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Synthesis in the context of The Economics of Ecosystems and Biodiversity (TEEB)

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Content

Forword

Natural capital constitutes the foundation for human wellbeing and is a key asset for economic prosperity. Nature provides a range of goods and services, commonly referred to as ecosystem services, whose economic invisibility has thus far been a major cause of their undervaluation and mismanagement. Developing our capacity to measure and monitor biodiversity, ecosystems and their services is therefore an essential step towards better management of our natural capital.

The international study on the Economics of Ecosystems and Biodiversity – known as TEEB - reviewed the status of biodiversity and ecosystem services and emphasized the need to both incorporate natural capital in standard national accounting as well as developing a broader set of economic and development indicators integrating biodiversity and ecosystem concerns. These recommendations were incorporated in the Strategic Plan 2011-2012 of the Convention on Biological Diversity and it is expected that by 2020, at the latest, biodiversity values are integrated into national and local strategies and planning processes, as well as incorporated into national accounting and reporting systems. This is great news from the policy point of view.

Nordic countries have always been at the forefront in working with environmental indicators, accountings and modeling. It was therefore a natural step for us to examine what the economics of ecosystems and biodiversity encompass in the Nordic context. As a conclusion of an extensive synthesis and analysis of existing information a comprehensive first cut assessment of qualitative, quantitative and monetary information available on the socio-economic importance and value of nature in the Nordic countries is now at hand. This TEEB Nordic study initiated and financed by the Nordic Council of Ministers (NCM) under the Finnish Presidency in 2011 has been compiled by The Institute for European Environmental Policy IEEP and the Finnish Environment Institute SYKE.

TEEB Nordic study draws conclusions and recommendations that are worth consideration at the political level. It clearly indicates that nature is of high socio-economic importance in the Nordic countries. The study shows that there are a number of concrete practices and examples on how to build on natural capital and benefit from nature in a sustainable manner. Therefore, it is now time to start mainstreaming these practices. This requires further development of comprehensive, enabling policy frameworks: secure good regulatory baseline, reform of harmful subsidies, investments in natural capital, innovative solutions for eco-efficiency and, finally, decoupling of economy from current extensive resource use and related negative impacts.

However, the assessment also highlights that there are significant gaps in terms of existing information on status, trends and more concrete socio-economic value of different services. No “quick fix” solutions are available but instead we need to work systematically towards a more comprehensive information base that can ensure long-term sustainable use of natural capital. We need to carry out national ecosystem service assessments, develop indicators for ecosystem services and elaborated national frameworks for their assessment. Furthermore, we need to complement overall national assessment with more focused, problem- and challenge-based assessments, for example focusing on the sustainability of forest-based biofuels and sustainability of fisheries. It will be essential to ensure that the assessments are utilized in the policy and decision-making.

Nordic countries should take an active role in championing truly “green” green economy that build on the wise use of nature’s capital. There is a solid basis for joining forces, finding synergies and leading by a joint example and continued Nordic cooperation.

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For independent case studies

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Executive summary

Nature – while considered to be valuable in and of itself – provides a range of benefits, i.e. so called ecosystem services, that fuel the global economy and underpin human and societal well-being. For example, healthy natural systems regulate our climate, pollinate our crops, prevent soil erosion and protect against natural hazards. They also help to meet our energy needs and offer opportunities for recreation, cultural inspiration and spiritual fulfilment. Nature also underpins our economies, with economic sectors such as agriculture, fisheries, forestry, tourism, pharmaceuticals, and food and beverage sectors directly depending on biodiversity and ecosystem services. In addition, a range of other sectors, including health and security, depend indirectly on nature. However, many of the benefits provided by nature – and the associated economic values – are not recognised by the markets and remain unacknowledged in decision-making by a range of stakeholders including politicians, administrators, businesses, communities and individuals. In other words, nature is almost invisible in the political and individual choices we make, resulting in us steadily drawing down our natural capital.

The Economics of Ecosystems and Biodiversity (TEEB)

A major international undertaking called "The Economics of Ecosystems and Biodiversity" (TEEB)[1] was initiated by the Environment Ministers of G8+5 countries in 2007. The objective of TEEB was to draw attention to the global economic benefits of nature and to highlight the growing costs of biodiversity loss and ecosystem degradation while highlighting opportunities arising from sustainable management, restoration and other appropriate conservation responses. The ultimate aim was to draw together expertise from the fields of science, economics and policy to enable concrete actions for raising awareness about the "true" value of nature and integrating these insights into decision-making processes at all levels.

[1] www.teebweb.org

Since the launch of the TEEB outcomes in 2010 several high level policy commitments have been made to integrate the value of nature into decision-making processes at global, national and local level. For example, both the Strategic Plan for Biodiversity 2011–2020 to implement the UN Convention on Biological Diversity (CBD) and the EU Biodiversity Strategy to 2020 urge countries to assess the socio-economic value of ecosystem services and integrate these values into national accounting and reporting systems. The fundamental role of nature's capital – ecosystems, genetic resources and species – in maintaining human well-being is also gaining more ground in the context of broader sustainable development, e.g. as agreed in the UN Conference on Sustainable Development (Rio+20) in June 2012. Nature underlines the very functioning of our socio-economic systems, creates a range of business opportunities and provides cost-effective solutions for different sectors. The recognition that natural capital is fundamental for our well-being and should be appreciated for its many values suggests that sustainable use, protection and restoration of nature needs to play should form a foundation for a green economy, i.e. economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities.

Synthesis of the socio-economic importance of ecosystem services in the Nordic countries – TEEB Nordic

Several Nordic countries and stakeholders have taken a stance in increasing the knowledge base on the value of nature and integrating these insights into policies and decision-making. Following in the footsteps of the global initiative, the Nordic Council of Ministers (NCM) and the NCM Finnish Presidency decided in 2011 to initiate a TEEB inspired synthesis in the Nordic context (TEEB Nordic). The aim of this synthesis was to bring together existing information on the socio-economic role and significance of biodiversity and ecosystem services for the Nordic countries (i.e. Denmark, Finland, Iceland, Norway and Sweden).

This document presents the outcomes of this Nordic synthesis. Based on the existing information available, the report identifies the range of ecosystem services maintained by healthy, well-functioning ecosystems and synthesises existing information on the present status, trends and socio-economic importance of these services. Finally, the report explores key opportunities and priorities for future policy action to integrate the true value of nature into decision-making processes, including possible areas for Nordic cooperation. An overarching aim of TEEB Nordic was also to complement the global TEEB initiative with interesting insights and concrete evidence from the Nordic countries. For this purpose six stand-alone case studies have been developed together with relevant Nordic experts (available in Annex II). In addition, a range of illustrative case examples are identified and documented.

Note: TEEB Nordic has been an independent synthesis, separate from the national ecosystem assessment currently taking place in or being initiated by the individual Nordic countries. It is hoped that TEEB Nordic will provide a useful source of information for these national in-depth assessments.

Socio-economic importance and value of Nordic ecosystem services

The results of TEEB Nordic reveal that, while in many ways similar to the global level, the range of benefits provided by ecosystem services in the Nordic countries exhibits some characteristics distinct to the region. While provisioning services provided by agriculture, forestry and fisheries remain essential also in the Nordic countries a number of other regionally important ecosystem services can also be identified. These include, in particular, reindeer herding (especially in the north), wood-based bioenergy, non-timber forest products such as berries, mushrooms and game, and recreation and tourism. In addition, there seem to be a range of existing and novel possibilities related to different bio-innovations (so called "bioeconomy"). Given the area coverage of forests in the region, it is not surprising that mitigation of climate changes (i.e. carbon storage and sequestration) is among one of the most significant – or at least most frequently discussed – regulating services provided by Nordic ecosystems. In addition, the importance of water purification (e.g. in the context of eutrophication of the Baltic Sea) and pollination are often highlighted.

In terms of information available, existing biophysical data on the capacity (status and trends) of Nordic ecosystems to provide services consists mainly of information on stocks, flows or indirect socio-economic proxies (i.e. the use and/or demand of service). With the exception of provisioning services, most of the information available is based on individual case studies with very little data available at national and regional level. Available data on the socio-economic value of Nordic ecosystem services consists mainly of information on the quantity and market value of stocks. In addition, a range of studies could be found that reflect the appreciation and public value of ecosystem services (i.e. people's willingness to pay for the improvement of services), including water purification and recreation. Important concrete information gaps include, for example, lack of estimates reflecting broader cultural and landscape values, lack of data on nature's role in maintaining health, and lack of information on the indirect employment impacts of nature. In terms of ecosystems, there seems to be considerable gaps related to marine ecosystem services (beyond fisheries). With the exception of provisioning services, most of the information available is based on individual case studies with very little data available at national and regional level. Also, surprisingly few estimates were found assessing the costs of service foregone or costs of replacing the service (e.g. regulating services). Finally, no national or regional assessment focusing on the socio-economic role of the ecosystem processes and functions supporting the maintenance of services could be identified.

Insights related to the value of some key ecosystem services are provided below. More comprehensive overview of the Nordic ecosystem services and their socio-economic importance (e.g. detailed references for sources of information) are available in the main body of the report.

Marine and freshwater fisheries and recreational fishing

Fishing in the Nordic countries is important both as an industry and as a hobby, leading to a high demand for sustainable management of fisheries resources. Professional fishing happens mainly on marine areas but freshwaters are popular amongst recreational fishermen. While the numbers of professional fishermen are fairly low across the Nordic region, the fisheries industry is of high national and/or regional importance. For example, in Greenland and Iceland (and the Faroe Islands) fisheries and fish production make the single most significant economic contribution to the welfare of societies. In terms of size of catches, Norway is the biggest fish producer of the Nordic countries (Table below).

Fishing is a very popular recreational hobby in Nordic countries, and there are over six million recreational fishermen (European Anglers Alliance 2002). In Finland, Sweden and Norway, 44%, 30% and 50% of the population, respectively, reported having engaged in some kind of fishing activity in the past year. The size of catch by recreational fishermen in Finland was 48 million kg in 1998 and 79 million kg in Sweden in 1995. In Sweden, the net value of recreational fishing has been estimated at almost 79.5 million EUR, exceeding the value of commercial fishing. (Sievänen and Neuvonen 2010, Statistics Sweden 2012b and 2012c, Statistics Norway 2012, Toivonen et al. 2000, Garpe 2008).

Table 1: Socio-economic importance and value of marine fishing in the Nordic countries

	Greenland	Iceland	Norway	Denmark	Sweden	Finland
Number of professional fishermen (incl. part time)	3,752	4,500 man years	12,993	2,088	1,600	2,195
Reference year	2004	2005	2010	2008	2012	2010
Source	Statistics Greenland 2012	Icelandic Fisheries 2012 / Statistic Iceland 2012	Statistics Norway 2012	Statistics Denmark 2012	Havs och vatten myndig-heten 2012	RKTL 2012
Size of catch (tonnes)	225,413	1,063,467	2,288,623	1,066,428	159,968	122,078
Value of the catch (mil of nat. currency)	Not available	132,979.2 mil ISK (~ 837 mil EUR)[1]	15,883.6 mil NOK (~2,105 mil EUR)[1]	3,435.5 mil DKK (~462 mil EUR)[1]	970.8 mil SEK (~110 mil EUR)[1]	26.5 mil EUR
Reference year	2005	2010	2011	2010	2011	2010
Source	Statistics Greenland 2012	Statistics Iceland 2012	Statistics Norway 2012	The Danish Directorate of Fisheries 2011	Statistics Sweden 2012b, 2012c	RKTL 2012

[1] Based on based on exchange rate in 2012.

Reindeer herding

Although the worldwide commercial production of reindeer meat is relatively small it is still a very significant source of income in Finland, Norway and Sweden. In north Finland, Norway and Sweden, i.e. Nordic areas where reindeer herding remains a common source of livelihood, approximately 6,500 Sami people work as reindeer herders (Table below). Reindeer husbandry continues to be a great importance in the Sami region because the shipping, trading and processing of its products provide numerous jobs. Reindeer herding is supported by policy action also because of its cultural importance, which goes beyond being merely a source of income. The main business related to reindeer herding is meat production. In addition, in order to increase their income, reindeer herders also engage with several other sources of livelihood such as hunting, production of decorative items and tourism. Degrading of pastures due to overgrazing is one of the biggest challenges for reindeer herding in the future. In addition, competing land use with forestry and natural predators might affect numbers.

Table 2: Socio-economic importance of reindeer herding in Finland, Sweden and Norway

Country	Herders	Reindeers (No)	Size land (km^2)	Organisation	Monopoly	Value of production (mil EUR)[1]		
						2004	2005	2006
Finland	5,600 Sami and non-Sami	186,000[2]	114,000 (33%)	57 reindeer herding cooperatives	No	>10	>10	13
Sweden	3,500 Sami; 1,000 non-Sami	227,000[2]	160,000 (34%)	51 Sami villages	Yes	<5	<5	7
Norway	2,936 Sami	165,000[2]	140,000 (40%)	80 reindeer herding districts	Yes	<10	<10	<10

[1] Based on 2.5–2.8 (FI), 1.5–2.0 (SE) and 2.0–2.3 (NO) million kg / year production of meat in 2004–2006.
[2] Data from 2000 in Finland, from 1998 in Sweden and 2001 in Norway.

Non-timber forest products: berries and game

While there are no on-going annual statistics on the amounts of *berries and mushrooms* picked and/or marketed across the Nordic countries, however a number of individual studies from Finland and Sweden provide some estimates (see Table below). In general, the Nordic forests produce several tonnes of wild berries annually with only a small fraction of them being used, most at the household level.

Table 3: Quantities and values of berries and mushrooms picked for markets in 2005 in Finland, Norway and Sweden. Source: Turtiainen and Nuutinen (2011)

Country	Berries		Mushrooms	
	Quantity (tonnes / year)	Value (mil EUR)[2]	Quantity (tonnes / year)	Value (mil EUR)[2]
Finland	12,027	11.862	426	1.019
Sweden	13,790	32.435[1]	Not available	Not available
Norway	350	0.524	500	1.873

[1]Value for mushrooms and berries together.
[2] Based on the source, the estimated values for NO and FI are based on collector's price whereas in Swedish the value is based on "… weather conditions and newspaper information".

The socio-economic importance of *hunting* in the Nordic countries is a combination of revenue providing activity, household subsistence value, and cultural and recreational significance. Around one million Nordic people go hunting every year – almost 5% of the total Nordic population. Estimates for the value of game meat were obtained from Finland, Sweden and Norway ranging between 44–125 million EUR (Table below). In terms of the national economy, game plays the most significant role in Greenland where hunting and whaling remain an important parts of people's livelihoods. In particular, hunting is of high socio-economic importance to local communities in terms of cultural identity and it also remains an important means of supplying households with preferred meat.

Table 4: Socio-economic significance of hunting in the Nordic countries

Country	Finland	Sweden	Norway	Denmark	Iceland	Greenland
Hunters (with licence)	311,000	263,000	195,500	171,119	12,227	6,539
Large mammals	Eurasian elk 68,423	Eurasian elk 80,974	Eurasian elk 36,400	Roe deer 128,200	Reindeer 1,229	Reindeer 15,092
Bears	179	181	3	NA	NA	Polarbear 124
Other species	Mallard 265,400 Wood pigeon 232,100 Black grouse 170,000	Roe deer 119,000 Mallard 91,500 Wood pigeon 71,000	Willow grouse 127,850 Wood pigeon 56,900 Red deer 39,100	Pheasant 721,400 Mallard 485,400 Wood pigeon 299,500	Rock ptarrigan 68,831 Greylag goose 45,828 Puffin 33,074	Guillemot 84,412 Harp seal 84,223 Ringed seal 71,260
Ref. year	2010	2007–2008	2010–2011	2010–2011	2010	2007–2009
Source	RKTL 2012	Hunters: Naturvårdverket website, other information: Kindberg et al. 2009. Årsrapport 2007–2008. Viltövervakningen	Statistics Norway 2012	Asferg 2011 Vildtudbyttestatistik for jagtsæsonen 2010/2011	Hunters: Heiðarsson et al. 2010, other information Statistics Iceland 2012	Statistics Greenland
Value of game meat	83 mil EUR	1,119 mil SEK (~125 mil EUR)	44 mil EUR	NA	NA	NA
Ref. year	2010	2005–2006	2001			
Source	RKTL 2012	Mattsson et al. 2008	Lunnan et al. 2005			

Regulating services: climate regulation, water purification and pollination

While more research on status of and trends in Nordic *carbon storage and sequestration* is required, some estimates already exist for the monetary value of carbon sequestration and storage. In Finland Matero et al (2007) estimated the value of carbon sequestration of Finnish forest trees to be 1,876 million EUR, and the value of change in mineral soil carbon stock to be 136 million EUR. In Sweden Gren and Svensson (2004) calculated the annual carbon sequestering value of Swedish forest to be between 29–46 billion SEK (2001 SEK) (~3.3–~5.2 billion EUR) based on the estimated consumption value of 11–18 billion SEK (~1.2–~2 billion EUR) and investment value of 18–28 billion SEK (~2–~3.2 billion EUR) (See the main report for further details).

While estimates are available for the global economic importance and value of *pollination*, no such overall estimates yet exist for the Nordic countries. A recent study from Finland, however, assessed that the value of honeybee pollination service of selected crops would be around 18 million EUR and of wild berries (bilberry and lingonberry) 3.9 million EUR (Lehtonen 2012). In addition to pollination of commercial crops, there are numerous home gardens in Nordic countries. An estimated value of pollination (by honeybees) in home gardens was 39 million EUR in Finland (Yläoutinen 1994, cited in Lehtonen 2012). In Denmark the value of the general insect pollination service was calculated to be worth 421 to 690 million DKK (~56.6 to ~92.8 million EUR) a year (Axelsen et al. 2011). In Sweden the value of honeybee pollination service was calculated to be 189–325 million SEK (~21.5–~37 million EUR) (Pedersen 2009a). When considering these values it must be noted that insect pollination of greenhouse crops is often provided by commercial pollinators.

Finally, in the Nordic countries many studies have been carried out to reveal the public appreciation of cleaner surface waters. A summary of these is provided in Table below. In general, these studies can be used as proxy indicators for the value of water purification for the general public (i.e. water purification as a public good). These studies are mainly based on willingness to pay (WTP) studies and do not, therefore, reflect market values or real economic gains.

Table 5: Examples of the estimated values for ecosystem's ability to improve water quality (public good)

References	Study area	Method	Estimated impact on recreational services
Appelblad, 2001	Sweden, River Byske	WTP for a day fishing license in the River Byske	WTP under unimproved environmental conditions: 89 SEK (~10 EUR); WTP under improved conditions: 142 SEK (~16 EUR); Consumer surplus: SEK 18 (~2 EUR) / day in 1996
Sandstöm, 1996	Sweden, Laholm Bay and entire Swedish coast	Recreation benefits from hypothetical 50% reduction of the nutrient load	Consumer surplus: 12–32 million SEK (~1.3–~3.6 million EUR) / year for the only Laholm Bay; Consumer surplus: 240–540 million SEK (~27.3–~61.6 million EUR) / year for the entire Swedish coast
Soutukorva, 2001	Sweden, Stockholm archipelago, Stockholm and Uppsala	Recreational benefits from a hypothetical 1-metre improvement in water clarity, 30% reduction of the nutrient concentrations	"Consumer surplus 59–93 million SEK (~6.7–~10.6 million EUR) / year in 1998 and 70–110 million SEK (~8–~12.5 million EUR) / year in 1999."
Söderqvist et al, 2000	Sweden, Stockholm archipelago, Stockholm and Uppsala	WTP (higher prices of tap water and agricultural products) for 1-metre improvement in water clarity	500–850 million SEK (~57–~97 million EUR) / year in 1999
Kosenius, A-K, 2010	Finland, Gulf of Finland	WTP for three nutrient reduction scenarios of different intensities in the Gulf of Finland	28,475–53,884 million EUR (total)
Atkins and Burdon 2006	Denmark, Randers Fjord in Arhus County	WTP for hypothetical improvement to obtain good water quality in the fjord	12.02 EUR / month / person over 10 years, totalling 5.5 million EUR a month over 10 years
Eggert and Olsson 2002	Sweden, southwest Swedish coast	WTP for preferred water quality improvements (for biodiversity bathing and fishing)	Mean average WTP from 1,400 SEK (2002 SEK) (~159 EUR) / person for avoiding reduction in biodiversity to 600 SEK (2002 SEK) (~68 EUR) / person for improving biodiversity levels. Extrapolating the results over the whole Swedish population leads to an aggregate estimate of 400–700 million SEK (~45.6–~80 million EUR) for either improving the cod stock or avoiding deterioration of marine biodiversity.
Vesterinen et al. 2010	Finland, inland and coastal waters	Recreational benefits from a hypothetical 1-metre reduction/improvement in water clarity	Swimming benefits loss under impoverished environmental conditions: 31–92 million EUR / year; fishing benefits loss: 38–113 million EUR / year. Swimmers consumer surplus under improved environmental conditions: 29–87 million EUR / year; fishers consumer surplus 43–129 million EUR / year.

