Forests and mankind: the relationship must be made sustainable

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FORESTS AND MANKIND

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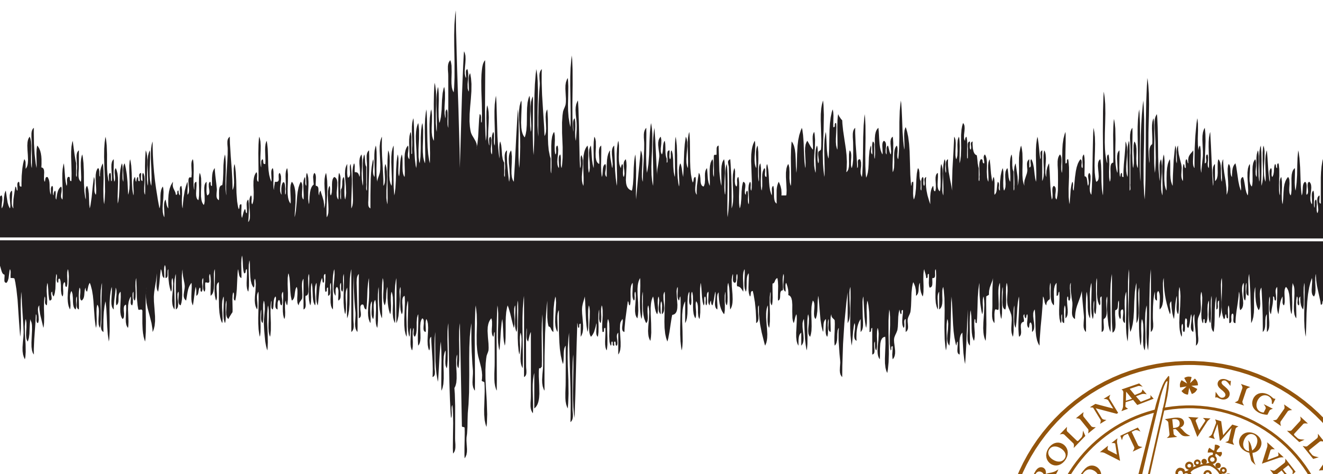

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INTRODUCTION

Forest and mankind are mutually dependent on each other and have been since the beginning of time. This dependency has only intensified since the Industrial Revolution as humans have become increasingly powerful—in fact, powerful enough to destroy all life on Earth.

The forests of Earth provide all living things with a number of so-called ecosystem services. These include resources such as drinking water and services like carbon dioxide absorption, among others. The services of the earth's ecosystem can be divided into four categories: provisioning, such as providing raw materials like wood; regulating, such as controlling the climate; supporting, such as maintaining nutrition and water cycles; and cultural, involving recreational activities and other aesthetic pursuits outdoors.

Along with these services comes mankind's responsibility for future life on Earth, and this responsibility also brings with it a number of difficult dilemmas. The overriding dilemma in relation to the forests is between the provisioning role of the forests to supply materials versus their regulating, supporting, and cultural roles; this is in addition to our need for energy versus the planet's need for CO2 absorption. Another dilemma is how to balance the expectations of the landowners with the expectations of the local population. A further, national dilemma can be found in a country like Sweden which is dependent on its forests as a natural resource. It concerns how to balance the utilization of raw material from the forest for traditional, but diminishing, paper production with the demand to use the wood for other purposes such as fuel and the production of chemicals.

When working through difficult dilemmas like those described above, evidence-based knowledge is of vital importance. Scientific research continually supplies such knowledge; however, science is unfortunately deeply compartmentalized. It is common for scientific disciplines to address associated questions and give related answers without any reference to perspectives outside the discipline; thus, the results of scientific research are difficult for policy and decision makers to utilize. Our idea is to bring together scientists representing a wide range of important disciplines to the theme of 'Forest and Mankind' wherein persons with perspectives from outside science add their different perspectives. As a result, this anthology covers a wide range of subjects and perspectives on the forest and mankind, and in the final chapter, we distill some common conclusions.

Forests And Mankind As Biological Beings

Overview

Humans, like all other living creatures on Earth, are dependent on the ecosystem services provided by nature including, not least, forests. These ecosystem services are commonly divided into four categories: provisioning, as in the production of food and water; regulating, as in the control of climate and disease; supporting, such as nutrient cycles and crop pollination; and cultural, which refers to spiritual, aesthetic, and recreational benefits. Ever since the dawn of the Industrial Age, the forests have been undergoing dramatic changes due to the actions of man, and the capacity for supplying ecosystem services has also changed. Will its capacity be sufficient for a sustainable world? And can people, as biological beings, survive under these new conditions?

In this anthology, Marianne Hall and Henrik Smith discuss the effects of developing the Nordic forests into production forests. These forests can be managed in different ways with differing results in terms of ecosystem services. Nevertheless, climate change creates new conditions and new requirements for production forests, and it is hard to foresee which management type will best lead to sustainability.
Magnus Löf notes that rapid deforestation is taking place in the world at the same time as its population increases. For the forests of the world to keep pace with the population increase, there is an urgent need for forest restoration. Löf discusses how this restoration should be done to satisfy the various demands on services from the forests.

Matilda Annerstedt examines one ecosystem service in particular, namely, the health-inducing aspects of the environment. It has been shown that visits to a forest can have many beneficial effects on our health, for example, lower blood pressure, as well as reduced cholesterol and stress levels. Moreover, the positive effects of exposure to the forest environment have been shown in both somatic and mental diseases.

Therefore, it is worth noting that efforts to retain biodiversity and the capacity for ecosystem services by good forest management not only relates to the lower species, but also to our own.

PRODUCTION, BIODIVERSITY AND CLIMATE CHANGE MITIGATION-CHALLENGES AND OPPORTUNITIES FOR MODERN FORESTRY

Marianne Hall and Henrik G. Smith

The image of the deep, dark forests of Sweden has been handed down through the centuries and has permeated the Swedish collective consciousness since our earliest childhood. Introduced by the fairytale world of John Bauer, with its trolls, towering tree trunks and moss-covered stones, amplified in the school-trip to the woods with orienteering exercises and packed lunches. Advertised in international promotions of Sweden as a land full of outdoor enthusiasts rushing from canoe trips to hiking trails or to cloudberry or blueberry picking in isolated tracts of pine trees. The image of Sweden as a country full of wilderness and primeval forests runs like a common thread, and it is hardly a coincidence that the official website for tourism and travel information Visitsweden.com promotes a tree-clad picture, captioned "The most Swedish of landscapes … A red-coloured cottage, glimmering lake in the foreground, deep forest in the background."(www.visitsweden.com).

Simultaneously, another image of the Swedish forests is emerging in media and the public debate: the image of the forest as a production site, as far from the vision of a wild landscape as a field of wheat. In this context, we see descriptions of hard-exploited tree plantations whose aim is to provide maximum economic dividends at whatever ecological price, and wood production plants where the protection of our natural heritage exists only on paper (Zaremba 2012) and where the goals of the Forestry Act to protect biodiversity (Åström 2013), cultural (Skogsstyrelsen 2013a) and social (Naturskyddsföreningen 2013) values are neither followed nor maintained. The Swedish Society for Nature Conservation accuses the Swedish Forest Agency of covering up the figures concerning breaches in nature conservation (Naturskyddsföreningen 2012) and for not taking action although they are aware of substantial transgressions (Naturskyddsföreningen 2011).

Is either of these descriptions of the Swedish forests and modern forestry correct? Have we administered the inherited richness and species diversity of the forests well vis-à-vis the need for wood and paper, or have we turned the most widespread type of Swedish nature into a mere wood production plant? Can we find our way forward towards a sustainable forestry which meets high demands for both production and conservation of species diversity, but also for new expectations, wishes and challenges resulting from climate change and the adaptation to a carbon dioxide-neutral society?

John Bauer, from Bland tomtar och troll, 1915

The forest we inherited

The forest which saw modern forestry evolve, in southern Sweden during the second half of the 19th century, was far from what we would call a wild, natural forest. Although forest ecosystems have dominated Swedish soil since the last glacial, their appearance has varied. The arrival of an agricultural society with slash-and-burn farming methods, grazing animals, and extensive use of wood for cooking and heating, building boats and later feeding blast furnaces, altered the species composition and density of the forests during the course of the centuries, primarily in southern Sweden. When the expansion of modern forestry took place in central and northern Sweden, also there traces of man's use of natural resources could be seen in the landscape, albeit more sparsely distributed in nature: the regions were still mostly covered by "natural" forests (Naturvårdsverket 2012a).

Nor did the virgin forests look like the high-columned halls of the sagas. They consisted instead of a mosaic of stands of trees whose ages and species compositions were determined primarily by forest fires and the regrowth in their wake. Areas with coniferous trees burned down now and then due to lightning or human activity. Most often the fires killed all the spruce trees and some of the pines, which allowed at first deciduous trees and then a new generation of coniferous forests to grow up

(Naturvårdsverket 2012a). Also insect outbreaks and storm felling created open areas in the compact forests, which permitted opportunistic species to establish. The general result was a heterogeneous forest landscape with great species diversity and many ecological niches.

The forest we administer

Forest ecosystems today cover more than 28 million hectares, or two-thirds of the surface of Sweden. Of these, 23 million hectares are productive forest land, that is, forests with a production rate of at least 1 m^3 per hectare and year. Only 3.5%, around 0.8 million hectares, of the productive forest land is within protected areas (Riksskogstaxeringen 2013).

The primary goal of the forestry that has been carried on since the middle of the 20^h century has been to provide the timber and pulp industries with raw material, which in turn implies striving for increased timber volumes and greater returns. This has resulted in denser and more timber-rich forests, and contributed to a more homogenous landscape with respect to age and species composition. Since the middle of the 1950's, the standing volume of wood in Swedish forests increased by 40-80%, with the higher figure for older forests, and the lower for younger ones. The percentage of young forests has also risen: the amount of land covered by forests less than 20 years old has doubled since the 1950's.

Also the total area of forest land has increased in later years. Agricultural rationalization and change has led to a decrease in the total area of land under cultivation from 4.7 million hectares in the middle of the 1950's to 3.4 million hectares today. The greatest share of this "new" land is reforested, primarily by Norway spruce (48%) or deciduous forests (37%). There has also been some development in the other direction– from dense forests to agricultural landscapes: the most common reason for this is that the forests have been fenced in and thinned out and used as grazing land supported by agro-environmental subsidies (Naturvårdsverket 2011).

The most common factor that determines which forests get to grow where has thus changed from forest fires to de- and reforestation, which in turn has altered the conditions for competing forest species. Indeed, the dominant type of forestry -- clear-cutting forestry -- leads to larger open spaces where the clear-cutting has been made and is thus reminiscent of the conditions after a forest fire. But replanting with refined plant material leads to both quick regrowth of new forests and a denser, more homogeneous area of coniferous trees without the intermediate stage of deciduous and mixed forest which is normal after a forest fire. When it comes to biodiversity, clear-cutting forestry has both advantages and disadvantages. Certain species benefit from large open spaces, including various types of butterflies, small rodents and some birds. These animals then enter the food chain and sustain predators. On the other hand, felling of older forests and the increasingly dense and dark forest landscapes negatively affect those species that are adapted to older and less dense forests, or who live in the borderlands between open areas and closed stands (Naturvårdsverket 2011).

Thus, a result of the modernization of forestry is that a large number of species must sustain in forests aimed for economically profitable production. In practice, many demanding species are restricted to land that has voluntary been set aside for environmental protection or forests used less intensively. Consequently -- how one chooses areas voluntarily set aside for protecting species, as well as how the remainder of the forest is managed, is extremely important. As investment in protecting environmental values in the forest may be in direct conflict with economically profitable forest production, it is vital that environmental measures are carried out so that they yield the highest possible benefits when it comes to protecting good habitats for endangered species. Knowledge about the endangered species in a region or area, and the presence of keystone species, must be given high priority when determining what measures are necessary for a particular landscape. Despite all our efforts, we cannot protect the most sensitive and demanding species within the frame of current forests aimed for production: they can survive only in protected areas (Niklasson and Nilsson 2005).

The forest we pass on – how do we want it to be?

Historically, agriculture and forestry have played an important part in the Swedish economy and international trade with raw materials and finished products. Its percentage of the Swedish economy – measured as the gross domestic product (GDP) – has diminished greatly during the 20th century. In 1900, agriculture, forestry and fishing made up 28% of the GDP. One hundred years later, in 2000, they contributed only 2% together (Statistiska Centralbyrån 2012). At the same time the use of forest biomass has risen throughout the entire 20th century, concomitantly with the expansion of the pulp and paper industry. In 2010, the total production value was 214 billion Swedish crowns (Skogsstyrelsen 2013b).

Yesterday's prerequisites, demands and desires regarding our forests are however not the same as today's. Climate change resulting from the fossil fuel-dependent economy and energy sector inherent in industrialism alter the rules, both for the species in the forests and for mankind's needs and priorities. The forest and its potential with regard to both climate adaptation and mitigation create new possibilities, opportunities and challenges.

Measures and changes in the Swedish forestry strategies have to answer to a broad spectrum of demands: desirable ecosystem services provided by forests include not only timber and raw materials for forest industries, but also biofuels, food sources like berries and mushrooms, clean water, potential for carbon storage as well as cultural and recreational values which have been shown to have positive effects on public health.

A well-managed production forest provides timber and potentially carbon storage, but a production system involving clear-cutting also contributes to a loss of habitat for many species, threatens biodiversity and recreational values, causes nutrient leakage and initially also carbon dioxide and methane emissions. If we create more or larger protected areas, after a several-hundred-year period of stabilization, their usefulness will be counted in terms of ecosystem services such as water regulation and purification, pollination and seed dispersal, and via direct economic returns from tourism and outdoor life (Naturvårdsverket 2012b). A forest reserve will also contain a relatively high carbon level in the biomass and soil, but further long-term carbon storage is marginal at best, if at all. We would naturally lose all the timber from the area that a production forest would have provided, and also the possibilities for a substitution effect of biofuels as replacements for fossil fuels.

Both of the alternatives thus lead to a conflict of goals between the aims of production and those of environmental protection. Internationally there is an on-going debate on whether the preservation of biodiversity occurs best in reserves or in production landscapes (Fischer et al. 2008, Phalan et al. 2011). Forest reserves will always be needed for certain species, but the increasing demands of multi-functionality of forests may require that we protect and preserve variation in production forests at the level of both the landscape and of particular stands. Since the economic costs for taking consideration of biodiversity often affect the individual landowner, while the profits are collective, the ecosystem services in the forests are affected by a kind of "the tragedy of the commons". This creates the need for policy implementation vis-à-vis which goals which are be prioritized at any specific place, and perhaps even the need for alternative strategies for how we make use of the forests.

Forestry without clear-cuttings

One alternative strategy in forestry is the so-called selective cutting forestry, in which one allows the forest to continuously maintain a relatively large leaf area, around 30%.

In this practice, the forest keeps a larger share of its functions in the carbon, water and nutrient cycles also in phases when timber is being removed, than if clear-cutting forestry is practiced. Under the condition that the strategy is well planned -- adapted to specific prerequisites for the specific forest location -- it may be possible to profit from it in the form of decreased emissions of methane gas (Lindroth et al. 2012) and reduced risk of nitrogen leakage. From a biodiversity point of view this management strategy favors species that require continuous shading or shelter. Heterogeneity in the forest landscape favors a greater biodiversity (Naturvårdsverket 2012b) but the outcome depends both on management strategies and how one chooses which individual trees are to be left in an area when the species composition and age of each individual tree are concerned.

Regarding carbon emissions, carbon storage and production, the comparison between clear-cutting forestry and selective cutting forestry is more difficult to make (Kuuluvainen et al. 2012). The Swedish Environmental Protection Agency reports that the ability of the forest to be a carbon sink, from a landscape perspective or over longer timescales (> 100 years), do not depend on forest management (Naturvårdsverket 2012b). However, as there are few forests in Sweden today where selective cutting is practiced, there is little scientific basis to quantify the effects of an altered forestry strategy. Measurements of the emissions of greenhouse gases from a short-term experiment with thinning made outside of Uppsala have indicated that the emissions of carbon dioxide from the soil increase significantly in connection with thinning, most likely due to the decomposition of roots and other organic material, but that the carbon dioxide balance on a stand level was affected only marginally. The carbon absorption decreased also initially, but the effect vanished within a year (Lindroth et al. 2012). The results from this experiment do not allow straightforward generalizations about longer periods of time or other areas. Thus, we do not know yet what effects a large-scale selective cutting forestry would have on either production or the ability to store carbon. Regarding a climate perspective, it is important to note that the possibility to extract residual biomass (branches, roots and tree tops) in selective cutting forestry diminishes, which decreases the amount of biomass what can be used as a substitute for fossil fuels.

Historically, clear-cutting and the resulting plantations of dense stands composed of only a few species is likely to have helped to maximize the production of biomass. But not even this is a self-evident, positive strategy for maintaining continuous high production (Gamfeldt et al. 2013). Climate change alters the preconditions for forestry, and experience and methods which worked yesterday face new challenges tomorrow. One such challenge is new disturbance patterns, both regarding insect attacks where the milder winters make the life cycle easier for many species, and changing patterns for storm damage and other extreme weather conditions. We do not know as yet whether serious storms will increase in number or in strength as a result of climate change, but on the other hand there is reason to fear that wetter soils and decreased depth of ground frost resulting from increasing temperature will make the forests more sensitive to winter storms. The experience gained from the storm Gudrun, which swept over Sweden in January 2005, implies furthermore that homogeneous spruce plantations are more sensitive to tree felling than other forest types. In the Kronoberg province, in the middle of the path of the storm, about 14% of the forestland and 17% of the volume was damaged. The worst afflicted were planted spruce, where the damage were 22%. For pine trees, the figure was only 13%, while damage of deciduous trees accounted for not more than 2% (Bodin and Morell 2013).

Concluding remarks

The decisions we make today about the forests will affect us far into the future. In order for landowners and politicians to make informed decisions, we need good scientific knowledge on what the different forms of forestry imply for biomass production and other ecosystem services that are of benefit for the society at large. Furthermore, we need to understand how an altered climate, with all the uncertainty inherent in trying to evaluate it, will affect conditions for production and preservation. Faced with an uncertain future, it may be a good idea to spread the risks and put our bets on heterogeneity for increased resilience (Elmqvist et al. 2003), for biological diversity, and for production-oriented returns from the forest.

Regardless of which path we take into the future – increased responsibility for the forest owners regarding both preservation and care of the forest properties, increased areas of protected forests in national parks and similar places, increased control and follow-ups of laws from authorities, other forest-preserving measures, innovations within forest enterprises, and so on – we will continue to see changes in the forest landscape. Changes – disturbance, succession and regeneration, new balance – in a cycle which never stops is the natural way. A responsible forest protection strategy involves control of the processes of change which preserve the resource base for our use of the ecosystem services and thus stability in the ecosystem, and which insures a sustainable use of forest land, today and for future generations.

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FOREST RESTORATION AND THE FORESTS OF THE FUTURE

Magnus Löf

Forests have served human needs throughout history as a source of food, fiber and spiritual reflection: today, society's awareness of its dependence on forests is as strong as ever. We depend on the forests for several ecosystem services such as fresh water, soil protection, food, carbon sequestration, timber and wood, energy, recreation, etc. In addition, biodiversity around the world depends on many different forest habitats. However, the forests are subjected to an increasing pressure from a growing human population and natural forests are still being converted to grazing lands or other agricultural uses. In Africa, Asia and Europe more than 60% of the once forested areas now have other land uses (Fig. 1) (Krishnaswhamy and Hansson 1999). This influences the climate and is a threat to biodiversity. Moreover, many remaining forests are subjected to intensive forest management, which reduces the complexity and number of tree species. Measures to improve the production of biomass from forests, which is necessary to reduce our dependence on fossil fuels, further decrease

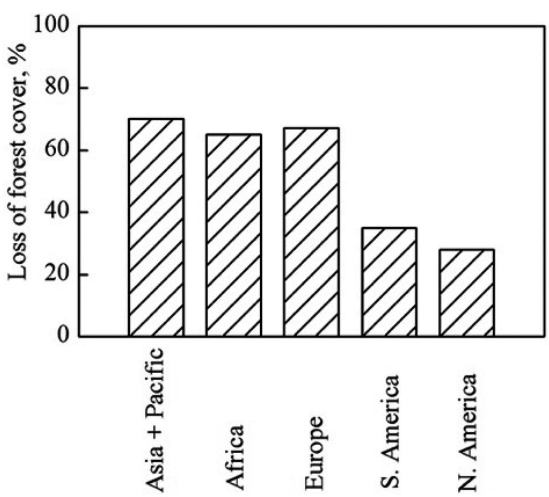

Fig. 1.
Lost forest cover in different parts of the world. Krishnaswhamy & Hansson 1999.

the amount of forests with high conservation values; further, fragmentation of important forest habitats is also a threat to biodiversity.

This unsustainable use of forests means that there is a need for forest restoration to reverse degradation and increase forest cover so that the remaining, relatively untouched forests better can be conserved (Lamb et al. 2005). More than 2 billion hectares globally are degraded and in need of restoration (Minnemayer et al. 2011). There is often confusion around the concept of restoration ecology or forest restoration. Most often the goals are to repair ecosystem functions, enhancing or enlarging specific ecosystems and habitats for endangered species or enhancing biodiversity in general (Dobson et al. 1997). In this article, I take a broad view of forest restoration including passive and active approaches to restore forest functions and structures (Stanturf 2005). For example, afforestation of former farmland can be achieved by relying on passive re-vegetation or natural regeneration or more active approaches such as planting or direct seeding. Rehabilitation of existing forests may include enrichment planting, conversion of monocultures to mixed forests (by natural regeneration or planting) and creation of dead wood, snags or green tree retention. In this concept, forest restoration is seen not only as a means to re-create natural forests with all their structures and functions: other types of new forest habitats or ecosystems may arise instead as a result of forest restoration.

Future forests and multifunctional mixed forest landscapes

Restoration of forests is a global issue. The "Bonn Challenge" (Reducing emissions from deforestation and degradation), for example, was launched in 2011, aiming at restoring 150 million hectares of lost forests and degraded lands by 2020 and contributing to achieve the REDD+ (Reducing emissions from deforest and degradation) goal, the CBD Target 15 (Convention on Biological Diversity) and the United Nation framework for food security (Anonymous 2013). However, many more forests need to be restored to reach aims on productivity, environmental goals and food security. How shall they be restored to meet all the demands and solve the problems that lie ahead? A new concept needs to be developed and agreed upon that can simultaneously meet multiple demands.

