Unit for field-based Forest research SLU **Birth year:** 1958 **Sex:** Female

Research interests in relation to Future Forests:
I am working at Asa experimental forest and research station and my two main research interests are; Ecology, behavior and pest management of the pine weevil (*Hylobius abietis*) and Establishment of a new tree species, Douglas fir (*Pseudotsuga menziesii*), in Sweden. The first one is aiming to find sustainable ways of reducing damage to conifer seedlings caused by the pine weevil without the use of insecticides. My research focus on how weevil feeding on conifer seedlings can be reduced by the use of different silviculture methods. My studies involve different site preparation methods, regeneration under shelter trees, tree species and seedling establishment. The main task in the second project is how to gain more knowledge of Douglas fir in southern Sweden with focus on establishment of newly planted seedlings. The research involves trials with provenances and planting after different site preparation methods. In collaboration with a Ph.D student I am also working on a review in the subject. Lectures, excursions and other ways of spreading information is an important part of my daily work.

The most relevant publications:

Örlander, G., Nordlander, G., **Wallertz, K**., & Nordenhem, H. 2000. Feeding in the crowns of Scots pine trees by the pine weevil Hylobius abietis. Scand. Journal of Forest Research 15: 194-201.

Örlander, G., Nordlander, G. & **Wallertz, K**. 2001. Extra food supply decreases damage by the pine weevil Hylobius abietis. Scandinavian Journal of Forest Research 16: 450-454.

Nordlander, G., Bylund, H., Örlander, G., & **Wallertz, K**. 2003. Pine weevil population density and damage to coniferous seedlings in a regeneration area with and without shelterwood. Scandinavian Journal of Forest Research 18: 438-448.

Wallertz, K., Örlander, G. & Luoranen, J. 2004. Damage by pine weevil Hylobius abietis to conifer seedlings after shelterwood removal. Scandinavian Journal of Forest Research 20: 412-420.

Wallertz, K. 2005. Pine weevil Hylobius abietis feeding in shelterwood systems. Licentaite thesis. Swedish University of agricultural Sciences. Alnarp 2005.

Wallertz, K. Nordlander, G. & Örlander, G. 2006. Feeding on roots in the humus layer by adult pine weevil, Hylobius abietis. Agricultural and Forest Entomology 8: 273-279.

Wallertz, K. 2009. Pine weevil feeding in Scots pine and Norway spruce regenerations. Doctoral thesis. Swedish University of agricultural Sciences. Alnarp 2009.

Wallertz, K. & Petersson, M. 2011. Pine weevil damage to Norway spruce seedlings: effects of nutrient-loading, soil inversion and physical protection during seedling establishment. Agricultural and Forest Entomology. Volume 13: 413-421.

Wallertz, K. & Malmqvist C. 2012. The effect of site preparation methods on establishment of Norway spruce (Picea abies (L.) Karst) and Douglas fir (Pseudotsuga menziesii (Mirb.) in southern Sweden. 2012; 0, 1-8, doi:10.1093/forestry/cps065

Wallertz, K., Frisk, J., Johansson, U. & Örlander, G. 2012. Etablering av odlingstester med douglasgran i södra Sverige. Odlingstester och proveniensförsök med Douglas, planterade 2009 och 2010. Swedish university of Agricultural Sciences, Unit for field-based forest research. In Swedish with english summary.

CV/CAMILLA WIDMARK

Degree:	Ph.D. in Economics	**Current appointment:**	Assistant professor
Affiliation:	Department of Forest Economics Sw. University of Agricultural Sciences	**Birth year:**	1973
		Sex:	Female

Research interests in relation to Future Forests:
Camilla Widmark is an economist with expertise in natural resource economics and policy. Her research ranges from classical economic theories, to institutional economics, common pool resource theories and policy. Land use management issues including policy implementation have been the focus of research, specifically regarding indigenous land use. More recently, Widmark's research addresses the policy on Swedish nature conservation (the Swedish model) focusing on the function and costs and benefits of nature conservation in Swedish forests, both in the societal point of view and individual forest owners. Questions, beside the economic valuation of nature conservation, are the function of the Swedish model as a policy tool as well as attitudes toward nature conservation among forest owners.