Recreation and tourism

Recreation activities in nature, i.e. outdoor recreation related to everyday life that people do outdoors near their home, are extremely popular in Nordic countries. For example, an average adult Finn does some kind of outdoor activity on average 170 times a year (i.e. around three times a week, with 1/3 of people doing such activity daily) (Sievänen and Neuvonen 2010). In Sweden, 36–56% of people reportedly use forests for walking at least 20 times a year (Romild et al. 2011). In Norway, hiking in forests or mountains is practised more than twice a month by almost half of the population (i.e. around 2.4 million people) (Statistics Norway 2012). Finally, in Denmark approximately 70% of Danes visited green areas several times a week, with parks and other open natural areas being the most popular green areas, followed by beaches (Schipperijn et al. 2010). Outdoor life can have significant impacts on regional and national economies. In Sweden, the value added from outdoor life expenditure was calculated to be 34,331 million SEK (~3,918 million EUR) and altogether spending on outdoor life would result in 75,637 job opportunities (Fredman et al. 2010).

Nature tourism, i.e. overnight trips with activities related to nature, is considered to be one of the fastest growing sectors of international tourism. For example in Lapland, Finland nature tourism is already the most important sector contributing the regional economy (Tyrväinen, 2006, cited in Bell 2007). No statistics specifically related to nature tourism are available for the Nordic counties. However, given the role nature plays in attracting tourism to the Nordic countries, general information on tourism can be used to indicate the socio-economic role of nature in supporting tourism. Yearly some 100 million nights are spent in different tourist accommodation establishments in Nordic countries by domestic or foreign tourists. In addition, nature is mentioned most often as a main attraction of holiday houses and there are perhaps more holiday homes per capita in Nordic countries than anywhere else in the world (1.5 million in total) (Müller 2007). Approximately 50% of Nordic people have access to holiday house and in Finland the figure is over 60% (Sievänen and Neuvonen 2010). Foreigners (including Nordic visitors to other Nordic countries) spend some 15 million nights at holiday houses.

Bioeconomy and bio-innovations

There is increasing interest from Nordic and Arctic countries in researching biotechnological application based on Nordic and Arctic genetic resources. Norway has the most developed and promising marine biotechnology sector focused on Arctic genetic resources. Furthermore, a number of Nordic plant compounds are currently used by the pharmaceutical industry, e.g. cardiotonic compounds from lily of the valley (*Convallaria majalis* L.) and foxglove (*Digitalis purpurea* L.) and endurance increasing compounds from roseroot (*Rhodiola rosea* L) (Fabricant and Farnsworth 2001) (Box below). Altogether 134 Nordic plant species have been identified that have medicinal or aromatic properties and that are of current socio-economic interest and that grow wild in the Nordic and Baltic region (Asdal et al. 2006). Recent examples of scientific screening of Nordic plants include sage species tested for their effect on type-2-diabetes in Denmark and Corydalis species on Alzheimer's disease (Christensen 2009, Adsersen et al. 2006).

Box 1: examples of Nordic bioeconomy and bio-innovations

Bioremediation and removal of undesired substance: The organic waste produced by paper mills is also a potential resource. Following this principle, methods to use paper mills' waste in protein biomass production have been developed. The pekilo process, for instance, has been developed in Finland for the production of single-cell feed using the fungi Paecilomyces variotii. The first commercial pekilo plant, built at the United Paper Mills pulp plant at Jämsänkoski, Finland, had an annual capacity of 10,000 tonnes of single-cell protein. Similarly, the fungi Torula utilis is used by the Boise-Cascade Corp. as a high protein food extender and animal feed. An industrial ethanol plant connected to a sulfite pulp mill is in operation at Örnsköldsvik in Sweden (Scheper et al, 2007b).

Pharmaceutical and medical uses: The Armi Project co-ordinated by the Finnish Forest Research Institute (Metla) ran from 2001 to 2004 and isolated some 600 strains of microbes from boreal and Arctic environments in soil sediment, stream water, snow, lichen and moss from Lapland in Northern Arctic Finland and Svalbard in the Norwegian Arctic. A European pharmaceuticals company has subsequently bought the rights to start screening the collection of bacterial strains collected as part of the Armi research for anti-cancer drug candidates. In Norway, a total of 180 million NOK (~23.8 million EUR) has been committed to the MabCent initiative by the Norwegian Research Council, the University of Tromsø and the associated biotechnology companies. Approximately 25% of this funding has been provided by the commercial partners. (Leary 2008).

Nordic medicinal plants: One of the most interesting medicinal plants in the world is roseroot, Rhodiola rosea L., (which grows wild in Nordic mountainous areas and is rare in temperate regions. Roseroot is said to be the northern ginseng and there are several roseroot products on the markets. In traditional medicine roseroot has been used for physical endurance, resistance to altitude sickness and in treatment of fatigue and depression. Worldwide there is high demand for roseroot, especially in the U.S and the demand is calculated to be approximately 20–30 tonnes / year. Due to high demand wild roseroot has become seriously threatened species in Russia and in central Europe. There is no current threat to wild roseroot populations in Nordic countries and also successful cultivation trials of roseroot have been made in Nordic countries. (Asdal et al. 2006, Economo and Galambosi 2003).

Blue mussel farming to improve water quality: In Sweden, several initiatives and pilot projects are underway to use Blue mussel farming to improve water quality. In Lysekil Municipality, a payment mechanism has been set up whereby the polluter (the local waste water plant) pays mussel farmers to remove nutrients from the coastal waters. Payments are based on the content of nitrogen and phosphorous in the harvested mussels. Project results show that 3,500 tonnes of blue mussels / year help to remove 100% of the nitrogen emissions of the Lysekil waste water treatment plant. The use of mussels to clean the nitrogen content of the waste water plant saves the municipality close to 100,000 EUR / year compared to using a traditional technique (Zandersen et al. 2009).

Conclusions and recommendations

Despite the significant gaps in the existing knowledge base, it is evident that a range of ecosystem services are of high socio-economic significance for the Nordic countries, either based on their market value or estimated value for the broader public. Natural capital (biodiversity, ecosystems and related services) also underpin socio-economic wellbeing in the Nordic countries. On the other hand, based on the existing evidence based it is also clear that several of these ecosystem services including, for example, marine fisheries, water purification and pollination, have been seriously degraded and several others, such as carbon storage, are facing serious risks. In addition, rather alarmingly the information available does not yet allow any conclusions to be drawn on the status of and trends in the majority of services, including processes and functions supporting their maintenance.

Integrating the value of ecosystem services into policy and decision-making processes has started in several Nordic countries. A range of concrete examples can already be identified where the socio-economic importance of ecosystem services has been recognised, leading to "greener" and more sustainable solutions for the use of natural capital. However, the concept of ecosystem services is still new to several sectors and, consequently, it still remains to be integrated into national policies and strategies, and business sector accounting and investment decisions. Consequently, it seems evident that further policy actions are needed to address the situation. Nordic countries are already well on their way towards a transition to a green economy. While the approaches taken towards "greening" the economy (or economies) are likely to differ between countries, the results presented in this report clearly indicate that future developments should be based on a sound appreciation of the value and role of nature in underpinning sustainable socio-economic development.

The outcomes of TEEB Nordic emphasise that the first step towards integrating the value of ecosystem services into Nordic policies and decision-making processes would be to *identify and develop a common set of indicators* to assess and monitor the status, trends and socio-economic value of ecosystem services. While the identified key ecosystem services might differ from one country to another, an overarching common set of (core) indicators would beneficial, enabling comparisons to be made within and between countries and regions as well as facilitating reporting under international policy-processes such as the UN Convention on Biological Diversity (CBD) and EU. As the assessment shows, there are significant gaps in the information available on the biophysical status of ecosystem services. Furthermore, there is a fundamental need to develop new and/or improve existing indicators in order to appropriately assess nature's long-term ability to supply services. In particular, appropriate indicators for many regulating services, both in bio-physical and socio-economic terms, are largely still missing. More data is available for the socio-economic value of ecosystem services (especially provisioning services), however even this data is inconsistent and allows no clear comparisons to be made between different Nordic countries. Consequently, the development of ecosystem services indicators – both bio-physical and socio-economic alike – is foreseen as one of the key required actions in the Nordic countries for future. It is foreseen that co-operation among the Nordic countries would be fruitful to ensure synergies and allow for comparative assessments.

The identification and development of indicators is needed to support the development of comprehensive *national frameworks for ecosystem and ecosystem services assessments* in the Nordic countries, finally paving the way towards the integration of natural capital into national accounting systems (see below). Significant synergies could also be achieved by enhancing Nordic cooperation in this area. In terms of developing frameworks for national assessments, a more comprehensive approach, better linking biophysical and socio-economic indicators, would be needed (e.g. linking the existing indicators into the "Drivers – Pressures –States –Impacts – Responses" model, DPSIR). The contribution of human-management of ecosystems' capacity to provide services, for example in the context of agriculture, should also be covered by the indicators, whilst it should also be been excluded from the natural measurement. Furthermore, there is a need to adjust the existing land cover databases to reflect the ecosystem related data to provide a more detailed and accurate knowledge about biodiversity, ecosystems and related services.

Building on the assessment and monitoring of ecosystem services, it is generally acknowledged that in order to be truly sustainable, economic systems need to build on a more comprehensive appreciation and understanding of the value of natural capital. This requires the *development of natural capital accounts* that improve the evidence base on the stocks of natural capital, integrate ecosystem services into existing national and/or regional accounting systems and, in due course, take into account gains and losses in the stocks and flow of services. It is foreseen that the development of accounting systems – in cooperation with international and European initiatives – will be one of the key priorities for Nordic countries in the near future. A number of studies already exist exploring the possibilities for and implications of integrating the broader values of natural capital into regional and national accounts. These studies indicate that conventional accounts underestimate nature-related wealth and potential sustainable development based on natural capital.

To complement "greener" and more sustainable accounting systems, a range of complementary approaches towards a transition to a green economy can be identified. In addition to avoiding, reducing and restoring environmental damage and conserving nature (i.e. business-as-usual approaches) more active approaches towards management of natural capital can be adopted. These include, for example, *pro-active investment in natural capital and nature-based risk management* via restoration, conservation and improved ecosystem management practices, including restoration of ecosystems for water management, carbon storage and other co-benefits, and implementation of protected area networks. For example, there is an increasing evidence base to suggest that restoration of wetlands can bring significant benefits to both people and biodiversity. A range of such examples also exist in the Nordic countries (e.g. TEEB Nordic case study by Salminen et al. in Annex II). In terms of investment in natural protection, clear evidence is available from Nordic countries that financial support for the management of national parks can be a highly cost-effective investment at regional level, proving 10 EUR return for 1 EUR investment for the region (see Kajala et al. TEEB Nordic case study in Annex II). Finally, approaches pursuing broader environmental sustainability such as measures for *eco-efficiency and wider resource efficiency* though resource pricing and fiscal reform can also be adopted (e.g. fisheries and agricultural subsidy reforms). Furthermore, *decoupling the economy from resource use and its negative impacts* through more radical innovation and changes in demand – supported by consumption choice changes through information provision – can be considered. Developing new clean products and processes, for example based on genetic and molecular resources, can also be a viable alternative for Nordic countries.

Building on this preliminary synthesis and insights Nordic policy and decision-makers at national, regional and local level can now show leadership and foresight in their actions to support the protection and sustainable management of benefits provided by nature. The policy response should not be limited to environmental policies, but should also be mainstreamed into key sectoral policies such as fisheries, agriculture, forestry, climate and energy, transport and tourism. Furthermore, action is needed at all levels of governance and across all key sectors, harnessing also the energy of markets, business, citizens and communities. TEEB Nordic has been the first attempt to gather and synthesise information on the socio-economic value of nature in the Nordic countries. It is hoped to be a useful resource for demonstrating and creating further policy action on the socio-economic importance of biodiversity and ecosystem services, both in the Nordic countries and on a broader internationally.

Finally, while the previously neglected economic values of ecosystem services need to be integrated into decision-making it is also important to improve the Nordic decision-making systems so that they recognise – and equally consider – the full range of broader socio-economic values, taking into consideration qualitative, quantitative and monetary evidence. Similarly, the approaches highlighted in this report should be considered complementary – not replacing – already existing strategies for biodiversity conservation. A range of reasons and arguments for nature conservation (e.g. cultural and intrinsic values) cannot be replaced by economics.

Concrete key policy recommendations for future actions, as identified by TEEB Nordic, include:

- Development of indicators and elaborated (national) frameworks for the assessment of ecosystem services (e.g. the socio-economic valuation of ecosystem services as along the lines of the UK NEA 2011), including biophysical status and trends, and socio-economic importance and value. The list of Nordic ecosystem services accompanied with direct indicators and proxies identified in the context of this scoping assessment can form a useful starting point for these developments
- Implementing the international commitment under the World Bank's WAVES (Wealth Accounting and Valuation of Ecosystem Services of which Norway is a partner) initiative linked to the UN led SEEA (System of Environmental and Economic Accounting) to develop natural capital accounts with a dedicated focused on the non-market benefits provided by biodiversity and ecosystems, possibly benefiting from and working together with the European Environment Agency (EEA) who is leading work on Ecosystem Capital Accounts
- A number of key gaps in the existing information base can be identified including, for example, lack of estimates reflecting broader cultural and landscape values, lack of data on nature's role in maintaining health, and lack of information on the indirect employment impacts of nature. In terms of ecosystems, there seems to be considerable gaps related to marine ecosystem services (beyond fisheries). Limited information is also available on the development of socio-economic importance of different ecosystem services in the future, e.g. possible future value of yet unidentified benefits. Finally, there is a need to further explore how the substitutability of ecosystem services via international trade affects their socio-economic value. These areas are recommended to be further addressed in the future
- Developing and further strengthening policy frameworks to manage the transition to a more resource efficient and green economies in the Nordic countries while working with nature and building on the pro-active management of natural capital. Key focal areas include securing the implementation of a comprehensive regulatory baseline, continued reform of harmful subsidies, making increased use of opportunities (including earmarking) for funding investment in natural capital (e.g. management of protected areas and restoration of ecosystems) and exploring innovative solutions for

eco-efficiency and decoupling of economy from resources (e.g. via nature-based innovations)

- Working together with business to encourage improving corporate accounting and partnerships that promote conservation and sustainable use of biodiversity and ecosystems. Although not the main thematic focus of this assessment, a number of Nordic examples exist where private sector engagement has led to cost-effective solution and benefits for the environment and biodiversity
- Identifying and agreeing on key areas for Nordic synergies and co-operation including, for example, development of compatible and comparable sets of (core) ecosystem service indicators and frame-works for ecosystem services assessments, identification of thematic areas for cooperation (e.g. assessment and sustainable management of ecosystem services provided by Baltic Sea and other marine areas, sustainable production of forest-based biofuels, assessment of carbon stock and sequestration capacity at Nordic level etc.). To facilitate cooperation, consideration should be given to establishing a dedicated working group for ecosystem services under the Nordic Council of Ministers
- In addition to advancing towards overall national level frameworks for integrating ecosystem services into decision-making, the Nordic countries (or specific regions) should also focus on identifying particularly important policy developments or implementation needs where assessment of the broader socio-economic value of nature would be important to secure sustainable outcomes, especially in the long term. Focusing on such problem- and/or challenge-based assessments is seen as important to complement the overarching assessments and monitoring of the state of Nordic ecosystems and their services and mainstreaming of this information into decision-making processes. While the specific policy challenges will vary across the Nordic countries, national TEEB initiatives and other similar approaches will help to catalyse the transition to a green economy

PART I:

Introduction to TEEB Nordic

1. Introduction

Nature – while considered to be valuable in and of itself – provides a range of benefits, i.e. so called ecosystem services, that fuel the global economy and underpin human and societal well-being (e.g. MA 2005, Kumar 2010, ten Brink 2011, ten Brink 2012). For example, healthy natural systems regulate our climate, pollinate our crops, prevent soil erosion and protect against natural hazards. They also help to meet our energy needs and offer opportunities for recreation, cultural inspiration and spiritual fulfilment. Nature also underpins our economies, with several economic sectors such as agriculture, fisheries, forestry and tourism depending heavily on biodiversity and ecosystem services. However, many of the benefits provided by nature – and the associated economic values – are not recognised by the markets and remain unacknowledged in decision-making by a range of stakeholders including politicians, administrators, businesses, communities and individuals. In other words, nature is almost invisible in the political and individual choices we make, resulting in us steadily drawing down our natural capital.

To address this, a major international undertaking called *"The Economics of Ecosystems and Biodiversity" (TEEB)*[2] was initiated by the Environment Ministers of G8+5 countries in 2007. The objective of TEEB is to draw attention to the global economic benefits of nature and to highlight the growing costs of biodiversity loss and ecosystem degradation. The ultimate aim is to draw together expertise from the fields of science, economics and policy to enable concrete actions for raising awareness about the "true" value of nature and integrating these insights into decision-making processes at all levels. TEEB is coordinated by the United Nations Environment Programme (UNEP) with a range of independent initiatives currently being implemented by several countries (e.g. Brazil, India, Germany and Norway) and international and European institutions.

Since the launch of the TEEB results in 2010 several high level policy commitments have been made to integrate the value of nature into decision-making processes at global, national and local level. The new Stra-

[2] www.teebweb.org

tegic Plan for Biodiversity 2011–2020 to implement the UN Convention on Biological Diversity (CBD) (UN 1993), adopted at the tenth meeting of the Parties in October 2010 (Nagoya, Japan), outlines that *"By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems"* (Target 2 of the Strategic Plan). The EU Biodiversity Strategy to 2020 launched in May 2011 echoes the same message, stating that the EU Member States should *"map and assess the state of ecosystems and their services in their national territory by 2014, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020"* (EU 2020 Biodiversity Strategy, Target 2 – Action 5). In addition, several other international conventions and organisations such as the Ramsar Convention for Wetlands, World Bank, European Environment Agency (EEA) and the International Union for Conservation of Nature (IUCN) have initiated concrete actions related to the socio-economic benefits and value of nature.

The fundamental role of nature in maintaining human well-being is also gaining more ground in the context of broader sustainable development. In particular, nature's capital – ecosystems, genetic resources and species – should form a foundation for a *green economy*, i.e. economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities (UNEP 2011). In June 2012, the UN Conference on Sustainable Development (Rio+20) agreed to consider green economy as one of the important tools available for achieving sustainable development and eradicating poverty (UNCSD 2012). Nature underlines the very functioning of our socio-economic systems, creates a range of business opportunities and provides cost-effective solutions for different sectors. The recognition that natural capital is fundamental for our well-being and should be appreciated for its many values suggests that sustainable use, protection and restoration of nature needs to play a key role in the development of more sustainable economies (ten Brink et al. 2012). Consequently, while the transition to a green economy will take different paths for different countries, depending on country's natural assets, economy and society, and priorities, natural capital should be perceived as a key driver in this transition. At the EU level, the role of natural capital in green economy has been integrated into the EU definition of and priorities for green economy (EC 2011a).

Building on the above, the Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) and stakeholders have also taken a stance in increasing the knowledge base on the value of nature and integrating these insights into policies and decision-making, e.g. by playing an active role in supporting the TEEB initiative. Norway has shown leadership in initiating a national ecosystem services assessment in 2011 (so called "TEEB Norway" initiative) and similar plans are also in the pipeline in other Nordic countries including Finland and Sweden. On a regional level, biodiversity and ecosystem services are one of the current priorities for cooperation carried out within the framework of the Nordic Council of Ministers (environment sector). Active collaboration to assess the value of marine ecosystem services is also taking place within the Baltic Sea Basin, coordinated by the BalticSTERN Network. (See Chapter 11 for more details).

Following in the footsteps of the global initiative, the Nordic Council of Ministers (NCM) and the NCM Finnish Presidency decided in 2011 to initiate a TEEB inspired synthesis in the Nordic context (TEEB Nordic). The aim of this synthesis was to bring together existing information on the socio-economic role and significance of biodiversity and ecosystem services for the Nordic countries (i.e. Denmark, Finland, Iceland, Norway and Sweden).

This report presented the results of the TEEB Nordic synthesis. It is hoped to be a useful resource for demonstrating and creating further policy action on the socio-economic importance of biodiversity and ecosystem services, both in the Nordic countries and internationally. The Nordic prime ministers have decided that Nordic co-operation will concentrate its resources and focus on the green economy for the next few years. Therefore, it is hoped that the synthesis will also help to support the Nordic countries to move towards a truly "green" green economy in the future.