How should the new forests look like? Multi-purpose mixed forest plantations, for example, can be designed to meet a variety of social, economic, and environmental objectives, and can provide key ecosystem services, help preserve the world's remaining primary forests, and sequester an important proportion of the atmospheric carbon released by humans (Booth and Williams 2012, Paquette and Messier 2010). In theory, mixed-species plant ecosystems produce more biomass than single-species ecosystems (Hector et al.1999, Pretzsch et al. 2010). This has been difficult to achieve in forestry, partly because forest industry has only been interested in the stem parts of the trees for pulp and timber production. With heightened awareness of wood production for bioenergy, the whole trees (including branches and sometimes below-ground parts) will be of interest. Thus, high-productivity, mixed stands might become a future option for forestry where high growth rate (and high carbon sequestration) might be combined with other important goals (Hulvey et al. 2013). For example, two-storied mixed plantations combining slow-started tree species valuable for environmental purposes in long rotations with fast-growing tree species in

Fig. 2.
Two-storied plantations might be one tool to achieve production and environmental goals simultaneously. Photo taken in southern Sweden illustrating a mixture of fast-growing Betula spp. and shade-tolerant Fagus sylvatica in southern Sweden.
© Magnus Löf

short rotations for production goals is an interesting concept to develop further. An example from southern Sweden is given in Fig. 2.

In the future, with a rising human population, we will depend on the forests to get many ecosystem services and for protecting biodiversity. Mixed forests are probably a better option than monocultures if the society wants to meet multiple objectives with its land use (Knoke et al. 2005, Gamfeldt et al. 2013). Since so many forests need to be restored in a near future, it is probably wise to establish them for multiple objectives. However, a typical dilemma during forest restoration via artificial regeneration is that few methods optimize the financial benefits and simultaneously improve other environmental services (Lamb et al. 2005). Therefore, such mixed forests should be restored with several objectives in mind, and high production should be one focus so that landowners may benefit from the activities. In addition, it is probably unrealistic for each forest at each site to solve many problems at the same time. Instead they should be considered as parts in multifunctional, mixed forest landscapes. However, although there is a huge potential in global forest restoration efforts, large-scale transformation of land-use patterns can lead to unintended environmental and socioeconomic impacts that could jeopardize the overall value of these projects. For example, the role of high productive mixed forests (i.e. new ecosystems) is unclear regarding protection of biodiversity, local incomes and food security and therefore need to be evaluated and analyzed from many perspectives before any implementation.

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CAN THE GLOBAL BURDEN OF DISEASE BE HELD AT BAY BY OUR FORESTS?

Matilda Annerstedt

Public health and the global burden of diseases have changed substantially in the last decades. Today we suffer from illnesses that often originate from our lifestyles and the environment. As is often assumed, it is not only the Western world that is affected, but this has become an international phenomenon, where only southern Africa differs, still being dominated by infectious diseases (WHO 2008). In the rest of the world, the greatest threats to public health are the so called non-communicable diseases (NCDs). These include conditions such as diabetes, cardiovascular problems, obesity, obstructive lung diseases, and mental illness (WHO 2010). For example, depression is to a high extent contributing to the disease burden, which means a considerable increase in mortality rates due to suicide (the rate of suicides connected with depression is around 7-10%) (Runeson 2013: 478-79).

A common denominator for these diseases is that they all have a multifactorial background and in order to come to grips with the problem, recognition of the underlying complex interactions and a system science thinking are necessary. To achieve this, we must combine and integrate knowledge about public health and ecology, in order to understand how we are influenced by our environment both positively and negatively.

Health promotion

The impact of environment on health are often discussed in terms of risks and threats, for example the consequences for health of climate change and environmental degradation.

However, researchers have lately become more and more interested in the positive, health-inducing aspects of the environment (Annerstedt 2011). Promotion and prevention programs have been shown to yield better results for public health than specific interventions aimed at treating existing disorders (Webster and Lipp 2009). This has led to scientific studies concerning possible correlations between time spent in forests and various health aspects demonstrating that these visits can have many beneficial effects for people, for example, lower blood pressure, reduced cholesterol and stress, and a positive effect on the body's immune system (Bowler et al. 2010: 456 and Bratman et al. 2012: 118-36). As a result of increased urbanisation, much of the research has been focused on urban and suburban forests (Hägerhäll et al. 2010: 223-34) but studies also in other types of forests have yielded significantly positive results (Lee et al. 2011: 93-100 and Tsunetsugu et al. 2013: 90-93).

Evidence for the effects of nature on health

A recently published report, based on a systematic review, concerning the influence of urban parks on health provided evidence that access to greenery leads to increased physical activity, a reduced risk of obesity, and decreased stress levels (Konijnendijk et al. 2013: 1-70). It is important to relate this to the undisputable positive effects on health that increased physical activity and diminished stress lead to. Among stress-related illnesses are depression, chronic pain, cardiovascular disorders, and diabetes (Währborg 2009). Our bodily functions work best when we are physically active and sedentary behaviour raises the risk of cardiovascular disease, cancer, obesity, high blood pressure, high lipoprotein levels, and osteoporosis. The Swedish National Public Health Institute (FHI) has stated that the goal for society must be to create attractive and supportive environments for physical activity (Scäfer-Elinder and Faskunger 2006). In this context, nature and forests are examples of these kinds of supportive environments and promoting accessible, restorative forest environments occurs to be a good investment for public health.

Public Health, Sustainable Development, and Cost Effectiveness

The health aspects and social values of forests are somewhat different from questions revolving around timber, raw materials, and sources of energy. At the same time, these relationships reflect the complexity in our societies today, one which we must learn to handle.

It is becoming increasingly difficult to differentiate urban from rural, health from environment, soul from body. In order to solve global or regional issues of public health and sustainable development today, we have to apply a multi-disciplinary, or perhaps even a transdisciplinary, approach.

"Ecosystem Services" (Millennium_Ecosystem_Assessment 2005) and "Green Infrastructure" (Benedict and McMahon 2006) are two examples of concepts which have been developed to meet the multi-facetted problems of life today. "Ecosystem Services" means that the world's ecosystems are studied from the standpoint that they all provide services for people's lives and health, often without visible costs. The costs seldom become apparent until the service is reduced or eliminated due to human induced environmental changes. In their chapter "Production, Species Diversity and Climate Goals – Challenges and Possibilities for Modern Forestry", Hall and Smith discuss how forests' ecosystem services not only provide wood and raw materials for forest industry, but also other values, such as berries and mushrooms, pure water, and recreation.

Studies are currently underway to explore how to evaluate nature's services economically to help authorities make decisions which include long-term responsibility for the environment, social values, entrepreneurship, and our continued existence as a species.

"Green infrastructure" is an overarching model which is used to support a long-term sustainable development through various incentives and management control measures for land users and politicians. The aim is to make room for nature through, among other things, an integrated use of land where "ecosystem services" is an important concept for consideration. This demands strategic planning and care for forests and landscapes, so that farming, forestry, recreation, and preservation of bio-diversity can all share the same area. Examples of how a green infrastructure can be implemented is through keeping or creating so-called biocorridors, areas designed for promoting biological diversity, for wild animals and plants, or bio-oases and eco-bridges. This also implies that land use and management, which contribute to the maintenance and renewal of sound ecosystems with biological diversity, is supported and prioritised over other activities which are not compatible with a green infrastructure. There are many other examples of how the concept 'green infrastructure' can be used in both planning and practice, but the common denominator is that the overarching ecological quality in the environment will increase in general, be cost effective, and contribute to a sustainable development of public health.

By using these types of models, knowledge and decisions concerning public health and forest conservation can be integrated in societal development. An example of this is how the World Health Organization (WHO) promotes 'win-win-win' situations, which benefit both public health and the environment, and at the same time are cost effective (WHO 2012).

A good example of a "win-win-win" situation is the volatile components in the forest, organic matter which is emitted by the trees. In Swietlicki's chapter "The Forest Helps Us Fight Climate Change", he describes how these substances contribute to a lowering of local temperature, thus decreasing the effect of climate change. At the same time intensive research is being carried on in Japan around the same organic particles, but from a health perspective. It has been demonstrated that spending time in the forest (in Japan, it is called "forest- bathing", or Shinrin-yoku) and breathing in these particles improve the body's immune system and can even increase our resistance to cancer (Li 2010: 9-17). Thus, the natural "ecosystem services" in our forests can contribute to better health and an improved environment with no costly investments. As Swietlicki states, however, it is necessary to have a broad, interdisciplinary collaboration and advanced research if we want to understand how these processes can optimally work together.

By implementing an all-encompassing approach, we can help decrease the conflicts arising around the resources of the forests and their uses. Increased collaboration between various actors and heightened awareness of how the forest system and the health system interact can give rise to and implement innovative ideas. This requires, however, a comprehensive understanding on the part of the decision-makers and authorities.

It is difficult for the individual forester to push the recreational values of the forest if there is little economic incentive in it; in the same way, it is hard for a licensed physician to prescribe 'forest therapy' before environmental and health politicians have begun to communicate and exchange knowledge and evidence between themselves. In order to pursue matters concerning the interactive processes between environment and health on an implementation level, it is also necessary for researchers to communicate and elucidate their knowledge for others.

Interdisciplinary research has made advances and among many other important messages, it is possible to announce that:

- Carbon dioxide absorption in the forests decreases the amount of air pollution, especially in urban environments. This lessens, among other things, attacks of asthma and other chronic lung diseases
- Peri-urban woods and forests aid in diminishing the effect of, and with it the mortality caused by, the so-called 'urban- heat islands', local increases of tem-

peratures in cities caused by the heightened absorption of heat by artificial materials.

- Spending time in the woods has several positive health effects, *e.g.* through increased physical activity and decreased stress levels; further, woods with higher biodiversity have a better effect on mental health than woods with a higher degree of monoculture.

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Forests And Mankind As Consumers

Overview

For as long as we have existed on Earth, humans and all other living creatures have been consumers in relation to the forests by using them for various purposes. For example, for thousands of years, shipbuilding and heating have placed a heavy burden on forests. Furthermore, over the centuries, the rapidly growing world population has accelerated the utilization of forest land for agriculture and energy production, with rapid deforestation as a consequence. This affects many intricate balancing acts in our biosphere. During the past few decades, the balance of CO_2 has been extensively discussed, and the forests of the world, together with the oceans, play a vital role in this. The question is—how can we as consumers utilize the forests for traditional products and services while, at the same time, mitigate the climate problems caused by the resulting CO_2 imbalance?

Pål Börjesson discusses the possibilities in Sweden to use more forest biomass for transportation fuel and thereby reduce the negative effects of fossil-based fuels without jeopardizing the sustainability of the forests.

Mehri Sanati points out ways to co-produce chemicals, transport fuel, energy from forest residue, and also waste biomass by gasification in a biorefinery system for utilization in the existing infrastructure.

Gunnar Lidén, Olov Sterner, and Marie-Francoise Gorwa-Grauslund give a historic background of the paper industry and present a way to utilize the forest biomass left by the now-shrinking paper industry. They note that trees are formidable "chemical factories", supplying a wide range of fine chemicals that can be further refined to high value-added products. In particular, they focus on the lignin part of the wood and suggest a production route via a sugar platform.

Wood, as a material, has the potential to replace other materials which require high energy input in their production; for example, CO_2 emissions could be reduced by replacing steel and concrete with wood in buildings. Leif Gustavsson explains that wood buildings are not only energy efficient during the production phase, but also in heating. On top of these benefits, they are also long-term carbon sinks.

However, it is not enough to find ways to better utilize the forests; one must also "walk the talk". To achieve this, good entrepreneurs are needed. Reine Karlsson presents a study of the importance of entrepreneurs when it comes to making use of hardwoods like birch; however, tradition dominates the practice. This is also the case in relation to gender balance. Female forest managers are shown to bring new aspects into forest management, and Marie Appelstrand discusses the effects of better gender balance and the obstacles in achieving this.

Humans can utilize the forest in many ways. The following contributions show a number of alternatives to the present praxis and what it takes to change that praxis.

FORESTS INSTEAD OF OIL?

Pål Börjesson

There is great hope that the forest will become an increasingly important resource of raw material to replace oil in products like fuels, chemicals, plastics and other products. The techniques for making these products from forest raw materials are largely developed today, but there are various obstacles which make the transition slow. The most important motivation for this change is the long-term climate benefits we will get when renewable raw materials replace fossil oil. Furthermore we will be less vulnerable thanks to a diminished need for imported oil while at the same time we create new jobs and develop new companies. We see before us a successive transition from today's fossil-based economy to a biobased one where renewable raw materials will dominate. From an historic perspective this is nothing new: for the entire history of mankind up to about one hundred years or so ago, we relied on biomass for our survival and development. In the end of the 19th c., the use of fossil coal rapidly expanded and after World War II, fossil oil took over as the dominant raw material. Hopefully in the future, the 20th and parts of the 21st centuries will be considered a "fossil-based parenthesis" in the history of mankind.

In Sweden, our dependency on oil decreased sharply in the latest decades thanks to an increase of forest raw material resources. Today, the use of bioenergy, coming primarily from the forest, is greater than that of oil in the Swedish energy system. The greatest increase of forest-based energy has occurred in forest industries and the district heating sector for the production of heat and electricity. Thanks to this development, our national emission of greenhouse gases has decreased by about 15% since 1990 at the same time that the GNP doubled. This decoupling makes Sweden globally unique and shows that it is possible to maintain high economic growth while at the same time decrease emissions of greenhouse gases. In other words, Sweden is already on the way to a biobased economy.

The oil that still remains is used mostly in the transportation sector, but also a certain amount is used as a raw material in the chemical industry. Globally, about 90% of all raw oil is used for energy while just under 10% is a raw material in making chemicals and products. In order to continue lowering our oil dependency in Sweden, we must thus above all develop alternative fuels, parallel with more effective transportation solutions. There is often a greater interest today however for using forest biomass for the production of chemicals and other special products than for producing biofuels. For example, the percentage of biobased chemical products has risen globally from ca. 3% in 2007 to around 8% today and is expected to increase even more to about 15% in 2017. In the long run, this development can favor the advancement of biobased fuels when the processes and products in several cases are similar, for example, cellulose-based ethanol, methane, and so on.

How long will the Swedish forests last if they are also used to replace the remaining oil in the transportation sector and the chemical industry? The present harvest of forest raw resources corresponds to more than 200 terawatt hours (TWh) in energy terms, which can be compared with the annual growth which is equivalent to about 350 TWh. This means that it is physically possible to increase the biomass harvest. More than half of today's forest raw materials are used for energy purposes while the rest is found in things like wood products and pulp. As a comparison, the energy supply in the Swedish energy system is about 450 TWh annually (excluding nuclear power heat loss). The use of gasoline and diesel for road transportation is around 80 TWh.

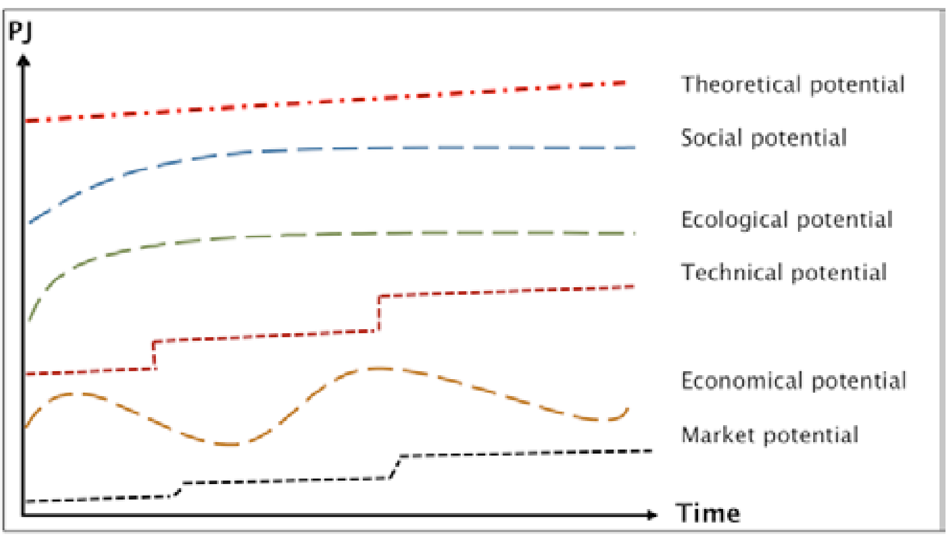

Fig. 1.
Schematic drawing that illustrates different potentials for forest biomass where the final market potential is considerably lower than the theoretical potential due to social, ecological, technical and economic limitations.

The potential for an increased harvest of forest biomass can be calculated in several different ways, where various types of limitations are included. This is illustrated in Fig. 1. Examples of limitations are social, ecological, technical and economic, all of which can vary over time. In the end the market potential depends on current commercial demand, which is often strongly dependent on policy.

One estimation is that taking out forest biomass in the form of residues such as tree tops, branches and stumps when felling trees, together with a certain amount of stem wood (damaged or otherwise not up to industrial standards) -- can increase by 30-40 TWh annually compared with today. This evaluation of potentials includes ecological, technical and economic limitations: that is, they are considered sustainable from an ecological and economic perspective, and do not compete with today's use of forest resources. Sufficient biomass is left in the forests to preserve both biodiversity and the long-term productivity of the land, but one condition is that wood ash is used to maintain the nutrient balance in the soil. The potential may increase in a longer term through improved productivity in forestry due to more developed plant material, more effective reforestation and possibly site-adapted fertilization in a limited part of the forest areal (up to five percent). One uncertainty here is how climate change will affect forest production in the future: for example, the growing period will be longer, but the risks for various kinds of damage will also increase.

A shrinking market for traditional forest products can free forest raw materials for new uses, such as biofuels and chemicals. One example is the decreased demand for newsprint. Today about 20% of pulpwood in Sweden is used for newsprint: if, say, half of this amount is freed up, forest raw resources equaling about 5-7 TWh become available for other uses. Added to this, abandoned and unused farmland can be used to make forest raw material: for example, fast-growing deciduous trees, which generate another 5-10 TWh of biomass annually.

All together, the potential for an increased amount of forest resources for new products can reach up to around 50 TWh of biomass in the long run without competing with today's need for raw materials. If this forest raw material is used for the production of biofuels, co-produced with other energy carriers in biorefineries with a high total conversion efficiency, 25-30 TWh liquid and gaseous biofuels can be produced together with a few TWh electricity and about 10 TWh district heating. This amount of biofuels corresponds roughly to one-third of today's use of gasoline and diesel for road transport. The remaining two-thirds oil-based fuels must be reduced through the use of more efficient vehicles such as hybrids and EV's, and more efficient transportation systems and solutions. If the increased potential of raw materials from the forest is used instead for making chemicals in biorefineries, the oil-based chemicals in use today could be replaced several times over.

Production costs for forest-based fuels are estimated on the average to about 7-8 SEK/liter for gasoline equivalents in future commercial plants, where some production systems can be a little cheaper, others, somewhat more expensive. Today's production costs for gasoline and diesel are about 5 SEK/liter of gasoline equivalent, just two or three SEK cheaper. When the current carbon dioxide tax on fossil fuels is included, the cost will be equivalent for fossil and biobased vehicle fuels. Future commercial plants for forest-based fuels will be large, however, in order to achieve important effects of scale: that is, the investment costs will also be extensive (several billion SEK). In turn, this implies great risks for investors, something which is a substantial obstacle for development today. Another considerable hinder is the lack of a long-term, stable policy in the area of biofuels that insures a long-term and stable market. These obstacles must be resolved before a significant commercial development of fuels from forest raw material gets off the ground.

Another decisive factor for long-term, commercial development of forest-based fuels and chemicals is that their production systems fulfill the sustainability criteria which are developing in international standardization systems. Two critical aspects are maintaining biodiversity and reducing greenhouse gases in comparison with today's fossil-based alternatives.

Calculations of the greenhouse gas performance for forest-based fuels and chemicals can vary depending on which method and what way of calculating are used. The Swedish (as other northern European) forest production differs from other global biomass production as our forests have long rotation periods. The time perspective is thus of decisive importance in the greenhouse gas calculations. If a very short time perspective is applied (some years), it can seem better to continue with fossil raw materials than to increase the recovery of logging residues, for example. The reason is that the sequestered carbon dioxide in the forest biomass is freed instantly when burnt, while it is freed slowly when the logging residues are left where they are to decompose naturally. If on the other hand a rotation period is taken into consideration, forest raw materials are normally always more climate-effective than fossil raw materials.

Other factors of major importance are the spatial resolution and also a determination of which areas should come under consideration — for example, a single stand or a property, or a larger area. If only a single stand is under consideration, it may be better to save the forest as a carbon sink and continue using fossil fuels than to fell it as a replacement for fossil raw materials and fuels. If on the other hand a forest property or large areas is being considered which has stands of all ages, the forest raw material will normally always be more climate effective than fossil raw materials.

Thus, a very narrow and limited perspective regarding time periods and areas can give misleading results for the climate effectiveness of using the Swedish forests as raw material instead of taking the fossil alternative. It is therefore quite important that relevant calculation methods taking the long rotation periods in the Swedish forests into consideration are developed in international standardization systems. Otherwise, new and unjustified obstacles could be created in the continuing development of new forest-based products and thus would hinder the replacement of even more fossil fuels.

Using our Swedish forest resources have already sharply decreased both our oil dependency and our greenhouse gas emissions. Conditions are good for continuing this development and for enlarging the role our forest resources have in the development of an increasingly more sustainable, bio-based economy.

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OPTIMIZATION AND HEAT INTEGRATION OF A BIOREFINERY CONCEPT

Mehri Sanati

A key to the energy system of the future is the availability of liquid fuels: chemicals together with electric power constitute the cornerstones of modern life. First-generation biofuel production can in some cases be ethically unsound. Second-generation biofuels do not suffer from this, since they do not rely on raw materials that in some form or another can compete with food production. Gasification of forest residue and also waste biomass represent a source of carbon and hydrogen that can be converted into a biorefinery system in a co-producing route to chemicals, transport fuels, and energy in order to utilize them in the existing infrastructure.

