

TURUN YLIOPISTON JULKAISUJA  
ANNALES UNIVERSITATIS TURKUENSIS

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*SARJA - SER. AII OSA - TOM. 248*

BIOLOGICA - GEOGRAPHICA - GEOLOGICA

# **IMPACT OF THE GLOBALIZING FOREST INDUSTRY ON ECOSYSTEM SERVICES:**

Corporate responsibility and the sustainable management  
of coupled human-environment systems

by

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Turku 2010

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ISBN 978-951-29-4227-5 (PRINT)  
ISBN 978-951-29-4228-2 (PDF)  
ISSN 0082-6979  
Painosalama Oy – Turku, Finland 2010

Impact of the globalizing forest industry  
on ecosystem services:

Corporate responsibility and the sustainable management  
of coupled human-environment systems

*Thesis*

Petteri Vihervaara

This thesis is based on the following articles, referred to in the text by their Roman numerals.

- I Vihervaara, P., Rönkä, M. & Walls, M. Trends in ecosystem service research: Early steps and current drivers. *Ambio*, *in press*.
- II Vihervaara, P. & Kamppinen, M. 2009. The ecosystem approach in corporate environmental management – Expert mental models and environmental drivers in the Finnish forest industry. *Corporate Social Responsibility and Environmental Management* 16(2): 79-93.
- III Vihervaara, P., Kumpula, T., Tanskanen, A. & Burkhard, B. 2009. Ecosystem services – A tool for sustainable management of human-environment systems. Case study Finnish Forest Lapland. *Ecological Complexity*, doi:101016/j.ecocom.2009.12.002.
- IV Vihervaara, P., Marjokorpi, A., Kumpula, T., Walls, M. & Kamppinen, M. Ecosystem services of fast-growing tree plantations: A case study on integrating social valuations with land-use changes in Uruguay. *Submitted manuscript*.
- V Kamppinen, M., Vihervaara, P. & Aarras, N. 2008. Corporate responsibility and systems thinking – tools for balanced risk management. *International Journal of Sustainable Society* 1(2): 158-171.

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	I	II	III	IV	V
Original idea	MR, MW	PV	PV	PV	MK
Study design	MR, PV	PV, MK	PV, TK, BB	PV, AM	MK, PV, NA
Data collection	MR, PV	PV	PV, TK	PV	PV, NA
Analyses	MR, PV	PV	PV,TK, AT	PV, TK	PV, NA
Manuscript prep.	MR, PV, MW	PV, MK	PV,TK, AT, BB	PV, AM, TK, MK	MK, PV, NA

PV=Petteri Vihervaara, MR=Mia Rönkä, MW=Mari Walls, MK=Matti Kamppinen, TK=Timo Kumpula, AT=Ari Tanskanen, BB=Benjamin Burkhard, AM=Antti Marjokorpi, NA=Nina Aarras

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## **INTRODUCTION**

Megatrends are major forces in societal development, such as are likely to affect the future in all domains of society (Larsen 2006; Kamppinen et al. 2003; Godet 2001). Such megatrends currently include globalization, commercialization and environmentalism. Many corporations and organizations, for instance, plan their strategies based on megatrends. Conceptual tools, such as ecosystem services and corporate responsibility, are needed to adapt corporations' operations and environmental management at a proper level within the megatrends framework. The forest industry offers an excellent research object in investigating how corporations control their impact on ecosystems in a changing operational environment, and how they respond to the challenges of globalization and other drivers.

Forests cover almost one third (41.9 million km<sup>2</sup>) of the terrestrial surface of our planet (Millennium Ecosystem Assessment 2005; FAO 2005). The ecological characters of forests vary from the tropics to the boreal latitudes. The role of forests for human well-being is crucial: forest ecosystems produce a wide variety of ecosystem goods and services, only a small fraction of which have economic relevance. The most important property of forests, in economic terms, has been their capacity to produce timber for saw-milling and fiber for the pulp and paper industry. However, forests also produce a much wider array of goods – food, game, medicines and firewood, to mention just a few – as well as participating in ecological processes, including carbon, water and nutrient cycling. Above all, forest ecosystems support the biodiversity that is vital to all ecosystem services and all human societies on Earth. According to the UN-supported Millennium Ecosystem Assessment (2005; hereafter MA) over 60 % of the world's ecosystem services have been degraded or used unsustainably. In addition to the loss of biodiversity inflicted by this degradation, the economic and public health costs associated with damage to ecosystem services can be substantial (MA 2005; Chivian & Bernstein 2008; Costanza et al. 1997).

Land-use changes play a key role in assessing the interaction of coupled human and environmental systems and the human impact on the landscape's capacity to provide ecosystem services. Forest ecosystems have been under particularly harsh pressure by humans; this has led to continuous deforestation in many areas, particularly in the tropics, and globally the forest cover is rapidly decreasing. On the other hand, afforestation and reforestation have led to an increment in forests, especially in some temperate regions. In boreal forests, intensified management practices have led to a net gain of forest biomass in many places, although degradation occurs as well (FAO 2005). The drivers behind these changes in land use and land cover are multiple; globalization, however, is an extremely important factor nowadays, since globalization processes can amplify or slow down other forces driving environmental change (Lambin & Geist 2007). In addition,

globalization is argued to be a central feature of coupled human-environment systems; this makes it even more important to take it into account in assessing the connections between global social and environmental changes (Young et al. 2006; Held 2000). In any case, globalization is an essential part of environmental management and strategic decision-making in internationally operating corporations, as in the forest industry.

Depending on the geographical and societal settings, in time and space, forests have been managed and harvested in manifold ways. Forestry for industrial round-wood acquisition has been a dominant land use form in many boreal forests, as in Scandinavia, throughout the 20th century. From the 1950s to the end of the 1980s the single, exclusive purpose of forest management for instance in Finland was to maximize wood yield; this was achieved by means of clear-cutting and planting even-aged forest stands. This also led to collisions with other land use purposes, such as conservation, recreation, tourism, and in northern Finland reindeer-herding. Over the past twenty years, however, alternative purposes in forestry have increased. New concepts, such as an ecosystem approach and sustainable forest management, have been introduced. Recently the forest industry has cut down production in the North, investing at the same time in the South. The varying impact of this shift on ecosystem services and on human-environment systems is poorly known.

The globalization of the forest industry is leading to a significant increment (average 1 million ha annually) in established, fast-growing tree plantations in the tropical, subtropical and temperate zones, especially in South America, Asia and Africa. In the year 2000, plantations covered 4 % of the world's forest area but contributed one third of the global wood supply; by 2040 this proportion is expected to increase to one half (FAO 2005). 78 % of plantations are established for wood and fiber production, for example for saw-milling and for the pulp and paper industry, but increasingly also for industrial energy production. The rest are for such purposes as land restoration, and soil and water protection. An important question needs to be asked: how can other ecosystem services be better taken into account in a plantation context in the future?

This shift of raw material production for pulp from North to South has had a varying environmental and social impact, depending on geographical and cultural circumstances. Numerous studies have been conducted on the effect of fast-growing plantations on the environment: the main concerns in this respect involve surface and groundwater effects, soil compaction and erosion, nutrient cycling and loss, and changes in biodiversity (Cossalter & Pye-Smith 2003). These same issues also affect human well-being, by way of ecosystem services. Only few studies, however, have investigated the effect of the establishment of tree plantations on the production of ecosystem services and on local human-environment systems (e.g. Chazdon 2008; Farley 2007; Rudel et al. 2005; Farley et al. 2005; Farley and Kelly 2004; Lindenmayer and Hobbs 2004; Cossalter and Pye-Smith 2003; Sedjo 1999; Cannell 1999).

Academic research has traditionally focused in greater and greater depth on the details of specified niches. However, many recent environmental problems and challenges, such as climate change or the degradation of ecosystem services, are caused by complex interactions between coupled human and environment systems (Loehle 2004; Nakicenovic & Swart 2000; IPCC 2001; MA 2005). Scientific generalists are needed to handle the multidisciplinary methods and approaches, such as systems thinking, which are essential in solving such problems (Bertalanffy 1969). The ecosystem approach and the applied environmental sciences bring together different paradigms and research traditions from the social, economic and environmental sciences, which nowadays are a prerequisite to integrating all aspects of sustainability in the environmental management of corporations. At the same time, stakeholders' demands for business responsibility are increasing the pressure toward a better implementation of sustainability in corporate operations (May et al. 2002; Bird et al. 2007; Santiso 2005).