The most relevant publications:

Widmark, C. 2006. "Reindeer husbandry and forestry in northern Sweden. The development of a land use conflict." *Rangifer 26* (2) pp. 43-54. Also 2009 at http://pub-epsilon.slu.se/1057/01/Widmark_C_091021.pdf

Sandström. C. Moen, J. **Widmark**, C. Danell, Ö. 2006. "Progressing toward co-management through collaborative learning: forestry and reindeer husbandry in dialogue". *International Journal of Biodiversity Science and Management*, 2, pp. 326-333.

Sandström, C. & **Widmark**, C. 2007."Stakeholder's perspectives on consultation procedures as a tool for sustainable co-existence between forestry and reindeer herding industry." *Forest Policy and Economics* 10, pp. 25-35.

Widmark, C. 2009. *Management of Multiple-Use Commons – Focusing on Land Use for Forestry and Reindeer Husbandry in Northern Sweden*. Doctoral Thesis. Umeå.

Widmark, C. & Sandström, C. 2012. "Transaction Costs of Institutional Change in Multiple Use Commons the Case of Consultations between Forestry and Reindeer Husbandry in Northern Sweden, *Journal of Environmental Policy and Planning* (forthcomming).

Widmark, C. Bostedt, G. Andersson, M. Sandström, C. 2013. Measuring Transaction Cost incurred by Landowners in Multiple Land-Use Situations. *Land Use Policy*. 30, 677-684.

CV/ANNELI ÅGREN

Degree:	Ph.D. Physical Geography	**Current appointment:**	Assistant Professor
Affiliation:	Forest Ecology and Management Swedish Univ of Agricultural Sciences	**Birth year:**	1973
		Sex:	Female

Research interests in relation to Future Forests:

Anneli Ågren is an assistant professor working with catchment science and stream biogeochemistry. Her research questions range from more process-based understanding and modeling of the forest landscape biogeochemistry to more applied science. She is leading the project "Reducing negative impact on surface waters due to bioenergy harvest - development of better digital maps", funded by the Swedish Energy Agency, with aims to create an opportunity for better land management practices with better soil trafficability assessments to reduce soil disturbance and optimizing operations timing. Ågren uses modern multivariate statistical techniques as well as GIS-models to model landscape hydrology and biogeochemistry. She also coordinates the ForWater strong research program on improving the modeling and prediction capability of how forestry affects water quality in a changing climate. She has published 15 peer-reviewed papers, where Ågren et al. (2007) is on the "most cited list" for the journal JGR-Biogeoscience.

The most relevant publications:

Ågren, A. and Löfgren, S (2012) pH sensitivity of Swedish forest streams related to catchment characteristics and geographical location - implications for forest bioenergy harvest and ash return. Forest Ecology and Management. 10.1016/j.foreco.2012.03.017.

Ågren, A., Haei, M., Blomkvist, P., Nilsson, M.B. and Laudon, H. (2012) Soil frost enhances stream dissolved organic carbon concentrations during episodic spring snow melt from boreal mires Global Change Biology. doi: 10.1111/j.1365-2486.2012.02666.x

Ågren, A., Haei M., Köhler S. J., Bishop K and Laudon H. (2010) Regulation of stream water dissolved organic carbon (DOC) concentrations during snowmelt; the role of discharge, winter climate and memory effects. Biogeosciences, 7: 1-13.

Ågren, A., Buffam I., Bishop K., and Laudon H. (2010) Sensitivity of pH in a boreal stream network to a potential decrease in base cations caused by forest harvest. Canadian Journal of Fisheries and Aquatic Science 67: 1116-1125.