Biomass, a renewable resource, is considered to have some potential to partially replace fossil fuels. The diagram (Fig.1) suggests a co-production of fuels, chemicals, and CHP (Combined Heat and Power) in order to improve economic and overall efficiency (low-heating value) of biomass as feedstock. A major problem in the production routes for biomass as feedstock is the presence of contaminants as particulate fractions and gases in the raw gas from the gasifier. The problem with a gasified biomass is that the fuel (biomass) cannot be purified before the gas is produced. To make an efficient purification of the product gas from the gasifier and to guarantee performance of the subsequent synthesis steps, the temperature of the product gas has to be decreased and then increased again. The heat needed for re-heating has to be taken from the conversion system itself and represents a loss of efficiency. However, a more efficient and innovative high-temperature clean-up system for submicron particulate presence in the product gas at high temperature, and in some cases high pressure (pressurized gasifier), is required in order to preserve high energy efficiency in the conversion route and also prevent catalytic poisoning of downstream processing units.

A feasible technical and economical high-temperature cleaner with regards to the removal of submicron particles is still lacking on the market. Instead of an innovative cleaner, an oil scrubber was used for the removal of tar and submicron particles.

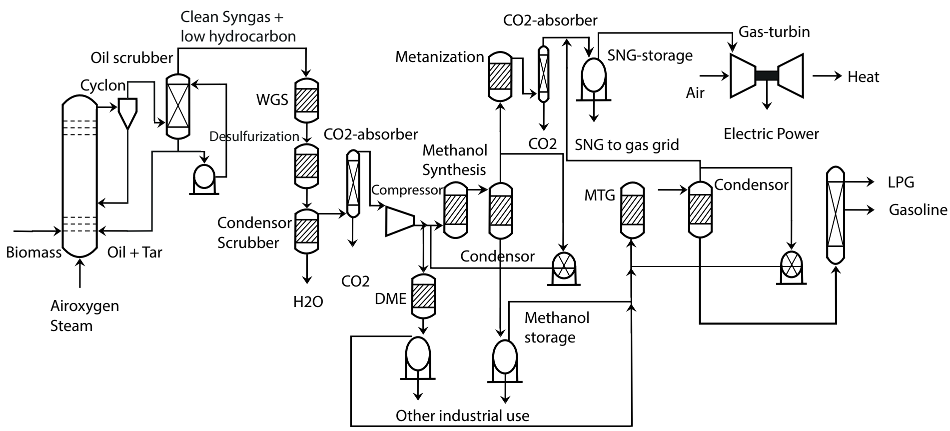


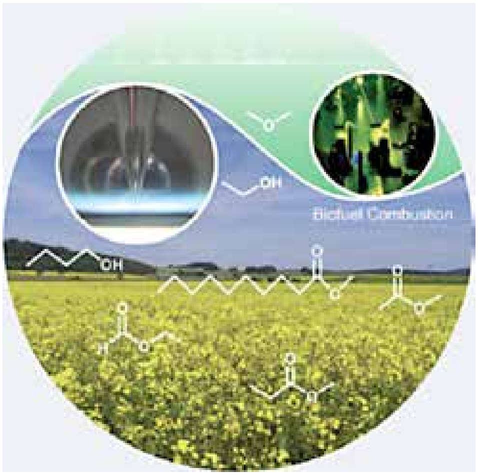
Fig 1.
Production routes of biomass-derived products – with methanol as the biofuel and/or chemical main product and CH4 (biofuel) and power as side products.

In this suggested flow diagram (Fig. 1) an oil scrubber is also suggested for the removal of fine particles. An oil scrubber is used to remove tar from raw gas: oil containing tar is re-injected into the gasifier, and the tar's chemical heat contents are then used and integrated in the process. An optimum shift process adjusts a suitable H_2/CO ratio for methanol synthesis and hydrogenates unsaturated compounds such as ethylene. The bleed-off gas from methanol synthesis contains CH_4, some C_2, CO_2 and a part of the CO and H_2. The methane will be recovered from this gas and if necessary a methanization step will be undertaken before removing the carbon dioxide. CO_2 is removed by a conventional amine process. The methane that is produced could either be used on site for power and heat production or be fed to a gas grid for industrial and domestic use. The proposed methodology eliminates the troublesome reforming units, and also high-temperature desulfurization of raw gas. Even though steam-reforming and desulfurization processes are not used, the overall efficiency of the system will be not influenced due to the tight integration of heat and energy into the suggested biorefinery system. The main aim of this anthology is to show how a refinery based on biomass can be constructed to get the maximum energy and heat output of biomass feedstock. This can be reached due to co-production of a variety of end products.

Biomass substitutes in comparison to products from fossil fuels should not have a negative impact on our health, society, and environment, nor should they compete with food production. Therefore, the suggested research and development program in this anthology needs expertise in the field of gasification, different proficiencies in cleaning technologies, high-ranking catalyst experts, biomass experts, a gas purification expert, research companies in the fields of biomass synthesis, an oil company, and the catalyst and chemical industries to expedite the development and commercialization of research outcomes. Finally, it should include expertise in social sustainability (including consideration of consequences due to the competition for resources traditionally dedicated to food production), health and environmental issues. In the end, a demonstration is required to show that the economics of biomass-derived products will be improved when the carbon content in biomass is of the same value as that in fossil fuels.

State of the art – market implementation

The biofuel market is at present in an initial phase in which most countries in Europe are slowly implementing legislation concerning mixing ethanol and biodiesel in gasoline and diesel. Some countries have implemented legislation that also enables pure biofuel (e.g., E85, biogas, and pure biodiesel) to be distributed and used, but most biofuel is still distributed by mixing and this will probably remain the case until 2020. Biofuels can still not compete with fossil fuels, and subsidies (e.g., tax exemptions, quota systems, and certification systems) will be required for a long time until the market is sufficiently developed to survive without them. A long-term increase in the oil price is possible, but this trend has been temporarily broken by the financial crisis, creating less incentive for biofuel production. Various international studies suggest that 4–8% of the world's transport-fuel demand can be met by first-generation biofuels as of 2020. Second-generation biofuels are not predicted to reach any significant market shares until after 2030. The demand for second-generation biofuels will increase in coming years due to national and pan-European incentives. High efficiency from well-to-tank will be a top priority. There is considerable demand for basic and applied research in this field and for the establishment of market chains to convert R&D into full-scale plants that produce substantial amounts of second-generation biofuels. The energy utilities and fossil-fuel distributors will play a key role by initiating demonstration projects once R&D has reached a stage where it can be demonstrated at a reasonable scale. The commercialization of second-generation biofuel processes must be built on experience and competence in existing indus-



trial structures (e.g., the automotive industry, energy utilities, engineering companies, and oil companies). These stakeholders are often multinational companies and as such depend on stable, long-term market indicators to make decisions concerning new technologies. Disseminating information and research about the biomass-based refinery project will play an important part in encouraging these stakeholders to move towards sustainable solutions for the transport sector.

The State of The Art - Biorefinery sub-systems (Fig. 1)

Biomass gasification processes can be carried out in a range of gasification systems to produce specific gas compositions for specific upgrading steps to be converted to biofuels, energy, and chemicals. Product gas compositions and impurities are changed by varying the gasification technology. The properties of the raw gas derived from different biomass gasification systems can be considered important factors influencing the downstream conditioning and synthesis of end products. However, a detailed flow diagram of downstream processes that takes into consideration the system's heat integration and preservation of the chemical-bond energy of feedstocks could help facilitate the production of end products irrespective of the gasification technology used. In Fig. 1, as seen in the flow chart, methanol is the main product (for chemicals and gasoline) while the side products are methane and energy. Fig. 1 also includes the direct synthesis of syngas to dimethyl ether (DME). The flow chart in Fig. 1 is based on heat integration and energy conservation in a system design based on biomass carbon value. The process efficiency, as presented in Fig. 1 in terms of conversion based on the biomass low heating value (LHV), can be improved by using different innovative techniques in the process to minimize heat loss and increase overall conversion – the main target of a biomass-based Biorefinery. The state of the art of the flow diagram in Fig. 1 will stress minimizing energy losses in the production routes by using a heat and energy integration system in order to gain a higher value of the feedstock's low heating value in conversion to products. The co-end products of the suggested biorefinery are methanol, methane, DME, and energy. In a biorefinery concept we need to address the entire value chain from biomass feedstock to the production of bio-based products and energy by thermochemical and possible biotechnological routes. Furthermore, it requires a sustainability assessment which includes society and environmental – health issues with regards to new products and processes.

Sustainability

For biorefineries to contribute to sustainable development, their production systems must meet the three generally recognized sets of sustainability criteria: i.e., they must be environmentally, economically, and socially sustainable. Many sustainability assessment tools apply a life-cycle perspective, which aggregates the sustainability impacts of a product system throughout its lifetime. An integrated assessment model that includes social, environmental and health factors with respect to new products and process is an important one. The approach of the assessment will be connected to particular physical locations where biomass is grown, the process is running and the products are distributed and also used. Alternative structures and scenarios such as feedstock types and ecological factors are also aspects that need to be examined. The various assessments are tailored after particular locations in term of availability to specific kind of biomass, storage and logistical issues, small/large scale operation, choice of final products. All of these mentioned criteria have impacts on sustainability assessment.

Final remark

The refinery concept and design of products vary in different countries based on availability of feedstock (hydrocarbons sources) and market demand of the products. Oil, gas, coal and biomass are considered as hydrocarbon sources. Biomass has also been mentioned as low-energy density feedstock. Therefore it needs an optimal design without the minimum energy losses during conversion processes from woody biomass to the products.

The refinery based on woody biomass (e.g., forest waste) and a main product such as methanol for application in chemical industries and transport fuel can be a proper choice for Sweden. Access to a pilot-scale gasification unit is of crucial importance in the development of a woody biomass Biorefinery. In Sweden we have access to most existing gasification technologies: pressurized entrained flow biomass gasification (PEBG) in Piteå, CHEMREC, pressurized circulated fluidized biomass gasifier (PCFB in Värnamo) and finally circulated biomass gasifier (CFB in Göteborg). There is no doubt that Sweden needs significant research in the field of bio-derived products. The development of these technologies as a Biorefinery system can follow hermochemical conversion or biological routes. Sweden is ranked high in biotechnology (biological) research and the manufacturing of pharmaceutical ingredients from a renewable source like biomass: this can bring in high profits thanks to already existing knowledge in the production technology (biotechnology).

POST-PAPER FORESTRY?

Gunnar Lidén, Olov Sterner, Marie Gorwa-Grauslund

"It smells like money" is a well-known quote to generations of Swedes living near a pulp-mill. And there is no question that the forest industry is – and has been - very important for the economic well-being of Sweden. About 60,000 people work directly in this industry and a few hundred thousand people's livelihood derives indirectly from the Forest industry. The export value from the Swedish forest industry was about 128,000 million SEK in 2011 (Skogsindustrierna: 2011) - a phenomenal sum.

Out of the total volume of 25 million tons of goods exported, about 10 million tons consist of paper and a few million tons of pulp. Paper is employed in many different ways, including a large and growing use in packaging and hygiene tissues. But what comes to mind for most people is its use in books, magazine and newspapers, or in more dignified language, as a carrier of information. Paper has been used for this purpose for a long time, following several previous means of storing written texts (Table 1).

From a technical standpoint, however, storing information moved beyond paper several decades ago. So what lies ahead? The concept of the "paper-free" office has been ruled out as a vision that will never come true – or will it? We probably should not look at our colleagues, but at our children for hints about the future. Recently on TV, there was a report about many children suffering from "pad-necks", i.e., strained neck muscles from looking too much at their iPads (the modern book!), and university students buy textbooks as e-books (challenging for example the concept of "open-book" exam). The shift has not gone unnoticed in the paper industry, either. The main European markets for Swedish paper (Germany, Italy and France) decreased by about 18% between 2000 and 2010. This was fortunately partly compensated by other growing markets – not least by a rapid growth of export to China. But what if the new, fast-growing economies take a "short-cut" and go directly into the "silicon-mode" of information storage and transfer? Looking at (Table 1), it is interesting to note that one transition – that from papyrus to parchment – is alle-

Material	Language /codes	Mode of information transfer	Used when?
Rock	Paintings, runes	The recipient of information has to travel to the rock	Stone age (20,000 B.C.)-
Clay	Cuneiform (Mesopotamia)	The carrier material can travel to the recipient	3000 BC -
Papyrus	Hieroglyphs	The carrier material can travel to recipient	3000 B.C. – 500 AD (Egypt)
Parch-ment		The carrier material can travel to recipient	500 A.D. -
Paper	Any written language	The carrier material can travel to recipient	105 A.D. (China) - 1500 A.D. (Sweden) -
Silicon	Digital storage	Only the information travels, but storage material remains stationary	1950 -

Table 1.
*Some of the key information carriers over years**

gedly said to have been triggered by a restriction in supply of papyrus from Egypt to the city of Pergamon, where a large library was located. In today´s situation, such a transition to other uses of biomass may instead be triggered by the lack of need for certain types of paper.

If the demand for paper decreases sharply, there are large structural changes to be expected in the pulp and paper industry globally and not only in Sweden. This change should be viewed, however, from the background that on a global scale, we are facing enormous challenges to supply energy in a sustainable manner and at the same time move towards a fossil-free society with decreased green-house gas emissions. Biomass – of all kinds – will be immensely valuable in this transition. It is important to point out that petroleum needs to be replaced not only as a fuel source, but also as a source of organic carbon. Whereas energy needs can be met in many different ways, such as solar energy, hydro power, wind energy, geothermal energy, tidal wave energy, etc., our need of organic carbon will have to be met largely by biomass.

How can the Swedish forests be used in a sustainable manner for novel products?

The amount of wood in Sweden is today roughly 3,000 million m^3. It is increasing and expected to reach a standing timber supply of about 3,200 million m^3 by 2030.

* largely based on Wikipedia information

The yearly wood harvest from the forests was about 72 million m^3 in 2010, of which roughly 1/3 was used for wood and manufactured products and 2/3 ended up in the pulp and paper industry. A large drop in the paper market could thus free a considerable amount of the pulp and paper fraction for other potential uses.

Certainly, many current uses of wood will continue, for example, "as is". The cellulose fiber also has a large value, not only in paper but also to replace cotton in textiles, for example. But there are many more and new possibilities. The factors cited above - climate concerns and finite fossil resources - have created more and more interest in using biomass as a source of useful molecules, such as for the production of bulk and fine chemicals, thereby expanding the wood value chain. One way to make the most use of the biomass in the future is to look at it from the concept of "sugar platform" and biorefineries as illustrated in Fig 1 (Kamm and Kamm 2007).

Up to now, it has not been of much interest to look for alternatives to petroleum and the petrochemical-derived compounds since these industries have provided

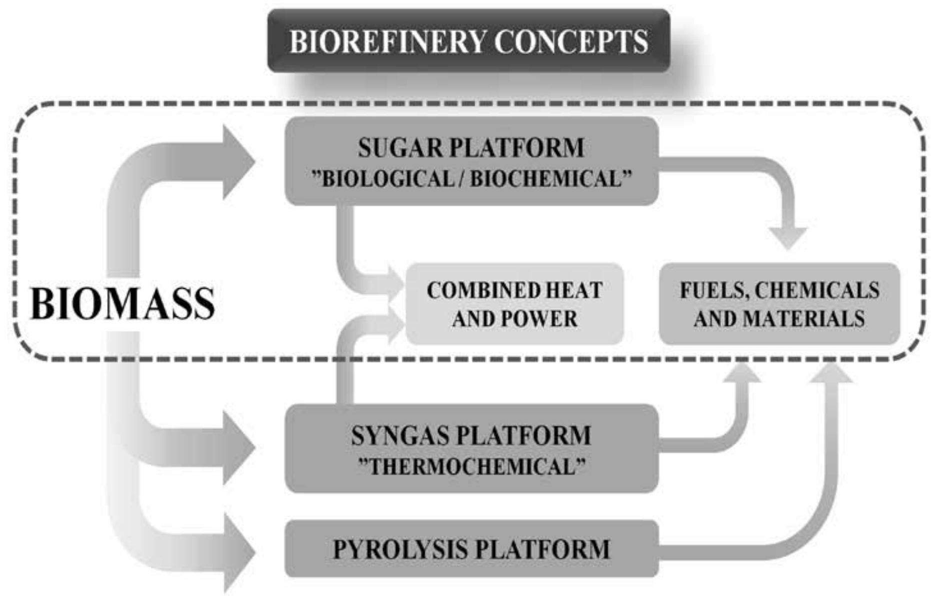


Fig. 1.
Examples of biorefinery concepts (Reprinted with permission from "Developments in bioethanol fuel-focused biorefineries" S. Mutturi, B. Palmqvist and G. Liden in "Advances in biorefineries: Biomass and waste supply chain exploitation" Ed. K Waldron, Woodhead publishing, 2014)

almost all of the carbon-containing molecules we need, food excepted. However, Sweden, with infrastructure and competence in place for harvesting, transporting and handling wood feedstock, can seize the opportunity to make a significant contribution to a dedicated, visionary and intelligent development of innovative process concepts to produce goods meeting the needs of the society in a sustainable manner.

Wood as a chemical factory?

On the molecular level, plants are by nature amazing chemical factories, in which for example terpenoids, carbohydrates, aromatic compounds, fats, waxes, and proteins are synthesized from atmospheric carbon dioxide and precipitated water. Compounds that are present in a free form can be isolated relatively easily, in such amounts that plants may replace the present sources if they have a practical use.

Today, carbohydrates represent the most valued fraction of the wood plant in the traditional pulp and paper industry whereas lignin, a complex polymer of substituted phenyl propane units (Fig 2), is regarded as a low-value by-product that is used as fuel in the recovery boilers (Fig. 3).

Interestingly, lignin is also regarded as a by-product in the new evolving biorefinery industry that focuses rather on the utilization of carbohydrates as a source of monomeric sugars, forming the basis of sugar-derived chemicals (exemplified by the well-known list of chemical building blocks proposed by the US Department of En-

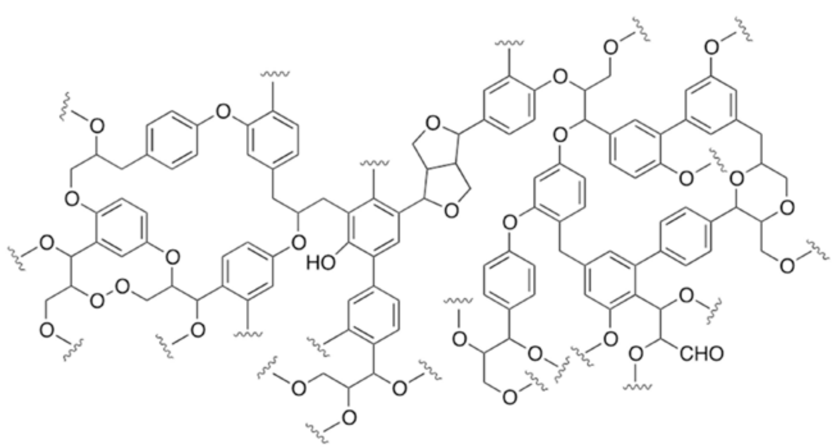


Fig. 2.
Schematic representation of a lignin structure.

ergy in 2004 (Werpy and Petersen 2004) or for the development of valuable polymer fibers (Fig. 3). There are actually very limited initiatives on lignin valorization and they focus mostly on finding direct uses of the lignin fraction, for example, as adhe-

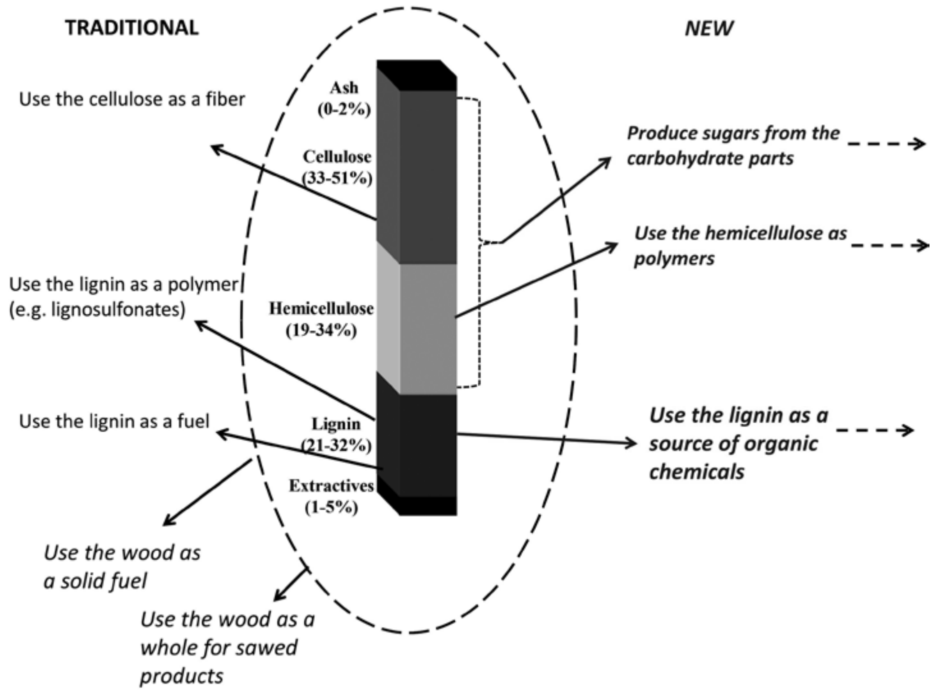


Fig. 3.
Examples of traditional and potential novel uses of wood biomass.

sives or binders, polymer modifiers and in carbon fiber production (Fig. 3).

So far, the use of lignin as a source of chemicals has barely been investigated although the complex biosynthetic machinery of lignin can, in principle, be reversed to produce low-molecular components. This could notably yield a large number of fine chemicals for the chemical industry, but in addition, a complex chemical matrix like lignin could provide us with a large chemical diversity from which we could identify and develop speciality chemicals, for example drugs and pesticides. By varying the conditions for the chemical or biological degradation of lignin, giving different kinds of oxidative or reductive reactions, numerous organic compounds are expected to be produced in mixtures. From such mixtures the useful components may be fished out following, for example, bioassay-guided fractionation. This would be a novel way to create chemical diversity based on a natural source, and may be a valuable alternative to combinatorial chemistry and classical natural product chemistry for the isolation of biologically active molecules. The Swedish pharmaceutical industry needs such alternatives badly.