The objectives of this thesis have been 1) to examine the impact of the globalizing forest industry on the provisioning of ecosystem services, and 2) to explore possible means for the sustainable management of coupled human-environment systems, which can enhance strategies of (Finnish) forest industries in the globalizing world. I studied the response of the forest industry to the challenges of globalization and other megatrends through two case studies: one in Northern Finland, where forest industry operations are diminishing, the other in Uruguay, where activity is on the increase. In addition, I carried out a survey of the literature on ecosystem service research; constructed a model of the impact of different drivers and pressures on the forest industry; and conceptualized the potential use of certain tools of systems thinking in corporate environmental management. The key findings of my thesis can be summarized as follows: in a situation where the forest industry is undergoing a process of radical change due to globalization and other major drivers, corporations need comprehensive management strategies to adjust their operations in diverse circumstances, characterized by variation and contingency in both ecological and socio-economic features. Ecosystem services and corporate responsibility are important new strategic tools in controlling the impact of a company on coupled human-environment systems. I have focused primarily on ecological and social aspects of ecosystem services, and to a lesser degree on economic effects, although I recognize their relevance with regard to the concept. The thesis consists of five articles, referred to hereafter by the Roman numerals I-V. A brief summary of the articles is as follows:

- I The first article surveys the development and current state of ecosystem service research, reviewing studies down to MA (2005), and briefly summarizing research published subsequently. The article considers the themes and target ecosystems of the studies, as well as their geographical and chronological distribution and multidisciplinary. The driving forces behind the research, and the role of international environmental policy and conventions, are also discussed.



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- II The second article focuses on corporate environmental management, examining the implementation of the ecosystem approach in the Finnish forest industry and the industry's environmental impact. The article describes the effect of various environmental drivers on corporate environmental management and the role of mental models in decision-making processes. The results are discussed in relation to responsible business management practices.
  - III The third article analyzes the impact of forestry at landscape level in the case of Finnish Forest Lapland. The study describes the effect of raw material acquisition by the forest industry in the boreal forest ecosystem on the whole coupled human-environment system. Another contribution of this study is the methodological development of GIS-based tools for sustainable land-use planning and ecosystem service assessment.
  - IV The fourth article analyzes the impact of forest transition on ecosystem service production in Uruguay, South America, where over the past twenty years a grassland ecosystem has been transformed into fast-growing eucalyptus and pine plantations. The responses of the local inhabitants are compared to observed ecological changes. The article also discusses the long-term sustainability and management of overall human-environmental systems.
  - V The fifth article summarizes conceptions of corporate responsibility and systems thinking. The focus is on the possible use of systemic tools, derived from the standards of environmental management and the guidelines of sustainable forest management, in the sustainable management of natural resources and in corporate risk assessment.

## **THEORETICAL AND CONCEPTUAL FRAMEWORK**

### **Globalization of the Finnish forest industry**

The main focus in this thesis is on describing and solving new challenges that globalization presents for the Finnish forest industry, which throughout the 20th century has served as the economic foundation underlying the development of Finnish society. One important reason to study the impact of the forest industry on ecosystem services, in addition to its economic relevance, was its wide-scale and relatively well-researched impact on nature. This thesis deepens the current knowledge of ecological effects of the forest industry to cover the effects on overall human-environment systems, and ecosystem services in particular. Additionally, the recent rise of environmental issues and corporate responsibility performance made it an interesting case for observing the implementation of sustainability in corporate environmental management. Before describing the setting of the forest industry as it currently operates, it is worth taking a quick historical overview.

Human well-being has been connected with forests through complex interactions throughout the past. Finns began to obtain economic benefits from forests during the 18th and 19th century with slash-and-burn farming and tar production; at this time forests were used but not managed (Puttonen 2006). Selection felling was a major cutting method from the mid-19th to the mid-20th century. Stand-based forestry, which in early years was practiced with wide clear-cuttings for instance in northern Finland, became common after the 1950s following the rapid development of the pulp and paper industries based on mechanical processing, and the consequent growing need for raw materials. The environmental performance of the Finnish pulp and paper industry have developed greatly from the levels of the period between the 1950s and the end of the 1980s to those of the 21st century, compared to many other branches of industry (Niskala & Pretes 1995; Davis-Walling & Batterman 1997; Kaila et al. 2005; Labuschagne et al. 2005; II). However, globalization has had an impact on the Finnish forest industry, especially pulp and paper production, and continues to do so: new investments in both raw material resources and manufacturing are often located in South America and Asia, where the majority of plantations are established and markets are growing rapidly (Niskanen et al. 2008; Cossalter & Pye-Smith 2003). At the same time raw material acquisition is decreasing in the North, for example in Finnish Lapland, while other forms of land use, such as recreation and tourism, are becoming socially more important.

In 2006 the share of the forest industry out of total Finnish exports of 61.4 billion € was 20%, while the share of the GDP was 3.8% (Statistics Finland 2007; National Board of Customs 2007). Since then the amount has slightly decreased. The four largest Finnish forest industry companies in 2006 in terms of turnover were Stora Enso (14.6 billion €),

UPM-Kymmene (10.0 billion €), Metsäliitto (9.3 billion €) and Myllykoski (1.5 billion €) (Finnish Forest Industries Federation 2007; Finnish Forest Research Institute 2007). The Finnish Forest Industries Federation is an interest group whose membership covers the entire pulp, paper and paperboard industries, and about 80 % of the sawmilling, plywood and wood products industry in Finland. These corporations, especially Stora Enso (**II**, **III**, **IV** and **V**), are the main sectors of the forest industry studied in this thesis, although the whole industry is considered as an entity. After this illustration of the study setting theoretical concepts of corporate responsibility and ecosystem services are presented in the light of the theory of coupled human-environment systems.

### **Ecosystem approach and corporate responsibility**

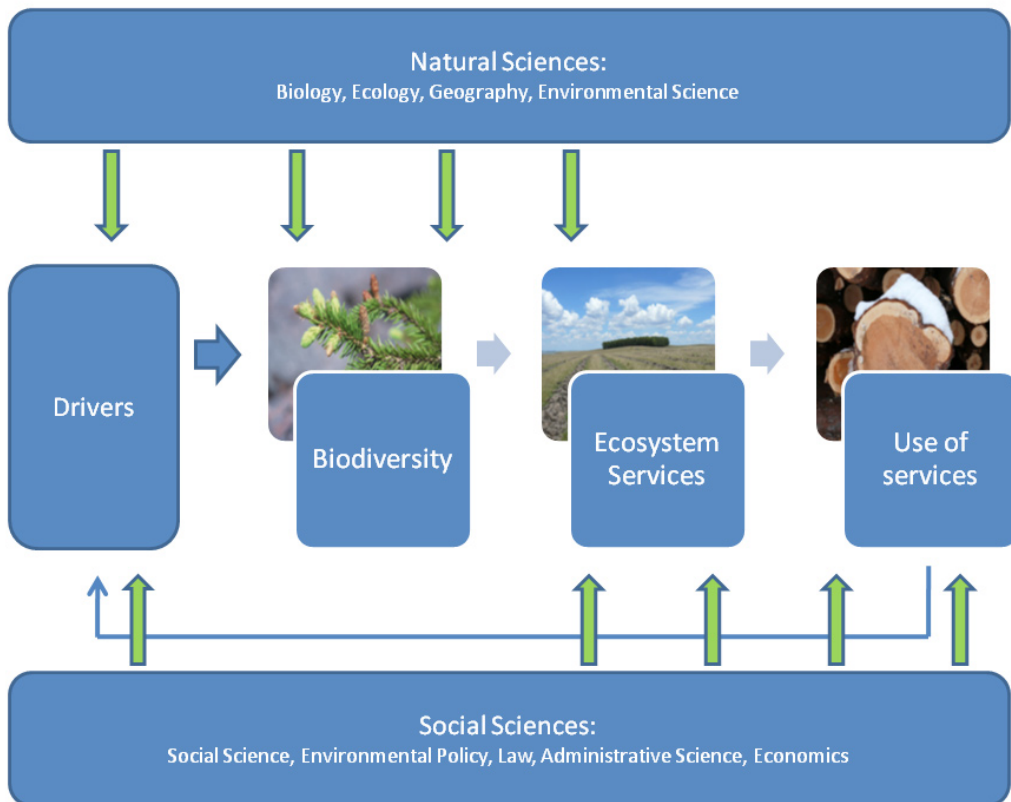
Historically the sustainable development (sustainable use) and the ecosystem approach are rather new ways of thinking in science, politics and business. Business life and ecosystems are closely connected in various areas: for example forestry, agriculture, fishery, and the overall exploitation of natural resources. The ecosystem approach was in fact launched at COP 2 (Conference of the Parties) in Jakarta in 1995, which created a primary framework for action under the Convention on Biological Diversity (CBD); more recently, COP 5 endorsed the description of the ecosystem approach and its operational guidance in Nairobi in 2000 (CBD 2005; Jäppinen et al. 2004). The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way (see also WWF & IUCN 2004). The ecosystem approach emphasizes the point that humans, with their cultural diversity, are an integral component of ecosystems. Governments, international institutes and the business sector are in key positions to adapt the ecosystem approach in practice.