2. Aims and structure of the report

2.1 Aims and objectives

Following in the footsteps of the global TEEB initiative, the aim of TEEB Nordic was to carry out a synthesis of the existing information on the socio-economic role and significance of biodiversity and ecosystem services for the Nordic countries. Based on the existing data, the project identified the range of ecosystem services maintained by healthy, well-functioning Nordic ecosystems and synthesised available information on the present status, trends and socio-economic importance of these services (e.g. gaps in the current knowledge base). Finally, the project explored key needs and opportunities for future policy action to integrate the true value of nature into decision-making processes, including possible areas for Nordic cooperation.

TEEB Nordic also aimed to complement the global TEEB initiative with interesting insights and concrete evidence from the Nordic countries. For this purpose six stand-alone case studies were developed together with relevant Nordic experts (available in Annex II). In addition, a range of illustrative case examples have been identified and documented throughout the report.

The overarching aim of TEEB Nordic is to raise awareness on the value of Nordic nature and by doing so facilitate policy action within the region. While TEEB Nordic has been an independent synthesis, separate from the national ecosystem service assessment currently taking place in or being initiated by the individual Nordic countries, it is hoped to provide a useful source of information for these on-going and planned in-depth assessments.

Key elements of TEEB Nordic include:

- Identification of Nordic ecosystem services
- Identification of indicators for Nordic ecosystem services
- Synthesis of the existing information on the status, trends and value of Nordic ecosystem services, including a range of concrete case studies and examples

- Identification of gaps in the existing information and knowledge base, based on the identified range of ecosystem services and related indicators
- Development of concrete recommendations for key future policy action on ecosystem services in the Nordic countries

2.2 Report structure

The TEEB Nordic report is divided into four distinct parts:

Part I provides an overall introduction to and policy context for the study (*Chapter 1 and 2 above*), outlining also the approach and methods used (*Chapter 3*).

Part II summarises the key rationale behind the economic assessment of ecosystems and biodiversity, providing a synthesis of the links between nature and socio-economic wellbeing (*Chapter 4*). In addition, it guides the reader through the basics of understanding and assessing the value of biodiversity and ecosystem services (*Chapter 5*) and how these values could – and should – be integrated into policy and decision-making (*Chapter 6*). *Note*: readers already familiar with these general aspects and considerations related to the value and valuation of nature can move direct to Part III.

PART III synthesises and analyses the information available on the socio-economic importance and value of Nordic nature. It provides a short description of the Nordic ecosystems (*Chapter 7*) and then moves on to identify the range of ecosystem services provided by these ecosystems, including a preliminary discussion on the flow of benefits from and trade-offs between these services (*Chapter 8*). Available information on the status and trends of Nordic ecosystem services (i.e. the biophysical availability of services) and socio-economic value of services (i.e. benefits humans derive from services) are assessed in *Chapters 9 and 10*. These assessments start by identifying sets of indicators and/or proxies for status and value and, based on these identified indicators, are finalised by assessing existing knowledge gaps. General conclusions of the synthesis are provided in *Chapter 11* and a set of stand-alone case studies from a range of Nordic countries are included in *Annex II*.

PART IV aims to move from knowledge to actions and briefly explore the policy response to the increasing information need and/or base on the socio-economic value of Nordic nature. As a basis for the discussion, a number of existing initiatives for ecosystem services in the Nordic countries are outlined in *Chapter 12*, whereas *Chapter 13* focuses on identifying key future priorities and opportunities for policy action. Finally, *Chapter 14* summarises general conclusions and recommendations from the study.

3. Approach and methods

3.1 Scope and terminology

This study aims to gather, analyse and synthesise existing available information on the socio-economic importance and value of Nordic nature. Consequently, new assessments and/or comprehensive economic analysis of ecosystem services (e.g. by the means of benefit transfer) fall outside the scope of this study. All ecosystems in all Nordic countries, i.e. Denmark, Finland, Iceland, Sweden, and Norway, have been included in the assessment, with the autonomous areas (Greenland, Faroe Islands and Åland) receiving specific focus where relevant (e.g. in some case examples and thematic areas).

It is important to note that TEEB Nordic does not aim to develop an overarching systematic framework for assessing the (total / net) socio-economic value of ecosystem services in the Nordic countries and/or within the Nordic region. The objective of the synthesis is also not to provide a comprehensive contextual analysis of the "flow" of Nordic ecosystem services in the context of the broader Nordic and global economy (e.g. effects of global trade and substitutability to the value of ecosystem services). These aspects are, however, considered to be important areas for further assessment in the future (See policy recommendations in Chapter 14).

Key concepts, terminology and classifications used in the report are outlined below, with further information and additional terms of relevance to the study provided in Chapter 4 (e.g. Box 4.1).

Ecosystem services: In the context of TEEB Nordic, ecosystem services are defined as the beneficial contributions of ecosystems to human well-being (MA 2005, Kumar 2012). These services include provisioning, regulating and cultural services and the processes and functions supporting these services (See Chapter 4 for further details). In addition, it is considered that ecosystem services consist of two distinct "elements": the ability of ecosystems to provide these services (i.e. the biophysical and ecological element) and the identification and use of these services by humans (i.e. the socio-economic element). Based on this anthropocentric view point, ecosystems' resources, functions and processes are generally defined as "services" when they are identified as beneficial to/by humans, either currently or in the future.

Note: given the objective of the synthesis (Section 2.1 above), TEEB Nordic purposefully uses the broad definition and classification of ecosystem services and does not attempt to systematise these services further for the purposes of a through and comprehensive socio-economic valuation of ecosystem services, e.g. as along the lines of the recent UK National Ecosystem Assessment (2011). Also, it is to be noted that the approach adopted in the context of TEEB Nordic does not attempt to systematically identify and synthesis information on ecosystem services per individual ecosystems. Therefore, the list of identified ecosystem services should be considered as a generic starting point for all Nordic ecosystems, including marine areas.

Ecosystem service indicators: Building on the above, the term "ecosystem service indicator" can refer to a number of different aspects of ecosystem services, including ecosystems' ability to maintain and provide services and the socio-economic importance and value of these services to individuals, businesses, broader human well-being and/or economies. In the context of this study a clear, conceptual distinction has been made between the biophysical and socio-economic indicators of ecosystem services, with dedicated sets of indicators identified for both. In practice, both types of indicators are required to assess and monitor the status and value of ecosystem services in a comprehensive and meaningful manner (e.g. to carry out ecosystem service assessments). In this context, two different categories of indicators have been identified: *direct indicators*, i.e. indicators considered to best capture the status and/or value of a service and *proxy indicators*, i.e. indicators that can be used in the absence of direct indicators and/or information to indirectly reflect the status or value of a service.

Socio-economic value of ecosystem services: In the context of the study, the term "value" is used to refer to the socio-economic benefits of nature (i.e. biodiversity and ecosystems) in a broad sense of the term, covering both economic and broader welfare benefits and using qualitative, quantitative and monetary information as an indicator of value. In several cases, it is not possible – nor even sensible – to try to identify or develop a monetary estimate for an identified ecosystem service. This is the case, for example, for several cultural services. This does not, however, mean that the benefits derived from and values attached to this service would by default be any less important than services with monetary indicators.

3.2 Methods

3.2.1 Classification of Nordic ecosystems

Building on the existing information, two different ecosystem classifications and related land cover data sets for Nordic ecosystems have been used in the context of the assessment. These are 1) Pan-European CORINE Land Cover database (CLC) data (CLC 2000) and 2) ecosystem classification by the NordBio2010 project, which studied the status and trends of biodiversity and ecosystems in the Nordic countries (Normander et al. 2009).

The insights from both CLC and NordBio2010 have been used to provide a synthesis of the current status and trends of Nordic ecosystems and their capacity to deliver ecosystem services. In general, the key environmental pressures and their impacts on biodiversity and ecosystems in the Nordic countries have been provided by Normander et al. 2009, consequently only a summary of this has been provided in the context of this report.

Finally, CLC has been used to create basic statistics on the coverage of ecosystems in the Nordic countries, and has been used in some of the models describing ecosystems' capacity to provide services (e.g. for some cultural and regulating services) (Chapter 9).

3.2.2 Identification, classification and valuation of Nordic ecosystem services

A *list of Nordic ecosystem services* has been developed on the basis of the classification adopted by TEEB (Kumar 2010) and the Millennium Ecosystem Assessment (MA 2005) reflecting the benefits provided by the Nordic ecosystems. For example, the list of provisioning services has been further developed to include a range of commonly recognised benefits provided by boreal ecosystems (e.g. berries, mushrooms, game, reindeer herding). In addition, special consideration has been given to highlight multiple cultural benefits and values associated with Nordic nature (e.g. recreational values and inspiration for art and design). Finally, special attention has also been given to identify and highlight the role of underlying ecosystem processes and functions (e.g. suggesting some possible indicators and proxies to measure their status and trends) with a view to draw more (policy) attention to their importance while duly acknowledging difficulties in their valuation.

Similarly, a *list of indicators* for Nordic ecosystem services has been developed. The indicators have been identified based on the existing key literature (see below), focusing specifically on indicators that could be used – or would need to be developed – to assess and compare ecosystem services at national level. For this purpose a range of existing global and sub-global indicators were adjusted to make them more applicable at a national level and to make some preliminary comparison between countries. The identified indicators include both existing indicators and proxies, and desirable indicators that still need to be developed to directly assess the status or value of a certain service, such as direct indicators for regulating services. In general, the identified indicators reflect the quantity (e.g. area of a certain ecosystem type producing specified ecosystem service, for instance coastal wetlands for storm protection), quality (e.g. share of ecosystem in natural state, for instance proportion of total forest area that is old-growth forests) or socio-economic importance (e.g. number of beneficiaries, revenue) of services. In addition, information on diversity of species and habitats and/or pressures on biodiversity were sometimes used to try to reflect the long-term resilience and sustainability of a service.

A distinction has been made between biophysical and socio-economic indicators, i.e. ecosystems' ability to provide services and the socio-economic value of these services, with dedicated sets of indicators being developed for both. This kind of clear distinction of the indicators has often either been missing or been presented in vague terms in many current listings of ecosystem services. The use of "supply and demand" indicators also makes them easier to fit within ecosystem service cascade models (Haines-Young and Potschin 2010a&b, Maes et al. 2012b). For each ecosystem service, 2–4 biophysical indicators and 2–4 socio-economic indicators (e.g. direct indicators and proxies) have been identified. The list(s) of indicators has been used as a check list to identify gaps in the existing knowledge base.

The synthesis of biophysical *status and trends of ecosystem services* is based on analysing existing information and developing a number of novel estimates for the Nordic countries, building on the work carried out by the European Commission's Joint Research Centre (JRC) and the PEER Network[3] (Maes et al. 2010, Maes et al. 2011 and Maes et al. 2012). Based on the JRC and PEER work it was possible to develop dedicated

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[3] The Partnership of European Environmental Research Institutes (PEER) network.

estimates for the biophysical status and distribution of some key ecosystem services in the Nordic countries (e.g. carbon storage, soil carbon content, nitrogen retention, pollination and recreation).

Finally, the synthesis of *socio-economic value of ecosystem services* in the Nordic countries is based on a synthesis of the existing information. In addition, available information on the employment and job opportunities of ecosystem services and/or nature has been synthesised. No preliminary socio-economic valuation has been carried out in the context of this study. For the sake of comparability, rough EUR equivalents have been provided for estimates available in ISK, NOK, DKK and SEK. These EUR figures have been calculated based on the following 2012 exchange rates (without taking into account inflation): 1 EUR = 157.58 ISK / 7.52 NOK / 7.43 DKK / 8.72 SEK.

There are significant gaps in the available biophysical and socio-economic information on Nordic ecosystem services. Consequently, the synthesis of existing information provided under Sections 9.2 and 10.2 is not able to systematically cover the full list of identified ecosystem services and/or indicators. The differences between Sections 9.1 and 9.2 and Sections 10.1 and 10.2 provide a clear indication of the overall gap between the (preferably) required and currently existing information.

3.2.3 Data sources, gathering and peer-review

The *overall framework* for the study (e.g. links between nature and socio-economic wellbeing, biodiversity valuation and policy action) has been synthesised as according to the global TEEB initiative and related publications, in particular ten Brink 2011 and Kumar 2010. In addition, a range of key literature related to the economic valuation of ecosystem services has been taken into consideration.

Key aspects related to the *state of ecosystems and biodiversity* in the Nordic countries have been summarised based on the national reports developed in the context of CBD, EEA SEBI (Streamlining European 2010 Biodiversity Indicators) and the EU habitats and birds Directives.

The *identification of ecosystem services and their indicators* in the Nordic countries has been primarily based on existing key literature and previous assessment studies including Millennium Ecosystem Assessment (2005), TEEB (e.g. ten Brink 2011 and Kumar 2010), UK National Ecosystem Assessment (UK NEA 2011) and PEER/PRESS I and II assessment (2010, 2012). In addition, European and international databases and classification systems (e.g. EEA SEBI, FP7 RUBICODE and EEA

CICES) and recent literature on ecosystem service indicators (e.g. Layke 2009, Staub et al. 2011) have been used.

Information on the *status, trends and socio-economic value* of ecosystem services has been gathered via an extensive review of the existing literature. A systematic, keyword facilitated search of scientific literature related to ecosystem services (e.g. relevant ecosystem processes and related benefits) has been carried out by using the Web of Science database. This search has been complemented by a wide-ranging search of professional reports, assessments, case studies and examples available online. International or national databases and official national statistics have also been used. Finally, some information was derived directly from or developed together with national or international experts.

Finally, TEEB Nordic study has been supported by a network of international and Nordic experts (e.g. experts participating the global TEEB initiative). These experts have helped to gather and review the information presented in this report. The names of the individuals and organisations providing peer-reviews to this study have been acknowledged under "authors and contributors" at the beginning of the report.

PART II:

Background: issues, methods and approaches for understanding and responding to the value of nature

4. Nature, human wellbeing and economic development

Nature and human welfare are fundamentally interlinked, with biodiversity and ecosystems providing vital benefits, i.e. so called ecosystem services, to our societies (Box 4.1). In addition to these anthropocentric benefits, nature and biodiversity also have intrinsic value in their own right that is worth protecting (Box 5.1). However, global change caused by land use and the unsustainable extraction of natural resources is leading to degradation of ecosystems and their services, accompanied by declining numbers and increasing extinctions of species (Rockström et al. 2009). Current trends and future predictions are alarming, with estimations that species are becoming extinct 100 to 1,000 times faster than in geological times (Pimm et al. 1995) and the projected future extinction rate predicted to be 10 times higher than the current rate (MA 2005). At a global level, it is estimated that nearly two thirds of ecosystem services have been degraded in just 50 years (MA 2005).

With biodiversity loss and the degradation of ecosystems predicted to accelerate there is an increasing concern that the losses may further compromise the provision of ecosystem services in the near future, leading to fundamentally risking our own socio-economic well-being. For example, it has been widely acknowledged that the loss of even one "component" of biodiversity, e.g. a keystone species, can trigger substantial changes in the services provided by an ecosystem (Box 4.1, see also case study by Kulmala et al. in Annex II). Furthermore, the importance for maintaining ecosystem services is increasing with the adverse impacts of climate change. An increased variability of rainfall, for example, is predicted to lead to greater risk of drought and flooding whereas predicted higher temperatures are expected to increase water demand (IPCC 2007). These changes will further emphasise the importance of well-functioning ecosystems and their ability to regulate and buffer against environmental changes, especially over the long term.

Box 4.1 Key definitions: biodiversity, ecosystems and ecosystem services

Biodiversity means "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (UN 1993).

Ecosystem means "a dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit (UN 1993). Every ecosystem is characterized by complex relationships between living (biotic) and non-living (abiotic) components (resources), sunlight, air, water, minerals and nutrients. Also, the abundance and diversity of species also play an important role.

Ecosystem services refer to the benefits that humans obtain from ecosystems. The Millennium Ecosystem Assessment identifies the following main categories of ecosystem services that contribute to human well-being:

- Provisioning services – products obtained from ecosystems (e.g. food, fibre, fuel, water)
- Regulating services – benefits from ecosystem processes (e.g. climate, floods, disease, waste and water quality)
- Cultural services – the non-material benefits people obtain from ecosystems (e.g. recreation, tourism, aesthetic, spiritual and ethical values)
- Ecosystem processes and functions necessary for the production of all other ecosystem services (previously refered to as supporting services) (e.g. soil formation, photosynthesis, nutrient cycling.

Further to the classification above, *habitat services* can also be recognised as a separate category of ecosystem services to highlight the importance of ecosystems to provide habitats for migratory species (e.g. as nurseries) and as gene pool "protectors" (maintain gene pool diversity and vitality) (Kumar 2010).

Ecosystem resilience refers to the capacity of ecosystems to cope with disturbances without shifting into a qualitatively different state, including without a disturbance to the provisioning of ecosystem services. It is considered that biodiversity increase the resilience of an ecosystem.

Stocks and flow of ecosystem services refer to, respectively, the capacity of ecosystems to deliver benefits and the flow of actual benefits to people. The scale of the flow can range from local to global. For example, direct benefits from pollination are experienced on a local scale whilst also supporting food security at the global level. An ecosystem that is degraded has a reduced stock of services, and the flow of benefits is lower as a result.

Natural capital is an economic metaphor for the (limited) stocks of physical and biological resources, including ecosystem services, found on Earth (MA 2005). To use the economic metaphor, ecosystem services flow from "natural capital stocks" just like interest or dividends flow from stocks and shares.

Green infrastructure: a strategically planned and delivered network of high quality green spaces and other environmental features, designed and managed to protect biodiversity and deliver a wide range of benefits and services to people. Green Infrastructure includes natural and semi-natural areas, features and green spaces in rural and urban, terrestrial, freshwater, coastal and marine areas. Protected areas are considered to be at the core of Green Infrastructure. (EC 2012b).

Links between biodiversity and ecosystem services are complex, with many factors influencing ecosystems' resilience and capacity to provide services. The diversity of organisms that lives, grows, reproduces and interacts within ecosystems contributes to ecosystem processes by helping to mediate local and regional flows of energy and materials. Some services are directly linked to the composition of species (e.g. bees' natural pollination capacity) while others depend on the role of physical structures and processes at the ecosystem scale (e.g. flood regulation). The loss of any "component" of biodiversity can trigger a change in the stock and/or flow of ecosystem services (Worm et al. 2006, Mace et al. 2011). Depending on the circumstances, such changes have the potential to influence both the magnitude and the stability of vital ecosystem processes. For example, the loss of bees is sparking worldwide concern because it directly affects natural pollination capacity, which is of critical importance to ensure food security. Moreover, there is also strong evidence that more biologically diverse ecosystems are more resilient to changing physical environments (Walker et al 1995). In the face of the impending impacts of climate change maintaining diverse ecosystems will thus prove vital to ensure the reliable provision of ecosystem services.

Consequently, protecting our natural environment underpins *broader human well-being* from global to local levels. In particular, the poor often depend most directly on ecosystems for basic goods and services and are therefore the first to suffer the impacts of ecosystems degradation. In developing countries about 80% of the population relies on traditional medicines and treatments extracted from natural sources for their healthcare needs (WHO 2008). This reliance on healthy natural systems for human livelihoods and well-being is apparent when examining the dependence of many rural communities on protected forests, pastures, wetlands and marine areas for subsistence and livelihoods. Moreover, conserving nature and natural capital also contributes indirectly to material human well-being by supporting enterprises that provide employment and income to sustain individuals, families, communities and societies. Finally, nature also provides a number of benefits related to aesthetic, spiritual and psychological welfare.

Given the reliance of most of human activity on natural systems, the loss of ecosystem services is expected to have direct repercussions to our *economic wealth*; however, these tend to be systematically underestimated (see Chapter 5). In general, economic prosperity heavily depends on the flow of services of four types of capital: man-made,[4] human, social and natural (ten Brink et al. 2011). The importance of natural capital, including biological resources and ecosystem services, as a production factor should not be overlooked as it maintains – and even expands – our options for sustainable economic growth and development. In more concrete terms, the number of sectors benefiting from ecosystem services represents a far larger share of the economy than many appreciate. For example, in the pharmaceutical industry 26% of all new approved drugs over the last 30 years are either natural products or have been derived from a natural product (Newman and Cragg 2012). The pharmaceutical industry has been estimated to directly derive 25–50% of its global turnover (total industry turnover 488 billion EUR) directly from genetic resources (ten Brink 2009). Similarly, human reliance on animal-pollinated crops demonstrates the value of the ecosystem services provided by pollinators. Globally, 75% of primary crop species and 35% of crop production rely on some level of animal pollination (Klein et al. 2007). Nature and ecosystem services also underpin the tourism sector that to a large extent depends on healthy, attractive and environmentally stable conditions to thrive. Tourism remains a primary source of foreign exchange earnings and one of the world's leading job creators (UNWTO 2010). The sector has been estimated to support over 200 million jobs (Backes et al. 2002) and reached in 2008 record earnings of 720 billion EUR (UNWTO 2009). Furthermore, the vast majority of Least Developed Countries rely on tourism for their economic development.