Biotech industries worldwide have already started developing a wide range of compounds from the sugar platform of lignocellulosic biomass. Will the Swedish forest industry be an active actor or a passive supplier for the lignin platform? The valorization of the wood "biofactory" requires shaping a new industry, just the way the pulp and paper industry was developed at the turn of the past century, and just the way the petrochemical industry grew and developed in the 1950's and 60's.

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BUILDING WITH WOOD – IS THAT A GOOD THING?

Leif Gustavsson

Globally, more than 80% of primary energy use is based on fossil fuels. The use of such fuels is increasing, and is expected to continue to increase, according to the International Energy Agency (Fig. 1), even if policy measures are implemented to reduce the fossil fuel use. This increases the greenhouse gas emissions, which leads to greater climate change. In temperate climates this can affect the growth of forests, and how we manage our forests and the use of the biomass we harvest.

The uses of forest biomass are multiple and the use-mix changes over time. The bioenergy and pulp and paper industries are large users, as is the construction sector, which globally consumes about 25% of all wood material. The residential and service

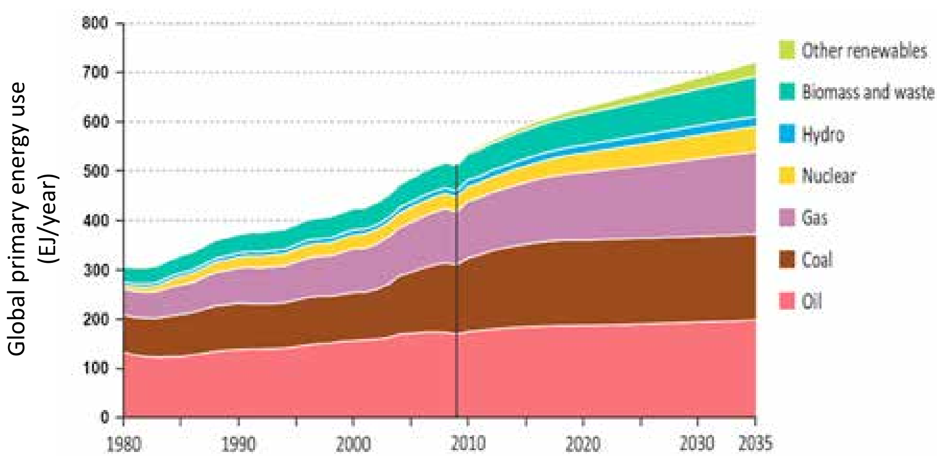

Fig 1.
Historical and projected trends of global annual primary energy use in EJ through 2035 with policy measures implemented for reducing the use of fossil fuel (the New Policies Scenario). (Adapted from International Energy Agency, 2011, page 76)

sectors account for about 35% of the global primary energy use. There is a large potential for creating a more resource-efficient wood-based built environment within the framework of ecological and cultural demands on the management of forests.

Changed usage of forest biomass is increasingly discussed in Sweden, linked to issues such as shrinking markets for newspaper and future production of biomotor fuels. In connection with this, biorefineries are often discussed as a way to use forest biomass more efficiently and to produce high value-added biomass-based products. Products from biorefineries could be chemicals and new materials as well as electricity, motorfuels and heat. Biorefineries may fit well within the existing pulp and paper industry's socio-technical systems, and can be an attractive development option for them.

A basic question in this context is: how to develop a competitive and resource-efficient use of Swedish forest biomass based on current and future needs in the society? Is it efficient, for example, to use forest biomass to produce motorfuels, which entails large conversion losses as compared to use of conventional fossil gas and oil, while at the same time continuing to use fossil gas and oil for the production of electricity and heating, where the forest biomass could be used more effectively? Can we instead decrease the use of fossil fuels, including gas and oil, in the electricity and heating sectors by creating biomass-based energy supply systems for an energy-efficient built environment considering a larger geographical area than Sweden as the EU? If this is the case, the reduction of fossil carbon dioxide emissions would be higher per ton of consumed forest biomass, and at a lower cost, than with the production of motorfuels from forest biomass. Plug-in-hybrid and electric vehicles with bioelectricity can be a resource-efficient way to allocate forest biomass for road transport. It is also possible to produce highly efficient biomotor fuels through black liquor gasification in chemical pulp mills, but the technique is still being developed and the production potential depends on the amount of chemical pulp produced.

Perhaps, we should also ask ourselves whether we should continue to use fossil gas and oil for energy and material purposes in a short-term perspective, where these natural resources are difficult to replace. In a long-term perspective, with increased knowledge and technical development there may be more possibilities to reduce the use of fossil gas and oil. Perhaps large-scale production of hydrogen from the sun and wind can become an alternative to provide the transportation sector with energy, while biomass can give us chemicals and materials. Motorfuels from forest biomass may also have a role in the future transportation sector. In any case, it is most likely that biomass will be a limited resource.

How biomass, sun and wind can be used optimally on a long-term basis for electricity, heating and motorfuels depends on technological development, and it is difficult today to assess which way is best. Therefore, it might be advantageous to strive for flexibility and avoid strong dependency on capital-intensive, long-lived energy structures. At the same time, it is important to consider whether we envision solutions based on today's established concepts and production systems and how they influence our thoughts about future possibilities. It is easy to hold on to existing solutions developed and refined over a long period of time, especially if they have been successful. The Swedish typewriter company Facit made popular mechanical typewriters and retained a technology which could not survive the competition from

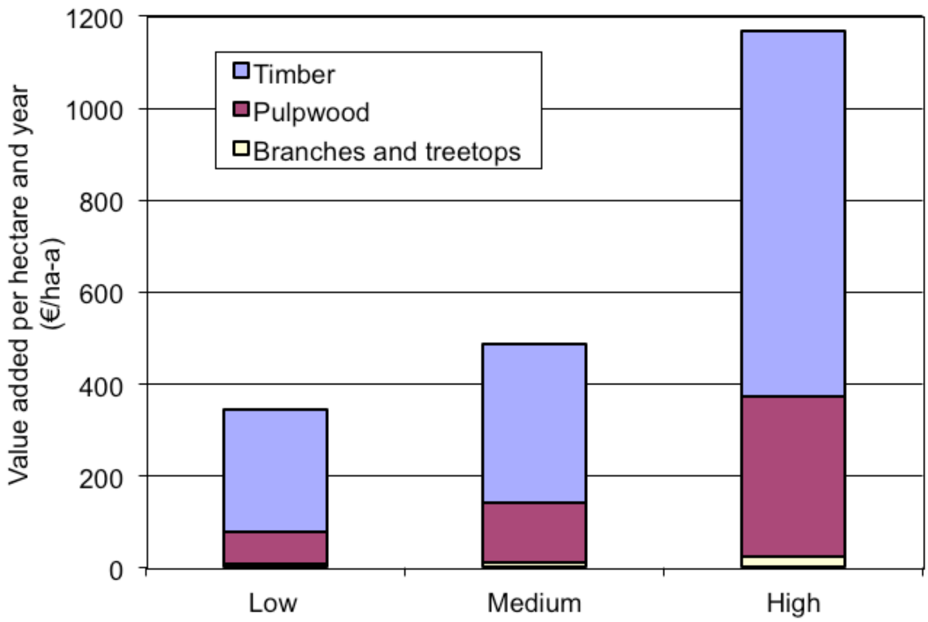

Fig. 2:.
Value-added for forest biomass in €$_{2005}$ per hectare and year for different production scenarios with low, medium-high and high added value. (Sathre, R. and Gustavsson, L., 2009, page 72) In the "Low" scenario, sawlogs are used to make sawn lumber, pulpwood is used to make market pulp, and forest residue is used to make pellets.

In the "Medium" scenario, sawlogs are used to make planed lumber, pulpwood is used to make newsprint paper, and forest residues are used to produce ethanol.

In the "High" scenario, half the sawlogs are used to make planed lumber and half to make glue-laminated beams, with the processing residues from both processes used to make particleboard, pulpwood is used to make lightweight coated paper, and forest residues are used to make methanol.

new electric typewriters. Nokia had been the leading cell phone producer globally, but fell behind in the development of smart phones and has now sold its cell phone production.

One area of use for forest biomass with high added value is building with wood. Fig. 2 shows that majority of the value-added per hectare of forest comes from timber, while the contribution from branches and tree tops is low. This is the case regardless of whether the biomass is used for more advanced products of high added value or for simpler products with a lower added value. Thus the tree trunk represents the greatest income for the forest owner. An increased use of wood in construction raises the demand and subsequently the price of timber which gives the forest owners incentive to increase their harvestings.

Building wood-frame houses also gives a large reduction in carbon dioxide emissions per hectare of forest land, seen through the whole life cycle of the house. Production of wood-frame houses requires less energy with lower carbon dioxide emissions than conventional alternatives, which need more cement and steel. At the same time, wood buildings store carbon dioxide, and when the wood material has come to the end of its life cycle, it can be used for energy. Both in forestry and when working with forest biomass, large amounts of residues are available and these can be used for energy purposes. Only 20-25% of the potential harvested forest biomass is built into the wood building itself.

The climate benefits from using forest biomass depend also on how much is harvested in relation to the growth of the forest. On a landscape level, harvesting should not lead to a decrease in the carbon stored in the forest and soil. This requires a sustainable forestry which leads at least to a situation where the forest growth balances the biomass harvest and the biogenic carbon dioxide emitted due to forest harvesting. This also means that if the growth of the forest increases, more forest biomass can be removed while still maintaining the amount of carbon stored in the forest. Forest management resulting in a high forest growth rate, combined with using harvested timber for wood houses and using logging residues to replace fossil coal within the electricity and heating sectors, give large climate benefits per hectare of forest land. Forest management resulting in a high growth rate implies that less forest area has to be used for a specific extraction of forest biomass. Thus, if we have a higher growth rate in parts of the forest land, more forest areas can be preserved for biological diversity and cultural values without decreasing the amount of forest biomass harvest or the stored carbon in the forests.

Fig. 3 shows the primary energy use for biomass-based heating and ventilation of a conventional house with three different heating technologies: electrical heating, bedrock heat pump or district heating with combined heat and power production. The house is assumed to be built in Växjö, Sweden with a concrete or wood frame. The choice of heating type has great importance for the primary energy use, while the choice of material for the frame is of marginal importance. It is not sufficient, however, to study the energy use only during the use of the house: a house must also be built, and at the end, torn down and the material taken care of, which all require energy. Therefore we need to analyze the energy needs for the entire life cycle of the building, which can be divided into three stages: i) the production phase, including the extraction of raw materials, production and transportation of the building materials and components, plus the erection of the building itself; ii) the use phase, including maintenance, renovation and possible rebuilding; and iii) the end-of-life phase of demolishing, recycling and finally disposing of the residual materials.

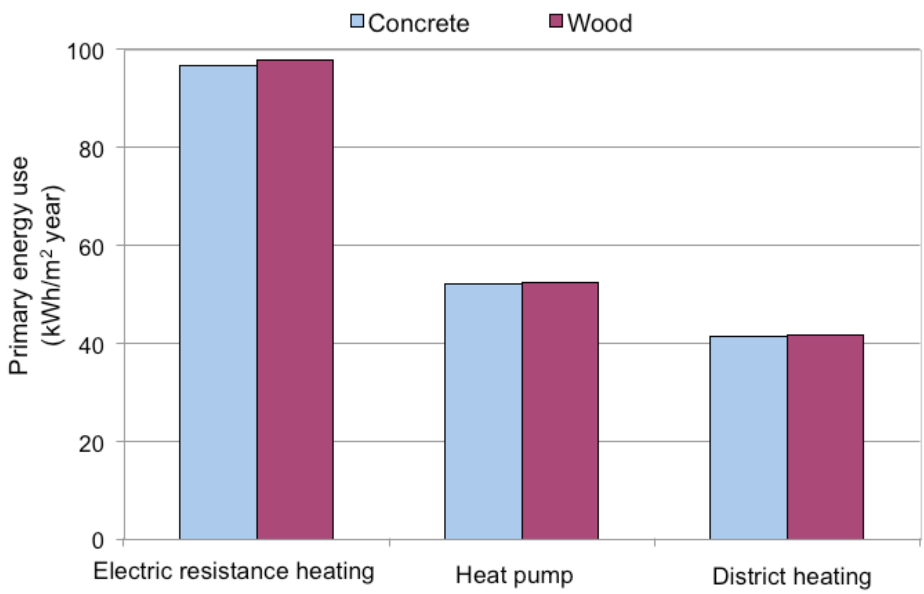

Fig. 3.
Annual primary energy use for bio-based heating and ventilation of a conventional house with electrical heating, a bedrock heat pump or district heating using combined heat and power production, in units of kWh per square meter heated building area. The house is assumed to be built in Växjö with a concrete or wood frame. (Adapted from: Dodoo, A., Gustavsson, L., & Sathre, R., 2012)

Fig. 4 shows the primary energy use for heating and ventilation of the same house as in Fig. 3 using district heating with combined heat and power production. The figure also shows the primary energy use while the house was being built (the production phase), the primary energy benefits arising at the end-of-life, as well as the energy content in the wood residue which is created when the house is built. The house is assumed to be in accordance with either the Swedish building code (BBR 2012), or a more energy-efficient passive-house criteria. Furthermore, the house is assumed to be built with a concrete or wood frame. It can be seen in the figure

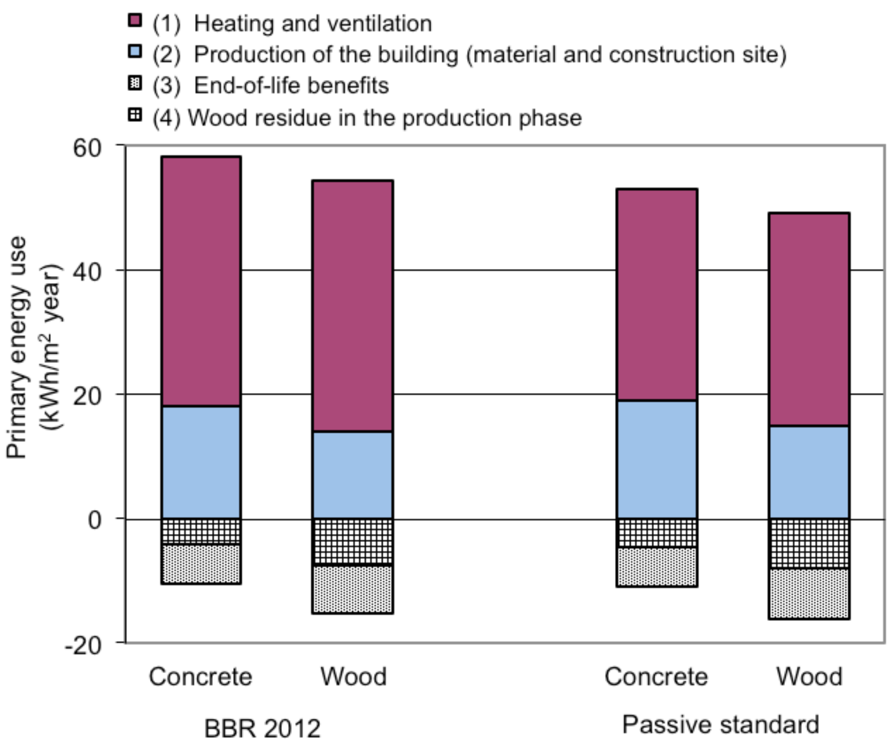

Fig. 4.
(1) Primary energy use for heating and ventilation of the same house as in Fig. 3 with biomass-based district heat from combined heat and power production, (2) primary energy use to produce the house, (3) primary energy benefits which arise at end-of-life, and (4) energy content in the wood residue which is created when the house is built. The house is assumed to be built with a concrete- or wood frame in accordance with the Swedish building code (BBR 2012) or a passive-house criteria. The assumed life of the house is 50 years and the primary energy use is calculated as annual values per square meter of heated building area. (Adapted from: Dodoo, A., Gustavsson, L., & Sathre, R. 2012)

that more primary energy is needed with the passive-house technology to build the house, but considerably less energy is needed during the use phase, resulting in total lower energy use for the passive house. It can also be seen that less energy is needed and more wood residues are available for building with wood than with concrete. Therefore, building passive houses with wood frames and heating them with biomass-based district heat, produced with combined heat and power plants, can be a part of a development towards a renewable-based, low-energy society.

It is possible to greatly increase the use of wood in multi-story buildings, as well as in infrastructure like bridges. Today about 10-15% of new residential multi-story buildings in Sweden are built with wood frames. As it was still forbidden to build wood-frame houses more than two stories high until the 1990s, the recent increase is pronounced. There are still plenty of possibilities for considerably increasing the amount of wood construction. In the EU, about one million apartments have been built annually in multi-story buildings, but the construction of multi-storied wood-frame buildings is marginal. There are also many possibilities for increasing the use of passive-house technology, which in 2012 was used in less than 5% of newly constructed multi-story buildings in Sweden.

Several sectors, resource chains, processes and actors are involved in the development towards an effective and climate-smart use of forest biomass. Both multi-storied wood buildings and the passive-house technology are relatively new phenomena for those who commission houses and for the actors in the construction business who produce them. Knowledge and attitudes about different materials and building systems go far back in time and are bound up in the prevailing innovation systems. The construction industry is considered to be particularly resistant to change, where strong structures and existing familiar patterns, often with a long history and developed around already established techniques and practices, make it difficult for new technologies to break through. In order to make changes, many strong actors are needed with the desire and perseverance to develop wood-based building systems which win confidence and are seen as advantageous by the actors in the construction sector.

There is a need for more research and development to facilitate our understanding of how we can optimize wood buildings through their entire lifecycles in regard to economy, climate and the use of natural resources. Which wood building system is most beneficial in various applications? What is the optimal use of energy in the use phase vs. the production phase? What combination of materials gives the best benefits? These are some of the questions that we need more knowledge about. We have to develop our knowledge as well about how an energy-efficient, built environment is best provided with renewable energy like bio-, sun- and wind energy, and how energy-efficient buildings work together with the existing district heating systems in Sweden.

Forest biomass can be used in many different contexts. One smart use can be to build very energy-efficient wood houses, heated with biomass-based district-heating using combined heat and power plants, perhaps in combination with solar energy. In any case, it seems more and more clear that when we seek answers for how to use forest resources in a good way, we need to consider the collaboration and development of multiple sectors and systems. It also requires understanding, and perhaps changing, the socio-technical prerequisites that affect the realization of different solutions.

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THE IMPORTANCE OF RENEWAL-ORIENTED, HARDWOOD-BASED ENTREPRENEURS

Reine Karlsson

Sweden is one of those rare countries which has many private landowners, and it also has large, green, and accessible forests with the right of public access. Many people in Sweden walk, hunt, fish, and pick berries and mushrooms in the forests, and a number of forest-related activities are available for children. Furthermore, a relatively high percentage of Swedes have a positive relationship with the forest and have forest and wood-related knowledge. This devotion is valuable as a basis for forest-related, sustainability-oriented entrepreneurship.

One basis for this paper is a three-year, €1.7 million project funded by the Swedish innovation research funding authority, VINNOVA (Karlsson, Palm et al. 2011). This multidisciplinary group of researchers and business actors aim to have business developments enhance the added value and utilization-efficacy of birch by business system development which promotes diverse entrepreneurship. The goal is to open up for sustainability-oriented revitalization through seamless collaboration and co-branding among a wide range of stakeholders and actors. One of the underlying motivations behind this is that almost everyone speaks in favor of sustainability-oriented change, but few people are actually truly engaged in renewal-oriented activities.

The limits for, and resulting risks of, the growth of monocultures give substantial arguments for biological, ecological, and cultural diversity. This issue was first noted in relation to biodiversity and, more recently, also in relation to social and societal diversity and empowerment, e.g., in combination with inclusive and integrative business ethics (Fergus and Rowney 2005). Sustainable forestry is attracting increasing attention and, in Sweden, this embraces a nature conservation interest for the diversity of hardwood trees; however, Sweden has had a long tradition of major investments in the expansion of softwood. The Swedish timber market demand for hardwood has been low over the past few decades and few Swedish landlords have invested in the cultivation of hardwood trees.

The Forest Stewardship Council (FSC) is a main actor for sustainable forestry. Their principles and criteria (1996) promote biodiversity and the development of sound forestry management. In addition to biodiversity, the FSC standard also promotes sound community relations, workers rights, and a wide perspective of the diverse benefits of the forest.

There is a need for the conceptual bridging of the many societal actors and stakeholders. The awareness of our dependence on the land has been an essential foundation for the advance of human cultures (Wirzba 2003). Wooden products and forest experiences provide the possibility to feel a connection with nature. Forests are important to many Swedes in many ways, as scenic areas and places to be present (Senge et al. 2004). Ekman (2007) presents an extensive exposé of the human dependence on, and feelings for, the forest in the development of European cultures. Moreover, a walk in a forest can give a pleasant feeling of being part of something greater. Our diverse natural world provides many sensuous places to reflect on the human role in the diverse web of life.

Dialogue for transformative learning

Before and during the VINNOVA project (Karlsson, Palm et al. 2011), a number of the interviewees stated that it ought to be possible to reduce the dissonance and mutual suspicion between nature conservation organizations and the companies that want to use (and thereby promote the growth of) hardwood trees.

The hardwood project includes a wide range of dialogues highlighting the fact that there are numerous differences in personal background and experiences at play; for example, something that is obvious and important to one person is sometimes rather incomprehensible to others. Furthermore, people tend to adhere to their own society's mainstream ways of thinking, and when a certain way of thinking has been established, it tends to be self-perpetuating. As a result, it is difficult for leading companies and experts to change their established way of thinking and conventional business principles (Christensen 1997). This means that it is a challenge to make progress with value-adding innovation for sustainable development through collaboration among a multifaceted range of stakeholders (Karlsson, Backman et al. 2011).