Ecological thinking has its roots in the 1960s and 1970s, when environmental problems first surfaced in the international media, simultaneously with anxiety about chemicalization and the first oil crisis. Business ethics and corporate social responsibility (CSR) were the themes of the ethical business debate during the 1980s and 1990s, although environmental aspects had emerged as a topic of debate already before that. The latest fusion of these terms is “responsible business”, which includes environmental, social and economic sectors; this has shortened the term CSR to “corporate responsibility” (CR) in ordinary language (Kallio & Nurmi 2005). The increasing interest of stakeholders has induced international companies to become interested in the impact of their activities on nature and ecosystems. Despite its wide positive implications, the “greening” of business has awakened many doubts as to its possibility both among supporters of classic or neoclassical theories of trade and among environmentalists supporting deep-ecological paradigms. Despite these problems, the ecosystem approach is, as Gale (2000) puts it, “creating space to engage in a fundamental rethinking of the paradigm governing humanity’s relationship with the natural world”. The ecosystem approach highlights the importance of understanding that biodiversity and

healthy ecosystems are crucial for life on Earth, and that their sustainable management is necessary for future societies and business. The implementation of ecosystem approach and challenges of corporate responsibility in the Finnish forest industry have been studied especially in articles II and V.

### Ecosystem services and coupled human-environment systems

The research orientation to which the concept of ecosystem services belongs focuses on the study of coupled human-environment systems (Folke et al. 2002; Holling 1973). The three main perspectives on ecosystem services are those of ecology and the other natural sciences, of economics, and of the social sciences, along with multidisciplinary combinations of these, including the ecosystem approach (Fig. 1). The original idea of ecosystem services and goods was presented by Odum already in the 1950s, in *Fundamentals of Ecology* (Odum 1959). He discussed the use of natural resources, in the form for instance of agriculture, forestry, hunting and fisheries, and addressed human populations as part of ecosystems.



**Fig. 1.** Ecosystem services are provided by biodiversity, and used for human well-being. Ecosystem services are multidisciplinary and can be studied by several disciplines (green arrows). (Modified from Similä 2009)

While the term ‘ecosystem services’ was coined at the end of the 1970s, the concept in its current form, i.e. referring to benefits derived by human beings from ecosystems, emerged in the scientific literature only in the 1990s (I, II). The concept of ecosystem services remains part of the biodiversity research that was launched ten years earlier, connecting it more closely to interaction with human society. Actually, ecosystem service research can be seen as an extended process: it starts with the natural sciences, continues with the social sciences, and ends with regulation and policy planning, which in turn are linked to economic factors (Fig. 1). Each stage, each research paradigm examines the same problem from a different perspective. Finally, the concept of ecosystem services offers shared tools and a value-neutral vocabulary (cf. Norton 2000) for multidisciplinary science, which is urgently needed in order to deal in a holistic and inclusive manner with the problems following from global ecosystem degradation and the complexity of coupled human and environmental systems.

There are various definitions and classifications of ecosystem services; one of the earliest inventories of these, by Daily (1997), has been used as a baseline in several subsequent classifications (e.g. De Groot et al. 2002; Kremen 2005; Wallace 2007). A breakthrough article on the value of the globe’s natural capital and assets by Costanza et al. (1997) was an important milestone in the rising understanding of the economic value of biodiversity and ecosystem processes, and the economic loss that may ensue from their unsustainable use. Today there is a certain consensus on using the classification by MA (2005), although it too has weaknesses. It divides ecosystem services into *provisioning services*, including such goods as food, fresh water, fiber, fuel, genetic resources, biochemicals, and natural medicines; *regulating services*, such as climate, flood, erosion, pest and disease regulation, water purification, pollination, water and nutrient cycling; *supporting services*, such as soil formation, photosynthesis and primary production; and *cultural services*, such as recreational, aesthetic, social, educational, and spiritual benefits (MA 2005; Table 1). Many of these services are declining, or will do so in the future, due to the impact of expanding human populations combined with rising living standards.

Recognizing and analyzing the causes and effects of changing land use, such as afforestation with plantations, requires an understanding both of decision-making processes and of the environmental and social factors that contribute to them (Lambin & Geist 2007; Lambin et al. 2001). Coupled human-environment systems have been at the focus of ecosystem service research (and vice versa), studying the environmental, social and economic linkages between changing land-cover and human well-being. A particularly important role in these changes is played by economic and institutional factors, together with globalization (II, III, IV).

The role of ecosystem services has also been emphasized in the forest transition theory (Mather 1992; Mather & Needle 1998), although it is admitted that transitions have little to do with the conservation of biodiversity. The impact on the surrounding ecosystem of establishing a tree plantation differs greatly according to whether it is planted in a

**Table 1.** Classifications and current trends of ecosystem services worldwide. Upward arrow means an increasing trend, downward arrow a decreasing trend; +/- means that the direction varies from one case to another (MA 2005).

Ecosystem Service	Sub-category	Status	Notes
<b>Provisioning services</b>			
Food	Crops	↑	Production increasing
	Livestock	↑	Production increasing
	Capture fisheries	↓	Production decreasing due to overharvesting
	Aquaculture	↑	Production increasing
	Game, wild foods	↓	Production declining
Fiber	Timber, wood	+/-	Forest loss in some regions, growth in others
	Cotton, hemp, silk	+/-	Production of some fibers decreasing, others increasing
Bioenergy		+/-	Fuel wood decreasing, some other forms increasing
Genetic resources		↓	Loss through extinction and crop genetic resource loss
Biochemicals, pharmaceuticals		↓	Loss through extinction, overharvesting
Fresh water		↓	Unsustainable use for drinking, industry and irrigation
<b>Regulating services</b>			
Air quality regulation		↓	Declining ability of atmosphere to cleanse itself
Climate regulation	Global	↑	Net source of carbon sequestration
	Regional and local	↓	Preponderance of negative impacts
Water regulation		+/-	Varies depending on ecosystem change and location
Erosion regulation		↓	Increasing soil degradation
Water purification and waste treatment		↓	Declining water quality
Disease and pest regulation		+/-	Varies depending on ecosystem change; natural control degraded by pesticide use
Pollination		↓	Apparent global decline in abundance of pollinators
<b>Cultural services</b>			
Spiritual and religious values		↓	Decline in sacred groves and species
Aesthetic values		↓	Decline in quantity and quality of natural lands
Intrinsic value of biodiversity		↓	Lost contact with nature due to urbanization
Recreation and ecotourism		+/-	More areas accessible but many degraded
<b>Supporting services</b>			
Photosynthesis		?	
Nutrient cycling		?	
Carbon cycling		?	

deforested and degraded region or in natural (or seminatural) grassland. Forest transitions are expected to affect at least soil quality, water quality and carbon sequestration (Rudel et al. 2005). Forest transitions can occur mainly in two ways: spontaneously, with the recovery of abandoned agricultural land, or through active planting associated with changed socio-economic drivers, as in the case of the forest industry. Understanding the possible impact of forest transitions, however, is in any case crucial for the development of more sustainable societies (IV, V).

Ecosystem services are part of the wider framework of the coupled human-environment system. The past twenty years have witnessed the rise of a number of new fields of research, including sustainability science, ecological economics, landscape ecology, resilience research, and ecosystem service research, although the roots of these disciplines may lie much further back in history. What they have in common is their position at the boundary between human societies and ecosystems; in fact, they are often abandoning such arbitrary boundaries altogether, and are fuelled by the accelerating rate of ecosystem change and human-induced global environmental threats. During recent years the conceptual apparatus of these disciplines has developed toward holistic models and the theory of coupled human-environment systems (Turner et al. 2003, 2007; Li 2004), which can be seen as an umbrella covering a multitude of disciplines. Coupled human-environment systems describe linkages between ecosystems and human society; in the case study of Forest Lapland, for instance, the coupled human-environment system consists of natural biotopes formed by local biota and human activity in the landscape that is illustrated by land-use decisions (III). Synonyms for such systems are socio-ecological (Gallopín et al. 1989; Young et al. 2006) and social-ecological systems (Berkes & Folke 1998). It is worth noting, however, that the complex relationships of human-environment systems are much easier to conceptualize than to identify empirically and especially to quantify (Young et al. 2006; Loehle 2004).

### **Sustainable natural resource management and mental models**

Ecosystem management is a branch of applied ecology that focuses on achieving a balance between the use and conservation of renewable natural resources, nowadays including biodiversity and ecosystem services (Boyce & Haney 1997; II, III, IV, V). In addition, ecosystem management is an attempt to slow down ecosystem degradation (cf. MA 2005), which is often caused by human population growth and the replacement of natural ecosystems by agriculture, forestry plantations, cities, urban sprawl, and the resulting fragmentation of natural habitats. Yaffee (1999) has divided different views of ecosystem management into three classes, anthropocentric, biocentric and ecocentric; this classification is quite commonly used for instance in sociology and philosophy in studying human values and attitudes toward nature (e.g. Rintanen 2004). Environmental management is a key operation in most modern business companies, especially in those which are closely involved in the exploitation of natural resources. The fact is that all



the above-mentioned paradigms are represented among environment managers, who help to decide on management appointments in corporations, municipalities and other institutions; this makes it essential that appropriate management practices be scientifically grounded. Guidelines and environmental standards are important everyday tools, which should be based on up-to-date scientific knowledge.