[4] i.e. manufactured capital (incuding fixed assets (such as buildings and structures, transport equipment, cultivated assets), inventories and valuables) and financial capital.

5. Understanding and assessing the value of nature

5.1 Why and how do we assess the value of nature?

Many of the values associated with benefits people obtain from nature (outlined in Chapter 4 above) are not acknowledged and/or accounted for in decision-making (TEEB 2010). The short-term, immediate economic gains of exploiting natural capital often tend to override the long-term welfare benefits of conservation and sustainable use simply because the latter are less tangible and not registered within our socio-economic framework. In other words, the values provided by ecosystems and biodiversity are broader than what is currently captured by the markets, resulting in *significant undervaluation of the overall benefits nature provides to people*. While some ecosystem services, such as most provisioning services, are traded in – and hence valued by – the markets, most do not have corresponding markets or prices. Moreover, many economic actors, including both individuals and companies, benefit from biodiversity and ecosystem services without paying any regard to – or providing any compensation for – the maintenance of those services. Consequently, a majority of the benefits provided by nature remain invisible to both policy- and decision-making and the society as a whole. This is the case, for example, with economic gains associated with the maintenance of different regulating services, such as climate and water regulation and mitigation of natural hazards (see Section 5.3 below). Consequently, when trade-offs between conservation and other policy objectives, such as agriculture, infrastructure and economic development, are being considered the final decision often favours the latter, at the expense of the environment, local communities and broader society.

The under-appreciation of the true socio-economic value of nature is seen as one of the underlying reasons for the continued loss of biodiversity, ecosystems and related services. The valuation of ecosystem services aims to capture the numerous values – market and non-market alike – that people derive from nature and to integrate these values into market-driven decision-making processes. By doing so valuation is hoped to support more sustainable use of natural capital and alleviate the increasing pressures imposed on ecosystems and biodiversity. In many cases, recognising the value of ecosystem services can facilitate better and more cost-efficient decisions and avoid inappropriate trade-offs, as it improves the quality and stability of the choices across all sectors and levels (ten Brink 2011). In particular, integrating the economic values associated with sustainable, ecosystem-based management into decision-making can demonstrate the benefits of conservation and restoration of nature (i.e. *benefits of investing in nature*) as well as the risks and costs of inaction on biodiversity loss and ecosystem degradation.

Consequently, valuation of ecosystem services represents a valuable tool to provide such economic information to improve policy-making. It essentially aims to analyse the link between ecosystem functioning and human well-being by assessing the economic consequences of changes in ecosystem provision. However, it is important to note that because valuation builds on the concept of ecosystem services it represents a purely anthropocentric conceptualisation of nature. Therefore, it only captures the values – past, current or future – related to human beneficiaries. This implicitly omits the intrinsic values of nature and therefore represents only a partial justification for the conservation of biodiversity and ecosystems.

Assessing the different socio-economic values of nature requires a careful analysis of the link between ecosystems and human well-being and hence a clear definition of the terms and typologies employed. It is essential to clearly delineate between ecological phenomena (functions), their direct and indirect contributions to human welfare (services), and the welfare gains they generate (benefits and related values) (Pascual et al. 2010). Finally, the meaning and conceptualisation of the value itself needs to be well understood and recognised (see Box 5.1).

There are different ways to assess the socio-economic value of nature and, in a very broad sense, the valuation of ecosystem services can be done at three levels – qualitative, quantitative and monetary (Figure 5.2) (White et al. 2011). *Qualitative analysis* generally focuses on non-numerical indications of value such as benefits to mental and physical health, social benefits from recreation, benefits related to security and broader well-being. *Quantitative analysis* focuses on numerical data, including the number of people visiting national parks, number of avoided health impacts, quality of water, or quantity of carbon sequestered. *Monetary analysis* focuses on translating the qualitative and quantitative aspects into a particular currency, for example by calculating the revenue generated by visitors to national parks or estimating the amount of avoided costs when maintaining nature's own ability to purify water or mitigate flooding. Values identified via qualitative, quantitative and monetary assessments, as well as values not yet known, captured or realised by humans, form the total value of an ecosystem (i.e. so called "total system value") (Figure 5.1).

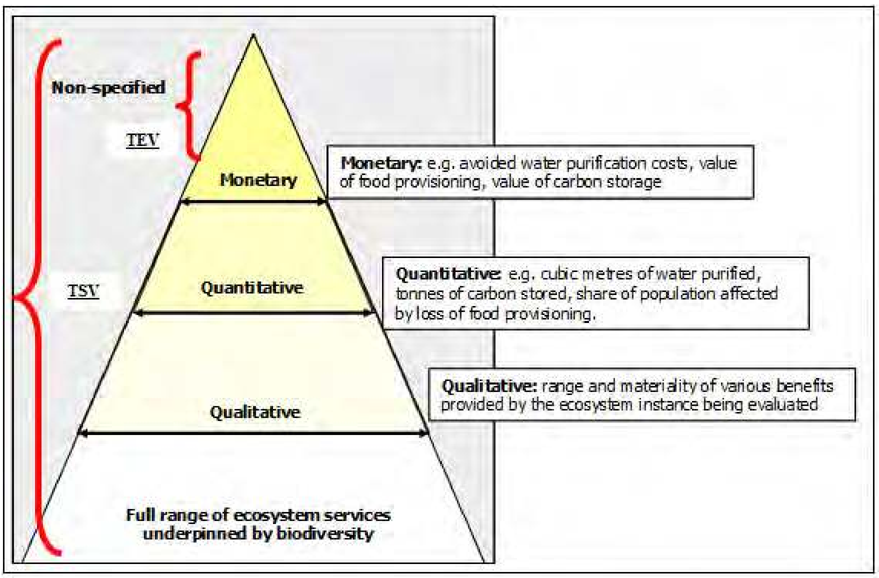
Box 5.1 Different meanings and conceptions of value

"Value" is a multi-dimensional, context-dependent term which is difficult both to conceptualise and operationalise. Initial distinction can be made between the *intrinsic and extrinsic values*. Whereas the extrinsic (also known as instrumental) values are derived from a certain anthropogenic goal, purpose or objective, the intrinsic values are associated with the value certain entity has "by (or of) itself". In other words, intrinsic values are independent of human utility or well-being and are often associated with ethical considerations.

Different scientific domains hold different views on how to measure and define the value of ecosystems. Of the existing definitions the Millennium Ecosystem Assessment definition (MA 2005) can be considered as the most commonly used. It defines value as "the contribution of an action or object to user-specified goals, objectives or conditions", measurement of which could include any kind of metric from various science fields, including ecology, sociology or economics (TEEB 2010). Consequently, the distinction is nowadays commonly made between ecological, socio-cultural and economic benefits and values (Ibid).

In general, several of the socio-economic values related to nature can be assessed in terms of *economic valuation* (See Annex I). The type of valuation approach used (i.e. qualitative, quantitative or monetary) depends on the time and resources available, type of benefit measured and decision-making process for which the benefit is measured. For monetary valuation the choice of method also depends on context, i.e. what is the policy decision, geographical scale, spatial and temporal resolution and costs of valuation (Barton et al. 2012). Generally speaking, qualitative assessment is the least challenging and resource intensive type of assessment, while monetary assessments are the most resource intensive. Given the non-market nature of several ecosystem services only a limited number of services are amenable to monetary analysis, in particular without increasing the required time and resources. Consequently, it is crucial to define the policy problem at hand (e.g. related information needs) and based on that select the most appropriate type of assessment to use for a given situation. In a number of cases, qualitative and quantitative assessments and the use of multi criteria analysis (MCA) can sufficiently support decision-making whereas in other cases a monetary assessment is needed to guarantee policy action. Please see TEEB 2010 for further guidance on the use of different approaches and assessments.

Figure 5.1 A "benefits pyramid" illustrating the relationship between the total economic value and the total system value



TEV = total economic value, TVS = total system value. Source: Gantioler et al. 2010, adapted from TEEB 2009.

5.2 Economic valuation within ecosystem service assessments

The approaches outlined above (the methods explained in detail in Annex I) can be used to design and carry out assessments of the benefits provided by ecosystems at local, regional or national level. Such assessments can be used to communicate the importance of ecosystems and related services in supporting sustainable economic development and human wellbeing, while also helping to inform decision-makers at different administrative levels about the implications of biodiversity loss and ecosystem degradation for broader policy goals such as climate change mitigation and adaptation, food and water security.

Developing *ecosystem service assessments* requires identifying the most suitable classification of ecosystem services and consequent development of indicators to reflect the value of these services. Various classification of ecosystem services are employed in the literature (e.g. Boyd and Banzhaf

2007, Wallace 2007, Costanza 2008, Fisher and Turner 2008) and it has been generally acknowledged that different classifications are required to address different policy goals and needs (e.g. see Fisher et al. 2009). For example, in the context of economic valuation it is particularly relevant to use classification that prevents double-counting the values associated with benefits. Such double-counting might arise when an ecosystem service supports the production of another service, i.e. when supporting and regulating services such as pollination and water regulation support the maintenance of production services.

After a suitable classification is identified, appropriate *indicators for the availability and supply (i.e. stock and/or flow) and socio-economic value* of each of the services needs to be developed. A number of such qualitative and quantitative indicators are already in use or being developed, based on the Millennium Ecosystem Assessment framework. However, a large gap still remains in the knowledge base and very few widely-accepted indicators exist. At present, there are more indicators available for provisioning services as these are incorporated into marketed commodities (e.g. wood for timber and fuel) than indicators to measure regulating and cultural services and the underlying ecosystem processes. Nonetheless, the use of ecosystem services indicators has already been demonstrated, such as in the case of UK National Ecosystem Assessment which provided a comprehensive assessment of the state of and trends in ecosystems in the UK (UK National Ecosystem Assessment 2011).

In order to assign values for ecosystem services at regional or national scale *aggregation and scaling up* of economic valuations, supported by "transfer" of results between areas, is usually employed. This involves gathering relevant primary valuation evidence and aggregating their results over the area (or population) being assessed, making use of the benefit transfer method (below). Scaling up of the values over large geographical areas to provide values of ecosystem services at large scale is rather problematic and due care needs to be taken to ensure robustness of the approach (see Pascual et al 2010). However, different approaches and methodologies to conduct such large scale assessment are currently being developed.

Benefit transfer method (also known as value transfer method) involves the application of values obtained from a particular context ("the study site") to estimate the value of another ("the policy site") (e.g. Desvouges et al. 1998, Navrud and Ready 2007, Pasqual et al. 2010, ten Brink et al. 2011). The basic rationale for employing this method is that there may be sufficient commonalities between areas (ecosystems, landscapes, regions) to allow values from one to be transferred to another.

Due to the relatively high cost of conducting new primary valuation studies for each particular area or ecosystem, and given limited data availability, this technique is usually employed to provide a cost-effective alternative for deriving overall value estimates of certain sites/ecosystems/regions. However, it has to be noted that the benefit transfer method involves many caveats and therefore it should be cautiously applied, and in a transparent manner (ten Brink et al. 2011). Greater awareness, guidelines and practice is needed of the benefit transfer errors that are considered legitimate in particular decision and policy-making contexts (Barton et al. 2012). Most importantly, it must be ensured that the values used are robust and, as many ecosystem services are highly context-dependent, great care needs to be taken when the values are transferred to ensure the similarities between the different areas. This requires a detailed understanding of the original and new areas as well as the underlying factors influencing particular ecosystem service provision and the socio-cultural context in which valuation is being conducted.

6. Value of nature and the policy response

There is an urgent need for policies and decision-making processes to take into account the range of different values provided by nature in order to effectively address the increasing – and fundamentally interlinked – concerns for biodiversity loss and human wellbeing. The necessary policy response can be seen to consist of certain key areas of action including 1) improving the way we measure and monitor the status and value of our natural capital and 2) reforming and improving the framework of policy instruments (e.g. regulations and incentives) aimed at sustainably managing our natural capital. With the use of such information and tools it will be possible to ensure that our socio-economic systems (e.g. markets) appropriately integrate the true value of nature, including reflecting the true costs of biodiversity loss and the degradation of ecosystems and their services.

6.1 Measuring and monitoring our natural capital

Without effective systems for measuring and monitoring the value of nature it is hard to appreciate the range and scale of impacts resulting from biodiversity loss and ecosystem degradation. Consequently, it is difficult to ensure sustainable management and stewardship of our natural capital. Informed policy decisions therefore require relevant and up-to-date information on the state of, trends in and pressures on the natural capital (e.g. biodiversity, ecosystems and related services). Moreover, improving measurement can be a cost-effective approach to identify and address risks early and avoid higher damage costs later.

Given the emphasis on existing markets and market price as a sole indicator for socio-economic value, *the majority of benefits provided by nature are not integrated into national accounting systems or captured by existing macro-economic indicators (e.g. Gross Domestic Product – GDP),* despite of the important role they play in supporting our wellbeing and wealth. Consequently, several of these benefits may be appropriated or degraded without any indication of the socio-economic consequences.

For example, traditional measures of national income, most notably GDP, can be a misleading indicator of national wealth, sustainability and/or societal well-being because they do not adequately represent the role of natural capital in underpinning wellbeing.

It is therefore increasingly acknowledged that the establishment of ecosystem service indicators and carrying out ecosystem service assessments, as outlined in 5.4 above, play an important role in improving our understanding of the true economic, social and environmental consequences, such as trade-offs, and integrating this knowledge into policy decisions (ten Brink et al 2011). Extending the application of ecosystem service indicators is necessary to support more efficient integration of the wider consideration of sustainability, including biodiversity conservation and the broader, non-market value of ecosystem services, in other sectors such as agriculture, forestry and fisheries. Moreover, establishment of a widely recognised and robust set of indicators for ecosystem services and integrating them into the national accounts (i.e. developing ecosystem accounting) is required to measure the true progress towards sustainability targets, estimate the efficiency of approaches taken and, if required, to improve their legitimacy and effectiveness.

6.2 Adopting appropriate tools for integrating the value of nature into policy and decision-making

Understanding the value of nature, for example through economic valuation, also forms a basis for reforming the existing policy tools in order to integrate these considerations into decision-making processes, or to develop new, innovative approaches to do so. This can take place via the adoption of different approaches and measures, such as rewarding benefits and reforming subsidies, supported by a comprehensive regulatory basis.

A clearly defined *regulatory framework*, building on a set of key principles (see Box 6.3) and our understanding of the true socio-economic value of nature, is an essential precondition for addressing pressures on and the degradation of biodiversity, ecosystems and related services. It provides an essential baseline (definition of rights and responsibilities, monitoring and sanctions) for introducing compensation measures and market-based instruments. Moreover, setting out clear rules and standards for the use of natural capital can also trigger urgent environmental improvements and help to reduce further pollution and hazardous events. In Sweden, for instance, following forest decline in the 1980s and 1990s, the Forestry Act was updated with new standards to be established to ensure that forests provide a valuable sustainable yield and at the same time preserve biodiversity. Recent statistics have shown positive results, with a substantial increase in the number of old or deciduous trees – and associated ecosystem services – recovered in the last 20 years (Swedish Forestry Act in Berggren 2009).

Box 6.3 Fundamental principles for integrating the value of nature into policies

Together with equity and social considerations, three closely related principles should guide the choice and design of policy instruments:

The polluter pays principle: The polluter pays principle (PPP) requires costs of biodiversity loss and ecosystem degradation to be "internalised" and reflected in the price of goods and services. The polluter has to take prevention or reduction measures and in some cases pay taxes or charges and compensate for pollution impacts. For ecosystem degradation, the polluter should pay directly for clean-up and restoration or pay a fine to help offset damage costs.

The user/beneficiary pays principle: The user/beneficiary pays principle is a variant of the PPP. Recipients benefiting from ecosystem services should contribute towards the cost of maintaining the service. For examppe, users of clear water should contribute towards the cost of conserving and/or sustainably managing the wetlands responsible for water purification.

The full cost recovery principle: This principle provides that the full costs of protecting or sustainably managing an ecosystem service should be recovered from the entity benefiting from the service.

Source: Adapted from Ten Brink et al. (2009)

In addition to regulation, one of the most critical steps for ensuring coherent and efficient policies is the *reform of subsidies* to reduce negative impacts of politically supported measures and activities on nature and to make public expenditure more effective. A subsidy can be defined as a government action that confers an advantage to consumers or producers in order to supplement their income or lower their cost (OECD 2005). The overall level of global subsidies and their consequent impacts on economies are enormous. The energy sector receives the largest subsidies in the world at around 423 billion EUR / year in 2008 (IEA 2010), followed by subsidies to agriculture estimated at over 190 billion EUR / year in OECD countries alone in 2006 to 2008 (OECD 2009). While not all subsidies are bad for the environment, some subsidy types have been identified as critical drivers of environmentally harmful activities and can result in losses of ecosystem services. For example, subsidies to the fisheries sector can have significant negative impact on the environment by encouraging increased fishing effort and contributing to the decline of global stocks. A 2007 study by the University of British Columbia estimated global fisheries subsidies at 22 to 26 billion EUR / year, of which at least 16 billion EUR contributes to overcapacity (Sumalia and Pauly 2007). Evidence from the Nordic countries shows, however, that reduction of subsidies can be carried out without devastating impacts on the fisheries industry. In Norway, subsidies were reduced from a peak of 116 million EUR / year in 1981 (approximately 70% of value added in the industry) to only 23 million EUR by 1994. This subsidy reform encouraged structural changes that over the years have helped to create a self-sufficient industry (OECD 2006) (See also Chapter 12).

The last two decades have seen increased efforts to phase out or reform subsidies in some countries with progress being made in understanding the scale of subsidies in different sectors, the extent and mechanics of their environmentally harmful effects and their cost-effectiveness. Recent international (global and EU) commitments have called for the reform of environmental harmful subsidies (EHS) in the context of resource efficiency. Experience has shown that successful reform or removal has the potential to alleviate environmental pressures and simultaneously increase economic efficiency and reduce the burden on government budgets (ten Brink 2011). Yet, progress on subsidy reform remains slow and protracted.

Several possibilities are also available to maintain ecosystem services by rewarding their maintenance and sustainable management through *payments and markets,* i.e. by adopting *market-based instruments (MBIs)*. The importance of MBIs in supporting the regulatory policies to halt the loss of biodiversity and deterioration of ecosystems is increasingly being recognised. MBIs can change the incentives available to private actors and contribute to more effective and efficient management of resources, biodiversity and ecosystem services. These instruments, including taxes, charges, fees and fines, commercial licences, tradable permits, quotas, liability rules, subsidies and payments for ecosystem services (PES) (see below), send out economic signals and can be adjusted to discourage harmful activities by increasing the cost of using certain services (e.g. requiring users to buy tradable permits). Targeted reinforcement of this kind can catalyse a shift to more environmentally friendly alternatives. In comparison to regulation, MBIs can give private actors more choice in selecting the most cost-efficient options.

A wide range of MBIs can be employed to help to preserve ecosystems and their ability to provide ecosystem services. MBIs can encourage the conservation and sustainable use of ecosystem services in different ways. Firstly, they can be used to increase the price of a (scarce) resource, encouraging decreased use of the resource and leading to diminished negative effects on biodiversity, ecosystems and related services. Pricing can also increase payments for the maintenance of services (e.g. carbon storage or flood control) and hence encourage due practice in conserving and restoring nature. MBIs such as quotas and tradable permit schemes can be used to control quantities by placing an absolute limit on the use of natural resources and therefore encouraging resource efficiency. Offset requirements and associated banking schemes can do the same, though their use will only contribute to conservation objectives under certain circumstances. Based on the polluter-pays principle, MBIs can also be targeted to assign responsibility for the cost of ecosystem damage to those causing it. This provides an economic incentive to the users of ecosystem services to incorporate potential environmental risks into their decisions and might also stimulate technological innovations. For example, in Denmark a tax of 37% on the retail price on pesticides was introduced in 1986, helping to contribute to a 47% reduction in pesticide use by 1999[5] (Sjöberg 2007). The tax is foreseen to be doubled from 2013 onwards with the tax base being changed from the value to the volume (Prof. Hansen, pers. com.). In addition, mechanisms aiming to improve market conditions, such as labelling schemes and information programmes, are sometimes categorised as MBIs. For example, the Nordic Ecolabel (established in 1989 by the Nordic Council of Ministers) has become the official eco-label for the Nordic countries to promote sustainable consumption and help consumers to choose environmentally-sound products.