The entrepreneur and renewal of the business system

The relationship between the actors in an established business system upholds a form of mutual trust and understanding which has been built through recurring contacts between the persons in the business system (e.g., between the companies in a supply chain). Figure 1 shows a wood-based supply chain, from forests to product customers, as a chain of business activities. It also illustrates the business system situation for an innovative company. To be able to raise its level of added value, a renewal-oriented company must find and develop supply-chain links to the salespeople and customers who are interested in the products with the new level of value. It is also necessary to develop a network of suppliers that can and want to deliver new kinds and qualities of wood. When a company tries to introduce something radically new, it tends to be difficult to develop an appropriate way of integrating it into the supply chain. There tends to be many unknown factors regarding the contacts with other business actors, both up-streams and down-streams, as illustrated in figure 1. A number of the interviewees have suggested that the first step ought to be to analyze and develop the interests of customers and salespeople, i.e., marketing and co-branding. Some have also suggested educating designers, architects, sales people and customers primarily about the wider variety of tree species and wood qualities. The development of new quality concepts, timely timber supplies, and logistics on the raw material side is also needed. In the VINNOVA project, one key aspect is that a large retailer with entrepreneurial ambition and company culture is involved as the main driver for the project. Their door-opening capability is used as a motivating factor for various kinds of transformative entrepreneurship.

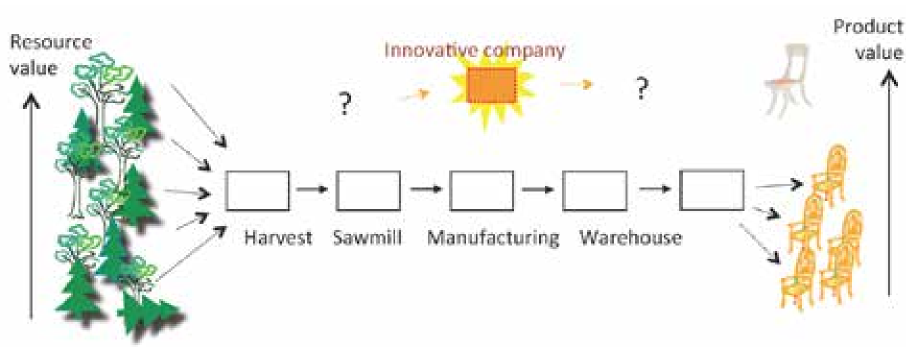

Fig 1.
An established business system, shown as a traditional wood-based supply-chain from forest to customer product and the deviating business position for an innovative company with a novel business idea.

Certain entrepreneurial actors, which have earlier tried to get started with new wood-based business ideas, have felt that there is too little general business development interest among the established actors in the forestry industry. To be able to raise the level of value for one step in a supply chain, it is necessary to build business relations that can enable and utilize these new qualities. As indicated in figure 1, actors with new forms of business ideas tend to feel rather lonely.

It is difficult for sustainability-oriented development actors like FSC and MISTRA to find ways to promote behavior that really works in favor of renewal. One aspect of resistance to change is that the profitability ambition has resulted in a rather single-minded focus on economics of scale, and this tends to work as conceptual entrapment. The financial prospects tend to look safest for business-as-usual activities, where most of the earlier investments have been made. However, the economic data alone do not show anything about the value of a new business idea which does not have any financial track record. New fields of business must be assessed in other ways and by other parameters than the present market prices, but the interviews indicate a lack of trust in other kinds of information. As a consequence, the forest landowners tend to be rather uninformed about long-term considerations. For example, most people do not have any clear understanding of the outlook that the sustainability-oriented information provides.

A new form of business needs to find a way to become part of a kind of supply chain and, in an analogous way, a new form of research needs to become part of some form of acknowledged scientific knowledge generation. A study that is multidisciplinary and interdisciplinary, which is performed with business actors, has to cope with scepticism from the established university tradition which tends to focus on in-depth knowledge in separate subject areas. Entrepreneurial research has to produce and deliver knowledge that has such quality and reliability that it can be trusted to become attractive on the "knowledge market". Furthermore, it is vital to make this knowledge available and useful as guidance and "dialogue tools" for entrepreneurs and to facilitate mutual learnings amongst a variety of actors.

One outcome from the VINNOVA project is the knowledge that it is vital to develop a conceptual frame that enables renewal-oriented entrepreneurs to show their sustainability advantages which can, for example, enable the elucidation of the multifaceted sustainability advantages of business models that make use of hardwood and in this promote the Scandinavian mode of diverse site-adapted forestry.

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GENDER EQUALITY AND WOMEN'S ENTREPRENEURSHIP: THE SHORT-CUT TO A MORE-COMPETITIVE FORESTRY SECTOR

Marie Appelstrand

The Swedish forestry sector possesses great potential for providing services and products based on the forest's 'soft' values and rural environment in combination with, or as an alternative to traditional timber production for industrial purposes (Appelstrand 2012, 2009, Umaerus et al. 2011). However, this potential is underexploited by large-scale forest companies as well as by private owners in terms of developing enterprises and entrepreneurship. At present, only one fourth of all small-scale forest owners engage in some forest-related activity other than traditional forestry (Umaerus et al. 2013). Even though 38 % of forest owners are women, the forest sector is one of the most gender-segregated in Sweden, and has not followed the wider move in other business sectors towards greater gender equality (Ds 2004:39). This is also the case for entrepreneurship in small-scale forestry enterprises, which to a great extent are dominated by men.

The discrepancy between the increasing proportion of women forest owners and their active involvement in management roles has been noted by the government, which has found that increased gender equality is a precondition for the sector's continued development and competitiveness (prop.2007/08:108). To facilitate an equal and sustainable rural development with more jobs and increased growth, the Ministry of Rural Affairs has launched a vision called 'The Forest Kingdom' (Skogsriket); to support this vision a special National Gender Equality Strategy (NGES) for the forestry sector has been introduced (Ministry for Rural Affairs 2011a 2011b). The strategy consists of three focus areas to the implementation: (i) education, (ii) work life (iii) private forest ownership. The objective is to insure that women and men are given the same opportunities to own and profit from their forests, and run or work in enterprises in the forestry sector.

Gender equality can be used as an analytical tool for focusing on a particular problem or issue as well as functioning as a concrete tool for implementing change - the National Gender Equality Strategy provides an important incentive for the sector to begin a comprehensive effort at development and change to bring about increased gender equality. The strategy is in line with the recent forest policy, approved by the Swedish Parliament in 1993, which emphazises a governance-oriented steering approach and focuses on soft steering methods. The strategy does not describe other means than knowledge transfer and information for meeting the objectives, however (Skogsstyrelsen 2011). Given this, one focal point is a discussion about to what extent a governance-mode soft-steering approach such as the NGES can act as the foundation for implementation of a strategy aimed at creating *both* more gender equality *and* a more competitive forest sector, and thus understanding the drivers and motivators as well as the barriers and opportunities for women's entrepreneurship in the forest sector.

In this context the concept *gender-equality* is defined as women and men having the same opportunities, rights and obligations in all facets of life (prop.1978/79:175).

The rationales for gender-equality and identity formation in the forest sector

There are often flaws in the evaluation of various political efforts such as The Forest Kingdom and the NGES, and therefore it is important to critically evaluate and challenge this type of activity. The possibilities and problems in selecting a governance-oriented strategy to achieve particular political goals such as increased gender equality in the forest sector, can use the following core question as a point of departure:

> How can the National Gender Equality Strategy and the vision of The Forest Kingdom create the preconditions for expanded women entrepreneurialism in, and thereby increase the competitiveness of, the forest sector?

The underlying social and behavioral science question is thus: is it possible to lead the target group to actions, behaviors and even identities in line with the objectives of the NGES and The Forest Kingdom vision using only the soft-governance models inherent in these documents? A central question addressed is *how is it possible to* *create a women entrepreneurial identity within the framework of the dominant gender order in the forest sector?* What expressions can this take? Is it expressed in 'soft green' or traditional activities? Gender equality is ultimately a democracy issue, but in the forest sector it is also an economic matter, as it is maintained that a gender-equal forest sector is a more competitive forest sector. Part and parcel of this equation is the assumption that women are expected to contribute new ideas, norms and values, etc. to the forestry sector. If women are seen as a means to modernize the branch due to their having gender-specific perspectives and characteristics, there is a risk that fundamental differences between men and women will be underscored, and a gender-marked image will continue to be projected.

To better address these questions, it is of great importance to identify the mechanisms associated with *the identity formation processes*. Here focus must be *both* on the cognitive and normative understandings of women's views and actions and on steps and measures on the societal, community, and individual levels to be taken by the authorities in order to implement the strategy under and also beyond the soft-governance means specified in the central policy documents.

Drivers and motivators for women as forest owners and entrepreneurs

In gender-legal research the difference between the *individual* and *structural* levels has been highlighted as not being laws, policies nor strategies that mandate that everyone should be treated equally, enjoying the same opportunities, equal rights and duties, nor to the eradication of gender-related norms. One explanation offered for the lack of positive results is that gender-neutral laws, policies and strategies that declare goals of gender equality at the *structural* level do not function as a means of change at the *individual* level (Svensson 2001). Ahl (2006) finds for example that a number of factors at different levels factor into women starting or not starting businesses:

- *structural factors*: support from authorities (advice, information, education), laws and rules, access to capital
- *social factors* : social network (social capital, intellectual capital), support network (family, friends, local population) cultural values and norms
- *personal characteristics* : cognitive abilities, values and motivation .

Several studies have furthermore shown that if both the structural and social components of support are present, then positive developments ensue. A Swedish study (Karlsson and Lönnbring 2005) highlights the success factors as a combination of support from family, the community and personal drive, and finds that these factors are more important than support from the local population and support from external networks. In antoher study, however, existing networks for women forest owners are found to be important for the individual women's competence acquisition and ability to be active and identify herself as a forester (Lidestav and Andersson, 2011).

Another example is given in "Farm Tourism in Spain: A Gender Perspective" where the importance of overlapping social, economic and personal drivers and motivation in succeeding as an entrepreneur is shown (Caballé 1999). One motivation for opening and developing a company can be to preserve the local community (see for example Sattler Weber 2007). The importance of business as a means of contributing to local projects and rural development is highlighted by Kjell Hansen in "Försäljning, vandrarhem, servering! Om kulturarv och landsbygdsutveckling" (Hansen 1999) Here, the author highlights the importance of businesses as a means of contributing to local projects and rural development. Yet another example is given in "Gender and motivation for Agri-tourism Entrepreneurship", where men and women are compared as business operators in the tourism sector in the US and one finds that the motivation behind rural tourism is to a great extent impacted by gender (McGehee et al. 2007). The drivers here were shown to be; increased income, opportunities for using existing resources and educating and conveying knowledge to consumers. In "Getting Down to Business and Off Welfare: Rural Women Entreprenuers" (Egan 1997) the importance of mentors and role models is pointed out. Women in this study had also developed an *entrepreneurial identity*, something that has gained increasing attention in research on gender and forestry businesses; a shift has occurred from the previous focus on rural women and issues of divisions of labor to the more recent interest in identities (see Trauger et al. 2008). Problems such as isolation, lack of business services, limited access to financing and a lack of understanding about local planning and the environment are pointed out in "Women Creating Wealth through Rural Enterprise" by Warren-Smith and Jackson (2004). The authors argue that specific support, starting from the grassroots level is important in dealing with these problems, something which should be considered regarding governance-oriented 'soft' strategies such as the NGES. In this context it is interesting to note that several studies show how policy programs designed to support rural business have often been carried out in a top-down fashion without specific knowledge about particular target groups (i.e. women) in a defined place, and have primarily focused on men's businesses within the primary business areas (ibid).

Final remarks on finding the balance in practice

The forest has traditionally been a male workplace, which has led to research about forestry work not paying attention to the role of gender. In the few studies on businesses in this sector, the conditions of women have not been explored. A recent report (LRF 2009) talks of "*genderblindness*" in perspectives on businesses in the forestry sector, where the normal image is that farmers or forest owners are men. Other studies have shown that women as business-operators have been made invisible both statistically (Sundin and Holmquist 1989) and in research (Pettersson 2002). The skewed gender distribution for men and women in the sector has also led to a decrease in the legitimacy of the sector in the eyes of the society at large due to its slower movement towards gender equality (JämLYS 2012). In order for the sector to continue to develop and be a future-oriented branch and increase its general legitimacy, it needs to follow the wider gender-equality trend.

Discussion and conclusion

The point of departure for the governance-oriented strategy (NGES), launched to increase gender equality and hence a more competitive forest sector, is that women and men should have the same opportunities to own and manage forests, and run or work in enterprises in the forestry sector. Based on this background, the paper discusses to what extent a governance-mode soft steering approach can function as the foundation for implementation of a strategy such as NGES, aimed at creating *both* more gender equality *and* a more competitive forest sector. In order to do this, it is of great importance to define and delimit the target group – women entrepreneurs – and the motivators involved, as well as the public authorities' understandings and ideas on how to implement the strategy. Special attention should be given to identifying barriers that stem from *gender-related norms* that contribute to gender segregation within the forestry sector.

Comprehensive and important questions for further research to explore are already indicated by several studies: that both structural factors and social components *in combination* are important for women to succeed as entrepreneurs in the forest sector. Motivators can be increased income as well as the wish to contribute to the local community and rural development. Barriers that may hamper this development can be found on both the structural and the personal levels: limited access to financing and business services and advice on the structural level, and at the personal level isolation and lack of understanding about local planning and opportunities.

Therefore specific support built from the grassroots level with sufficient knowledge about the target group is crucial for facilitating a more gender-equal entrepreneurial identity for women within the forestry sector. Given this, the preconditions for the soft steering governance approach to facilitate a successful implementation needs to be further explored, preferable through case studies, in order to understand the interaction and dependence between the factors at the different levels. However many of the guiding ideas and mechanisms that *governance* uses are normative in the sense that they describe an ideal as well as an empirical reality. To get the ideal to work in reality is probably the greatest challenge for the governance perspective at large, as well as for the implementation of the National Gender Equality Strategy.

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Forests and Mankind–
The Dilemma

Overview

People are not only biological and consuming individuals, but also the only animal that is capable of analyzing the future and planning for it. This creates a dilemma or, rather, a series of dilemmas. The overriding question is—how can we use forests as a source of energy and raw materials while, at the same time, secure their capacity as suppliers of ecosystem services and regulators of vital processes in our biosphere? Part of the answer requires a further question—how can we balance our planet's need for CO_2 absorption with our own quest for energy?

Sofi Qvarnström reflects that neither the discussion on these issues, nor the arguments, are new. These questions were already being addressed late in the nineteenth century when the newly formed forest companies in Sweden were criticized for deforestation and for cheating farmers out of their forests, thereby ruining them and forcing them move to the city.

Both sides of the debate, now as well as in the nineteenth century, argue in a biased and unilateral way. Some refuse to see the complexity, some use only sources that support their own agenda, and others are overconfident in science and refuse to see that the question is not only scientific, but also about conflicting values.

Erik Swietlicki examines the effect of aerosol particles on the balance between earth's incoming and outgoing energy radiation. Aerosol particles nucleate cloud formation which reduces energy influx. The emission of volatile organic compounds from the forest can form such particles thus creating a regulating mechanism. Air pollution is another source of nucleating particles. As we have now made considerable progress in improving air quality in order to protect human health, we have also decreased the aerosol cooling effect. Air quality and climate change issues are thus intrinsically linked to each other, and this example stresses that we cannot tackle one without the other.

In her second contribution, Marie Appelstrand discusses the dilemma caused by the expectations on the forest from landowners on one side, and the local population/nature conservation movement on the other. In one case in southern Sweden, the combination of soft law approach and partnership between all stakeholders has proved successful in overcoming this dilemma. Collaboration around knowledge-building, trust-building, and conflict solution mechanisms are some key factors behind the success.

Bengt Järrehult points to the dilemma between traditional forest-based production characterized by large investments, large production volumes, and small profit margins on one hand and hi-tech, forest-based production characterized by high value-added, flexible production, and large margins on the other. The paper industry is one example of the former, but it is slowly changing. Alternatives for industrial, forest-based production exist, but all require entrepreneurial business development which is currently lacking in the established forest industry.

Leif Brodén points out that the road to a sustainable society holds a number of new product and business opportunities related to the forest. In order to make the most of these opportunities, industrial actors need to be open-minded, willing to utilize research results, and able to engage in the development of the sustainable society.

Finally, Henrik Teleman underscores the need to draw a picture or formulate a clear vision of a future sustainable, bio-based society; a society in which modern technology goes hand in hand with bio-based materials

GREEDY FOREST COMPANIES AND IDEALIST TREE HUGGERS? A HISTORICAL PERSPECTIVE ON THE RHETORIC OF CONTEMPORARY FOREST DEBATE

Sofi Qvarnström

Forest policy and natural resource management have been debated topics in Sweden for more than one hundred years. In the late 20th century, when the industrialization of the north of Sweden accelerated and forest companies began buying forestland in large quantities from the farmers, the so-called Norrlandsfrågan, the Norrland issue, was intensely debated in the press, in parliament and in literature. As a matter of fact, there are striking similarities between now and then.

In Spring 2012, the journalist Maciej Zaremba published five articles entitled 'Skogen vi ärvde', 'The Forest We Inherited', in the newspaper *Dagens Nyheter*. He vehemently criticized the Swedish forest policy and described a deforested landscape where there is no place for either man or protected species. The articles were much discussed – both praised and criticized – and received replies from industry, the Swedish Forest Agency (Skogsstyrelsen), forestry contractors, the Swedish Society for Nature Conservation (Naturskyddsföreningen) and scientists.

In January 1894, a journalist, Jonas Stadling, started a documentary series called 'Vår irländska fråga', 'Our Irish Question', in the newspaper *Aftonbladet*, a series that would go on for eight months with more than twenty articles. Stadling had visited the northern regions of Sweden and described a poor and vulnerable population and reckless and greedy forest inspectors. In the articles he criticized the forest companies for deforestation and for cheating the farmers out of their forests and thereby ruining them and making them move to the cities. Responses and contra-arguments came from scientists in cooperation with the head of one forest company (Frans Kempe, Mo och Domsjö) and from a representative in the parliament (Curry Treffenberg, county governor in Sundsvall during the strike in 1879 and Kempe's father-in-law). Both Zaremba's and Stadling's articles were later republished in book form.

Aim and Questions

Already in 1894, the debate was irreconcilable and polarized. What unites the two debates and what makes them different? What is there to learn by comparing the two? This is the point of departure for this article: its aim is to try to understand the deadlock and why the debaters always seem to be talking past each other.

Similarities in argument and style

First of all, there are striking similarities between Stadling and Zaremba in style and genre. They use a literary style, with fictive traits and passionate imagery, and they mix reports, arguments, narratives, interviews, and testimonies. Personal meetings and individual experiences are very important to both of them. The criticism toward the forest companies, and in Zaremba's case, towards the Swedish Forest Agency and the government, is emotional and has a post-colonial power perspective: the little man/the farmer is exploited and defenseless before the State and the big forest companies. They both contrast the past and the future, where the past is portrayed as an idyll and the future as degeneration or devastation. Zaremba opened his first article with a description of the forest in Storfors, Värmland, before it was harvested by the Stora Enso company, saying that it was, in short, enchanting and captivating: tall pines and spruces, the ground covered with moss, small gullies on the slope toward Mögen Lake. He continued by contrasting the view seven months later -- the view was most similar to the battlefields of Verdun: meter-long stubs towering among the lumber where there used to be shady forest paths, here and there a solitary tree, otherwise desolation (Zaremba 2012: 11–12). Stadling's description of the situation in Härjedalen one hundred years earlier is similar: he says that when you have come down the slopes towards Ljungan River, where in times past majestic pine crowns rose in the air, now you see only withered branches. Wherever you turn your eyes, you encounter the same abominable devastation: stumps, tops, here and there, ruins of a log cabin (Stadling 1894: 63).

A major problem, seen both in Zaremba's and Stadling's argumentation, is the inability and the unwillingness to recognize what the question is *really* about. They refuse to admit that the forest policy is contradictory and that they themselves have no answer. This is seen, for example, in Zaremba's discussion of proprietorship *contra* the Right of Public Access (allemansrätten). The title of the article series, 'The Forest We Inherited', indicates that this is a key issue for him. His point is that we think of the forest as ours – and in some aspects it is ours – despite the fact that somebody else owns it. The forest is a part of our culture and it influences our way of thinking and living. In a certain sense, we all have a right to the forest, to walk in it or to pick berries and mushrooms. How come, then, we have no say when it comes to decision-making?

The question is legitimate, but has no easy answer. Individual owners and private companies own most of the forestland in Sweden (www.skogsstyrelsen.se). The forest is their source of income and in a certain sense it is logical that they get to decide what happens on their property. Nevertheless, there must be laws and regulations to follow. When a biotope is found, we must recognize that, there is a conflict between the values of nature and those of economic profit for the forest owner. The owner's decisions will vary depending on the various values and interests. But still, it is the owner's decision. The forest is not ours in this sense: it is on loan to us. However, Zaremba seems to ignore this, because when he addresses his opponents' arguments on ownership, he rallies and tells a fictional story of a future archaeologist who writes her dissertation on "an ethnic group called foresters" and their exclusion from the rest of society. He caricatures the polarized opinions and he speaks ironically of an article in the professional journal *Skogen* (*The Forest*), where townspeople are described as ungrateful, spoiled and talking foolishly about the forest as "our forest": he says that it is only a matter of time before they try to take the right to farm their land from the forest owner (Zaremba 2012: 128). The implication is that the reader should renounce the views of *Skogen*, but the reason for doing so is missing. How far is Zaremba willing to push the argument of the general public's right to the forest? What is a valid argument if you want to argue against proprietorship?

The responses to Stadling and Zaremba are very different in character, but they also share important characteristics. They have a more traditional disposition, the argumentation is linear and straightforward, the tone is lower key and the style is literal and technical. But most important, many of them argue in a way that makes it look like they are discussing actual facts, not arguing for or against a controversial belief. Their arguments are hidden, not least because of the fact that many of them claim to speak for the sake of both industry and nature. This is especially noticeable in the response in our time from the head of the Swedish Forest Agency, Monika Stridsman, and from a group of professors at the SLU (Swedish University of Agricultural Sciences). Stridsman argues that the Swedish Forest Agency first and foremost has to follow the law. She criticizes Zaremba's one-sidedness and objects to several of his arguments, but does so mostly by saying only, "This is not the case," and that they have a policy that states that clear cutting should be reduced (DN May 16, 2012).