The question of governance is crucial in debating the design of good policies for the sustainable management of ecosystem services (e.g. **IV**). A good example is carbon cycling, associated with climate change. Carbon sequestration and storage are nowadays one of the key services that have been foregrounded in climate change mitigation and adaptation strategies (Wright et al. 2000; Smith & Scherr 2002). Carbon sequestration and storage are also the best example of global markets for ecosystem services, with such examples as the EU emission trading scheme, the CDM afforestation and reforestation projects of the Kyoto Protocol, and the planned REDD mechanism for the post-Kyoto 2012 climate regime. In particular REDD would contribute to a wide array of ecosystem services produced by protected primary forests, even though the main motive driving the mechanism is climate change (FAO et al. 2008).

The question of governance brings us to mental models (**II, IV**). The theory of mental models is used to explain decision-making processes in environmental management (Hukkinen 1999). Mental models are composed of representations that enable persons to have beliefs, attitudes, desires, etc. (Johnson-Laird 1983; Quinn & Holland 1987; Morgan et al. 2001). Mental models incorporate basic knowledge structures, such as taxonomies and causal schemata. A mental taxonomy concerning environmental risks, for example, can support various beliefs, desires and intentions. Mental models are explanations of individuals' thinking processes, based on a personal conception of the surrounding world, which instinctively contribute to behavior and decision-making (Senge 1990; Hukkinen 1999). A mental model consists of the intellectual tools that an expert applies, first in conceptualizing the ecosystem approach and then in acting it out. Mental models are culturally shared constructions of reality, and there are typically various models available in any individual organization. An individual's level of education or knowledge of a certain topic may be one reason why people have different valuations and attitudes for instance toward a given environmental problem. Mental models have various features that make them interesting in terms of natural resource management. First of all, mental models form hierarchies: particular models concerning particular corporate actions are subsumed under general models concerning the legitimacy and social acceptability of the industry. Secondly, mental models are conservative: innovations in industry and environmental thinking are related to mental models already in use. (Hukkinen 1999; Johnson-Laird 1983.) For example, if a general model postulates that corporate environmental policies are sound, an innovation in environmental thinking is understood as something already performed but miscommunicated or misunderstood (**II**; cf. Morgan et al. 2001). A shift in a mental model is a slow process, which is why their role in the mitigation or adaptation of rapid environmental changes is so important.



## MATERIALS AND METHODS

Because of the broad scope of the general topic, this thesis comprises a wide array of methodologies drawn from natural science, social science, business administration and policy framework analysis. It has sometimes been challenging to operate at the boundary of natural ecosystems and human society and still try to keep one's focus on the key point, that of ecosystem services. The main methodologies used in this thesis were meta-analysis, (thematic) interviews and GIS-modeling. The work of the thesis has been carried out in collaboration with several cooperative stakeholder groups, including academics, environmental managers and corporate administrators.

### Study areas

The empirical core of this thesis is based on field surveys carried out in the extreme locales of the globally operating forest industry: in the boreal forests of Finnish Forest Lapland and on fast-growing tree plantations in Uruguay, South America (**III** and **IV** respectively). Detailed maps of the study areas are presented in the original papers.

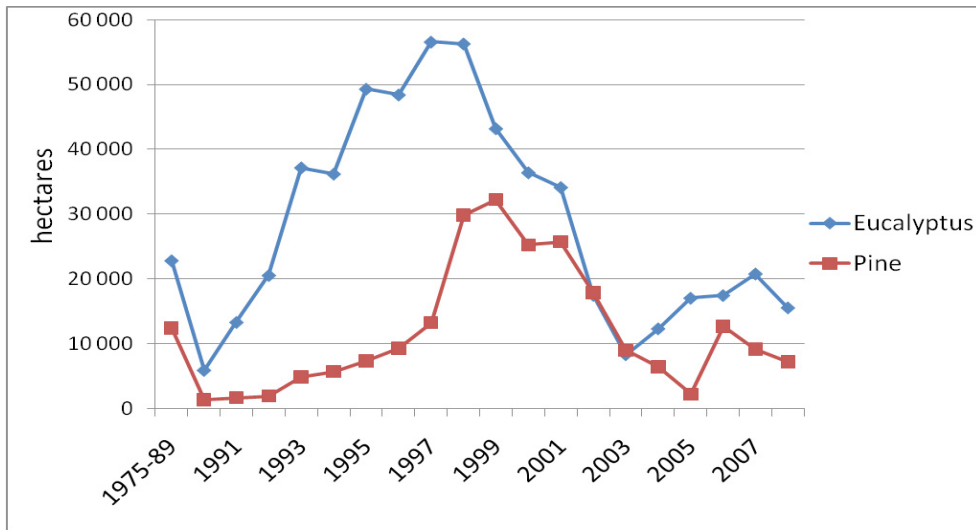
Traditionally, the Finnish forest industry has obtained the necessary raw materials from boreal forests, especially in Scandinavia and Russia (**V**). In Upper Finnish Lapland, the state-owned Metsähallitus (Forest and Park Service) has about 254 700 ha of forest in commercial use, accounting for some 10 % of the total land area owned by Metsähallitus in the region; almost all of these commercial forests are located in the municipality of Inari (Sihvo et al. 2006; **III**). Besides producing fiber and timber, boreal forests provide multiple other ecosystem services, and planning the multiple use of forests is nowadays a crucial part of sustainable forest management in Finland. Tree trunks harvested in most of Finland are normally 50 to 100 years old (Kankaanpää et al. 2002; Sippola 2002; Rounsevell et al. 2006), but in Forest Lapland harvested trees are often as old as 200 to 300 years (Sihvo et al. 2006; Wallenius 2007). The study area of Forest Lapland lies at the border zone between the Arctic tundra and boreal forest biomes (between 67 and 69 degrees latitude), where ecological processes, such as tree reproduction, photosynthesis and decomposition, are slow (CAFF 2001; Wiegolaski 1997; Stark 2002); the ecosystem is therefore very fragile under sudden human impact. The vegetation zone of Forest Lapland is dominated by Scots pine (*Pinus sylvestris*), and covers the swathe from the treeline of the spruce (*Picea abies*) to that of the pine (CAFF 2001). The vegetation growth period in the study area varies from 100 to 140 days, and the heat summation ranges from 600 to 750 °C degree days (1971-2000), compared to 750-1000 in other areas of commercially used forest in northern Finland (Metsätalouden kehittämiskeskus Tapio 2006). Precipitation varies from 320 to 420 mm per year. The local flora and fauna have evolved and adapted to harsh environmental conditions, but not to the high rate and impact of modern land-

use changes caused for instance by forestry. Other important land use forms along with forestry are reindeer herding, conservation, tourism and mining.

During the past twenty years, the forest industry has increasingly shifted fiber production from the slow-growing North to the fast-growing South (Cossalter & Pye-Smith 2003; FAO 2005; Marjokorpi 2006). Plantations have been established in South America, Africa, and Asia. Uruguay, which offers an extreme opposite to the boreal forests of Finnish Lapland, is one of the most important countries for the Finnish forest industry. Uruguay is located in the temperate zone of the southern hemisphere (between 30 and 35 degrees latitude), with a climate varying from hot summers (average January temperature 24-25 °C) to cool or cold winters (average in July 11-12 °C). Annual precipitation ranges from 1300 to 1400 mm (Dirección Nacional de Meteorología del Uruguay 1977-2000). The case study presented in the article IV was conducted in central Uruguay, in the Departments of Durazno and Tacuarembó. Most of the country belongs to the Uruguayan savannah ecoregion (Locklin 2001). There are almost no species data available for the original, virgin pampa grassland, as the vegetation of almost the whole country has been altered over the past 200 years by grazing cattle and sheep. The main vegetation type today is a scrub and grassland ecosystem known as “natural pasture”, which covers over 70 % of the land. Native forests cover only 5 % of the country; they are located mainly along rivers and have a high biodiversity. Plantations are allowed to be established only on natural pasture. The planned area for the establishment of plantations in Uruguay is estimated to cover 4-6 % of the land area (World Bank 2006; FAO 2005; pers. comm. with FAO representative in Uruguay Heimo Mikkola; Ministerio de Ganadería, Agricultura y Pesca 2009; pers. comm. with director of the Dirección Forestal Carlos Mantero). The majority of plantations consist of eucalyptus (570 000 ha in 2008; 55 %) and pine (235 000 ha in 2008; 43 %) (Fig. 2). The rotation cycle of eucalyptus plantations is 8-12 years for pulp, 15-20 years for sawmills, and over 20 years for furniture and special products. Pines are harvested when they are 18-20 years old and are used mainly for timber. Other land use forms are (free-grazing) cattle and sheep husbandry, the cultivation of soy, cereals, rice and fruits, and small-scale tourism.

## **Literature surveys**

One important characteristic of ecosystem service research is its multidisciplinary; the theme has been examined from at least environmental, economic and social perspectives. Because of the novelty of the concept of ecosystem services, a proper framing of the various branches and extensions of this broad field of research was seen as important. At the start of the thesis work, we carried out a survey of the literature from the Web of Science, collecting the largest part of studies examining ecosystem services down to 2005 (I). Since the publication of MA in 2005 the number of studies focusing on ecosystem services has expanded considerably, making it difficult to study all recent publications



**Fig. 2.** Development of eucalyptus and pine plantations in Uruguay (values represent hectares of plantations established per year).

with the same intensity as in the case of the earlier data, used in the first article of the thesis. Another intensive literature search was carried out to collect information on the transformation of grassland into plantations and the effect of afforestation on various ecosystem services (IV).