The existing markets do not fully recognise the value of nature. Public and private *payments for ecosystems services (PES)* can be used as an instrument that can be applied to reward the maintenance of ecosystem services at different scales. PES are payments targeted to incentivise the maintenance and sustainable management of ecosystem services, giving those responsible for protecting or maintaining a service an incentive to continue to do so. For example, water utility companies can pay land owners and -managers to protect water catchments. PES schemes offer major potential to obtain new funds and they can be particularly rele-

[5] It is to be noted that the tax was ccompanied by a range other measures (e.g. reduced cultivated area, increased area with organic farming supported by other measures and a ban on several harmful pesticides and biocides) and conseqently the 47% reduction cannot be fully attributed to the introduction of tax.

vant in situations where trade-offs exist between different land-uses by tipping the balance to make conservation more profitable for the landowner. There are already more than 300 PES programmes in existence (Wunder et al. 2008) which typically target maintenance of water quality, improving carbon sequestration, protecting soil or conserving biodiversity. International PES opportunities include the UN Framework for Convention on Climate Change (UNFCCC) proposal for REDD+, a proposed Green Development Initiative to support the implementation of the UN Convention for Biological Diversity (CBD) and other emerging initiatives which could have far reaching benefits to support direct investment in biodiversity, public good and natural capital across a wide range of ecosystems.

In general, PES schemes are flexible and can be established by different actors. While they are often seen as mainly government financed, an increasing number of schemes are financed voluntarily by private companies and individuals. However, mainstreaming the adoption of ecosystem services markets faces several challenges and constraints. There are also risks associated with poor regulation of rent-seeking behaviour of actors in offset markets, with examples of the possible negative conservation consequences of poorly designed biodiversity offset and habitat banking schemes (Vatn et al. 2011). This highlighting the importance of careful design and preparation to ensure that PES schemes are effective and appropriate for local conditions (ten Brink et al. 2011b).

Biodiversity offsetting and banking are other instruments currently being discussed, with the potential to avoid increasing cumulative losses to biodiversity and associated impacts on the provision of ecosystem services. Biodiversity offsets are compensatory mechanisms to remediate the negative environmental impacts of particular projects, essentially aiming to achieve "no net loss" – or preferably "net gain" – to biodiversity (e.g. Hansjürgens et al. 2011). The offset should provide measurable biodiversity benefits (credits) that can be used to compensate for the damage (debits), with the given credits being comparable to the debits. Credits result from actions such as the protection of valuable habitats that are at risk of loss or degradation (risk aversion offsets) or enhancement, restoration or creation of habitats and associated species populations. Offsets can however take time to provide biodiversity benefits, leading to significant losses of biodiversity in the interim. Offsets also tend to result in fragmented and isolated compensation measures that may not be viable on a wider landscape scale thus failing to offer long-term conservation benefits.

Biodiversity or habitat banks have the potential to be constructive mechanisms for delivering offsets, and address some of the limitations of simple offset requirements. Biodiversity banks create an MBI to turn offsets into tradable assets (credits). The resulting biodiversity credits are traded in a similar fashion to that of emission permits within the EU Emission Trading Scheme (ETS), although the system is more complex than carbon trading due to the more heterogeneous nature of the good being traded. Depending on design, biodiversity credits can be produced in advance and be stored over time, allowing for increased flexibility. Experience to date shows biodiversity offsets and banks, if they are well-designed and build upon strong regulatory frameworks, can be efficient MBIs to help businesses compensate for the residual unavoidable harm from development projects.

Establishing effectively managed coherent systems of national and regional protected areas (PAs) proves essential to conserve biodiversity and maintain vital ecosystem services, such as water purification and erosion control (Dudley and Stolton 2003, Stolton et al. 2006). Thus, recognising the *socio-economic role of protected areas* and investing in the establishment and management of these areas can be seen as a one way to integrate the value of nature into policies and decision-making. Designating an area as protected does not necessarily guarantee success, however without appropriate management PAs often fail to meet their objectives. External pressures, lack of financial resources, local conflicts and poor management capacity are frequent obstacles hindering PAs from reaching their full (socio-economic) potential. Policy makers can strengthen the effectiveness of PAs through a clear national framework, including a clear legislative basis, and by ensuring funding models provide the right incentives and sufficient financial stability for effective management. Using the broader ecosystem services perspective is a powerful approach to inform management planning, to unite different motivations for conservation and to distribute the burden of access restrictions in an equitable manner (Wittmer and Gundimeda 2012). Once the full range of provided ecosystem services is taken into account, the benefits of Pas often exceed the costs (Kettunen et al. 2011, Jacobs 2004). Evaluation of benefits and costs associated with ecosystems within protected areas can support fundraising, while monetary values can help to translate ecological concerns into economic arguments. To address funding gaps financial resources need to be secured through for example innovative funding instruments and adequate international funding.

Building on the possibilities above, several Nordic countries and stakeholders are already taking steps to initiate policy action on the value of nature and integrating these insights into policies and decision-making. For example, there is an increasing interest to explore the possibilities for ecosystem accounting in the Nordic countries. Several initiatives are also underway to support so-called forest "bioeconomy" that is aimed at diversifying markets for forest resources, including developing markets for new biodiversity-based products. Finally, pioneering attempts have been made to highlight the socio-economic value of protected areas at regional and national level (see TEEB Nordic case study by Kajala in Annex II). A more comprehensive account of these initiatives is provided in Part III below.

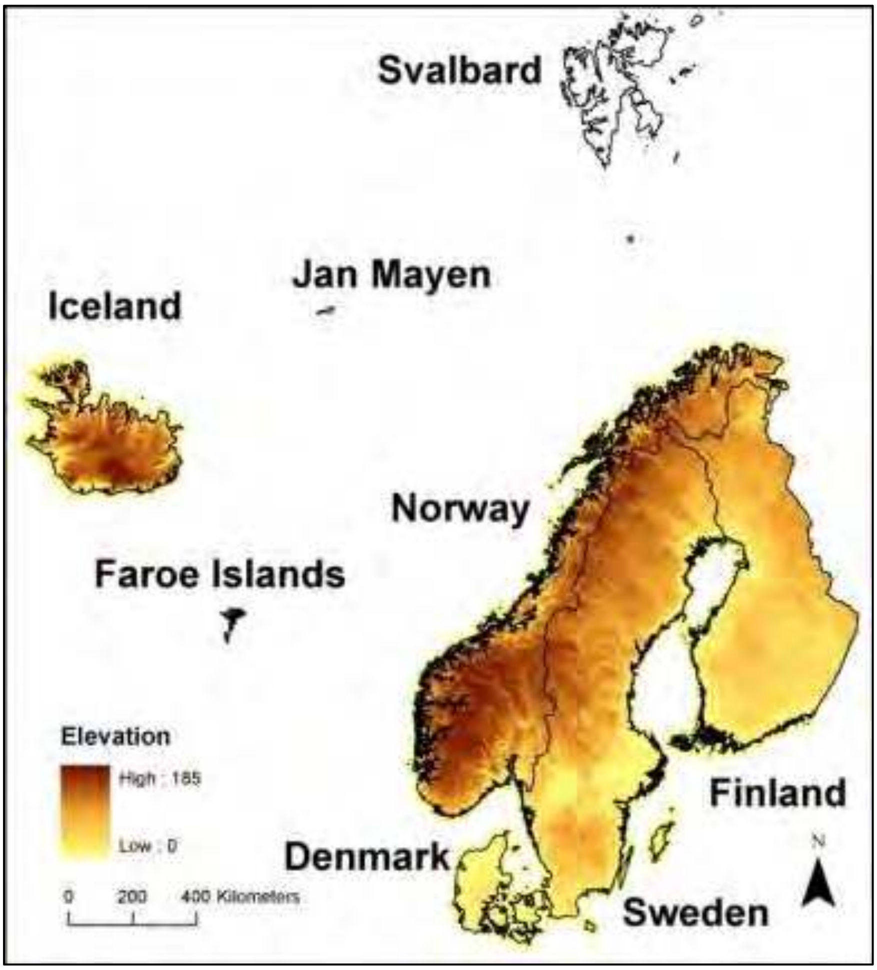
PART III:

The value of Nordic nature

7. Nordic countries and ecosystems

The Nordic countries are Denmark, Finland, Iceland, Norway and Sweden (in alphabetic order) (Figure 7.1 and Table 7.1). In addition, the Nordic region includes the three self-governing regions of Greenland (DK), the Faroe Islands (DK) and Åland (FI). Finland, Sweden and Denmark are members of the EU, and consequently subject to the EU 2020 Biodiversity Strategy, while Norway and Iceland are members of the European Free Trade Association (EFTA), participating in some EU initiatives. All Nordic countries are also Parties to the CBD, making them politically committed to implement the global biodiversity targets for 2020.

Figure 7.1 Map of the Nordic countries



Data source: EEA: Elevation map of Europe. © SYKE, © European Environment Agency.

Table 7.1 Key statistics of the Nordic countries. Source: SEBI, CLC2000

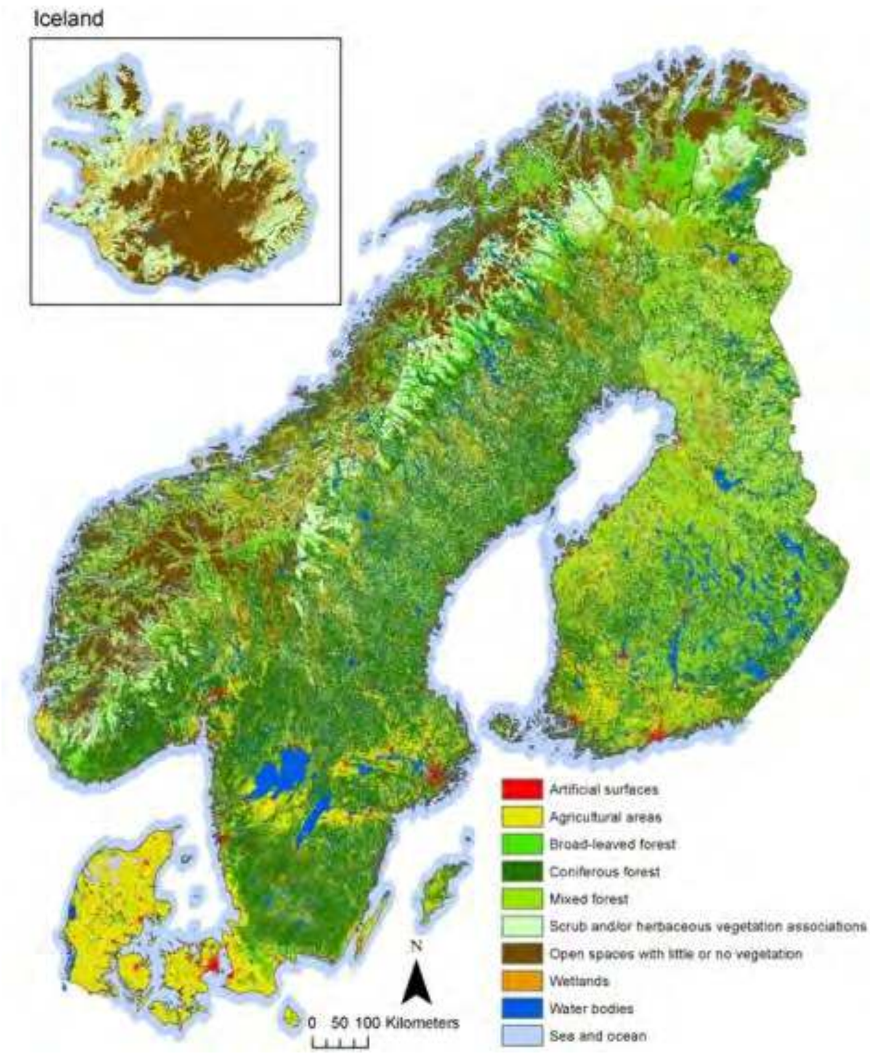
	Denmark	Finland	Greenland	Iceland	Norway	Sweden
Area (total)	43,000 km^2	391,000 km^2	2,166,000 km^2	103,000 km^2	385,252 km^2	450,000 km^2
Population size	5.4 million	5.2 million	0.057 million	0.3 million	4.8 million	9.2 million
Population density	128 / km^2	17 / km^2	0.027 / km^2	2.9 / km^2	12.4 / km^2	20.4 /km^2

Biogeographically the Nordic countries belong to the Palearctic region with five biogeographical zones present in the area: arctic (Norway, Iceland, Greenland), alpine (Finland, Sweden, Norway), boreal (Finland, Sweden, Norway), Atlantic (Norway, Denmark) and continental – nemoral (SE, DK). In addition, a boreo-nemoral zone (or hemi-boreal vegetation zone) marks the transition between the temperate deciduous forests of the nemoral zone and the coniferous forests of the boreal zone.

The nature of land cover in the Nordic countries varies from broad-leaved forests in the south of the region to the Arctic tundra in the north and from boreal forests adapted to continental climate in the east to the high slopes of the fjords in the west, characterised by high yearly precipitation. This variation is presented in Figure 7.2 below. In addition, Greenland has a very unique nature dominated by glaciers but also supporting unique ecosystems such as tundra and marine ecosystems with diverse fauna and flora.

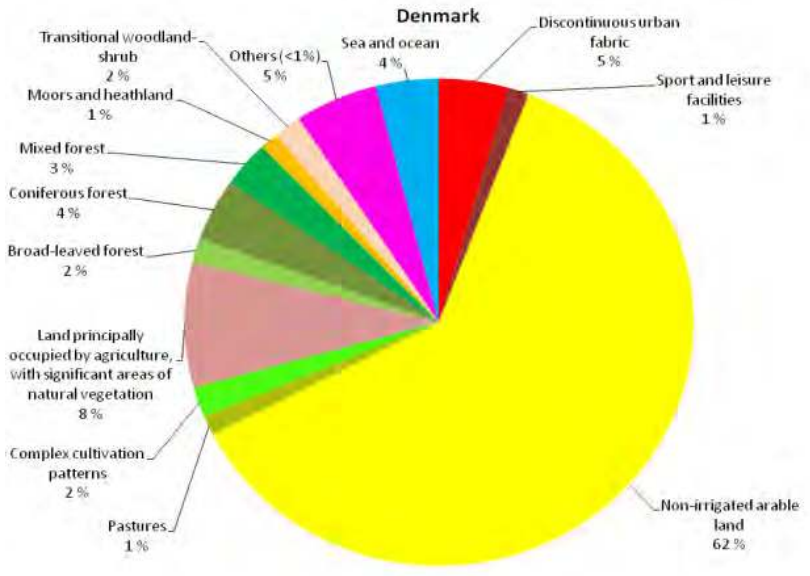
Based on the CORINE land cover (CLC) data (Figures 7.2 and 7.3), Denmark is characterised by agriculture with non-irrigated arable land covering 62% of the land area. In Finland and Sweden forests take up 57% and 54% of the surface area respectively (28% and 46% of coniferous forests, and 27% and 4% of mixed forests). In comparison, forest cover in Denmark is only 9%. In Norway, forests cover is 32% of the land (18% coniferous and 13% broad-leaved forests). Iceland is dominated by moors and heathlands (35% of the area), which also account for 14% of land cover in Norway. Peat bogs are also relatively common, covering around 6–7% of all Nordic countries except Denmark. In addition, bare rocks cover 23% of Iceland and 7% of Norway.

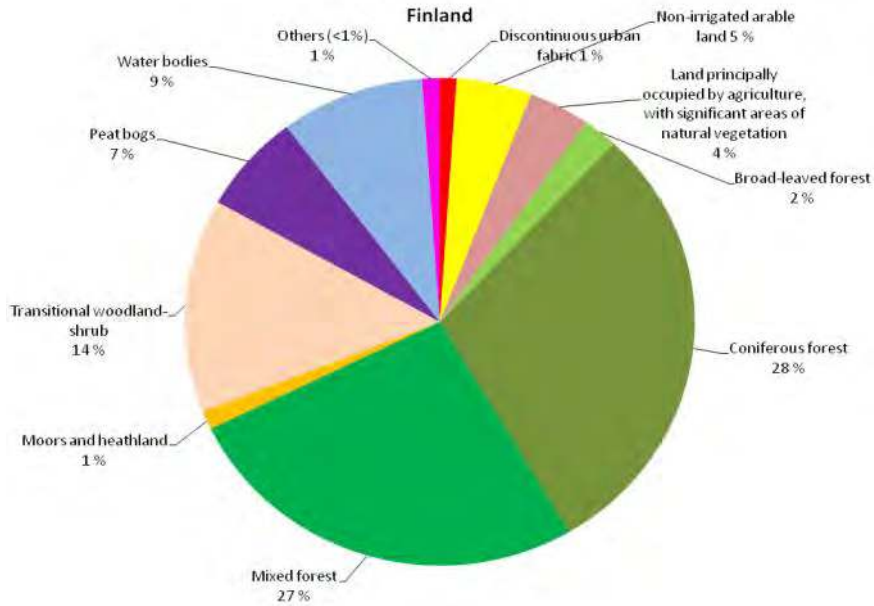
Figure 7.2 CORINE Land Cover (CLC) classifications in the Nordic countries

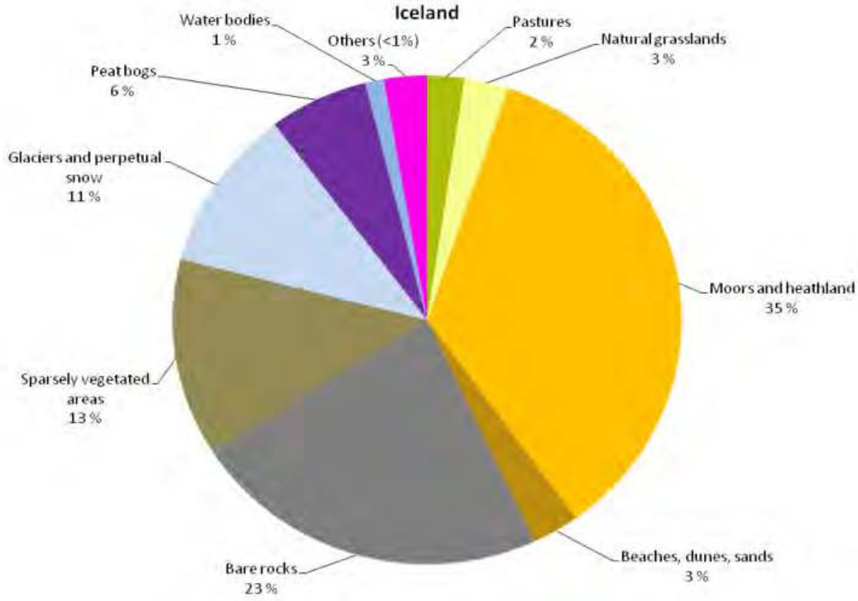


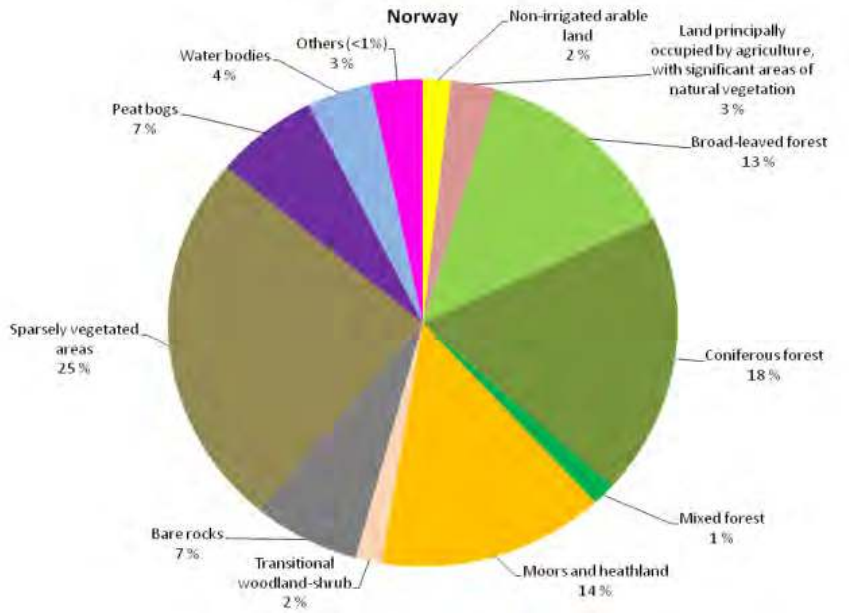
Data source: EEA: Corine Land Cover 2006 raster data – version 16 (04/2012). © SYKE, © European Environment Agency.