The professors from the SLU are not as polemical: they acknowledge the importance in Zaremba's criticism but they object to his biased description. Their main argument is that there is a difficult conflict of interest between nature values and forest production and they describe some of the conflicting goals that have to be taken into consideration. Here, they are close to reaching the heart of the matter. They exemplify by using the conflicting Swedish environmental objectives Reduced Climate Impact and A Rich Diversity of Plant and Animal Life. Forest fertilization that absorbs carbon dioxide gives an increase in biomass fuel, but also has negative consequences for biological diversity. They are also aware of the ethic, social, cultural, economic and proprietary aspects that must be taken into consideration (DN May 16, 2012). But still, they seem to put too much faith into what they call "value-neutral knowledge" and scientific facts and that this – albeit together with ideological, economic, cultural and emotional arguments – will lead us to the "right" decision. I would like to ask right for whom? And what is value-neutral knowledge? When does a fact turn into an interpretation? From a rhetorical perspective, a factual description will never be completely value-neutral, and facts (not just values) are dependent on the acceptance from an audience in order to actually function as facts. Rather than talking about value-neutral knowledge, the rhetorical concept of *doxa* can be used to describe what the scientists are aiming at. *Doxa* (from which 'orthodoxy') is the domain of opinion, belief or probable knowledge that cannot be questioned at a specific moment in time in a society, but that in the long run can change when and/or if new arguments arise for a new thesis (Rosengren 2011, passim).

Already the responses to Zaremba's article series show that scientific knowledge is not always value neutral. In a later article, climate scientists claim that clear cutting is not climate-smart; two days later, other scientists assert the opposite (clear felling is climate-smart) (DN May 30, and June 1, 2012). The different conclusions can be explained by the fact that the measurements of carbon dioxide emissions are made in different ways and related to distinct norms and values. In other words, scientific knowledge needs interpretation, and interpretation means relating to values in some ways. Despite this, these scientists talk about carbon dioxide emissions and their effects as if this were an undeniable fact. There is an unwillingness to recognize that science is also value laden and, further, that there is a tendency to believe that we can find the Right Answer simply by having faith in Science. However, in fact, these two articles clearly show that it is not as simple as that. Even if scientists were to agree on which kind of forestry technique is best for the environment, there would still be disagreements as to how to assess the importance of the forest industry (in terms of export value, jobs, etc.) compared to environmental objectives (diversity, biotopes, sustainability, etc.) As has been shown, there are scientists who are well aware of these conflicting goals, but they do not discuss how to solve them.

On the other hand, the argument from industry and the contractors is simple: we do take the environment and nature into account. We already have a good forest policy, says one (Lantbrukarnas riksförbund Skogsägarna in DN May 22, 2012). Another states that Swedish coniferous forests are robust ecosystems (Pelle Salin, contractor, in DN May 16, 2012). The defenders in 1894 used the same strategy: Carl Bovallius, professor in zoology and the most prominent spokesmen for the industrial agenda (though in close cooperation with Frans Kempe, the head of Mo och Domsjö) argues that a rational forest management (that is, an industrialized forest management) is the best solution for the farmers, the forests and the economy (Nya Dagligt Allehanda, NDA February 20, 1894). He wants changes in forest legislation, changes that enable the owner of the lumber mill to secure his need for timber and, at the same time, maintain a population of farmers. His main argument is that the forest industry in Norrland is beneficial – but also necessary – for Sweden's economic and technological development.

Differences in place and position

As we have seen, the rhetoric of 2012 has several similarities with the rhetoric of 1894, both in terms of arguments and style. But of course, there are also differences. The most crucial change is the place and position of the farmer. Those who criticized "*baggböleri*" in the 1890's took a stand for the farmer and the peasantry. The farmer was deprived of his forest, deceived and impoverished. Stadling wanted to empower him. Today, the farmers have their own voice, but what is more interesting, it is a voice in harmony with the forest companies. They share the same views, as for example when representatives for Lantbrukarnas riksförbund, Federation of Swedish Farmers, state that Sweden already has a good forest policy (DN May 22, 2012). A forest contractor from Jämtland in the north of Sweden goes even further and argues that if the forest is going to contribute to prosperity and development, extreme nature conservation cannot be tolerated (DN May 16, 2012). The state, the forest companies and the farmers argue for the proprietor's right to decide over his own property, for "individual responsibility" and "voluntary actions".

Of course, not all farmers have changed sides. Zaremba speaks of farmers who fight vigorously for *not* having to cut their forests and others who lament their lost childhood dreams. But this actually distinguishes Zaremba's articles from many other critical attitudes towards the forest industry nowadays. Nature conservation has been the dominating argument for the past 50 years, but it is not a prominent theme in Stadling's articles as knowledge about nature conservation then was scarce. There is a link between Zaremba's cause and the case in 1894, however. They both reflect on man's place in the forest and the forest's place in man. What does the forest mean to man, and what are man's responsibilities toward the forest? Zaremba brings back the existential dimension in the forest debate – although this time it does not concern only the farmers, but all of us, mankind in general. Stadling's articles make us see the forest as an integral and important part in the modernization and industrialization processes. In retrospect, the optimistic hopes and the absolute confidence seem naïve and simplistic. But that should make us humble and prevent us from saying things like, sure, the forest has been misused now and then (mining, "*baggböleri*", pasturage, pesticides), but not anymore because now we have learnt from these mistakes and nowadays nature conservation is adequate (DN May16, 2012).

Conclusion

So what can we learn from this short examination of some of the arguments in the two forest debates initiated by Stadling and Zaremba? First of all, a historical perspective reminds us that we should always be prepared to reconsider and re-examine our positions and opinions, but it also shows us the strong continuity in the debate. If the goal is to create a more constructive debate, this is the first step. But even more important, we must understand the deadlock today -- that is, the conflict between conservation and industry, environment and economical interests -- as a consequence of the debaters' different perspectives: a humanistic perspective collides with scientific and industrial ones. The sides are biased and one-sided: Zaremba because of his refusal to see the complexity and for using only sources that support his agenda, the antagonists because of their overconfidence in science or dependence on economical factors. Most important, though, is the inability on all fronts to see that the question is about conflicting values. If the parties could recognize this, and speak openly about the different values at stake, the discussion could achieve more.

In Marie Appelstrand's article "From Confrontation to Dialogue. Developments in Swedish Forest Policy and Administration" in this volume, we meet a successful example of this strategy. She discusses an application of new modes of governance in environmental management in the project called the Östra Vätterbranterna Partnership. The project group focused on finding and defining social norms and bonds within the community and between different stakeholders and organizations. She concludes:

> Through these activities even the land owners became interested in conservation, and a dialogue was initiated with authorities and other actors about the best forms for protecting the natural value areas. With a common understanding and agreement of problems and goals, the foundation for solving problems and finding solutions was laid and cooperation within the project developed (Jonsson 2004).

Another central, conflicting value discussed above is man's place in the forest and his rights and responsibilities. While Zaremba emphasizes the existential dimension, the industry underlines the forest's potential to create wealth and the nature conservationists focus on the protection of the plant and animal life. The parties have different agendas, and they relate to different norms, traditions and habits of thought: that is why they have so much trouble reaching an agreement. In one way they should not reach an agreement, because these central but conflicting values cannot and should not be erased or totally resolved. All perspectives bring important values to the question. The point is the importance of trying to recognize, understand and accept other perspectives and other approaches regarding a question. There is no single truth and our knowledge is always anchored in a society. What is a fact is dependent upon time, place and context (Rosengren 2011). The challenge for the parties in this debate is to recognize the conflicting agendas and at the same time acknowledge the legitimacy of the opponents' standpoints. Only then can a constructive and productive dialogue develop.

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THE FOREST HELPS US FIGHT CLIMATE CHANGE

Erik Swietlicki

Forests around the world provide innumerable services to humankind, many of which are discussed in this anthology. Among the more obvious examples, we think of our forests as a supply of raw material for buildings and furniture, and a source of renewable and CO_2-neutral energy. Humans have tapped this ubiquitous and seemingly endless resource ever since our ancestors first learnt to harness fire or assembled branches and twigs into simple dwellings, and even long before that.

In our day and age, our addiction to fossil fuels has resulted in huge releases of carbon into the atmosphere in the form of the greenhouse gas CO_2, which has committed the Earth to a future increase in global temperature that is way beyond our present "comfort zone". We are now entering the Anthropocene, a new geological era during which humankind (Greek: *anthropos*) makes such an impact on our planet that he is well in parity with other geological and natural forces.

The question then arises: What can life on Earth – excluding the irresponsible humans, that is – do to mitigate or even counteract climate change? Or, retaining the perspective of this anthology, what can our forests do in this respect?

Our records of the Earth´s climate history (so-called paleoclimate records) clearly show that the climate has gone through several drastic and rapid changes in the past, with no human influence whatsoever. Obviously, this tells us that the Earth system may respond in many intricate ways through various feedback mechanisms to external forcings such as astronomical changes in solar insolation. So there may be some hope that nature itself could mitigate human-induced climate change. Well, can it?

Obviously, living plants use atmospheric carbon dioxide during their photosynthesis to transform carbon into organic matter such as cellulose and lignin. This constitutes a huge sink of the greenhouse gas CO_2 from the atmosphere to the terrestrial biosphere amounting to about 2.5 PgC (billions of tons of carbon) annually, equivalent to about a quarter of all carbon released from the combustion of fossil fuels.

The problem is that this carbon sink is neither permanent nor very long-lasting. Once the plants die they start decomposing, and the carbon is returned to the atmosphere, typically as CO_2. However, when the decomposition proceeds in anaerobic conditions, the carbon will instead be released in the form of the even more powerful greenhouse gas methane (CH_4). Unfortunately, such conditions have been shown to prevail for some years following a clear cutting of boreal forests, since the forest soils tend to be waterlogged once the trees are removed and their efficient transport of water from the soil to the atmosphere is cut off. This process is called evapotranspiration.

In order to establish a more permanent terrestrial carbon sink, we have to increase the amount of forest biomass to keep up with our persistent release of fossil carbon. At present, we are not even close to maintaining this balance. Nearly half the amount of fossil carbon emitted into the atmosphere remains there. If we persist

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Trees, the sun, the atmosphere and clouds all work together in complex ways to partly offset human-induced climate change."

in emitting fossil greenhouse gases, forests would have to spread quickly across the face of our Earth, thereby greatly increasing the terrestrial biomass. Thus, reducing our emissions of greenhouse gases is the only feasible way forward. Indeed, both in Sweden and in the EU, there are tentative plans for how to achieve a carbon dioxide-neutral society by the year 2050, showing that it is possible. In essence, we have to drastically reduce our emissions of fossil carbon while increasing, or at least maintaining, the carbon sinks.

In passing, we may note that the only "permanent" carbon sink is created by returning the fossil carbon to the geological reservoir from where it came, now in the form of carbonates, which is unfortunately a very slow process working on a time scale of about one hundred thousand years. Forests may nevertheless buy us the time we so desperately need to mitigate and adapt to climate change.

Climate change is caused by a perturbation in the Earth's radiation balance. Roughly 70% of the short-wave radiation received from the sun is absorbed into the Earth´s atmosphere or at the surface, where it is converted to long-wave (infrared) radiation that is reemitted back into space. The greenhouse gases prevent parts of this long-wave radiation from escaping back into space, thus increasing the amount of energy available on or near the Earth's surface. As a result, the global temperature will increase steadily.

As discussed above, forests have a major influence on the Earth's radiation balance through their role as a powerful carbon sink, thus affecting the concentrations of greenhouse gases and thereby also the outgoing flux of long-wave radiation.

Forests may also affect the incoming flux of short-wave solar radiation. They do this in basically two ways: Forests, in particular boreal forests, are fairly dark and absorb more short-wave radiation than brighter land surfaces such as deserts, fields of grass and snow-covered terrain. An increase in the global forest cover may then both mitigate climate change by acting as a carbon sink, and at the same time aggravate global warming by absorbing more solar radiation compared to a more open and less densely forested landscape. Climate model calculations have shown that a conversion of farmland to boreal forest may have unwanted consequences for global climate. The mitigating effect regarding climate change resulting from an increase in the terrestrial carbon sink may actually be completely offset by the concurrent decrease in surface albedo (fraction of short-wave radiation energy that is reflected by the surface).

The other way is for forests to interact with the short-wave solar radiation with the airborne particles that are produced in large numbers by forests.

In short, organic gases emitted by forests will help grow airborne particles to sizes where they both scatter visible light efficiently (direct effect) and may form cloud drops and alter cloud properties (indirect effect). Both these effects will increase the reflection of sunlight back into space (the albedo) and thereby cool the planet. How does this work?

Forests emit gases in the form of volatile organic compounds (VOC). These gases react with other gases in the atmosphere (oxidants) and then form other and more oxidized compounds that are typically less volatile than their precursors. As a result, these organic compounds want to leave the gas phase and condense on existing surfaces. In the atmosphere, the only surface available is provided by airborne particles. In the scientific literature, these are called aerosol particles, and span in size from tiny one-nanometer particles to grains of about a tenth of a millimeter in diameter.

As the organic compounds originating from the forest condense onto the existing aerosol particles, they add mass to the particles and grow them to large sizes. Eventually, they will become large enough (roughly larger than a tenth of a micrometer in diameter) to act as cloud condensation nuclei (CCN), which means that they will be able to form cloud drops at relative humidities above 100 % and thus contribute to the formation of clouds. As experienced from everyday life, clouds are very important for the radiation balance. When a cloud blocks the sun, we immediately sense a drop in temperature caused by the blocking of solar radiation to our skin. Clouds also reflect infrared long-wave radiation from the ground. This warming "blanket" will typically cause cloudy nights to be warmer than if there were no clouds.

It has been shown in numerous studies that the short-wave reflective capability of the cloud – the cloud albedo – is indeed quite sensitive to the number and size of the cloud drops present in the cloud. It works like this: the more particles there are that are large enough to act as condensation nuclei, the more cloud drops there will be in the cloud that is formed. More clouds drops also mean that the drops will be smaller, since there is only a certain amount of water vapor available in the air that can condense on the particles when the cloud is formed. This water then has to be shared by more drops, making them smaller.

More numerous and smaller cloud drops will make the cloud more reflective in the short-wave range. This may seem to be somewhat of a paradox, since it also means that clouds formed in polluted air containing many particles will be more reflective, and thus more cooling, compared to clouds formed in clean air with few particles. There is now general consensus that this pollution-induced, cloud-cooling effect has served to mask a significant fraction of the warming caused by the greenhouse gases and has thus delayed global warming. As we have now made considerable progress in improving air quality in order to protect human health, we have also decreased the aerosol cooling effect, meaning that we are soon about to experience the full warming effect of the greenhouse gases. Air quality and climate change issues are thus intrinsically linked to each other, and we cannot tackle one separate from the other.

Now let us go back to the forest. We can actually detect many of the volatile organic compounds that are emitted by trees in the forest. They smell nice! Pine and spruce trees emit compounds such as alpha-pinene. This, and other so-called monoterpenes (a family of $C_{10}H_{16}$ compounds), is what makes a boreal forest smell the way it does. Limonene, another monoterpene, is found in lemons and oranges, and is often added to detergents and hygienic products to give them a fresh citrus smell. Even if the forests emit these carbon-containing compounds in sufficient quantities for our human nose to be able to sense them, they still only make up less than 1% of the total forest carbon flux. Still, that is enough to make an impact on the radiation balance above boreal forests, and thus also climate!

In collaboration with colleagues in the Nordic countries and across Europe, our research has recently shown that forests indeed have a cooling impact along the lines outlined above. The findings were published in *Nature Geoscience* in April 2013 (Paasonen et al. 2013). We based our conclusions on an extensive set of observations of atmospheric particles collected over land in environments ranging from clean, semi-Arctic areas to polluted agricultural areas.

The trick is that the emissions of volatile organic compounds from the forest increase with increasing temperature, causing also the concentrations of large particles of biogenic origin to increase. These aerosol particles serve as seeds for cloud formation, leading to the reflectance of incoming sunlight and a reduction in surface temperatures. In a future warmer climate, this natural feedback mechanism may actually dampen further warming. Nature is fighting back! But is it enough to save us from global warming caused by our emission of greenhouse gases?

We estimated that almost 50% of all particles over the European continental area that are large enough to form cloud drops (CCN) were formed through the temperature-dependent mechanism. Regionally, in particular over boreal forests far from pollution sources, the cooling effect was significant. Still, when averaged globally, the cooling effect was estimated to be fairly modest in comparison with the warming caused by the greenhouse gases.

In summary, forests may respond in various intricate ways to global warming induced by increased levels of greenhouse gases in the atmosphere. Such feedback mechanisms may be both positive, further aggravating global warming, and negative, serving to dampen rising temperatures. Forests do this by modifying both the outgoing long-wave infrared radiation and the incoming short-wave radiation, thus altering the radiation balance of Earth. The processes involved are typically complex, non-linear and highly inter-related.

An adequate understanding of these processes demands coordinated and highly inter-disciplinary research efforts, requiring a combination of modeling on different spatial and temporal scales, detailed laboratory process studies and long-term field observations.

At Lund University, research on all these aspects is carried out within the framework of several larger coordinated research constellations: we are developing the dynamic vegetation model LPJ-GUESS, which can be used to model regional and global carbon fluxes in the past, present and future. In this model, the terrestrial vegetation is not static, as is often assumed in climate models. Instead it responds to climate change and greenhouse gas concentrations.

The greenhouse gas fluxes to and from various ecosystems is observed in a Swedish and pan-European network of sites (ICOS). The measured carbon fluxes are examined and modeled within the Linnaeus Centre of Excellence for studies of the carbon cycle (LUCCI).

Within the Strategic Research Area MERGE, we are developing an Earth system model, which is basically a global climate model with an additional description of the biosphere (here LPJ-GUESS for terrestrial vegetation). Another closely linked Strategic Research Area (BECC) examines the impact of climate change on biodiversity and ecosystem services. BECC, MERGE and ICOS-Sweden are coordinated via CEC, the Lund University Centre for Environmental and Climate research.

In addition to these examples, several other groups across the University at large deal with various issues related to forests and climate change.

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FROM CONFRONTATION TO DIALOGUE–DEVELOPMENTS IN SWEDISH FOREST POLICY AND ADMINISTRATION

Marie Appelstrand

Nature conservation conflicts are often complex and difficult to resolve, costly and time-consuming to handle. Many different interests and actors are involved in such processes, which over past decades have caused long-term conflicts over land use in Sweden. The previous environmental policy was characterized by several problems and challenges, and many land owners were negative towards what they saw as a 'policy of restriction' and felt themselves excluded from decisions about their properties (Appelstrand 2007). In the forestry sector the current forest policy also emphasizes the land owners' extensive responsibility to voluntary get engaged in protecting valuable core sites on their land, through both formal protection and voluntary set-asides. In such a situation of expected beyond-compliance outcomes, conflicts between production and environmental goals are likely to arise. To create a change and to enable the possibility to meet environmental goals, the government has decided to broaden nature conservation work and initiate a new direction with more flexible protection forms, instruments and working methods that can lead to increased participation and can stimulate land owners' interest in nature conservation (prop. 2008/09:214). Thus, more actors will participate in the process and cooperation between authorities, land owners, interest organizations, NGOs and other actors will be improved. Work with land owners will be strengthened by more actively incorporating the knowledge and engagement. Local influence and involvement will also be boosted in order to create common values and goals and in this way stimulate self-interest (gaining a return from the property, autonomy) that will lead to the common public interest (protection of valuable nature). Increased information and knowledge transfer, and in part new ways of working in public environmental administration are needed to attain these goals. In addition to an altred role for public authorities, this entails also shifting direction from direct legal steering to 'softer,' inclusive steering and modes of impacting the behavior of various actors.

New tools and forms of cooperation at the landscape level

In the Swedish government bill *Sustainable protection of nature areas* (prop. 2008/09:214) a new approach was presented for environmental work on areas of great natural value, entailing new roles for the administrative and regulatory authorities and challenging their capacity to move from more traditional hierarchical structures to softer, flexible processes based on co-operation. This development goes hand-in-hand with the growing trend towards deregulation and less state intervention in environmental management, implying a stronger emphasis on *new governance structures* and market-driven processes. The transformation of the environmental public administration can be described as a progressive transition from 'rowing' to 'steering' and finally, to 'serving' and facilitating, representing different perspectives on the role, values and meaning of administration (Appelstrand 2012).

However many of the guiding ideas and mechanisms that governance uses are normative in the sense that they describe an ideal as well as an empirical reality. To get the ideal to work in reality is probably the greatest challenge for the governance perspective. An example of a successful application of new modes of governance, soft regulation and innovative forms of steering, in keeping with the new orientation towards focus on environmental management, is the Östra Vätterbranterna [ÖVB] project in the southern part of Sweden.

From confrontation to dialogue – The Östra Vätterbranterna Partnership

In Sweden, people have been aware for several years of the fact that new tools and forms of cooperation at the landscape level are needed in order for forestry and environmental conservation to co-exist in areas where there are many land owners. This awareness has been expressed in several projects and initiatives. One of these projects is *the* Östra *Vätterbranterna Partnership*, a successful example of the new orientation towards environmental management as formulated in the government bill "Sustainable protection of nature areas": new working methods with a focus on collaboration and increased dialogue by involving more actors and utilizing a greater combination of steering instruments.

The ÖVB-area lies on the eastern slopes of Lake Vättern in the southern part of Sweden, and is an important area of high biodiversity and red-listed species. The area is 43,000 ha of which 23,000 ha is productive forestry land, with around 1000 private holdings. The average forestry holdings is 23 ha, and for agricultural land, 12 ha. A long practice of small-scale forestry and agriculture including haymaking, grazing and lopping of tree branches, combined with a lakeside climate contribute to a mosaic of cultivated land and deciduous forests with high biodiversity (Asp and Jonsson 2002, Jonsson 2004). The ÖVB-area is of great natural value and listed by WWF as one of 100 hot-spots for forest biodiversity in Europe as well as being important for recreation and tourism. The area is also characterized by having a large number of land owners with small holdings, as well as a number of authorities and environmental organizations interested in the area. Due to the conflicts and lack of trust between forest owners, public authorities and local NGOs the ÖVB-project began in 1998 as a top-down initiative started by the County Administrative Board. The time prior to the project start was a period characterized by serious conflicts between the nature conservation movement and forest owners' organizations. Even coordination among authorities in the area functioned badly. Conflicts took place over the establishment of new nature reserves and an ongoing inventory of woodland key habitats. Representative of the relevant authorities and the other stakeholders became part of the project Östra Vätterbranterna, whose aim was to create a dialogue forum as a first step in resolving the conflicts. Since this initial establishment, a group comprised of the County Administrative Board (CAB), the Swedish Forest Agency (SFA), the municipality of Jönköping as well as representatives of the Federation of Swedish Farmers (FSF), the forest owners' association Södra Skogsägarna (SÖDRA), the World Wide Fund for Nature (WWF) and the local branch of the Swedish Society for Nature Conservation (SSNC) has been in operation. In addition, a reference group comprised of local land owners was created, to act as a sounding board for the project group (Jonegård et al. 2011).