## Interviews

A large part of the research data of this thesis consisted of interviews (II, III, IV). The role of interviews is crucial in filling in gaps in knowledge and providing a big picture of this complex issue: how the strategies and everyday practices of the forest industry impact on various stakeholders and social groups and on the dependence of the local population on natural goods and services under various circumstances. Experts, decision-makers, and a broad sample of laypeople were met with and interviewed, using open and semi-structured interviews, during field trips in the study areas in 2007 and 2008. The interviews were either tape-recorded (II, partially III and IV) or the respondents were asked to fill out a questionnaire (IV). In the case of Uruguay, structured interviews were chosen as a research method rather than for instance empirical field surveys and mapping or ethnographic interviews, because we wanted to maximize the pool of respondents to cover all aspects of social heterogeneity, such as gender and age, and variance in values in different geographical locations. A total of 80 laypersons were randomly selected for interviews at the Uruguayan study sites, although balancing the age and gender structure of informants (IV). Experts (12 in article II, 20 in III, and 22 in IV) were chosen for interviews from among companies, research institutes, universities, administrations, land-use specialists (such as for instance reindeer-herding, agriculture and tourism) and

non-governmental organizations (NGOs); they were treated as cultural specialists or key informants. The raw material was classified following the objectives of each case and key figures were calculated. The results of the interviews were used to analyze the role of mental models in environmental decision-making, and the valuation of ecosystem goods and services by local people (Spradley 1979; Werner & Schoepfle 1987; Schensul et al. 1999; Hukkinen 1999; Morgan et al. 2001). Details of the interviews and their analysis are described in the original papers.

### **GIS modeling and databases**

In the case studies of this thesis, temporal and spatial changes in land cover and land use were examined using a combination of data from the literature, the statistics, and the remote sensing and geographical information system (GIS) databases (**III**, **IV**). The observed changes were used to map the landscape's capacity and potentials to provide ecosystem services. The selection of relevant ecosystem services was based on the needs of the local communities and on an examination of potential indicators (Burkhard et al. 2008). Landsat TM satellite images from 1987 down to the present (**IV**) and the European CORINE2000 land-cover database (hereafter CLC2000) (**III**) were the key sources of data (CLC2000 Finland 2005), and were used to analyze changes in the capacity of habitats to provide ecosystem services (cf. Burkhard et al. 2009). Stora Enso's own GIS database was also used to analyze the proportions of different tree species in the study area in Uruguay (**IV**). The satellite images were corrected and analyzed using the ERDAS software (Environmental Systems Research Institute, Inc. USA). The suitability of CLC2000 for assessing the regional distribution of ecosystem services in Europe was also tested (**III**). CLC2000 includes a satellite image map and a raster land cover database with 25 m x 25 m resolution covering the whole of Finland. This database has been generalized so as to fit with the European land-cover map, with a minimum mapping unit of 25 hectares. The CLC2000 comprises 44 land-cover classes, 34 of which occur in Forest Lapland. In addition, other possible databases which might be useful for ecosystem service assessment were studied. Details of the methodologies used in the case studies are presented in the original papers.

## RESULTS AND DISCUSSION

The thesis is constructed out of rather different articles, in order to cover all aspects of globalization of the forest industry and its impact on ecosystem services. I first surveyed the current state of ecosystem service research (I) and the prevailing atmosphere among environmental experts in the forest industry (II). I then focused on two field studies, one in Finnish Lapland (III) and the other in Uruguay (IV), where I studied in particular methodological development, valuations by the local population, and the governance of ecosystem services. In the last article (V), I examined the management of the globalizing forest industry from the point of view of corporate responsibility.

### Ecosystem services and ecosystem approach (I, II)

The review of published research on ecosystem services showed that their number started to grow in the mid-1990s, although there had been some publications already before then. The MA (2005), supported by the United Nations, has obviously accelerated the study of ecosystem services, while at the same time the public has started to become familiar with the term and to be interested in it (I). The growth of this field of research seems to follow the pattern seen with the concept of biodiversity ten years earlier (I, II). Our survey of the views of environmental experts concerning various terms, such as ecosystem approach, ecosystem services, biodiversity and sustainability, supported the idea that before innovations in environmental science are implemented in applied fields, for instance in ecosystem management, they have to be demonstrated over and over again (Hukkinen 1999; Morgan et al. 2001; II). The experts' awareness of the relevant concepts, and their opinions on them, support this postulate. Sustainability was familiar to all of them and was regarded as important – but the term appeared in scientific publications already decades ago. The ecosystem approach was not very well known, and thus was considered more or less irrelevant or useless, even though it too has been discussed in the literature at least since the 1960s (CDB 2005; II). These, however, are broad concepts, actually closer to paradigms; they are related to the individual's training and personal values, and are dealt with in scientific research in more of a philosophical, conceptualizing manner, rather than empirically. Two newer terms, biodiversity from the 1980s and ecosystem services from the 1990s, are more concrete issues, which can also be studied with the traditional tools of ecology and other natural sciences. Biodiversity was relatively familiar to all the experts, and was considered to be important by a majority of them. Ecosystem services divided opinions most: it was totally unfamiliar to one third of respondents, but despite that more than half considered it an important concept (II). The history of the debate on global climate change has been similar: it took more than twenty years of hard scientific debate before it was taken seriously by the general public and by policy-makers (Nakicenovic & Swart 2000; IPCC 2001; Stern 2007).

Before 2006, most ecosystem service studies considered provisioning or regulating services, and studies focused on assessment and management (**I**). This illustrates the applied nature of ecosystem service research. The most commonly studied ecosystem types were watersheds and forests, while there were only few studies on agricultural systems or oceans. Most studies were conducted in North America, Latin America, and Asia and the Pacific, by North-American and European researchers. There were fewer studies focused on Europe than might have been expected based on the number of European ecosystem service researchers. More ecosystem service research in Africa should be encouraged. One fifth of studies were conducted by multidisciplinary research groups; the corresponding authors were most commonly ecologists, followed by economists. In the future, key issues in ecosystem service research will be ecosystem change and vulnerability (**I**). These assumptions are supported by Naidoo et al. (2008), who estimated that the urgent needs of ecosystem service research in future are as follows: 1) global assessments, with better distribution maps of where ecosystem services are produced; 2) quantification of the likelihood of land-use conversion and its probable impact on service provision; and 3) a better understanding of the values and flows of benefits to nearby and distant human populations. Naidoo et al. (2008) were able to find data for only four ecosystem services to represent their global geographic distribution: carbon sequestration, carbon storage, grassland production of livestock, and water provision. We believe that ongoing mapping projects and vulnerability assessments will develop the tools for a more efficient assessment of ecosystem services and for the planning of sustainable societies.

One of our aims in the article I was to find out the role of international policy processes and conventions, such as the Convention on Biological Diversity, the Kyoto Protocol or the MA, in shaping the focus of science. Our results do not indicate that these are the main drivers of ecosystem service research as such, although international agreements may enhance research funding and implicitly increase interest in its findings (cf. Andrén et al. 2008). Rather, the process is the reverse: policy shifts are the result of scientific evidence and of societal pressure on the international environmental policy agenda. However, there are at least two main reasons for the current momentum in ecosystem service research: 1) globally increased human pressure on nature, which underpins the need for sustainable use of natural resources and the development of valuation and regulation methods, and 2) the concept's capability to translate complex ecological functions into a common and neutral vocabulary, serving a multidisciplinary forum for scientific and political debate (cf. Norton 2000; Fig. 1). The concept of ecosystem services deepens and extends the view of traditional environmental and conservation sciences so as to include humans as part of the systems.



## **Corporate responsibility and environmental management (II, V)**

The forest industry has been a pioneer in the development of responsible business practices, but this might presumably not have occurred without pressure by stakeholders, such as environmental NGOs (Mikkilä & Toppinen 2008; Mikkilä 2006; Kuisma & Lovio 2006; **II**; see also Kourula 2009); however, the forest industry has been active for instance in developing energy-efficient technologies and guidelines for sustainable forest management (**II**). The environmental management of corporations has been improved during recent decades, for instance with the development of certificates and standards reflecting and measuring corporate responsibility (such as PEFC and FSC certificates for forest management, and GRI guidelines for CR reporting). The forest industry, however, continues to encounter considerable criticism, partly due to the new challenges of globalization. The results of this thesis also emphasize an ambivalence: many stakeholders, and in particular environmental experts and managers in the forest companies, agree with the observation that the environmental performance of the (Finnish) forest industry has improved dramatically, while at the same time many other stakeholders are unsatisfied with current situation and are demanding more concrete actions, for instance in developing softer forest management strategies (continuous growth, broader FSC certifications, better planning of multi-use in forests etc.). During the research project it was found out that one main reason for the situation is the challenge of communication (**II**, also **III** and **IV**). The lack of information concerning the current state of affairs was felt to be equally frustrating both by environmental experts in the companies and by those stakeholder representatives who were the most critical of the current mode of operating. Our analysis supports the view that there are conservative mental models in both pools, and that overcoming these barriers needs constant and profound cooperation and stakeholder engagement. Understanding the impact of these mental models on decision-making is crucial for sustainable environmental management.