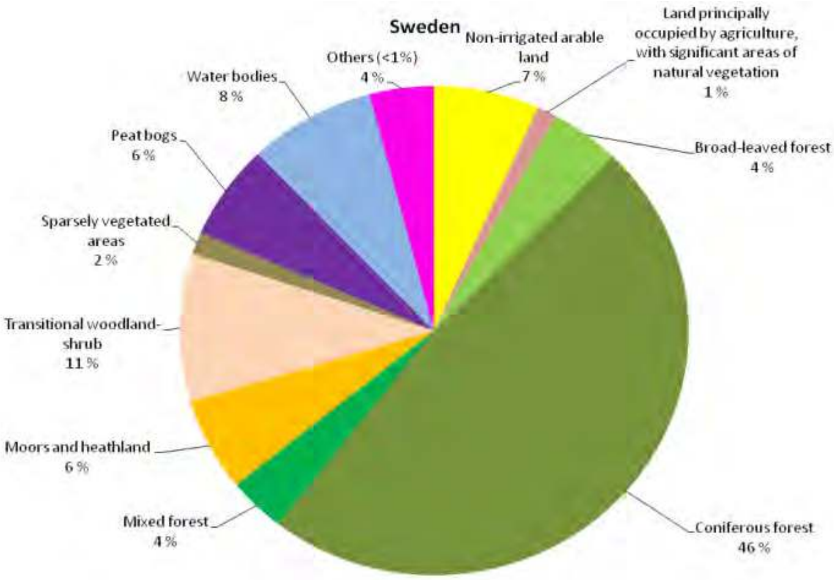
Figure 7.3 a–e: Main land cover types of the Nordic countries. The classes of which share of the total land cover were less than 1% are summed together to the class "others"






Iceland
Water bodies
1 %
Others (<1%)
3 %
Pastures
2 %
Natural grasslands
3 %
Peat bogs
6 %
Glaciers and perpetual snow
11 %
Moors and heathland
35 %
Sparsely vegetated areas
13 %
Bare rocks
23 %
Beaches, dunes, sands
3 %


Norway
Non-irrigated arable land
2 %
Land principally occupied by agriculture, with significant areas of natural vegetation
3 %
Others (<1%)
3 %
Water bodies
4 %
Peat bogs
7 %
Broad-leaved forest
13 %
Sparsely vegetated areas
25 %
Coniferous forest
18 %
Mixed forest
1 %
Bare rocks
7 %
Transitional woodland-shrub
2 %
Moors and heathland
14 %



Data source: EEA: Corine Land Cover 2006 raster data – version 16 (04/2012).

7.1 Nordic ecosystems: status and trends

In evolutionary terms, Nordic ecosystems are rather young as the whole Fennoscandia area was covered by ice during the last ice age approximately 10,000 years ago. This is one of the reasons why few endemic species are found within the Nordic region. The first human activities influencing Nordic ecosystems included hunting, gathering and slash-and-burn agriculture. However, most areas remained sparsely populated and consequently Nordic ecosystems stayed rather intact – almost in their pristine state – for a long time after the ice age (in many areas until the beginning of the 20th century). (Hallanaro and Pylvänäinen 2001)

Towards modern times (i.e. after the 1950s) human pressures on nature increased everywhere in Europe due to increased economic activities such as industrial forestry and modern intensive agriculture, resulting in drastic changes in land use and increased acquisition of natural resources. In general, the area of constructed ecosystems has increased in all countries with an average growth of 15% since 1990. There has been a slight increase in the area of forest ecosystems during recent decades accompanied by a decline in cultivated land. More detailed information on the changes in Nordic ecosystems is given in Box 7.1 below.

Ecosystem change and degradation are key reasons for the decline of species. Globally, the status of less than 3% of known species has been assessed so far. Compared to this global figure, knowledge on the status of Nordic biodiversity is considerably better. For instance, in Finland and Sweden the conservation status of 45% and 43% species respectively (approximately 21,400 and 20,800 species) has been evaluated (Rassi et al. 2010, Gärdenfors 2010) (Table 7.2). Changes in forest ecosystems, such as decreasing amounts of decaying wood or forest management activities, have been concluded to be the primary threat in the case of 30.8% of endangered species in Finland. In Sweden, almost half of the red-listed species (2,020 of 4,338) were found in the agricultural landscape (Berg 2010). The overgrowing of meadows and other open ecosystems was a primary threat for 25.7% of Finnish endangered species (Rassi et al. 2010). In addition, infrastructure development, construction of waterways, intensification of agriculture, mining and drainage of peatlands (for forestry and peat harvesting) were among the most significant causes of biodiversity loss (Rassi et al. 2010, Berg 2010) (see below). It is likely that these threat factors are common across the Nordic countries.

Table 7.2 Status of biodiversity in the Nordic countries

	Denmark	Finland	Greenland	Iceland	Norway	Sweden
Number of known species	30,000	45,000[1]	9,400	9,300	40,000	50,000
Number of assessed species	6,442	21,400	115	1,519	18,500	20,800
Red-listed species (CR, EN, VU)[2]	1,471	2,247	36	234	3,886	3,052

Source: SEBI.

[1] Data has been updated based on Rassi et al. 2010.

[2] Critically endangered (CR), Endangered (EN) and Vulnerable (VU).

Today, there are several pressures and threats affecting biodiversity and ecosystems (see Box 7.1, Normander et al. 2009). Habitat loss and degradation of ecosystems are the primary reasons behind biodiversity loss and the loss of ecosystem services at the global, regional and national scale, and this is also the case in the Nordic countries. Intensification of land use to support agriculture, forestry and new rapidly increasing bioenergy production are among the key drivers behind the observed negative trends. Furthermore, the decline of traditional farming practices, such as low-impact grazing and hay-cutting, and a shift towards intensified land-use characterised by modern techniques and external nutrient inputs threaten species adapted to traditional farming regimes. As a result, abandonment of cultivated land, cessation of grazing and consequent overgrowth are endangering the survival of several semi-natural habitats, especially in the southern parts of the Nordic region. As regards forests, old growth forests tended to provide habitats for the majority of endangered species in Nordic countries. Commercial forestry with high-intensity logging (generally clear-cutting) may have significant negative impacts on biodiversity and a range of ecosystem services. Another driver for both abandonment of cultural landscapes and forest regrowht has been substitution of domestically produced agricultural and timber for imports.

Within aquatic ecosystems, eutrophication via atmospheric deposition of nitrogen and leaching from agricultural fields has significantly affected both the structure and functions of coastal and inland water bodies. In particular, several naturally nutrient poor (i.e. oligotrophic) lakes and the Baltic Sea have been affected. In marine areas, commercial fishing – especially trawling –is known to cause damage to marine biodiversity, ecosystems and related services, for example, via reduction of stocks and benthic disturbances. Oil and gas exploration and production impact on marine biodiversity especially in Norway (e.g. see case study by Magnussen in Annex II) and they may also have an impact on marine areas around Greenland in the future. An important threat to Nordic wetland ecosystems has been lowering of the water table due to drainage and water abstraction. Mires and peatlands have been altered, in particular, in Finland but also in Sweden to increase timber production, or extract turf for energy from peat bogs (Turunen 2008, Lindholm and Heikkilä 2006, Hallanaro and Pylvänäinen 2002).

Intensification of human settlements and infrastructure (e.g. development of transport networks) result in fragmentation of many remnant ecosystems causing isolation that can drive some small populations to extinction. This is especially the case in the southern, more populated areas of the Nordic countries. At a local scale, urban sprawl threatens green areas that are exploited for development. In the intact areas and ecosystems still in their (semi-)natural state, increased tourism and recreation may increase pressures on nature with trampling and disturbance having possible negative impacts on some sensitive fauna and flora. Such influences have already been reported in Norway and this is an acute issue around urban areas in all the Nordic countries. Finally, pollution with environmental contaminants is affecting all Nordic countries, with a special threat to the vulnerable ecosystems in Greenland.

As everywhere else, the numbers of invasive alien species (IAS) continue to rise in the Nordic countries posing risks to biodiversity and the structure and functioning of ecosystems and the services they provide. Over 1,300 non-native species have established themselves in the Nordic region (Nordic Council of Ministers 2008). Examples of such harmful species with serious effects on biodiversity or ecosystem structure include American mink (negative impacts on water fowl) and Hogweeds (negative impacts on human health). Other examples of the species that might pose serious threats and also economic costs are Colorado beetles (destruction of potato crops) and pine wood nematode that poses a serious risk for pine forests and could influence the export of timber.

Finally, the impacts of climate change are a great concern for the Nordic countries. This is especially the case in arctic areas; in southern parts of the region climate change is still considered subordinate to the other threats listed above. In terms of negative impacts, in Finland the existing studies indicate negative impacts of climate change on some bird species, for example migration and nesting times changing compared to the available food resources, or changes in distribution patterns (Rainio et al. 2006, Virkkala and Rajasärkkä 2011). On the other hand, some new species such as butterflies have extended their range to the Nordic countries following the changed climate conditions. The influence of climate change on a number of ecosystem services was recently assessed in Finland showing that, for instance, increased precipitation can increase flooding and the nutrient loads to water bodies, increasing eutrophication. Increased temperatures can accelerate decomposition rates, bringing about increased nitrogen availability that can enhance forest growth rates. This can also influence other biodiversity depending on their adaptation capability (Bergström et al. 2011, Devictor et al. 2010). Despite serious influences of climate change on ecosystems, climate change was determined to be the primary cause of threat for only three species in Finland (Rassi et al. 2010).

To counter these threats, policy measures such as the implementation of EU environmental legislation and financial support to environmentally sustainable practices (e.g. organic farming) are also taking place in the Nordic countries with some positive effects. Improved standards for water quality (supported by the EU Water Framework Directive) have helped to reduce eutrophication of inland waters, improving the ecological status of lakes for example in Finland and Denmark. The same positive trend has been observed for Nordic streams, although the current ecological status of river systems is not as favourable. Furthermore, restoration of ecosystems (e.g. wetlands) has increased in, for example, Denmark and Sweden. It is foreseen that efforts in restoration will continue to increase throughout the Nordic region once implementation begins of the so-called “green infrastructure”, i.e. a network of green spaces and other environmental features to enhance the conservation of biodiversity and delivery of ecosystem services. The establishment of green infrastructure is one of the new goals of the EU Biodiversity Strategy for 2020 (Target 2).

However, not all existing policy measures are equally good for biodiversity. For example, in Iceland it is expected that government supported regional afforestation projects will double forest cover in the low lands in over the next few years, mostly due to planting of alien species which might have a significant future negative impacts on biodiversity. Luckily, attempts to return the native Icelandic mountain birch forests have also been launched (Thrainsson and Davidsdottir 2012). In Denmark, Sweden and Finland the EU Common Agricultural Policy (CAP) and its agri-environment payments have played a key role in supporting sustainable management and conservation of agricultural systems (Aakkula et al. 2010). Recent assessments indicate that the nutrient load from agriculture has been decreasing for both nitrogen and, in particular, phosphorus. This has been primarily due to the decrease in the use of artificial fertilisers. Instead, the leaching of nutrients of manure from (large) animal production is becoming a more serious problem.

Box 7.1 Trends in Nordic ecosystems

The trends of the main biomes are as follows (Normander et al. 2009):

Constructed or highly artificial ecosystems: The area of constructed ecosystems has increased in all countries with an average total growth of 15% since 1990, leading to increased pressure on biodiversity.

Regularly or recently cultivated ecosystems: The area of farmland has decreased by about 3% since 1990; The share of fallow land has dropped dramatically, from 11% in 2005 to 6% in 2008 (following the phase-out of EU set-aside schemes); The share of organic farming stands unchanged at 6% since 2000.

Marine ecosystems: Not assessed by Normander et al.

Coastal ecosystems: The area of dunes and seashore meadows has decreased dramatically in Denmark (not documented in the other countries). The area of Norway's coastal zone that is affected by buildings has increased by 5% since 1990.

Inland surface water ecosystems: The ecological quality of lakes (measured as nutrient loads and visibility depth) has improved in Denmark and is unchanged in Finland since 1990; The ecological quality of running waters has improved in Denmark since 1990 (no data for the other countries). There is relatively good data availability for running waters but more limited availability for standing waters.

Un-vegetated or sparsely vegetated ecosystems: These ecosystems are mainly found in the alpine zones of the Nordic region, but there is no historical data to illustrate changes in this biome.

Mire, bog and fen ecosystems: The area of mires has decreased by 9% since 1950 and by 1% since 1990. The share of pristine (non-drained) mires has decreased by 47% since 1950 and by 5% since 1990 in Finland and Iceland.

Grassland and shrub heathland ecosystems: The area of grasslands has decreased by 40% since 1950. The area of grasslands has increased slightly since 2000. The area of scrubs and shrub heathlands has decreased by 40% in Denmark since 1950 (no trend data for the other countries).

Forest ecosystems: The area of forest has increased by about 3% since 1990. The share of old-growth forest has increased since 1990 (except for in Finland).

7.2 Protecting Nordic ecosystems

The first protected areas were established in the Nordic countries at the beginning of the 20th century. National parks, strict nature protection reserves (known also as "nature parks") and wilderness areas form the basic structure of the conservation areas in Nordic countries. The coverage of these areas varies between countries with the largest areas still in their natural state present in Finland, Sweden and Norway (Table 7.3 and Figure 7.3). The EU-wide Natura 2000 network of protected areas forms a basis for biodiversity conservation especially in Finland, Sweden, and Denmark with its European "extension" the Emerald network being implemented also in Norway (Directorate for Nature Management 2007).

Table 7.3 Protected areas in the Nordic countries.

Protected areas	Denmark	Finland	Greenland	Iceland	Norway	Sweden
Number of Natura 2000 sites	246	1,859	NA	NA	NA	531 (SPA), 3,981 (SCI)
Area of Natura 2000 sites	3,590 km^2 (8.4%)	50,000 km^2	NA	NA	NA	29,857 (SPA), 64,449 (SCI) km^2
National parks[2]	5 No info	37 9,789 ha	No info	3 1,330,500 ha	40 4,440,000 ha	29 738,096 ha
Other protected areas[2]	329 1,094 ha	8,220 938,800 ha	No info	103 1,693,100 ha	2,701 4,690,000 ha	4,692 4,543,332 ha

Source: SEBI, CLC2000.
[3]Metsahallitus (FI), Statistics Sweden 2012a, EarthTrend 2003 (DK), Statistics Norway 2012, Statistics Iceland 2012.

In addition to the protected areas networks, other environmental regulations and sectoral policies provide protection to Nordic nature (see Chapter 11 for further details). Everyman's Rights (see box 7.2) also play an important, albeit indirect, role in protecting Nordic ecosystems by creating a feeling that nature is a "common property" and increasing general consciousness and responsibility of and positive attitudes towards its protection.

Protection of forests is one of the key characteristics of the Nordic region. In the European context Nordic countries, especially Finland and Sweden, have quite vast areas of protected forests.[6] In Finland some 3 million ha of forests is protected (State of Europe's forests 2011), mostly in the north (almost 15% of total forest area). Approximately 15% of Denmark's forest area protected, but its area is only 92,000 ha. Sweden has approximately 1.3 million ha of protected forest area, and in Norway 4% of forests has been protected (Schuck 2006). It is noteworthy that in more northern and eastern Europe, protection of forests typically means strict prohibition to use forests while in more southern and western Europe active management of protected forests is practiced. (State of Europe's forests 2011).

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[6] Protected forest area calculated consisting MCPFE - Ministerial Conference on the Protection in Europe (2003) classes 1.1-1.3 and Class 2. Class 1: Main management objective "biodiversity": 1.1: no active intervention, 1.2: minimum intervention, 1.3: conservation through active management, Class 2: Main management objective "protection of landscapes & scenic natural elements".

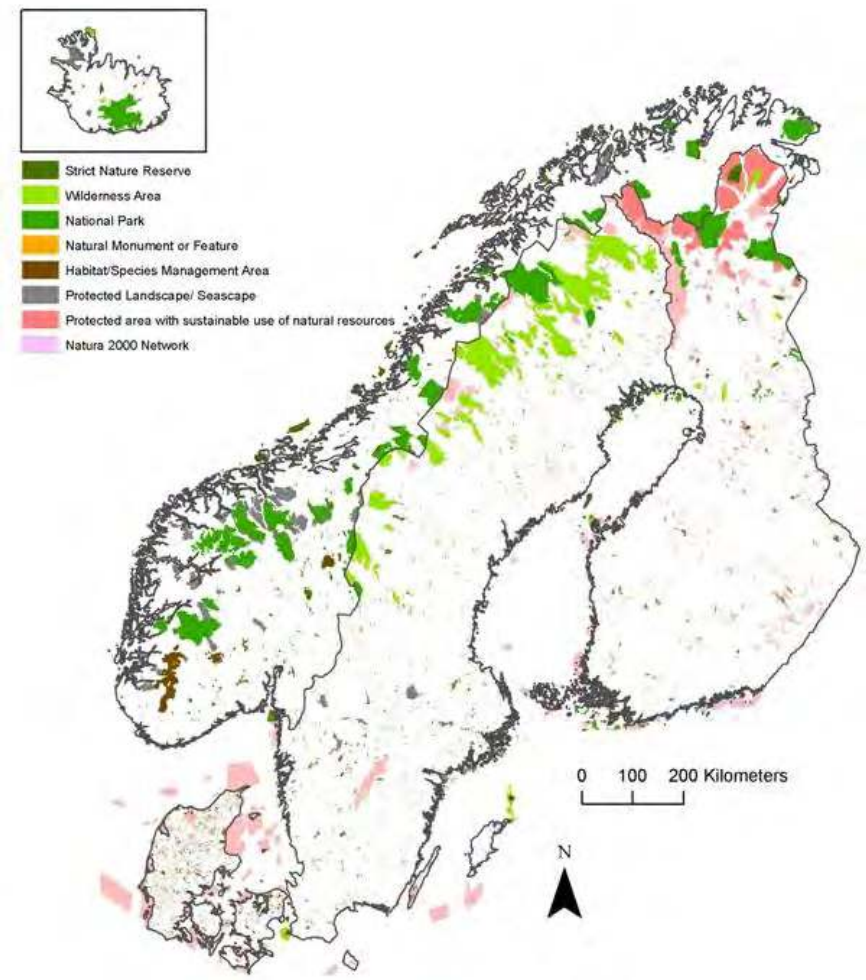
Box 7.2 Everyman's Rights in the Nordic Countries

The terms "Allemannsretten" in Norwegian, "Allemansrätten" in Swedish, "Almannaréttur" in Icelandic and "Jokamiehenoikeus" in Finnish all translate into "Everyman's Rights" or "Freedom to roam". These are consuetudinary national laws based on a long established set of shared customs and traditions. These rights allow free access to the land and waterways, and to collection of natural products in both public and private lands. Naturally, there are restrictions related to local boating, fishing, hunting, timber collection and protected species and areas. In addition, Everyman's Rights do not cover activities which damage the environment or disturb others.

The cultural and legal concept of Everyman's Rights belongs strongly to the Nordic Countries, particularly to Iceland, Finland, Sweden and Norway, whilst in Denmark there is a more restricted Freedom to roam on private land both in terms of legislation and physical access opportunities (Højring, 2002). In other EU countries, with few exceptions, the medieval legislative tradition concerning common rights to the landscape has not survived as effectively as in the Nordic Countries, due to different land-ownership history and higher population density. Everyman's Rights have an important cultural/historical value in the Nordic Countries, where the concept of free access has been part of national identity for Centuries.

In addition, such rights have huge, positive repercussions on the recreational and provisional services supplied by nature. Outdoor recreational activities such as hiking, skiing or bird watching are extremely popular in the Nordic Countries. Forest products are picked for personal and commercial use, to a value of several million EUR every year (see Chapter 12). These rights also generally apply to foreign citizens, facilitating and encouraging international tourism and businesses. For instance, the Italian Dalla Valle has established a solid and renowned business on exporting boletes, benefitting from the advantages of Everyman's rights. At the peak of a boom harvest in 2003, 1,100 tonnes of mushrooms were collected with revenues around 5.5 million EUR, and the number of pickers supplying the company was reportedly between 15,000 and 20,000. Everyman's Rights therefore also have a social value for generating considerable economic opportunities for businessmen and rural dwellers (Cai at al. 2011).

Figure 7.3 A map of protected areas in the Nordic countries



Data source: EEA: Nationally designated areas (National – CDDA). © SYKE, © European Environment Agency.