The project group had no formal hierarchical structure, with horizontal as well as vertical collaborations. Its ultimate goal was to find *the 'social key habitats'*, i.e. functioning social norms and bonds within the community and between different stakeholders and organizations, drawing on the components of social resilience: relations of trust; reciprocity and exchange; common norms, rules and sanctions; and connectedness (Käll 2007 & Folke 2006). An important precondition for creating *trust* was that both the land owners and conservationists demanded that 'all cards be laid on the table' with regard to the mapping and inventory of the area's natural points of natural values. Through these activities even the land owners became interested in conservation, and a dialogue was initiated with authorities and other actors about the best forms for protecting the natural values. With a common understanding and agreement of problems and goals, the foundation for solving problems and find solutions was laid and cooperation within the project developed (Jonsson 2004).

Challenges and critical aspects

Even if the example of the ÖVB case seems to have been a successful application of 'smart regulation' and new modes of governance, some weaknesses of this approach must be acknowledged to obtain a balanced discussion. Up to now this platform or arena with its 'soft' approach and steering forms in line with the New Public Service Model has been quite successful, but it is naturally an open question as to whether this degree of success can be developed or maintained over time, or whether it can function only within a specific context or time period. Some central issues to address are what happens if new types of conflicts arise that the group cannot deal with, or if the key individuals leave the group? Will the dynamics continue to work? What impact would this have on the coherence and continuity of cooperation in the project?

In this context it is also an open question whether this dialogue-based, New Public Service-inspired mode of working is the optimal way to deal with the conflicts over the functions of the landscape, forestry production and preservation, or whether there are other sustainable solutions for similar potential fields of conflict? As applied in the ÖVB case, the soft-law approach provides incentives for individuals to achieve beyond-compliance outcomes within the existing regulatory framework. The governance-oriented forms of steering initiated by the establishment of the project-group, 'the arena', made it possible to broaden nature conservation work and take a new direction with more flexible protection forms and the participation and involvement of more actors. An important aspect of such participatory conflict resolution has been discussed by Kirton and Trebilcock (2004) who note that when a broader array of stakeholders are involved there is a risk that soft law may promote compromise, or even compromised standards, and lead to uncertainty as actors remain unclear about the costs. This might affect legitimacy as well as accountability and ultimately erode the trust that the partnership is built upon.

Finally, the lack of state funding and financial support for nature conservation is a drawback that has to be brought to the fore. A positive outcome of the project was the growing interest in and understanding of conservation issues among the land owners. The interest for instruments such as habitat protection and nature conservation agreements exceeded the ability of authorities to meet the economic implications of land owners' demand. If the state aims at promoting beyond-compliance outcomes and stimulating land owners' interest in nature conservation, there must be sufficient means for actually realizing this.

Conclusion: getting the ideal to work in reality

The soft-law approach has a comparative advantage in stimulating new regimes with innovative principles and norms; the ÖVB-case is a recent and interesting example of this (cf. Arts et al. 2011: 57-73). The ÖVB partnership could best be described as a successful *adhocracy,* a less hierarchical organization facilitating collaboration and adaptation due to the freer positions of individuals within the organizations where management and governance include components of resilience such as knowledge building and bridging, trust building, conflict mechanisms, and highly developed collaboration (Wondolleck & Yaffee 2002). What is distinctive for this whole process is the development of a new way of thinking about how the landscape can be developed for social and economic benefit with strong local support, and for being an arena for research and teaching as well as for preserving ecosystems and biological diversity. This is an example of multi-functionality, where several different goals collaborate and strengthen each other. Here we see an emphasis on bringing new actors into the policy formulation, interpretation and implementation arena, the development of new networks, the role of information and debate in producing 'enlightened self-interest' and common frames of understanding in line with new modes of governance. Creating an arena for cooperation and collaboration - where the arena in itself is the tool - has made it possible for the public authorities to make use of various forms of flexible instruments: inventories forming the basis for guidelines and programs, mutually agreed upon by all parties, paving the way for voluntary agreements, certification and other soft instruments. The role of regulatory authorities during this process has moved from rowing through steering to serving - towards becoming a facilitator, or an engine that as a partner promotes collaborative structures and cooperation.

The ÖVB partnership has now, after more than fifteen years, been established as a permanent forum and arena for collaboration, consultation and development of the natural assets and forest products and services. It is often referred to as a success story, and the fact that the project group was established and functioned as a safe forum and a legitimate arena for developing trust and cooperation seems to have been of major importance for the positive results in solving the ongoing conflicts. Several studies conclude that the project has fostered a more general understanding of conservation issues which has resulted in many new protected areas (Appelstrand 2012: 186-199, Berglund 2010 and Käll 2007). The process also seems to have affected the work of the authorities, the SFA and CAB, as the ÖVB project has altered their working methods, helping them to carry out their obligations in a more efficient way and in better contact with each other and other stakeholders.

The ÖVB project is often referred to as a success story, but are the findings of the ÖVB project applicable in a broader context? Some of them are context-specific, but others can probably be of general applicability. Findings from two case studies confirm that ambitious norms and goals are more easily achieved in soft-law institutions than in legally binding ones, and the ÖVB process has fostered a more general understanding of conservation issues that, in turn, has led to many new protected areas (Berglund 2010, Jonegård et al. 2011 and Käll 2007). In the specific ÖVB context individual initiatives, personal engagement and competence were crucial for the positive outcome, but to be aware of them might help to identify and draw on similar aspects in other contexts. From a long-term perspective, one should also be able to foresee what other types of conflicts can arise in the future and which power relations these can bring especially in a case such as ÖVB where the whole process appears to depend on key individuals to keep the dialogue on-going and developing. The process is demanding in terms of both time and work-effort, and the combination of these factors, plus the apparent dependence on key charismatic individuals makes the partnership vulnerable.

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CAN THE FOREST BE USED FOR ANYTHING WE WANT?

Bengt Järrehult

The overarching global question is how we can use the forest as a source of raw materials, chemicals and energy while at the same time preserving its ability to support and regulate vital processes in our biosphere and give us good health and pleasant experiences.

In the Scandinavian countries, we have a forest which grows too slowly to be really effective in absorbing CO_2. Calculated per unit area, 15-20 times more biomass is produced in South America's eucalyptus and acacia plantations than what we can get from our typical northern forests. The carbon dioxide sequestration is thus 15-20 times more also. If we should make use of our forests in a more effective way by fertilizing them, we decrease this lead, although at a cost which has other consequences such as a marked increase in eutrophic waterways, lakes and seas. The question is whether it is worth it. This implies that even though our forests *are* rather significant CO_2 absorbents today, this is not at all in parity with what can be achieved in other places, like Bahia in Brazil. What we would preserve in the form of "support and regulation of vital processes in our biosphere" regarding CO_2 is thus on a relatively low level globally. There are other biological processes of importance, like flora and fauna, and these we will preserve – something which is relatively easy – combined with a sensible use of the forest as a source of raw material.

When we extract chemicals and materials from the forest, we must take into consideration the special conditions that we have up here with slow-growing biomass, longer fibers, special extractive substances, and so on, which allows us to compete on an international level. We have to avoid creating 'commodity traps' already from an early stage: what is difficult of course is finding those unique materials which will give us an advantage over the 'broiler forests' – it is possible, however. One example I would like to offer, even if it is on a small scale, is the spruce tree knots which usually come from spruces growing north of the Arctic Circle, and which constitute the raw material for substances which work against hormone-induced cancers. Two Finnish researchers, Bjarne Holmbom and Christer Eckerman, won the Wallenberg prize in 2008 for this discovery. The volume of this material is not great but the market is the whole world: a clear case of so-called value-based pricing here, not competitor-based or cost-based. They can do this because they have something which is totally new on the market and where they do not have to worry for the time being about competitors or that the market is so familiar with the production process that the client can demand to get the material for a 'cost plus' price.

We can improve our health and have pleasant experiences in a forest that does not need to be a primeval one. Only two percent of these primordial forests are left in Scandinavia (I have heard that people in Malaysia are demonstrating because we in Scandinavia are destroying our primordial forests, just as we in Sweden demonstrate against Malaysia for cutting down their rain forests) but they need to be managed and varied. This means that even our 'cultivated forests' (as opposed to Southeast Asia's rubber tree and oil palm tree plantations with their 'straight-as-an-arrow' rows) still can provide us with large personal enjoyment value. They tempt, they invite, they encourage people to go for walks, feel close to nature, pick berries and mushrooms, hunt: even if they are cultivated and cleared, they still feel 'natural' to their visitors.

The question above addresses in particular how to balance the planet's need of CO_2 absorption in the forests against people's need for energy.

Once again, it is the global absorption of CO_2 in the world's forests which is of importance, an aspect which the northern forests cannot do as well as the tropical and subtropical ones. People's need for energy should *not* come from what we extract from the forests. Today a significant part of the day's small-scale need of energy comes from wood, however. What I am thinking of is the need of the poorer population to have firewood for making food and so on. There are large international research and development projects underway here where alternative stoves have been developed (i.a., solar-powered) and alternative fuels (e.g., cow manure). Nor should we forget burning wood for reasons other than for acquiring energy: the slash-and-burn agricultural technique for creating new, arable land. We must put a stop to this through creating better ways of retaining the fertility of poor people's land that is already used for crop growing: this can be achieved through education and modern technology. Just look at the "Green Revolution" and the fantastic results it has brought to us.

Furthermore, there are studies which indicate that the extraction of energy from biomaterial is, and should be, a transitional phase which will be replaced by energy probably based on fuel cells and hydrogen as well as industrially expanded solar energy supplemented by wind power. We should not forget that in fact, the forest today makes a considerable contribution to our energy supply through energy from the really large wind turbines that are built to reach far above the tree tops. This is a smart way to sustainably use the areas where our slowly growing forests are found. The real value of the forest should therefore be found instead in its ability to provide us with complicated molecules and truly good construction material. We should work even more than we do today on replacing concrete, whose manufacture produces an incredibly large amount of CO_2, with renewable material that in its "production" even sequesters CO_2, such as timber. (see "Building in Wood – Is This a Good Thing?" by Leif Gustavsson in this volume). If we make sure that the wood we use does not ultimately rot and that even better use of its composite structure is made than is the case now, we have great chances of accomplishing this.

A sociological-political follow-up question is how we can achieve a balance between the expectations of the forest owners vis-à-vis the forest and those of the local population?

This does not have to be a clash of interests. To paraphrase Martin Luther King in his famous speech of almost 50 years ago, I also have a dream. That dream is that the forests will be the source of raw materials for a large number of production units in the fields of chemicals and materials, where each unit employs perhaps 10-100 persons. These small-scale factories should be able to produce as much or greater value as the forests provide today, but with a completely different business model. The ruling business concept today is to produce enormous volumes but with very low profit margins. This business model supports mega-structure factories that are near the logistically favorable coasts, but which produce something which has a further reduced profit level, as we are all aware of. The large-scale paper and pulp industry is in crisis and it will not be saved by making it even bigger, at least not here in Scandinavia. If we look instead at another business model, where much smaller volumes of a product are produced with much greater profit margins, we see typically other effects: these factories are more stable in more ways because they are not all aimed at producing the same thing. There will be a mutual and positive interdependence between the forest owners and the local population regarding the production of these new products. Today, profits are generated far from the places where the forests are harvested, and furthermore in incredibly large amounts, which for reasons of efficiency lead to clear cutting, something which creates conflicts between the local population and the forest owners. In this new scenario, we would not be as limited by high logistic costs since the manufactured material would have a kilo value far greater that what we have today, thereby creating *relatively* lower transport costs.

An overarching question for Sweden is how we can develop production and products from our Swedish forest raw materials that would allow us to replace the declining export of pulp, paper and sawed wooden products. The replacement products must have the same or greater value added as compared with the traditional forest products.

It is here that research and entrepreneurship have to go hand-in-hand. In Sweden we have invested in a great deal of research around the forest and its real and potential products. Unfortunately, we in Scandinavia are not sufficiently on the cutting edge regarding the fastest growing areas of research such as hydrogels, nanomaterial, bio-chemicals, pyrolysis and ionic liquids: we tend to do most of our research on the 'old, familiar' areas like lignin, pulp, fractionation and composites, something we do most likely to provide fast and easy support for the existing paper and pulp industry. This kind of research, which is aimed at a specific target or industry, can be called 'closely related' research to what is currently produced. Should we change horses in midstream in our research on the forest industry in Scandinavia? No, it is probably too late – instead, we must make use of the research that has already be done within other, adjacent areas and apply it to the accrued knowledge in our own field. This is where Frans Johansson in his book *The Medici Effect* believes that the great discoveries are made, in the interfaces between different areas of knowledge. When this is done, we can start experimenting with trying to commercialize this in various parts of the world. The only way to succeed here is to learn by doing, often by trial and error, but hopefully sufficiently painlessly and cheaply to let us continue until we succeed.

In today's interconnected society, carrying on research is not our primary mission: it is instead that we try to reap the benefits from all the relevant research results which have already been and are being made globally. One very good example of making use of these are the 100-odd different 'innomediaries' (innovation intermediaries) who have sprung up in the last 10 years, following in the footsteps of Open Innovation from Henry Chesbrough's book of the same name from 2004. One example is the Boston-based company called Innocentive, where you can present a challenge to a staff of 300,000 researchers spread out all over the globe. They do the research, you pay for the patent and then you commercialize it. Reaching results seems to be the easiest part in this process, even if it is difficult enough as it is, compared with turning it into a profit-making enterprise.

What the forest industry is lacking are entrepreneurs. The ones we have definitely do not work within the giants within forest enterprise, but in the small start-up companies separate from any big corporations. A Finnish colleague said to me a few years back that if you are working in the paper and pulp industry and notice that you are truly an entrepreneur, quit your job and leave the big company that is your employer now. Several examples (unnamed but close to home) have shown how hard it is to nurture incubator activities within the walls of the big corporations. In an international study covering many different types of industries, not just our own, it was shown that the average lifespan for an incubator is 3.8 years. This is far too little time in our industry to build up a commercial activity that can stand on its own two feet. Furthermore, there are studies which indicate that more or less none of the big corporations is capable of taking the product specifications and business plans generated by incubators and implementing them directly into their regular operative reality, which up to now has been based on 'efficiency' and 'lean-orientation'. By 'efficiency' we mean doing things in 'the right (usually process-controlled) way', to cut costs and time to market. This puts a stop to all new initiatives which are the least bit uncertain. According to a large study by IRI in the USA, the solution is to connect up an 'accelerator' to the incubator (O'Connor et. al. 2008). An accelerator is a small unit with its own Profit and Loss account, but which can be located in a large corporation in a so-called ambidextrous way where it is the commercial side in a half-separate unit which has its own R&D, production, marketing and sales side by side with the old company's corresponding units. Borrowing people temporarily for a specific time period or having a unit without critical staffing mass has proven to have a 0% success rate. One has to have a semi-autonomous unit covering all critical parts to be able to launch a new product or service The difficulty however is getting accepted by the top management to start on a small scale in an iterative and scalable process where you do not know beforehand how big the affair could become – since no one has been there before. To get permission to do this in normally slow, traditional and conservative businesses – and forestry enterprises are counted among them – is difficult, very difficult indeed, but necessary.

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CLIMATE BENEFITS AS A BUSINESS STRATEGY

Leif Brodén

After almost a decade of working with climate, it is time to reflect on what we have achieved and how our future work should look. At the same time that the climate issue itself appears to be evolving into a larger issue of general sustainability, some 'climate denial' still exists. Companies whose managers do not believe in a connection between carbon dioxide and the danger of temperature rise risk looking for future revenues in existing business models. The ability of companies to be productive is crucial however for effective environmental work. Political regulations for the initial period have been met with some skepticism from the business world, to say the least: there are however good exceptions. More attention has been paid to the value of the evidence of whether warming can be made credible than to the ways companies can put sustainability into their strategies. Thesis and anti-thesis in the climate question runs the risk of suffering from a certain degree of theological fatigue. If there is a paradigm shift here, then it concerns the fact that we can no longer behave digitally, 'binarily', with regard to all the new knowledge. It is no longer a question of either-or -- it is both-and. A company cannot satisfy its owners through customer benefits only: it must show all those interested that it can do it with concern for the next generation. Short-term profit in a sustainable perspective. Not either-or, but both-and. The rising interest in and worry about sustainability on the part of the customer is one reason that the 'good company', caring about the future, is more successful in capturing new business possibilities. Beyond customer benefit, there is a value in itself in handing over a world worth living in to the next generation.

Another reason to argue for some form of paradigm shift is that finite resources must satisfy the needs of an increasing population. Great care is placed on whether the peak has been passed or not for one or another raw material and whether the price mechanism will be able to regulate supply and demand. In forward-thinking board rooms, more and more often questions of how renewable products can be made, and their future influence are discussed. If the first two hundred years of industrialism were based on a view of resources as infinite, our awareness today is of just the opposite. Maintaining the idea of an endless supply of raw materials will be as difficult as arguing for the opposite of diversity.

At the same time that the concept of sustainability is creeping up from both a commercial and a value perspective, most of the measures within the area of climate still remain to be taken. The main path that people follow is to reduce emissions through agreement on and pricing of carbon dioxide. The various problems around who should reduce what and how much and at what price (and why?) have hindered any global agreement so far. Based on the members' own goal formulations, the European Union has agreed that in 2020, 20% of the countries' energy will be renewable. The member countries have different incentives for promoting the transition to fossil-free energy. The Swedish (and the Norwegian) system is based on green electricity certificates. In Sweden the system has implied increased production of electricity primarily from bioelectricity and wind power and is generally considered a success. Critics have claimed (justifiably) that almost all production of electricity in Sweden (and Norway) were fossil-free already from the start and thus, carbon-dioxide neutral. After the substaintal conversion to biomass-heated district heating systems, the remaining large potential is within bio fuels which still mainly is fossil based.

The Kyoto Protocol offers a possibility for countries to include even their growing forests as a basis for effective climate control. The European Union rejected this definition and classified forests as carbon-dioxide neutral. The starting point for this reasoning is that growing forests sequester carbon dioxide when photosynthesis occurs and that an equal amount is released when the forest dies. This reasoning can be legitimate if the forest remains intact over time, but there is a greater risk that we lose out on the entire potential of what the forest can actually contribute vis-a -vis climate control and sustainability.

Globally we are assiduously deforesting our planet at a rate of 0.2% per year. Behind such a seemingly low figure are hiding enormous amounts of carbon dioxide which are freed into the atmosphere as a result. About 20% of this estimated annual emission of carbon dioxide is a result of this deforestation. Globally the forests are thus not carbon-dioxide neutral, but carbon-dioxide negative. Stopping the deforestation is the most effective measure in decreasing the emissions in the quickest possible way.

Mathematically we can continue the reasoning by stating that if we afforested instead of deforested, we would need a global growth of 0.8% to sequester the remaining 80% of the yearly emitted carbon dioxide through photosynthesis. Is this possible? One thing is sure: the answer depends on whom you ask. Let us state, however, that Sweden has had an annual 0.8% net growth of forests over the latest 150 year, and there are countries with higher figures than Sweden. China is one such example. Who knew that? For the Swedish annual gross growth of over 100 million m3 far more than 100 million tons of carbon dioxide are needed for photosynthesis. How much carbon dioxide do we emit in Sweden every year? The answer is 50 millions tons, totally. Thus, Sweden is not self-sufficient regarding carbon dioxide. We are missing the point if we just routinely assume that our forests are carbon-dioxide neutral. Furthermore, in our case they are carbon-dioxide positive.

Sweden is almost unique in its diligent planting of natural production forests. Almost comically diligent regarding the level in the debates that try to elucidate all the special interests that the forest has to cover. Almost 90% of forest growth in Sweden is explained by the fact that we so energetically set plants of better and better quality into the ground every year. Other countries do not plant at all. There is a great potential here to globally increase forest growth. Theoretically it is sufficient to set plants in existing production forests, thus sequestering the net emissions for many future decades. Increased density of existing production forests means that no new land needs to be taken. The cost of planting two trees and thus sequestering one ton of carbon dioxide for the next hundred years is calculated at 1-2 Euros.

Thus this provides arguments for two powerful measures for reducing atmospheric carbon dioxide: stopping afforestation and planting forests. A third is needed, however: use the forest where it yields the greatest benefit commercially, nationally, climate-wise and in a long-term perspective. We have a weakness for burning the forest as a first stop in a product lifecycle during the initial climate awakening. The European Union's 2020 goal is said to require huge amounts of forest, as new hydropower is scarce, windpower despite everything has a marginal effect and solar energy will be delayed for a few more years. If the EU wants to be self-sufficient, with its own forests to reach the goals of renewal in the area of energy, then real afforestation in the EU is required. Apart from being politically complicated, the fact remains that the carbon dioxide component in these burnt trees will just change venue and enter the atmosphere instead.

From an environmental perspective, burning the forests can be motivated where they are in a growing phase. Exporting wood, chips and pellets to produce green electricity and replace existing fossil electricity which is used primarily for direct heating of badly insulated houses make a backward environmental hash of everything. The true profit lies in insulating the houses. Wasting resources is still a waste.

The most environmentally positive production today is building wooden houses instead of concrete ones. First of all we sequester the carbon dioxide for a long time period, and secondly carbon dioxide is used in the production of concrete. Furthermore, if we use established passive techniques and remove the need for heating, we reduce the need of fossil energy in many countries. In the same way we can make great climate benefits when we replace fossil alternatives in areas other than energy. Wood fibers are not only renewable but are also recyclable and can be reformed. Let us use fibers in as many fossil replacement products we can, and let us thereafter get energy from it. Everything will not be energy, of course. The perfect recycling system has yet to be invented. Even here wood fibers have an excellent ecological trait in their degradability. Think if all the plastic bags floating around in the world's oceans, bags which according to calculations will take one thousand years to break down, had been made of paper! Being biodegradable means that the coming generation can use the same raw ingredients. A world with a belief in endless resources (and endless oceans) obviously lacks the ability to set values on things we cannot see.