The main drivers that influence the current and future state of the forest industry are: 1) climate change, which is also closely connected to energy questions; 2) globalization, which has stimulated competition, affected resource availability, and led to an over-capacity in pulp and paper; 3) international policies, both in trade and in environmental affairs; 4) communication; and finally, 5) a mental shift among customers towards a deeper awareness of climate change and the need for sustainability, followed by other environmental issues, such as biodiversity (**II**, **V**). The latter in particular raises the level of responsibility, which may need rapid strategic responses from companies if they want to be among the upper echelon of proactive operators. One example of how increased responsibility has already been implemented in the forest industry is the increased number of EMAS registrations (Kuisma & Lovio 2006).

Current awareness of the concept of the ecosystem approach, and implementation of such concepts as for instance ecosystem services, supports the idea that the development

and shift of mental models, as already noted, are slow processes (Hukkinen 1999; Morgan et al. 2001; **II**). But what does this mean for purposes of environmental management? As I already mentioned in the previous chapter, we can assume that before a particular environmental problem reaches the international political agenda or becomes part of corporate environmental management practices, a huge amount of empirical research has already been done and the drivers for the problem have long been visible, as we have seen for instance in the discussion of climate change or in the shift of environmental management by the forest industries since the 1950s. On the other hand, the forest industry has rather rapidly adopted the guidelines of corporate responsibility in their strategies, despite the lack of long-term research on the background (Ketola 2005; Mikkilä 2006; **II**). One explanation for this ambivalence may be that corporate responsibility as such does not affect the foundation of the industry, such as raw material acquisition, while for instance an ecosystem approach may directly affect the ecological baseline and might thus be interpreted as an economic risk. Short-term economic goals have to be juxtaposed and reconciled in corporate environmental strategy planning with long-term ecological milestones. Some concrete means for fitting the ecosystem approach into corporate decision-making are for example cooperation with NGOs or international research organizations, which benefit both parties, and specified research projects on certain topics, which can be upscaled. The further development of certificates, of tracking systems for wood origin and for processing technologies are also relevant tasks. In addition, conceptualization of the tools of systems thinking could help to integrate the complexity of environmental management into concrete implementations (e.g. Godet 2001). Our results show that such useful concepts might include life cycle assessment, regionality, industrial ecosystems, and ecosystem services (**V**).

Life cycle assessment has already been used in the forest industry, at least in Finland, and it can be used especially in considering the carbon footprint of products or material flows of products and services (see Nissinen et al. 2007). Regionality is an important tool, especially in connection with the globalization of the forest industry. Regionality is often seen as an anti-force to globalization (e.g. Florida 1995). Regional thinking recognizes the limits of ecosystems better than globalization. At the same time it focuses on recycling and technological development in seeking a competitive advantage. Industrial ecology aims at viewing the industrial system as a whole. The idea of an industrial ecosystem is to explore how the industrial system works and how it is regulated, and to understand its interaction with the biosphere (Allenby 1999; Jelinski et al. 1992; Erkman 1997). The fourth concept, that of ecosystem services, is discussed in more detail below. (**V**)

The implementation of the ecosystem approach in everyday practice in corporate environmental management is already true at some level, many companies, for instance, take into account the principles of sustainable forest management and of sustainable plantation forestry to mitigate possible negative impacts on biodiversity (**II**; Marjokorpi & Salo 2007). Further focus, however, is needed on the application of mental models and



on various pressures that affect ecosystems and the current state of the forest industry. Sustainable forest management has been developed and tested by forestry professionals, with the primary goals of balancing conservation, production, and the use of forest goods and services; the emphasis is on production. In contrast, the goals of the ecosystem approach are balancing and integrating conservation and the use of biological diversity, with the emphasis on conservation (WWF & IUCN 2004; see **II**). Today, the (Finnish) forest industry belongs to the upper echelon of global corporations with regard to environmental management. There are still pressures caused by e.g. the establishment of plantations, associated for instance with changed land use and land cover or the use of ant-killers, and increments in energy wood harvesting in boreal ecosystems, just to give some examples, may have a strong negative but thus far unknown impact on ecosystem services, which should not be ignored. At the same time some forest industry operators have also implemented several responses to the pressures; for example, they have made commitments through Codes of Conduct to eliminate illegally harvested timber from their supply chains (**II**). Increasing cooperation among stakeholders, as well as encouraging new international policy processes, such as assessment of the economy of ecosystems and biodiversity, are crucial for achieving a sustainable future.

### **Sustainable land-use planning and forestry in Finnish Forest Lapland (III)**

Land use has been one major challenge to resolving the disparate interests of forestry (including the forest industry) and other land-use forms (especially reindeer herding) in Forest Lapland (Hallikainen et al. 2006; Sihvo et al. 2006; Heikkinen 2007; Raitio 2008; Liimatainen et al. 2006; Harkki 2002; **III**). An examination of the land-use pattern in the study area shows three different groups of actors, with different interactions: nature conservation, as a public good, is supporting other softer land-use forms but restricting hard ones. Recreation, together with tourism-related land uses, has special social but also increasing economic importance. Hard land-use forms have various negative impacts on all the others, but have been economically important, especially for local communities. From this perspective, forestry has a highly negative impact on two of the other land-use forms assessed. We found that of the four main categories of ecosystem services, the cultural ones were the ones most affected by forestry; the impact on provisioning and regulating services was minor, and in the case of the supporting services we found no impact of forestry worth noting. (**III**)

One of the main tasks in article III was to develop a methodology for studying the distribution of ecosystem services on a regional scale. Our study demonstrates that a lack of concrete data would not be a limiting factor for ecosystem service assessment in landscape planning. The CLC2000 classification was used as a main resource. It is comparable across Europe and cost-effective to use. Some of the CLC2000 classes were unsuitable for evaluating for example important reindeer pastures. In particular forest classes lack separate categories for pine and spruce, clear-cuttings, or young and old

forests, which are important for example in terms of reindeer herding (Forbes & Kumpula 2009). Old spruce forests with arboreal lichen form very important late winter pastures. The CLC2000 data did not contain sufficiently detailed information on the road network, paths or infrastructure in the area. Detailed data were provided by the Finnish National Land Survey, and buffer zones of direct and indirect impacts were created around roads, paths and other infrastructure.

The processing of different materials from social, geographical and ecological databases is challenging, but it is necessary in order to achieve long-term sustainability and find a balance between conflicting land-use pressures. Selecting indicators to assess relevant ecosystem services in a specific case and on a specific scale is important in order to identify particular “problem-sheds” (cf. Burkhard et al. 2008). The indices applied in our case study can be used either spatially, comparing properties of ecosystem services between separate regions, or temporally, comparing changes in their provision in one region at different times. Assessment methods for supporting services can be more universal, because of the similar, relatively general needs of all humans. Needs for provisioning and cultural services may be strongly culturally-dependent and may therefore vary in different regional settings. The CLC2000 database can probably be used for ecosystem service assessments on a larger, national and continental scale. For accurate regional and local assessments it needs to be combined with other, local databases. We encourage the development of greater compatibility of assessment methodology in future studies, with particular focus for instance on the use of more detailed classifications of habitats and their capacity to produce ecosystem services.

Our methodology for calculating ecosystem service indices emphasizes the regional importance of large habitats. But, this should be handled with care: it might lead to an interpretation whereby other habitats, with lower values, are less important for the production of ecosystem services. Many small areas can be very important for some particular feature. The habitat class of running water, for instance, was assigned a relatively low index value due to its small surface. However, it is of huge importance for instance for recreation, fish production and water regulation. An improved evaluation of the production of ecosystem services, involving a wide range of experts and precisely identified habitats rather than the sometimes inaccurate CLC2000 classes, could perhaps yield sharper results. The sustainable use of natural resources and biodiversity are based on the idea that the yields of goods and services obtained from ecosystems, such as animal populations, will not decline over time (Boyce & Haney 1997). This determination of sustainability can be set as a goal of sustainable landscape planning, in which the continuous production of ecosystem services is secured in the long term. Taking into account the very low growth rates of boreal forests north of the Arctic circle, it is arguable whether timber provisioning services can be used in a sustainable manner in these regions at all (Cyffka et al. 1999; Burkhard 2004).

It is vital to study ecosystem services and their importance for human well-being in order to avoid conflicts in land use. As noted above, cultural services show a high contrast between protected and intensively used areas. It could be argued that harder land-use forms, which may transform the land cover drastically, do not immediately reduce the capacity for supporting or regulating services. In the long run, however, even a slight decline in production capacity for provisioning or any other class of services will lead to unsustainable development. The estimates in article III are fairly general; the principal focus has been on the development and application of a methodological framework. Nevertheless, the results should encourage environmental decision-makers to identify and strengthen positive interactions between different land-use forms. The application of the concept of ecosystem services has proved to have great potential for introducing and developing new tools for researchers, stakeholders and decision-makers. It can help to take ecosystem characteristics, and their importance for human well-being, better into account. I conclude that this approach to the regional distribution of the ecosystem services can contribute to a better understanding of human-environmental systems and to future expert-based decision-making. Similar conclusions have been drawn in other recent studies considering ecosystem services and their relation to surrounding human systems (Burkhard et al. 2009; Burkhard & Müller 2008; Naidoo et al. 2008; Rounsevell et al. 2006; Zurlini et al. 2006).