Ågren, A., I. Buffam, K. Bishop, and Laudon, H. (2010) Modeling stream dissolved organic carbon concentrations during spring flood in the boreal forest: A simple empirical approach for regional predictions, J. Geophys. Res., 115, doi: 10.1029/2009JG001013.

Ågren, A., I. Buffam, M. Berggren, K. Bishop, M. Jansson, and H. Laudon (2008), Dissolved organic carbon characteristics in boreal streams in a forest-wetland gradient during the transition between winter and summer, J. Geophys. Res., 113, G03031, doi: 10.1029/2007JG000674.

Ågren, A., I. Buffam, M. Jansson, and H. Laudon (2007), Importance of seasonality and small streams for the landscape regulation of dissolved organic carbon export, J. Geophys. Res., 112, G03003, doi: 10.1029/2006JG000381.

CV/LARS ÖSTLUND

Degree:	Ph.D. in Forest Ecology	**Current appointment:**	Professor
Affiliation:	Dept of Forest Ecology and Management, SLU, Umeå	**Birth year:**	1960
		Sex:	Male

Research interests in relation to Future Forests:
Lars Östlund's research focus on the long term history of forest use and forest management in Scandinavia and North America. A particular interest of his has been the changes of forest ecosystems, including timber volumes, stand and landscape structure of forest, and biodiversity and which all are highly related to today's research issues on how to manage forests in a sustainable way in the future. Lars Östlund works interdisciplinary with historical methods, palaeocological methods and dendrochronology to investigate specific research questions related to ecosystem changes and human land-use in the past. Lars Östlund currently supervises four PhD-students, who are working on topics ranging from the history of forest management in Scandinavia, Sami forest use and the history of conservation in modern forestry. He also supervises a number of master students, teaches at undergraduate/graduate level and is head of department with responsibility for post-graduate studies.

The most relevant publications: *(48 journal papers, ca 50 books/book sections etc)*

Gunnarson B.E., Josefsson T., Linderholm H.W., **Östlund L**. (2012) Can legacies of past human forest use bias modern tree-ring climate reconstructions? Climate Research, 53: 63-76.

Liedgren, L & **Östlund, L** (2011) Heat, smoke and fuel consumption in a high-mountain stállo-hut, northern Sweden - Experimental burning of fresh birch wood during winter. Journal of Archaeological Science 38: 903-912.

Josefssson & **Östlund** (2011) Increased production and depletion: the impact of forestry on northern Sweden's forest landscape In Antonsson & Jansson (eds) Farming and forestry in Sweden since 1900 – geographical and historical studies. SNA, Stockholm.

Josefsson, T., Gunnarson, B., Liedgren, L.G., Bergman, I. & **Östlund, L**. (2010). Historical human influence on forest composition and structure in boreal Fennoscandia. Canadian Journal of Forest Research 40: 872-884.

Josefsson, T., Hörnberg, G. & **Östlund, L**. (2009). Long-term human impact and vegetation changes in a boreal forest reserve: implications for the use of protected areas as ecological references. Ecosystems 12: 1017-1036.

Östlund, L., Ahlberg, L., Zackrisson, O., Bergman, I. & Arno, S. (2009) Bark-peeling, food stress and tree spirits - the use of pine inner bark for food in Scandinavia and North America. Journal of Ethnobiology, 29(1): 94-112.

Ericsson, T.S., Berglund, H. & **Östlund, L**. (2005) History and biodiversity of woodland key habitats in south boreal Sweden. Biological Conservation 122: 289-303.

Östlund, L., Zackrisson, O. & Hörnberg, G. (2002) Trees on the border between nature and culture – Culturally modified trees in boreal Scandinavia. Environmental History 7(1): 48-68.

Linder, P. & **Östlund, L**. (1998) Structural changes in three mid-boreal Swedish forest landscapes, 1885-1996. Biological Conservation 85: 9-19.

Östlund, L., Zackrisson, O. and Axelsson, A.L. (1997). The history and transformation of a Scandinavian boreal forest landscape since the 19th century. Canadian Journal of Forest Research 27: 1198-1206.