Sweden has all the prerequisites for taking care of the majority of the new business possibilities which result from the expectations that companies will take greater responsibility for the environment, climate and sustainability. Sweden's production of electricity is already in principle carbon-dioxide free, however: for this reason, green electricity certificates are not needed. The forests contain large amounts of carbon dioxide and we will lose out on their potential if we are satisfied that they are only carbon-dioxide free and are sufficient for heating uses. Furthermore, we will have a scarcity of material if the first, last and only use of wood fibers is to heat water. Larger climate benefits are achieved when renewable fibers replace the fossil alternatives such as plastic and chemicals, are recycled a number of times, and finally become energy (or decompose). There is the risk that the consequence of the EU's 2020 will result in enormous amounts of forest being burnt with low value and weak or no climate benefits. Energy can very well be developed from renewable fibers but in that case should be directed towards refined processed biofuels, different types of biopropellants. Traditional forest products most often defend their existences from a climate perspective, with wooden houses topping the list. New bioproducts and new business possibilities are just around the corner, biomaterials, textiles, biopropellants, bioplastics. The pioneers whom are still able to focus on research and its context will be the winners also in the new world requiring sustainable practices. The new world defining sustainability as a critical prerequisite for all business may seem threatening to some and challenging for others. Already at this early stage we are able to separate winners from others.

BUILDING A BIOBASED SOCIETY WITH ATTENDANT PROBLEMS

Henrik Teleman

You wrapped the blade with sticky, insulating tape in masculine black that 'vulcanized'– a manly material, unknown to my academic family. In the south of Sweden you hardly played ice hockey – there was nearly ever ice. Hockey sticks made of wood were used for *land* hockey. We're talking now about the end of the 60's and beginning of the 70's. Wait a minute – was it really made of wood? No, not just wood, it was made of *ash*. My next hockey stick was made of some kind of plastic.

For the last couple of years, the words 'biobased society' have been popping up, especially in the world of research policy. Until then, the mantra was 'sustainable cities'. Most people seem to be in agreement that there will be about nine billion people (9,000,000,000) in the world in 2050. If nine billion people are to live like we do in Sweden, the carbon content in each GNP-dollar has to decrease 130 times in order not to destroy the climate. Around the turn of the last century, people were talking about factors five and ten, in my view completely realistic goals. But a factor of 130? The de facto progress made today is eaten up by increased consumption and vacation trips to more and more distant places.

The question is what will hit us first: a climate crisis, overexploited biotopes, or lack of raw materials with resulting armed conflicts, where peak oil more than most other shortages will send extreme shockwaves into the economic systems. With the most recent global economic depression in mind, we can also imagine a general systems collapse. The latter may have benefits as well, as economic declines tend to be good for the environment in general and the climate in specific.

China is buying up land and mines in Africa and is trying to ensure its access to food and raw materials for the future. It is not difficult to believe that the producers of raw materials in general and those of renewable raw materials in specific will be tomorrow's winners. None the less, you can catch a whiff of desperation today from the Swedish forest companies. No increase in newspaper subscriptions in Asia nor improvement in the world economy can compensate for the decline in newspaper reading in Europe or its collapse in the USA. Currently the activity circulating around more or less 'smart' wood based products is at a feverish level. Some of them have a longer way to go before becoming products, while others are already here, such as various types of textile pulp. It is no less than a sign of a new world order when the Indian textile giant Aditya Birla bought the Swedish Domsjö Fabriker in 2011. To a great extent, viscose can replace cotton, the latter causing severe environmental stress. The problem is that more new materials and products are necessary in order to maintain the need for Swedish wood fiber. The warning light is blinking ever stronger and faster as the newly created composite materials are in fact not selling. They are not used for real products, since they are easily outcompeted by their fossil-based rivals. The possibility of long-term declining pulpwood prices is also under discussion…

In reality we have already been in a biobased society. The hockey stick doesn't go so far back in time but I myself live in a house which until it was renovated in the middle of the 60's was more or less completely biobased. The house, built in 1895, is a child of the marriage between the rural society and early industrialism in Sweden insofar as the standing timber logs in the walls were sawed. (Ten years earlier the logs would have been lying and would have been cut with an axe.) The logs are joined with dowels, the beams are fixed with wooden bolts and the roof was covered with wooden shingles. The total amount of iron used in the construction cannot be more than a few kilos. The rural society's production of functional objects was based on a deep, fundamental knowledge of the characteristics of wood from various species of trees, as well as on their properties due to how they had grown. For example, birch is tough and hard, good for furniture, while oak is used for frame beams or various exposed places in a barn, resinated fir is good for window material, tree forks for ribbing, the angle between root and tree cut out carries and stiffen joist floors. Through different physical procedures in living trees, their material properties could also be refined and improved. And – ash wood was best for hockey sticks. The list needn't stop at construction material: clothes were biobased (linen, wool), as were tools, and people warmed themselves and their homes with firewood.

The world population is growing – we in the western world don't need to get a 'better life', but many others do – while at the same time our finite resources are insufficient to meet the growing needs. In order to ensure reasonable material conditions huge amounts of biomass will have to be produced in all possible forms. One major problem for the development of the biobased society is the understanding of nature in general, and particularly of the forests.

When business and many leading politicians – somewhat generalized – now claim that it will be 'business as usual', although we'll get around in electric cars instead of petrol driven ones, the environmentalists have by tradition concentrated on keeping nature as untouched as possible, perhaps picturing for themselves nature as being in some way "good" (I do not wish to belittle their importance in opposing nuclear power or criticizing poisonous emissions, and so on.) The conflict between production and preservation is greatest for the forests, which many people consider more basic and untouched than arable land. Few things cause such an uproar as when areas in the forest full of mushrooms disappear after a clear-cutting, although there is hardly a forest which is not the result of deliberate cultivation in Sweden.

Many people consider nature as something good, even morally right, with great inherent value. But nature is completely amoral – it merely exists, regardless of how it looks. When we humans have totally ravaged our earth and only cockroaches and rats are left, this is still nature. This nature is not particularly pleasant – *we* wouldn't like it and it couldn't nourish us. A rich and diversified flora and fauna – what we consider to be 'good' nature – is 'good' insofar as it is good *for us.* If we use nature in order to survive, or even to have a good life, it is 'good' if this use does not affect other things that are important for humans. If we poison things that our own species is dependent on for survival, as we to a great extent already have done regarding air and water, or if we wipe out whole stocks of fish, this is counterproductive, no question about it.

The conflict exists in the relation nature – culture, when we alter nature and limit its 'free' development and often its biodiversity in order to increase the production of things we need or think we need. *We are soon facing the challenge of feeding nine billion people. Virgin land and nature untouched by human intervention could perhaps feed some hundred million people.*

In the last few years, forest and wood industries have adopted climate issues as one of their most important concerns. Wood and how you use it bind carbon dioxide, firewood is carbon dioxide neutral, the forest is a carbon sink – but in that case, the forest must be growing, not be a preserve with a high percentage of fully grown or dying trees and so on.

If we start to examine the arguments more closely, we find it difficult to get answers. In Swedish forests, much of the carbon dioxide is bound in mycorrhiza. Badly carried-out felling on land with bad carrying capacity or sloppy soil scarification leads to large, fast carbon dioxide emissions, something I never see the forest industries commenting. They want to cultivate as intensively as possible with the help of artificial fertilizers. Preserves are supplemented with spruce plantations regardless of the fact that it was these same plantation monocultures which suffered worst during the storm called Gudrun in 2005.

At the same time, the Swedish Society for Nature Conservation ducks the question of how we should go about increasing the production of biomass. Instead, it wants to increase both the preserves and the so-called nature forestry – a forest management method which causes the forest companies to froth at the mouth. They comment on the need for renewable raw materials by saying that the number of people who eat too much is greater than the number who eat too little, and we must eat less meat. It isn't difficult to think that they are making things easy for themselves, while at the same time it isn't hard to understand the arguments for good biodiversity. Biodiversity creates not only a forest which is pleasant, it also provides ecological robustness and a wealth of species that we can develop new, exciting materials from.

The industrial forestry's spruce plantations were, due to the storms in 2005 and 2007, a very bad affair economically for many of us Småland farmers: the recurring attacks of the spruce bark beetle and the fir root rot did nothing to cheer us up, either. Nor is it certain that the dominant practice of clear-felling gives me as a forest owner a better economic gain in the long term. The forest industry claims however that it yields 40% greater volume than selection felling. At the same time, untouched nature and good biodiversity do not feed and warm the billions of the world – pristine nature is not the same as social sustainability.

What is a biobased society? In the first place, it is naturally not just a question of wood. It can be linen, wool, and so on. Very roughly, we could claim that it is a matter of molecules, fibres, fuel, timber/wood and other things. Fibers can be used for paper, packaging material, insulation, plastics, clothing and much more, like nanofibre, for instance. Today, we can make window panes out of wood, even if this is only at the development stage so far. We can also burn wood, gasify bio residues, and make diesel from the residues of paper production. We build various things from timber. Many other products are made from wood, such as medicines. The spruce trees that are destroyed by root rot are sent to Norway to be turned into vanillin.

Ever since the Virserum Art Museum began to work with everything that can be made of wood I've heard industrial and university people say that wood must become an engineering material. By this they mean that construction wood must be calculable in the same way as steel. The answer has up to now essentially been glulam, something we have been able to produce for over a hundred years. The sawn timber industry delivers the same products since its inception in the end of the 19th century: beams, crossbars and boards. The material in the products – spruce and pine – is the same with one remark: as the classification of timber to be sawn now is being phased out, we can assume that the strength and form stability of the finished product will deteriorate. To a great extent, research is directed towards a greater use of wooden materials, to its strength and to more efficient production (both in the forests and in the sawmills). Research on materials or products that function in another way or which are grown in a different manner, or have another 'content' is barely mentioned in contexts of wood-mechanical industry. To a certain degree, cross-laminated timber can be considered an exception.

It is perhaps not so strange that proactive research is seen primarily on the paper and pulp side – that is, with the chemists. The major part of earnings and research is traditionally found here, in the forest industries. While a modern paper mill has little in common with the rag-based production of the 19th-century, a sawmill is in reality only a very modern version of a large farmer´s sawmill – something which probably is the reason for the different cultures regarding research and development.

Today in a modern factory, my complete house could be cut out in a couple of hours or so. It would only remain to put it together like an assembly kit, very strong with dowels and no messy nail plates. The right type of wood for the right job. The right fibre in the right place. CAD and CNC are great things! At the Hamburg Housing Expo in the autumn of 2013, a five-story building called the Woodcube was exhibited. The walls of the house are 30 cm. thick and are completely made of wood, supplemented by two wood fibre mats. The various layers of wood have thin channels to give the walls more insulating air. The building completely lacks sealing layers – instead, it takes in and gives out moisture. In order to avoid the traditional glue used on cross-laminated timber (CLT), the walls are held together by beech dowels which are first dried to a 5% level of moisture and later swell up in the walls. The lack of all-covering layers of glue naturally allows moisture mobility, a necessary condition to prevent water from condensing inside and causing damage. The risk of harmful emissions also decreases. It is clear that the Woodcube is a much stronger house than a normal lightweight construction that is taped together with nail plates of various types.

The Woodcube in Hamburg, like many examples in Germany, Austria and Switzerland, can cause a Swede to hang his head. How is it possible that things which are tried out with no prejudice, and are even common in these countries, are so unusual and revolutionary in our own? The lack of innovation spirit in Sweden applies not only to technical and sustainable solutions beyond practice of today, but also to a high degree to design. Sweden is the second largest exporter of forest and wood based products in the world. How does our wood architecture rank? Making use of the cultural heritage of wood should be the same as making use of a sustainable and economical possibility. In Canada, the province of British Columbia has taken the first step by passing the First Wood Act, which states that wood as a construction material should always be the first alternative when erecting publicly financed buildings. In addition to Canada's being the number one export nation in forest and wood-based products in the world, it also takes care of 'the wood culture'. Individual municipalities can then adopt the law. Something municipalities also outside the province is doing today.

Our possibilities to make calculations today exceed many thousand-fold those we had in the sixties, the golden age of the art of engineering. That goes also for our ability to understand and control growth processes. We can culture human tissue in order to heal burns, but, we have basically nothing more advanced coming from the forests than a 2 inch x inch beam. A biobased future must mean that we make full use of the possibilities of many different types of tree species, from the molecular level to the construction phase. We must be able to control the pattern of growth so that we can achieve the best properties, which can even imply that we once more use tree forks when we want curved or bent forms that are naturally strong. We do all this to save finite resources. The biobased society will be both high- and low-tech, with a high level of knowledge and high technical precision, but nature will do the job. The goal will be to do as little as possible with as short transportation distances as possible. The knowledge about the use of wooden materials passed down from our forefathers – can today be reached by calculation. Nanofibres *and* wattle and daub.When lack of raw materials and above all *the lack of energy* becomes acute our industrial society will be forced to change, not the least in our way of looking at and organizing production. Wood should not only be an engineering material, but an *intelligent* engineering material in the same way as cultured human tissue.

This means a paradigm shift for forestry as well, whose future character is difficult to plan considering the long rotation periods. The only thing we know with certainty is that much will always be good. But old 'truths' don't always hold true – an example is the tale of the birch tree, a scourge in the 60's and 70's but attractive pulpwood today. Prices are also climbing now for aspen pulp. At the same time forest researchers believe that climate change makes it extra precarious to put all one's eggs in a single basket. The biobased society will demand both as large volumes and as wide a choice of material properties as possible. In the long run, this will give greater economic value and, especially, a larger biological diversity in the forests. At the same time that the production conditions must be used optimally regarding the type and care of trees, some forestry practices will look more and more like gardening in order to be able to deliver wood with special properties. Especially the need for production of precise qualities will lead to more people engaged in the forests. The well-tended family forest can easily become the song of the future.

Because the step to the bio based society is so great, the picture of it is vague. Despite the intensity of the discussion the vision is non-existent. We must realize that the sustainable, bio based society means a shift of paradigm. It looks different and functions differently. The production of biobased products will not be sufficient to replace the fossil wastefulness. The biobased society must be a sparing society.

In order for researchers to know what to focus on, they need images. They must *visualize* the biobased society. Regarding industry, it's a question of moving on and going beyond the production of wood, pulp and paper, in order to visualize a new way of living. Totally new business models must be created. It will no longer suffice for the forestry industries to employ only foresters, workers, chemists and engineers and work with minimal communication budgets.

While working with Virserum Art Museum's fourth big exhibition on wood and sustainability – WOOD 2013 – we were struck by the lack of ability of the majority of actors to communicate and present current research. They had demonstrators but couldn't lend them out since they had only one! One wonders how research will ever be able to connect and anchor with reality?

In this connection, industry and research are also approaching a paradigm shift. The Bauhaus School must have been the world's most successful institution of higher education in relation to its budget, the number of staff and the number of students. During its existence between 1919 and 1933, the school moved from Weimar to Dessau, and on to Berlin. The story ends with the Nazi takeover. Together with Russian constructivism, it answered to the demands and possibilities of modern times: industrialization, urbanization and the social state. In the "good society" everyone would have the right to a modern, light and practical home. In principal there is no building construction in the world today, which doesn't in one or another way relate to the functionalism which originated in the Bauhaus School. But Bauhaus was not merely an engineering school – it was just as much a school for art, architecture and design, with a strong orientation towards social welfare thinking. Today we are facing equally large challenges. The sustainable society's – our version of the Bauhaus ideas – must be transcending many borders and gathering together not only engineers but also social researchers, politicians, artists and architects. And why not ordinary, everyday citizens?

The work on the biobased society begins by asking, maybe not the right questions, but at least questions about the society of the future in a broad, transboundary, and – in particular – open and curious way.

CONCLUDING REMARKS

Many perspectives surrounding the relation between forests and mankind need to be discussed and can be found in the contributions to this anthology. The forests of Earth supply us humans and all other living creatures with a number of vital services and products. Firewood and building materials are a couple examples of products we have taken for granted for a long time. Since the industrial revolution, we have learned to develop ways to utilize wood and its fibers for paper-based products such as printed media, packaging, and hygiene products. During the past few decades, other services of global importance have come into focus as well. The role of forests in regulating the CO2 content of the atmosphere is a widely discussed topic in particular. Deforestation is caused by the demand to meet the basic needs of a rapidly growing population, and the result is the Earth's reduced capacity to absorb CO2. Forests, which are a fantastic resource, can therefore simultaneously save and destroy our quality of life on Earth.

On the national Swedish scene, forests play an important role for our national economy as a base for a considerable part of our exports and, as a result, our welfare. The same holds true in tropical forest countries like Brazil, for example. In Brazil, increasingly efficient forestry methods provide for the development of living conditions while, at the same time, challenge the traditional wood suppliers in Northern Europe and North America. As a result, the demand for pulp wood from our slow-growing boreal forests has decreased. We need to find good uses for our well-managed, growing forests—an important national resource—by evaluating alternative options in an open and transparent way. The aim should be to produce more products while, at the same time, preserving and enhancing the role of forests as an ecosystem provider. We need to take a fresh look at the role of forests both globally and nationally.

When considering the actions to counter the negative developments described above, relevant sustainability criteria must be taken into account. Sustainability is based on a simple principle: everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, and these fulfill the social, economic, and other related requirements of present and future generations. Sustainability is important for ensuring that we have, and will continue to have, all the resources necessary to protect human health and our environment for coming generations.

The background for this insight includes the projection that the world population will grow to around ten billion during the next 35 years. About eight of these ten million will live outside Europe and America and they will have reached a standard of living not much different from ours. It is obvious that much development is required to make this future society and its relation to the forest and its ecosystem sustainable.

One obvious measure is to reduce fossil-based emissions by replacing fossil resources with biological and renewable ones. Wood is one such renewable resource, but the resources of the forest are by far not sufficient to replace all fossil resources presently used. Therefore, it becomes vital to use the renewable forest resources where they make the best contribution to sustainability. A number of possibilities are presented and discussed in this anthology.

The future certainly includes the further development of products and services, but also a change of our lifestyle and consumer patterns as well. To get an idea of the speed with which our society changes, just imagine life some thirty years ago when the Internet did not exist and ponder the changes in lifestyle and consumer patterns since then—how little of the new we could foresee back in the 1980s.

In this anthology, it is argued that the forest's natural resources should be looked upon in new ways and not simply as a source for energy, timber, and cellulose fibres. In the future, wood from forests should be viewed as a renewable supply of valuable carbon-based molecules which can be synthesized into high value-added fine chemicals and as a supply of ultra-strong cellulose microfibrilles which can be used to build unique materials. The role of the forest in creating beneficial cultural and health effects must also be considered as they are important to our quality of life. Further opportunities will most certainly appear as science continues to develop.

It is up to us humans as the most powerful creatures on Earth to select and develop those opportunities that will best contribute to securing the resources needed to protect human health and our environment, meaning, toward a sustainable society. This is a great task with many stakeholders, and scientists have one important role, policy makers have another. However, as pointed out in this anthology, it is not enough to further develop technical solutions and policy regulations; these solutions must come into use and become realities. In this effort, all relevant resources need to be coordinated. This should be done in an industrial, business-based context, and naturally with respect for other human values. This means that corporate business also must take part and work together with government and academia.

In this respect, the most obvious role of science is to identify and characterize new opportunities to utilize the resources of the forest, especially wood. These opportunities must be evaluated not only with regard to technical performance, but also for their economic and social implications in regard to their potential to contribute to sustainability. Also, the scientific results need to be presented in forms that makes them accessible to decision makers both in public authorities and in private business. However, it is not only technical solutions we need, but it is also, essential to understand how human attitudes develop and what is needed for new ideas to be implemented. Answers can also be found within the social sciences.

Policy makers need to take a long-term view, follow science closely, and create policy that remains stable for long time, as in "sustainable policy for the sustainability society". To support this, an additional research program designed to support decisions should be developed. Such a program should be aimed at compiling scientific knowledge from all relevant disciplines and presenting systems-oriented knowledge to be used by decision makers.

The motive for business to engage should be obvious. The long-term needs which form the base for business relating to future forests means life or death for future generations. This must be the greatest business opportunity of the century. In the short term, there may be the need for extra incentives to divert the focus away from the present dwindling businesses to businesses that fulfill the long-term basic needs of humans and other living organisms.

New business models need to be developed, and forest owners, industry, and entrepreneurs have to be given good incentives to act. It could be argued that taking part in this process of implementing new business models is vital to the survival of companies involved in the present forest industry. It is also a way for companies to develop its corporate social responsibility.

Three things seem essential to reach a sustainable relationship between the forest and mankind. Firstly, knowledge is lacking and ongoing research in all fields related to the subject need to continue. Primarily, the need to understand the ecosystem services provided by forests, how they contribute to human welfare in the wider sense, and how the production of these ecosystem services is affected by the various forms of utilization of forests. Given that there are so many radically different scientific fields involved, the awareness between scientists from different fields in regard to the overriding problems and goals needs to be increased. This is a responsibility for the research community.

Secondly, further incentives for business development are needed in both forestry, the forest industry, and other industries potentially related to the forest. Entrepreneurs should be welcomed both from within and outside the companies and universities. Furthermore, companies and entrepreneurs should be encouraged to take an active part in scientific research and vice versa. This is a responsibility for both government and private enterprise.

Thirdly, the development of a future sustainable society will not be accomplished without deep involvement from business. This is a long-term responsibility for both business itself and for policy makers, as business needs stable policy. The knowledge and ideas presented in this anthology will hopefully give some inspiration.

In conclusion, scientific research in the subject of forest and mankind needs to continue, but awareness and coordination between various disciplines also need to be strengthened and efforts will be needed in order to make the results accessible for decision makers. Moreover, policy makers will need to develop long-term regulations and effective practices to implement the regulations, and industry will need to develop entrepreneurial approaches and participate actively in both scientific research and policy making with the aim of developing the "business of the century".

Are we ready?

Gunilla Jönson and Thomas Johannesson, editors

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