### **Integrating the ecosystem services of plantations with local valuations in Uruguay (IV)**

In the case of the recent development of fast-growing plantations, in Uruguay too economic and institutional factors together with globalization are playing an important role in land-use change (FAO 2005; World Bank 2006; Stora Enso 2009; Marjokorpi 2006; **II**; **IV**). The impact of changing forms of land use on the provision of ecosystem services, however, has been only partly studied. Our results in article IV showed that the rapid change from grassland to plantations over the past twenty years has affected the proportional delivery of many ecosystem services in Uruguay. We examined valuations by the local population with regard to ecosystem services, and the recognition of ecosystem services by experts and lay people.

Although the term ‘ecosystem services’ as such was unfamiliar to the local respondents, they recognized the concept, especially in the case of provisioning services (**IV**). Cultural services too were rather well recognized, but regulating and supporting services were quite poorly recognized or not recognized at all. The meaning of biodiversity and different biotopes for ecosystem functioning were poorly known – they were mentioned to be important, but their capacity to provide ecosystem services was vague for the lay public. The most important goods or services linked with native forests were the provision of firewood, regulation of the local climate and improvement of air quality, and

protecting biodiversity. The benefits of certain natural biotopes, such as wetlands and dry forests, for several regulating and supporting services and biodiversity conservation were weakly recognized by the local people. However, we found that in particular regulating services, such as carbon sequestration and storage, erosion prevention and the role of biodiversity, are quite well recognized by substance specialists. These different mental models may contribute to conflicts in natural resource management and sustainable plantation forestry, if the scientific evidence, the official regulations and the conceptions of the local people are not convergent. It should be noted that if the ecosystem services of biodiversity and native biotopes are poorly known, they may be inadequately recognized also in the plantation context. (IV)

The general attitude of the lay public towards the increment in tree plantations and the forest industry in Uruguay was positive. However, there are certain other cases, for instance in Brazil or Indonesia, where the establishment of plantations has been followed by conflicts arising from questions of land-ownership, the destruction of primary or secondary forests, or other land-use issues (Gritten 2009; WWF 2008; Cossalter & Pye-Smith 2003; Carrere & Lohmann 1996). The studies of this thesis found no significant differences in attitude either between city-dwellers and people living in rural areas or between people of different age. Gender, however, did play a role: men were more positive towards the new plantations than women.

Ecosystem services are co-determined by three separate institutions: scientific evidence is provided by researchers, environmental regulation is handed down by the authorities, and the use of services is based on the needs of local people (IV). In addition, it is worth bearing in mind that the impact of a plantation on ecosystem services varies considerably depending on the ecological and societal properties of a particular human-environment system (cf. Cossalter & Pye-Smith 2003). Our findings in Uruguay indicate that the experts' views were more consistent with recent scientific knowledge than those of the locals. Experts recognized the possible impact of plantations on carbon cycling and water yields, while carbon sequestration was not recognized by the local inhabitants at all (cf. Smith & Scherr 2002; Jackson et al. 2005), and water issues were actually exaggerated compared to the scientific evidence available for Uruguay or similar regions (e.g. Silveira & Alonso 2009; Silveira et al. 2006; Alonso & Silveira 2006; Stora Enso 2009; Farley et al. 2005). For locals issues of most concern related to the establishment of plantations were 1) water balance, quality and quantity, 2) soil quality and fertility, and 3) the impact of chemicals (fertilizers, herbicides and pesticides).

In future studies, special attention should be given to including the meaning of ecosystem services for the local society. Previous studies of the impact of forest transitions on ecosystem services have covered biophysical processes quite comprehensively, although some wide geographical gaps still remain. The results of this study also agree with some earlier studies that the management of biodiversity issues in a plantation context is important and may have a positive effect in terms of ecosystem services

(e.g. Marjokorpi 2006; Lindenmayer & Hobbs 2004; Guo & Gifford 2002; Bernhard-Reverstat 2001), although the role of biodiversity for ecosystem service production (as for the whole function of the ecosystems and for resilience) is a topic of wide debate (Andrén et al., 2008; Hooper et al. 2005; Folke et al. 2002; Holling 1973). It may be beneficial for the sustainable management of coupled human-environment systems to extend forthcoming research so as to increase the role of local people as an integral part of the ecosystem studied.

Governance and the regulation of ecosystem services are another new issue in the plantation context; this is discussed more detail in article IV, but is definitely an important issue for future research. In a country like Uruguay, where the economic importance of forestry has increased rapidly and is expected to continue doing so in the near future, the sustainable management of ecosystem services is important for the future development of plantations. Sharing the right to use provisioning ecosystem services is often done best at the local level, following the principles of the ecosystem approach (CBD 2005). When the responsibility is shared down to the lowest possible hierarchical level, the control and management of ecosystem services can be monitored effectively. Placing a corporation at the same level with other local private land owners, however, may be complicated, due for instance to economic competition in a case where new markets are established for ecosystem services but participants are operating at different magnitudes of scale, and further consideration is needed to work out how governance can be arranged equitably (see Ostrom 1990; Vatn 2008). Many regulating services are much too complex to be shared equitably by the local people or the local authorities, and it may thus be best for them to be regulated at the national or even at the international level. Those ecosystem services which have a potential global impact, such as biodiversity values, should be covered by international agreements, as in the case for instance of carbon trade schemes. REDD is a good example of this kind of mechanisms which has a positive impact on ecosystem services.

In some circumstances, market mechanisms can be an effective tool for the conservation of ecosystem services. Markets can be designed to capture the economic values of ecosystems and provide conservation incentives (MA for Business Summary, 2005). However, it is important to recognize that poorly created and failed markets can lead to the serious and long-term degradation of ecosystem services (cf. Ostrom 1990; Landell-Mills & Porras 2002). PES systems have a great potential to increase sustainable forest management and conservation, including plantations (Richards & Jenkins 2007). The role of government is crucial, for instance in creating PES providers and establishing institutions for trading and monitoring ecosystem services. In Uruguay, the ministries of agriculture, forestry and environment (MGAP and DINAMA) will play a key role in planning if PES schemes are launched in the future, but forestry companies as big landowners, NGOs and other stakeholders should also be included in the planning.

## CONCLUSION

In this thesis, I have touched upon the tip of the complex iceberg of globalization, corporate environmental management, and their combined impact on ecosystem services in different locations. Globalization, commercialism and environmentalism are megatrends which currently affect changes in the forest industry. Corporations face many challenges to adjust their operations in different locations, both in the North and the South, in diverse circumstances with varying ecological and socio-economic features. I posit that the concepts of ecosystem services and corporate responsibility are important new strategic tools in controlling the impact of companies on coupled human-environment systems. While in this thesis I have placed greater focus on ecological and social aspects of ecosystem services, it should be kept in mind that economic aspects play an important role as well.

Rather than offering specific solutions, the individual projects forming part of this thesis have raised new questions; but they have also widened the focus to recognize the multitude of participants and stakeholders connected with the sustainable management of coupled human-environment systems, and ecosystem services in particular. From the academic point of view, a coherent research approach to ecosystem services definitely needs to be multidisciplinary. First of all, ecosystem services have to be properly identified, their volume quantified, and their distributions, both spatial and temporal, described. This is basically the task of natural scientists. Secondly, the social and economic relevance of ecosystem services needs to be assessed; this is often the work of social scientists and economists. Thirdly, the sustainable governance of ecosystem services needs to be arranged at the appropriate level. Application of the means of regulation is primarily carried out by administrative scientists, legal experts and policy analysts. My aim in so saying is not to divide or separate different fields of science, but rather to emphasize the importance of the simultaneous integration of multidisciplinary and transdisciplinary tools and approaches of coupled human-environment systems theory. From the point of view of applied science and management, it is also relevant to identify the key stakeholders – providers, users and regulators of ecosystem services – in a particular case where land use or the exploitation of natural resources may affect ecosystem services.

Despite the above reservations with regard to the complexity of the topic, some of the findings of this thesis can be highlighted to construct a mental map of the impact of the globalizing forest industry on the provisioning of ecosystems services:

1. Ecosystem services are found everywhere in nature, and each branch of industry has a different impact on them (**I, II**). Globally, ecosystem services have been studied most in forest and watershed ecosystems, while there have been only few studies dealing with agricultural systems or oceans. Ecosystem services have been



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studied especially in North America, Latin America, and Asia and the Pacific, by North American and European researchers. Surprisingly, only a few studies have been situated in Europe or Africa. Only about 20 % of the study projects in our data had been conducted by multidisciplinary research groups, most often with an ecologist and second most often with an economist as corresponding author. Our results did not support the idea that ecosystem service research is mainly driven by international policy processes and conventions, but international agreements may nevertheless enhance research funding, and implicitly increase interest in the content of research publications.