8. Nordic ecosystem services

8.1 Identification and classification of Nordic ecosystem services

Identified ecosystem services in the Nordic countries are presented in Table 8.1. In terms of *provisioning services*, timber production has an important socio-economic role in forested regions, while agricultural provisioning services such as cereal production are important in particular in southern parts of the Nordic countries. Reindeer herding remains an important livelihood in the north (Lapland) whereas fisheries provide significant income in coastal areas and around large inland lakes. In addition, berries, mushroom and game are of special importance to the Nordic countries, both in terms of income and associated cultural values (see Chapter 13).

Cultural services are very predominant in the Nordic countries, ranging from recreation and tourism (e.g. wildlife photography or whale-watching) to less tangible Nordic traditions and values for indigenous people. In this context it needs tobe acknowledged that Everyman's Rights are a special part of many cultural services in the Nordic region (Box 7.2 above).

Finally, identified *regulating services and ecosystems' supporting processes and functions* are broadly comparable to many other regions and ecosystems, although Nordic ecosystems may have some particular properties (for example related to long winters and precipitation) affecting basic ecosystem processes such as pollination and carbon sequestration.

Table 8.1 Nordic ecosystem services identified in the context of TEEB Nordic (buiding on Kumar 2010 and the Millennium Ecosystem Assessment 2005)

ECOSYSTEM SERVICES	
Provisioning services	
Food (provisioning of)	Cattle and dairy production Cattle and dairy production: organic Cereals Cereals: organic Fruit production (from orchards) (apple, plum, pear) Fruit production: organic Reindeer herding Fishing: fresh waters Fishing: marine Aquaculture: fresh water Aquaculture: marine Game (e.g. Eurasian elk and white-tailed & roe deer, bear, other forest game (eg. hare, grouse), water fowl) Berries (non-cultivated) (e.g. bilberries, lingonberries, cloudberries, cranberries and buckthorn) Mushrooms
Raw material and fibre (provisioning of / provisioning sources for)	Timber production Timber production: sustainable Energy: fuel wood Energy: other bioenergy Fodder and forage: hay Fodder and forage: lichens Fertilizers (guano) Fibre: wool Fibre: leather and fur Fibre: down from wild birds (e.g. Common Eider, Somateria mollissima)
Medicinal resources / biochemicals (provisioning of / provisioning sources for)	Medicinal products (natural) Natural food supplements and "health / super" foods (natural) Cosmetics (basis / material for) Biochemicals / pharmaceuticals (basis / material for) Non-medicinal biochemicals (natural) Models and test organisms
Ornamental resources (provisioning of)	Traditional handicraft Fashion and jewellery Natural dyes and colorants / dye plants Decorative plants (wild)
Genetic resources (provisioning of)	Traditional variants and races for crop- and husbandry animal improvement (plants and animals)
Fresh water (provisioning of)	Fresh water (provisioning of): drinking and potable water, water for other types of human consumption

Regulating services	
Climate regulation	Carbon storage Carbon sequestration Climate patterns (local and regional)
Disturbances, natural hazards and extreme events (prevention and mitigation of)	Flood prevention / mitigation Storm protection Avalanche prevention / mitigation Mud flow / floods
Water / water flow regulation	Drainage and stabilisation of water flow (non-flood related) Drought mitigation Irrigation Aquifer recharge
Biological control	Pest control (natural) Disease and pathogen control (plants, animals and humans) Air quality regulation Water purification and waste treatment Soil fertility (maintenance of) Pollination
Cultural services	
Recreation and tourism (opportunities for)	Recreational and tourism enjoyment (general) Recreational and tourism outdoor activities (hiking, running, skiing etc.) Recreational hunting Recreation and tourism related to fishing Recreation and tourism related to berry and mushroom picking
Art, design and culture (inspiration for)	Design (fashion, interior design etc.) Art (literature, paintings, photography etc.)
Cultural and spiritual values, identity and experience	Nordic values and identity Samí culture’s values and identity Inuit culture’s values and identity
Mental well-being and health	Stress and related problems and illnesses (reduction of) Aesthetic values and information Education and research (information for) (i.e. cognitive development)
Supporting ecosystem processes and functions / habitat services	
Ecosystem processes (maintenance of)	Nutrient cycling Soil formation Photosynthesis Biogeochemical cycles Stability and resilience of ecosystems (maintenance of)
Lifecycle (maintenance of)	Nursery habitats Seed dispersal Species interactions between trophic levels (maintenance and control of)
Biodiversity (maintenance and protection of)	Genetic diversity Species diversity Habitats diversity

8.2 Flow of Nordic ecosystem services: who benefits and where?

The Nordic region is characterised by relatively low population densities, especially in the north (Figure 8.1). Denmark is the Nordic country with the highest population densities and, in general, the southern areas of Finland, Sweden and Norway are significantly more densely populated that the rest of the countries. In Iceland, population density is relatively high only in the capital region. These overall low population numbers and the distinct north – south gradients in population densities make the Nordic region rather unique in terms of the flow of ecosystem services, i.e. when estimating the use of and demand for different services and trying to match that with the resilience and capacity of different ecosystems to deliver these services. Finally, low population densities are one of the key factors enabling free public access to nature, including several ecosystem services such as berries and mushrooms (i.e. Everyman's Right).

The low population densities also mean that, while some ecosystem services might be scarce at the *local level*, in several cases a shortage of services is not generally an issue at the *regional level*. This is the case, for example, with several provisioning services such as game, berries, mushrooms and fresh water. Marine fisheries are, however, an exception to the rule with several fish stocks suffering from overfishing within the Nordic seas (See Chapter 9). Plenty of opportunities are also available for cultural services and there is hardly any shortage of or competition for areas suitable for recreation and tourism. However, several regulating services such as pollination and water purification are in short supply at the local and sub-national level (see Chapter 9). This is due to general trends in land use, which are responsible for degrading ecosystems' ability to maintain their regulating functions across the region (Chapter 7).

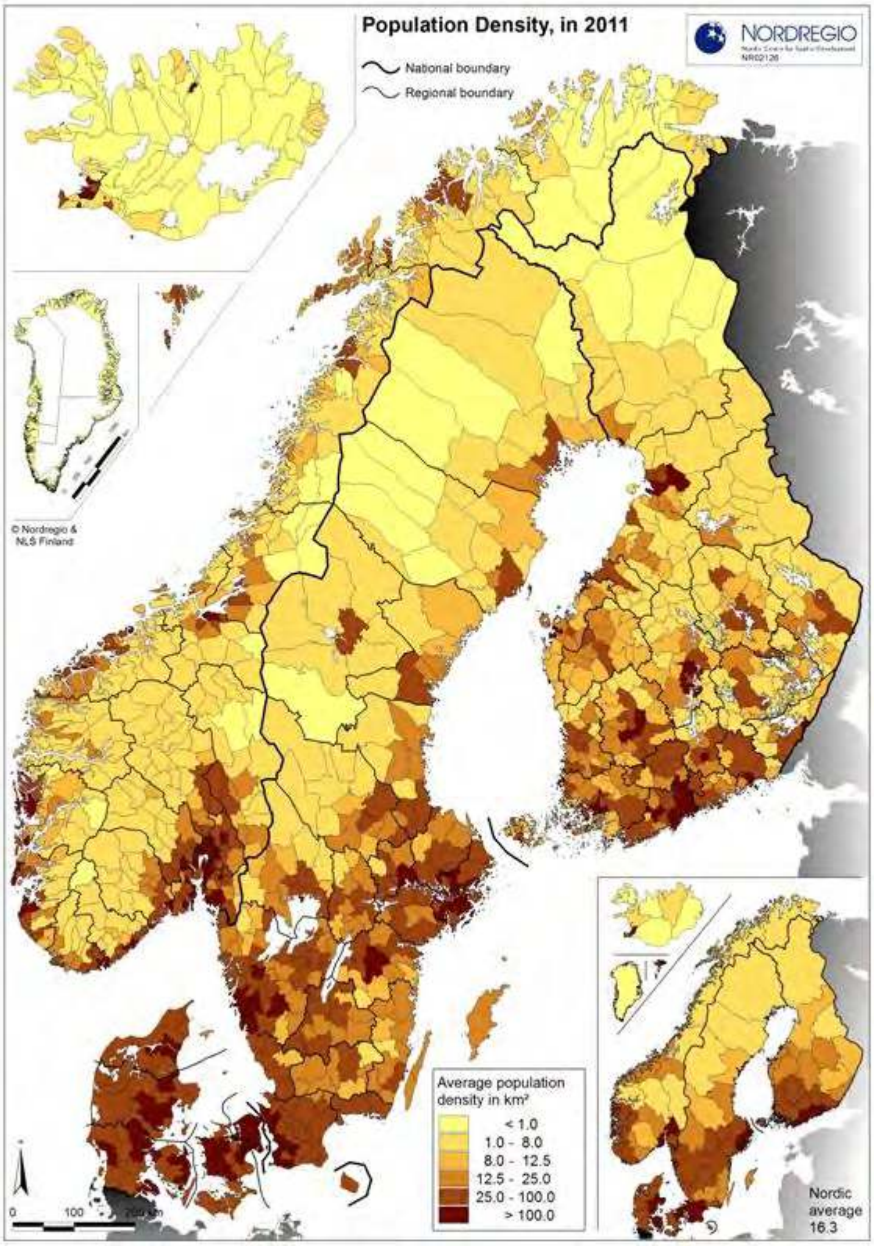
At the *national level*, there are also a number of interesting dynamics related to the north – south gradient of Nordic population density. In general, the significantly higher number of people in the south means that, in addition to local consumption and use, the flow of several provisioning services such as food takes place from north to south. On the other hand, the flow of recreation and tourism is often the reverse, with people visiting less populated areas of natural beauty for recreation and tourism (e.g. Lapland). As elsewhere, regulating functioning on a scale of wider ecosystems (e.g. purification of water within watersheds) flow on a regional level in the Nordic countries, mainly within but also sometimes between countries.

On a *Nordic scale*, fish seem to be one of the key biodiversity resource "migrating" between countries (e.g. between bordering rivers and across the Baltic Sea) and therefore they benefit from joint management at Nordic level. This is the case, for example, with migratory species such as Baltic Sea salmon. Also, ecosystem services related to or contributing to the quality of marine ecosystems, such purification of water by watersheds in the Baltic Sea basin, seem a common cause of concern for the Nordic countries.

On a *European and global level* (through trade) the Nordic forests are still a notable source of timber, wood and pulp, even though the significance of these resources has decreased during the past decade. On the other hand, the role of Nordic forests as a source for bioenergy has considerable increased. With climate change, Nordic forests have become important for storage of carbon and they also play an important role in maintaining the global capacity for carbon sequestration. Nordic countries are also a popular destination for European and global tourists.

Finally, it is important to note that the consideration above – while based on the evidence presented in Chapters 9 and 10 – only present some very basic and preliminary considerations on the "flow" of Nordic ecosystem services. A dedicated assessment considering, for example, substitutionality of services within the Nordic region and at the global level would be required to obtain a more detailed and comprehensive picture of these aspects.

Figure 8.1 Population densities in the Nordic countries



Data source: Nordregio Nordic Centre for Spatial Development. © SYKE, © Nordregio.

9. Nordic ecosystem services: status and trends

9.1 Identification of indicators

Making conclusions on the biophysical status of and trends in ecosystem services (i.e. ecosystems' ability to provide services) relies on identifying indicators that either directly or indirectly reflect the biophysical status of services. In general, indicators of ecosystem services' status and trends can be divided into indicators for the availability of a given service (quantity) or for the general status of natural system(s) (quality), both reflecting ecosystems' general capacity to maintain and provide ecosystem services.

Table 9.1 provides a list of identified direct indicators and proxies for Nordic ecosystem services, with a view to creating the most comprehensive and informative basis for gathering further knowledge for future assessment and monitoring of services. The identified list of indicators can therefore be considered as a "wish list" of information that would ideally be needed to form a reliable picture of the status and trends of different services. Consequently, a number of direct indicators have been identified for which information is not yet readily available. For example, in the case of several regulating and cultural services, the most appropriate and/or only direct indicators for an ecosystem service might be *composite indicators or model-based results* that combine a number of biophysical and ecological characteristics forming a basis for the benefits people experience (i.e. service) (Maes et al. 2011, 2012). While some pioneering examples of composite indicators and models already exist, such indicators still remain to be developed for most of the identified services. Also, it is foreseen that the existing composite indicators require further development and testing before being considered for wider use. In Norway the Nature Index[7] is an example of a composite

[7] http://www.environment.no/Topics/Biological-diversity/The-Norwegian-Nature-Index-/

indicator, distributed by ecosystem, which has some properties as an ecosystem quality/function indicator.

It is also to be noted that while quantified indicators – especially proxies – can be useful in assessing the status of and trends in the availability of services, for example in documenting the maximum "availability" of a service in given time, they do not necessary reflect the overall long-term *sustainability* of the use of service (e.g. sustainable level of extraction). The identified direct indicators in Table 9.1 reflect this by foreseeing the need to develop indicators – or sets and baskets of indicators – that somehow better integrate aspects of sustainability (e.g. estimated sustainable levels of production or carrying capacity). This is especially the case for provisioning services.

Finally, while applicable at any level or scale, the list of indicators identified in Table 9.1 is foreseen to be suitable as a starting point for developing indicators for Nordic ecosystem services also in the *national context*. Ideally, similar sets of indicators would be available for each ecosystem service in each Nordic country; however, the results of the scoping study outlined in Section 9.2 reveal that the available data is inconsistent at best (e.g. mainly available at case study level) and mainly proxy indicators are currently available.

Table 9.1 **A list of identified direct and proxy indicators to estimate and monitor the status of Nordic ecosystem services, suitable to be explored to be adopted at national level. Indicators highlighted in grey are not known to be readily available yet or require development. It is also to be noted that the proxy indicators do not necessarily reflect the sustainability of the status and trends in the long-term, especially for provisioning services.**

ECOSYSTEM SERVICE	Identified direct indicators	Identified proxies[1]
PROVISIONING – Food (provisioning of)		
Cattle and dairy production[6]	*Sustainable* (max) density of cattle (estimated) *Sustainable* cattle / dairy production (estimated)	Density of cattle (current) Cattle / dairy production (current)
Cattle and dairy production: organic[6]	*As above*	*As above*
Cereals[6]	*Sustainable* area / yield of cultivated crops (estimated)	Area under cereals production (current) Cereals production (current yield)
Cereals: organic[6]	*As above*	*As above*
Fruit production (from orchards) (apple, plum, pear)[6]	*Sustainable* area for / yield of cultivated fruit (estimated)	Area under fruit production (current) Fruit production (current yield)
Fruit production: organic[6]	*As above*	*As above*
Reindeer herding[6]	*Sustainable* density / carrying capacity of reindeers (estimated)	Density of reindeers (current) Size of the reindeer herds (stock) / country (max)
Fishing: fresh waters and marine	Total stock / population size of fish in commercial use (estimated) Reproduction rate of the fish in commercial use (estimated)	Size of catch (current) Number of fish species in commercial use (current)
Aquaculture: fresh water and marine	*Sustainable* yield / carrying capacity for aquaculture (estimated)	Amount of cultured fish and other key sources (current)
Game	Population size of species Reproduction rate of species	Number of hunted animals (current) Amount of game meat (current)
Berries (non-cultivated)	Total (natural) berry production of ecosystems (estimated)	Harvested yield (actual)
Mushrooms (non-cultivated)	Total (natural) mushroom production of ecosystems (estimated)	Harvested yield (actual)
PROVISIONING – Raw material and fibre (provisioning of / provisioning sources for)		
Timber and fibre for pulp production	Timber increment / tree growth[1] Forest coverage available for timber production[1]	Timber stock (current) Volume of harvest (current)
Timber production: sustainable	*As above* but under FSC etc. scheme	*As above* but under FSC etc. scheme
Energy: fuel wood	*Sustainable* total area / volume of the growing stock (stem wood)	Quantity / use of solid wood fuels: small-scale housing (current) Quantity / use of solid wood fuels: heating and power plants (current)

Energy: other bioenergy	*Sustainable* coverage of forests for bioenergy production (estimated) *Sustainable* amount / volume of growing bioenergy stock (estimated)	Volume of harvested bioenergy source(s) (current)
Fodder and forage: hay	Total areal coverage of areas for hay production (hay fields, meadows etc.) [1] *Sustainable* quantity of harvested hay (estimated)	Quantity of harvested hay (current)
Fodder and forage: lichens	Coverage of lichens in dry forests (e.g. on the basis of satellite images) Quality of reindeer pastures	Area of old-growth forests in reindeer herding districts
Fertilizers (guano)	Production of guano by bird colonies (estimated)	Gathered amount of guano (estimated)
Fibre: wool	Wool stock available (e.g. based on number of sheep)[1]	Gathered amount of wool (estimated) Number of sheep
Fibre: leather and fur	Leather / fur "stock" available (e.g. based on number / population of animals used) [1]	Gathered / used amount of leather (estimated) Number of animals that form key source for leather
Fibre: down from wild birds (e.g. Common Eider, *Somateria mollissima)*	Amount of down *sustainably* available (estimate)	Gathered amount of down (estimated) Number of breeding pairs of species
PROVISIONING – Medicinal resources / biochemical (provisioning of / provisioning sources for)		
Medicinal products (natural)	Population size / stocks of species used[2] Potential future use of medicinal plants from nature (estimated)	Status of biodiversity Number of existing / already used medicinal plants and other resources
Natural food supplements and "health / super" foods (natural)	Total yield(s) available / production of species used (e.g. berries) [2, 3] Potential future use of natural supplements (estimated)	Volume of resource (e.g. berries) used currently Number of existing / already used species (e.g. berries)
Cosmetics (basis / material for)	Population size / stocks of species used[2] Future potential for discovering new "raw material" and innovations from nature (estimated)	Status of biodiversity Number of currently used species
Biochemicals / pharmaceuticals (basis / material for)	*As above*[2]	*As above*
Non-medicinal biochemicals (natural)	*As above*[2]	*As above*
Models and test organisms	*As above*[2]	*As above*
PROVISIONING – Ornamental resources (provisioning of)		
Traditional handicraft	Population size / stocks of species used[2] Potential future use of resources from nature (estimated)	Status of biodiversity Number of currently used species
Fashion and jewellery	*As above*[2]	*As above*
Natural dyes and colorants / dye plants	*As above*[2]	*As above*
Decorative plants (wild)	*As above*[2]	*As above*

PROVISIONING – Genetic resources (provisioning of)		
Traditional variants and races for crop- and husbandry animal improvement (plants and animals)	Number of traditional races (known / estimated)	Status of genetic biodiversity (crops / agro-ecosystems)
PROVISIONING – Fresh water (provisioning of for consumptive use, with focus on the role of ecosystem's biotic elements)		
Fresh water (provisioning of): drinking and potable water, water for other types of human consumption	Surface area and flow of fresh water available (connected to populated areas)[4] Surface area and volume of aquifers (connected to populated areas) [4] Share / coverage of water bodies [4] Surface water flow (estimated) [4]	Number of private wells in region
REGULATING SERVICES		
Air quality regulation	Deposition velocity (height of vegetation and leaf area index) for 3 km buffer of artificial CORINE class NOx / particulates removed by urban vegetation	Coverage / availability of green zones in the urban areas Number of days of poor air quality in urban areas
CLIMATE: Carbon storage	Amount of total carbon (C) storage in ecosystems biomass, e.g. above-ground of forests C stock, soil C stock, mire / bogs / marine / wetlands etc. C stock	
CLIMATE: Carbon sequestration	Amount of sequestered C of forests Amount of sequestered C in marine ecosystems Amount of sequestered C in other ecosystems	Share of middle-aged (12–40 year) forests from all forests Abundance of sea grass meadows and other marine / coastal ecosystems important for carbon sequestration
CLIMATE: Climate patterns (local and regional)	Index of land cover characteristics having influence in local / regional / global climate Index of marine ecosystem characteristics having influence in local / regional / global climate	Frequency of extreme weather events and temperatures
NATURAL HAZARDS: Flood prevention / mitigation	Index flood protection characteristics, based on topography and area coverage of natural / semi-natural wetlands in risk areas Area coverage (%) of natural / semi-natural wetlands in flood risk areas	Number of flood events / year / region (in flood risk areas) Duration of inundation periods (in flood risk areas) Land use change along the water-ways under flood risk Regulation in place to protect natural areas important for natural hazard mitigation
NATURAL HAZARDS: Storm protection	Index for storm protection, based on surface area of natural vegetation and other relevant characteristics in risk areas Surface area (%) of natural vegetation in storm risk areas	Coverage of coastal wetlands Regulation in place to protect natural areas important for natural hazard mitigation
NATURAL HAZARDS: Avalanche prevention / mitigation	Index for avalanche prevention, based on surface area of natural vegetation and other characteristics in risk areas Surface area (%) of natural vegetation in avalanche risk areas	Number of harmful avalanches / year / region Regulation in place to protect natural areas important for natural hazard mitigation
NATURAL HAZARDS: Mud flow / floods	Index for mud flow prevention, based on surface area of natural vegetation and other characteristics in risk areas Surface area (%) of natural vegetation in mud flow risk areas	Number of harmful mudfloods / year / region Regulation in place to protect natural areas important for natural hazard mitigation