2. The ecosystem approach is a strategy for the integrated management of land, water and living resources, promoting conservation and the sustainable use of natural resources. The implementation of the ecosystem approach in corporate environmental management is covered to some extent, but further focus may be needed on its application to corporate responsibility in relation to ecosystem services. Some of the pressures that affect ecosystems, such as the establishment of plantations and increments in energy-wood harvesting, are still relevant, while there are also effective responses in companies, e.g. C-o-C tracing systems for wood origin, certificates, and guidelines for sustainable forest management. The main drivers that influence the current and future state of the forest industry are climate change, globalization, international policies, communication, and the increased awareness of customers of environmental issues. **(II)**
3. The current development of GIS methodology, combined with the available national and international social, geographical and ecological databases, offers a good baseline for applied regional ecosystem service assessments and mapping projects **(III, IV)**. For instance the European CORINE Land Cover database can be used for comparable assessments on a national and continental scale. The capacity of different habitats to provide various ecosystem services can be derived from the CORINE land cover classes and expert evaluations, which can be further situated on a map with GIS. Additionally, the impacts of different land use forms on ecosystem service production can be presented following the methodology developed in article III.
4. Conservation as a land use form preserves nature's potential for ecosystem service production **(III)**. In our case study of the North, forestry did not have a major effect on supporting or regulating services. Provisioning services were slightly decreased. The most significant effect of forestry was that on cultural services, appearing as a decreased recreation valuation and multi-use possibilities of heavily logged forests. Decreased cultural services may be also a source of conflicts in land use issues in Finland **(III)**.

5. The establishment of plantations is on the increase (**IV**). The impacts of fast-growing tree plantations on ecosystem services can be totally different in the South compared to native boreal forests in the North (**III, IV**). However, each case is unique; the impact of a particular plantation on ecosystem services depends for instance on the site's geology, physical conditions, original biodiversity, ecological properties, and other forms of land use. The interpretation of the impact of a plantation on other ecosystem services depends to a considerable extent on the cultural valuations of the local community.
6. Governance and regulation of the sustainable use of ecosystem services have the best chance of success when common ground and common goals have been achieved among researchers, the authorities and the lay public. The role of government is crucial, for instance in creating PES systems and establishing institutions for trading and monitoring ecosystem services. In the Uruguayan case, local people recognized provisioning and cultural services rather well, while regulating and supporting services were inadequately recognized (**IV**). An interesting aspect of the results in paper IV was that the locals did not recognize the meaning of carbon sequestration in a plantation context; this underlines the importance of information delivery – also a relevant issue in most poor tropical or subtropical countries, where forests are degraded or lost due to weak land use policies.
7. In the future, the sustainable management of natural resources and ecosystem services will be crucial for the forest industry (**II, III, IV**). Information about the values of local people, integrated with observed long-term land-use changes, forms a basis for acceptable land-use planning. In addition, the sustainable management of ecosystem services needs to take into account the impact of land use on biodiversity. Sustainability, of which the ecosystem approach can be seen as one example, can be taken more effectively into account in corporate environment management by applying the tools of systems thinking in decision-making (**V**). Systems thinking in one form or in another is a precondition for balanced economic, social and environmental management.



## ACKNOWLEDGEMENTS

The thesis began with the CORECO (Corporate environmental responsibility and the ecosystem approach) project, funded by the Academy of Finland (n:o 111152) and directed by Dr. Matti Kamppinen. In addition, the study has been funded by the Maj and Tor Nessling Foundation, the Cultural Foundation of Finland, and the Turku University Foundation. The support of MTT Agrifood Research Finland has also contributed to the success of the project. Metsähallitus assisted the fieldwork in Finnish Lapland on several trips, offering accommodation, snowmobiles and other material support. Stora Enso Uruguay offered valuable help with accommodation and the collection of material. I wish to cordially thank all these organizations for their help in making this work possible.

A number of people contributed to this endeavor either directly or indirectly. First of all, I wish to thank my supervisors: Professor Mari Walls, Dr. Matti Kamppinen, and Professor Pekka Niemelä. Mari offered extremely valuable advice and encouragements through the process, helped in designing the subprojects, and arranged my working conditions as flexibly as possible. Matti, my intellectual mentor, encouraged me in all phases of the thesis, commented constructively on manuscripts, trained me in conceptual writing, broadened my perspective on multidisciplinary, and – perhaps most importantly – always welcomed me home when his prodigal son returned from abroad with empty pockets. Pekka jumped in in the final stretch of the project, but since then has offered endless help on whatever questions arose and motivated me to complete the project on time.

I would also like to say a special thank-you to Dr. Mia Rönkä and Dr. Antti Marjokorpi. Mia was actually my first connection in getting invited to join the newborn CORECO project, and after that she offered invaluable support and collaboration with some of the subprojects of the thesis. Antti offered altruistic help already in commenting on my early study plans and in planning the plantation subproject at the beginning of the thesis. In the process he improved my skills as a researcher and offered valuable comments on the manuscripts and the synopsis – I have learned much from Antti and have enjoyed collaborating with him. I also want to give special thanks to Dr. Juha Hiedanpää and Dr. Markku Kanninen, who kindly reviewed this thesis and gave valuable comments to improve it.

I am grateful to Nina Aarras and Jenni Heinonen, my friends in the CORECO project, for their cooperation: our interesting discussions have widened my scope of corporate responsibility to other sectors of society. I also want to thank Piia Nurmi and the members of the CSR research circle (CSR Tutkimusrinki) for enjoyable side-events during the past years.

The subproject dealing with Forest Lapland would never have been as fruitful as it was without our excellent CLMIRF team: Dr. Timo Kumpula, Dr. Benjamin Burkhard,

and Mr. Ari Tanskanen – many thanks to you all. Thanks to the Chief Cook Kumpula, there has always been enough reindeer meat in our symposiums. You, friends, taught me how difficult it can be even for experts to decide on the right minimum number of datasets for analysis under varying conditions, from hot springs to cold mountains. I further wish to thank Dr. Sakari Kankaanpää, who offered invaluable help and support in Saariselkä, Hammastunturi and the UKK National Park. In addition I would like to thank collectively the numerous other people who supported our work, with interviews, discussions and material acquisition, or otherwise deepening my knowledge of forestry, and name in particular Juha Sihvo, Arto Naskali, Timo Lehesvirta, Jakob Donner-Amnell and Leena Leskinen.

I would like to thank several people at Stora Enso Uruguay, who kindly supported and helped with the subproject in Uruguay in many ways. My special thanks go to Kaisa Tarna-Mani, Bevan Lock, Horacio Giordano, Maria Martinez, Martim Terra, Andrea Storace, Ralph Schmidt-Liermann, and Mr. José from Tres Arboles. I also want to thank Dr. Heimo Mikkola (former FAO representative in Uruguay), Dr. Kyösti Ruuttunen and Mr. Adrián Stagi for their wonderful help and excellent recommendations of interviewees for the study. In addition, I wish to thank Dr. Santiago Carreira and Professor Mario Clara for their introduction to the local fauna. Finally, I would like to thank the staff of the Finnish Embassy in Buenos Aires, Argentina, for their interest in the study and for interesting discussions, as well as Professor Jussi Pakkasvirta for discussion of the current political situation and its relation to the forest industry in Latin America.

During the all subprojects of this thesis I have met many people, experts and laymen, who contributed to the thesis itself or to unofficial discussions which implicitly have helped me to process this complexity in my mind. I wish to thank you all collectively, but with the warmest and most personal thoughts. Dr. Ellen Valle kindly revised the language of the thesis, for which I wish to give her my warm thanks.

I want to thank my friends, who every now and then have shared some shrinking bits of free time with me: the *fishermen* Hannu Turpeinen, Lauri Nikkinen, Samuli Helle, Harri Vehviläinen, Teemu Virtanen, Mikko Nieminen, Pasi Halme and Anssi Teräs, and the *gardeners* Lassi Suominen, Timo Kosonen and Mikko Ollikainen. And all my other friends and colleagues whose names are not mentioned here: many thanks to you too.

I am deeply grateful to my beloved parents Irmeli and Kalevi for all their support throughout my life, and especially for their help with childcare during the last years, which has sometimes been crucial to the completion of the project. I likewise wish to thank my dear parents-in-law, Marika and Jaakko, for all their help. My warm thanks also belong to my grandparents – Irma and Erkki from Kuopio and Hillevi and Tuure (in memoriam) from Askainen – for their inspiration, enthusiasm, care, and constant belief in me.

My greatest gratitude goes to my family: to my wife Armi and our wonderful daughters Pihla and Saimi. Armi, your support and encouragement in the course this journey have

been gigantic. You are a wonderful partner in the sailboat of life. Pihla and Saimi: your joy of life is fantastic, and things have their right balance with you. I dedicate this work to you and the generations to follow. I hope you will share my dream of a peaceful, fair and diverse planet, where children and all biota will be able to grow in safety.

Watching over the growth of children and trees

Kuopio, March 2010

A handwritten signature in cursive script, reading "Pellen Vihrova". The signature is written in black ink and features a long, horizontal flourish extending to the right.

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