WATER and WATER FLOW: Drainage and stabilisation of water flow (non-flood related)	Index based on soil infiltration capacity (vertical flow) and sub-surface water flow (horizontal)	Coverage of un-drained wetlands, peatlands and mires in natural state
WATER and WATER FLOW: Drought mitigation	Index for drought mitigation based on areal coverage and quality of water-storing ecosystems in drought risk areas (e.g. un-drained wetlands, mires in natural state) Coverage (%) of water-storing ecosystems in drought risk areas (e.g. un-drained wetlands, mires in natural state)	Loss of areas important for water storage (e.g. drained wetlands etc.)
WATER and WATER FLOW: Irrigation	Water availability for irrigation near arable lands (e.g. 1 km buffer)	Amount of water used for irrigation
WATER and WATER FLOW: Aquifer recharge	Coverage (%) of areas important for recharge (e.g. ridges)	Number / coverage of areas important for recharge under land use change (e.g. urbanisation) Regulation in place to protect natural areas important for groundwater
Water purification and waste treatment	Retention of nitrogen (N) by water bodies and floodplain vegetation Nitrogen (N) retention capacity	National N mass balance Lake retention + peat land retention + estuaries Total N removed Area of agricultural buffer zones Regulation in place to mitigate erosion
Erosion	Index for erosion prevention capacity (based on land use, slope, soil properties and climate data, assigned with natural vegetation leading to surface area share of natural vegetation in 10 km grid)[5] Existing coverage of buffer zones for shores and deep slopes	Erosion risk (estimated) Reforestation of eroded areas Regulation in place to prevent erosion
Soil fertility (maintenance of)	Index for soil health, taking into consideration C content, soil fauna and other relevant characteristics Level of intactness of land cover in fertile soil types Status of soil microbial characteristics % of C	Total amount of fertilizers used
Pollination	Index for pollination capacity (based on no. of species needing to be pollinated, no. of species pollinating, no. of ecosystems important for pollinators / habitat quality, days available for flying) [5]	Coverage of ecosystem border zones important for pollinators [e.g. forest-agriculture] Number of nectar plants in the area
BIOLOGICAL CONTROL: Pest control (natural)	Diversity / status of pest controlling species groups General status of biodiversity (i.e. providing resilience against pest outbreaks / general control of population dynamics)	Frequency of pest outbreaks Observed new alien species with possible harmful impacts
BIOLOGICAL CONTROL: Disease and pathogen control (plants, animals and humans)	Diversity / status of (known) pathogen and disease controlling species groups General status of biodiversity (resilience)	Frequency of disease outbreaks

CULTURAL SERVICES		
RECREATION and TOURISM: Recreational and tourism enjoyment (general)	Share of land cover with high recreation value[5] (high recreational value defined based on degree of naturalness, presence of protected areas, presence of lakeshores and coastlines, and quality of bathing water)	Number of protected areas Days spent in nature Visitors / national parks or conservation areas
RECREATION and TOURISM: Recreational and tourism outdoor activities (hiking, running, skiing etc.)	*As above*	Area of protected areas Length of nature trails and paths Days spent in nature Time spent for recreational outdoor activities Visitors / national parks or conservation areas
RECREATION and TOURISM: Recreational hunting	Access to nature (e.g. frequency of forest roads, vicinity of areas)	Access to nature (e.g. frequency of forest roads, vicinity of areas)
RECREATION and TOURISM: Recreation and tourism related to fishing	*As above*	*As above*
RECREATION and TOURISM: Recreation and tourism related to berry and mushroom picking	*As above*	*As above*
Aesthetic values and information	*See proxy*	Number / coverage of valuable landscapes UNESCO World Heritage sites (related to natural beauty)
Education and research (information for) (i.e. cognitive development)	Number / coverage of protected areas in 3 km buffer from urban areas Number / coverage of green areas within urban areas	Number / coverage of protected and/or scientifically valuable areas
ART, DESIGN and CULTURE: Design (fashion, interior design etc.), art (literature, paintings, photography etc.),	*Difficult to assess directly / indirectly*	*Difficult to assess directly / indirectly*
CULTURAL and SPIRITUAL: Nordic, Sami and Inuit values and identity	*Difficult to assess directly / indirectly*	*Difficult to assess directly / indirectly*
Mental wellbeing and health: stress and related problems and illnesses (reduction of)	Number of protected / recreation / green areas within certain buffer from urban areas Number / coverage of green areas within urban areas	*No proxies identified*
Supporting / maintenance / habitat services – Ecosystem processes (maintenance of)		
Nutrient cycling	N deposit / regions Phosphorus runoff to streams from fields / region	Use of externally (of the ecosystem) produced fertilizers Shifted cultivation of N retention plants
Soil formation	Formation of soil based on geology, climate, biota, time (rate) Number and diversity of nematodes (*Annelidae*) / ha	Litter decomposition rate
Photosynthesis	Net Primary Production (NPP) (energy capture) (e.g. marine ecosys-tems) Leaf area index	

Biogeochemical cycles	Number of biochemical metabolism types in area (redox); Changes in major elements controlling the cycles (stoichiometry)	Chelation (metal ion binding to an organic compound)
Stability and resilience of ecosystems (maintenance of)	Coverage (%) of ecosystems in natural state Mean species abundance (MSA) as indicator of biodiversity	Reported ecosystem shifts / events of thresholds exceeded Frequency of disturbances (e.g. clear-cut)
Supporting / maintenance / habitat services – Lifecycle (maintenance of)		
Nursery habitats	Abundance (number and area coverage) of recognised nursery habitat types	*No proxies identified*
Seed dispersal	Number of species depending on animal vectors for their dispersal (fur, intestine, storages) Number of identified vectors for seed dispersal endangered	*No proxies identified*
Species interactions between trophic levels (maintenance and control of)	Composite indictor reflecting energy and material flows Number of key functional traits within a trophic system (estimated)	Number and abundance / population size of recognised key stone species Number and abundance of top predator species (control)
SUPPORTING / MAINTENANCE / HABITAT SERVICES – Biodiversity (maintenance and protection of)		
Genetic diversity	Number of populations (of selected indicator species) Reported variation between populations	Status of habitat and species diversity Populations (%) known to have passed through evolutionary bottle necks
Species diversity	Mean species abundance (MSA) (species-area index) Share (%) of endangered species of estimated original total number of species in area	Share (%) of endangered species in current number of species
Habitats diversity	Number of recognised habitats in the area (e.g. from European nature information system – EUNIS) Habitat diversity	Number of habitats with high life cycle supporting value

1 Indicator does not reflect sustainability, which needs to be reflected separately.
2 When continued collection of "raw material" needed.
3 Overlap with other biodiversity resources listed above (e.g. berries).
4 Indicators do not take into consideration quality (nutrients, bacteria), in general in Nordic countries quality of inland water considered good.
5 Composite indicator / index developed by the Joint Research Centre (JRC) available.
6 Supply of ecosystem service significantly enhanced by humans, therefore estimated sustainable level of production would be the best available indicator for ecosystem's capacity to maintain service.

9.2 Existing knowledge on status and trends

Note: there are significant gaps in the existing data on the biophysical status of Nordic ecosystem services. Consequently, the synthesis provided under Chapter 9.2 does not cover the full range of ecosystem services and indicators outlined in Chapter 9.1. The gaps between the required and existing information are analyses and discussed in Chapter 11.

9.2.1 Provisioning services

At national level, information on the status of and trends in provisioning services is mainly available through proxy indicators reflecting the current use of ecosystem services, rather than the overall capacity to sustainably provide or maintain the service. For *agricultural goods* (cattle and livestock, cereals and fruits and fodder) some proxy data and land cover based data were found for most Nordic countries. For *reindeer* data were found for all the relevant countries (Finland, Iceland, Norway, Sweden). For *fish and aquaculture* proxy data were found for every country (apart from aquaculture data for IS). For *game* good statistical proxy data were found for every country (see below). For *berries and mushroom* statistical proxy data considering gathered amounts were found for Finland, Norway and Sweden and in addition some estimates of total annual production capacity were available for Finland and Sweden. For *timber and forest-based (bio-)energy* provisioning capacity good indicators and land cover based data were found for every Nordic country, while for non-forest based energy data was missing. For *fibres, medicinal, biochemical and genetic resources, model organisms, and ornaments* some socio-economic proxy data were found (see Chapter 10) but direct biophysical data was mainly missing. For *drinking and potable water* potential the proportional area of fresh water classes based land cover data was used.

Agricultural goods and fodder

Agriculture in Nordic countries is characterised by climatic constraints; winter is not suitable for farming and summer (i.e. the main growth period) is quite short. Intensive agriculture is concentrated in the south of the region whereas northern areas are usually more extensively farmed. However, there are great differences between Nordic countries; Denmark and Iceland represent the two extremes. Denmark is mostly characterised by agriculture: over 65% of its area is under agriculture. In

Iceland, only 1% of area is cultivated and most of that is grassland. Sweden and Finland represent perhaps the average, with 5–7% of their land area covered by agricultural land, and in Norway the share of agriculture is 2%. The amount of agricultural land in hectares is approximately the same in Sweden, Finland and Denmark, i.e. over 2 million hectares. (CLC 2000, Haagelsen 2011)

General statistics on the production of agricultural goods are provided in Table 9.2 below. In general, Denmark is the Nordic country characterised by big farms and intensive agriculture (Eurostat 2012 and Statistics Denmark 2012) with an average farm size of 60 ha. In Sweden and Finland farm sizes are moderate (average size 37 ha) whereas an average Norwegian farm is only 20 ha. While the overall volumes are small, animal production is most common in Norway and Iceland. In Iceland almost all farms have animals (cattle or sheep) and in Norway 60% of farmers are specialised in animal husbandry (with 40% of those specialised in dairy) (Statistics Norway 2012).

As for *organic agriculture*, Sweden has most organic agricultural area with 14% of all agricultural area under organic farming in 2011 (approximately 440,000 ha and some 5,000 farms)[8] (Table 9.2). In Finland, Denmark and Norway organic agriculture covered around 8%, 5.6% and 5% of all arable land respectively (around 185,000, 148,000 and 47,000 ha). In Iceland in 2010 there were little over 18,000 ha of organically managed fields but only 33 organic farms, although organic farming has grown more in Iceland than any other Nordic country (Haagelsen 2011).

Table 9.2 Production of agricultural goods in the Nordic countries.

	Sweden[1]	Finland[3]	Denmark[5]	Norway[6]	Iceland[7,8]
Agricultural area (ha)	3,085,365[1]	2,286,684[3]	2,646,400[5]	998,668[6]	129,000[7]
Farms (no.)	71,000[1]	61,584[3]	42,099[5]	44,734[6]	3,045[7]
Average farm size (ha)	37[1]	37[3]	60[10]	21[10]	Not available
Cereals area (ha)	962,800[1]	1,103,255[3]	1,469,168[5]	2,979,36[6]	3,317[8]
Cereals, production (tonnes)	5,108,736[9]	3,871,64[9]	9,075,471[9]	1,241,052[9]	Not available
Average barley yield kg/ha	4,285[1]	3,510[3]	5,300[5]	3,120[6]	Not available
Ley area* (ha)	1,209,529[1]	666,802[3]	320,914[5]	652,463[6]	122,000[7]

[8] Number includes also areas in conversion.

	Sweden[1]	Finland[3]	Denmark[5]	Norway[6]	Iceland[7,8]
Permanent grasslands* (ha)	Not available	32,049[3]	199,859[5]	177,367[6]	Not available
Cattle farms (no.)	21,586[1]	14,935[3]	13,576[5]	16,500[6]	829***[7]
Cattle (no.)	1,537,000 (2010)[1] 1,599,657[9] (average 2000–2010)	914,053 (2011 971,184[9] (average 2000–2010)	1,571,050 (2010)[5] 1,662,544[9] (average 2000–2010)	862,485 (2011)[6] 930,143[9] (average 2000–2010)	73,781 (2010)[8] 69,527[9] (average 2000–2010)
Other animals (no.)	1,748,937 pigs[1] 485,946 sheep and goats (average 2000–2010)[9]	1,375,230 pigs[9] 114,653 sheep and goats (average 2000–2010)[9]	12,940,181 pigs[9] 146,539 sheep and goats (average 2000–2010)[9] 13,173,060 pigs (2010) [9]	802,823 pigs[9] 2,445,818 sheep and goats (average 2000–2010)[9] 1,045,495 sheep (2011)[9]	41,770 pigs[9] 464,088 sheep and goats (average 2000–2010)[9]
Organic area (ha)***	438,878**[1]	184,797**[4]	148,145[5]	46,833[6]	18,000[11]
Organic farms (no.)	5,042**[2]	4,036[4]	2,671[5]	2,314[6]	33[11]
Organic cereals (ha)	61,104[1]	43,493[4]	39,254[5]	8,108[6]	Not available
Organic leys (ha)	163,240[1]	77,876[4]	96,392[5]	8,599[6]	Not available
Organic cattle (no.)	221,035[1]	40,591[4]	164,523[5]	31,836[6]	Not available

Note: numbers are not directly comparable between countries, since sources of information and methods differ between countries.
Sources: Jordbruks statistics årsbok 2011,[1] Jordbruksverket 2012,[2] Matilda Maataloustilasto 2012,[3] Evira 2012,[4] Statistics Denmark 2012,[5] Statistics Norway 2012,[6] Icelandic Agricultural Statistics 2009,[7] Statistics Iceland 2012,[8] NB Forest Info 2012,[9] Eurostat 2012,[10] Haagelsen 2011.[11]
*These numbers should be viewed only as indicative, since counting methods differ between countries
**Including also area/farms under conversion
*** Dairy cow owners

Timber and forest-based bioenergy

Nordic countries are characterised by forest and as much as 44% of the total Nordic land area is covered by forests. Most of the forest area is found in Sweden (28.6 million ha) and Finland (22.1 million ha) with Norway following with 10.3 million ha. Denmark and Iceland have the smallest forest cover with 0.6 and 0.16 million ha, respectively (San-Miguel-Ayanz 2011, Traustason and Snorrason 2008). Most of the forest is coniferous forest with Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*) dominating. Birch is a common deciduous tree in central Scandinavia while in more southern areas oak and beech forest are also present. Most of the forests are dominated by one or two tree species, mostly coniferous; only 16% of all forests are true mixed forests, with coniferous and deciduous trees (Normander et al. 2009). The majority of Nordic forests are dominated by domestic species, with the exception of Iceland and Denmark where 70 and 50% of the forests, respectively, are planted with introduced species.

The growing stock of forest in North Europe (including Baltic countries in addition to Nordic countries) is 8,114 million m^3 (Köhl et al. 2011). While making up 25% of the total European (without Russian Federation) growing stock (32,692 million m^3), a large share of the wood is used in Nordic countries (Köhl et al. 2011) (see Chapter 10 for information on harvest). In terms of sustainably managed forests, there are approximately 20 million ha of FSC certified forests in the Nordic countries (197,086 ha in DK, 394,990 ha in FI, 284,844 ha in NO, 11,563,015 ha in SE) (FSC 2012).

With the exception of Denmark and Iceland, the majority of Nordic forest is regenerated naturally and, consequently, classified as being semi-natural (San-Miguel-Ayanz 2011). Sweden has the largest area of totally undisturbed forest at almost 10% of total forest area, with Norway and Finland following with under 5%. Most of the Nordic forests are between 20 to 80 years old and the share of older forest is growing in all countries other than Finland (San-Miguel-Ayanz 2011). Like elsewhere in Europe, the overall forest area is increasing in Scandinavia (San-Miguel-Ayanz 2011). Also, the coverage of forests consisting of more than a single tree species is increasing. This is especially true in Denmark, where the forest area has more than doubled since the end of the 19th century. This is mainly a result of systematic planting of coniferous tree plantations (Levin and Normander 2008, cited in cited in Normander et al. 2009) (See also case study by Zandersen and Termansen in Annex II).

Marine and freshwater fisheries

The main *marine* areas for Nordic fisheries are the north-east Atlantic, Norwegian Sea, Barents Sea, North Sea and Baltic Sea. Pelagic and coastal areas of the Norwegian Sea, Barents Sea and Svalbard are the most important areas for Norwegian fishermen, although they also use the north-east Atlantic and North Sea / Skagerrak (Statistics Norway 2012). Most Danish fish comes from the North Sea (Danish AgriFish Agency 2012a) whereas Finnish fishermen operate almost totally on the Baltic Sea (RKTL 2012). Almost half of Swedish landings come from the Baltic Sea but Swedish fishermen also fish on the North Atlantic and North Sea (FAO 2012a). Greenland uses the north-west Atlantic (Statistics Greenland 2012) whereas Icelandic fishermen mostly fish on Icelandic grounds / Iceland Sea (Statistics Iceland 2012). In general, around 200 fish species live in the Nordic marine areas (including Greenland

Sea, Barents Sea, Norwegian Sea, North Sea) whereas a mixture of around 100 marine and freshwater species have adapted to the brackish waters of the Baltic Sea (Hallanaro and Pylvänäinen 2002). Some species, such as the Baltic salmon, may also migrate seasonally between fresh, brackish and/marine waters.

The most important Nordic marine fish species are *cod, herring and capelin*. Some 1 million tonnes of herring, 570,000 tonnes of cod and 460,000 tonnes of capelin have been caught annually during recent years (Table 9.3 below). Baltic herring is the most important species from the Baltic Sea along with Baltic cod and sprat (Pylvänäinen 2010). According to Garpe (2008), Finnish fishermen land 95% of Baltic herring, while Swedish fishermen land the remaining 5%. The catches may vary substantially between years according to stock fluctuations/migrations (FAO 2010). However, based on the available information (Table 9.3), the Nordic catch of marine fish can total up to around 4.9 million tonne / year, with Norway having the highest annual catch of over 2 million tonnes, followed by Iceland and Denmark with around 1 million tonnes / year.

As elsewhere, overfishing of marine species is also a serious problem in the Nordic countries with the stocks of several key fish species, such as cod, being significantly diminished over the past decades (see Box 9.1 below). For example, in Greenland fishing for crabs peaked in 2001 when 14,247 tonnes were caught however since then catches have steeply declined and in 2008 the catch was only 2,169 tonnes (Statistics Greenland 2012). When the most commonly fished species have become scarce, interest in other species has risen. For example, since the depletion of cod stocks in Greenlandic waters, shrimp and halibut have become the most important species for Greenland fisheries (Statistics Greenland 2012). In Iceland, haddock, saithe, blue whiting and mackerel have become increasingly important as capelin and herring stocks have declined (Iceland Ministry of Fisheries 2012). Following a reduction in cod catches the Norwegian lobster fishery has become increasingly important along the Skagerrak coast (Garpe 2008). From the 1970s onwards, stricter quotas and sometimes temporary total bans have been places on fishing of some species or stocks and that has led to recovery of some stocks – but there are still unsustainably managed fish stocks in the Nordic region. The trend in catches from the north-east Atlantic has been fairly stable with the lowest point in the early 1990s and a current downward trend (FAO 2010).

Professional *freshwater* fishing in the Nordic countries is small compared to marine fishing, mainly taking place in Finland and Sweden where fishing is concentrated to the few big lakes such as Saimaa and

Päijänne in Finland and Mälaren and Hjälmaren in Sweden. The main species are vendace in Finland and pikeperch in Sweden (Table 9.3 below). Altogether there are some 56 fish species in Nordic countries' freshwaters, of which 13 are introduced species (Lehtonen et al. 2008). The main problems with freshwater fishing lie in water quality issues (eutrophication and acidification) and not so much in overfishing, although this might happen to some degree (Lehtonen et al. 2008).

Table 9.3 Marine commercial fish catches per landings in the Nordic countries

	Greenland (catch)	Iceland (catch)	Norway (catch)	Denmark (landings into DK)	Sweden (catch)	Finland (catch)
Size of catch / landing (tonnes)	225,413	1,063,467	2,288,623	1,066,416	159,968	122,078
Catch / landing by species (tonnes) for 6 most commonly fished species	Shrimp 137,864	Norwegian spring-spawning herring 187,894	Herring 633,489	Herring 138,414	Fish for fodder 92,885	Baltic herring 92,400
	Greenland halibut 41,910	Cod 178,516	Capelin 360,629	Blue mussel 27,862	Herring/Baltic herring for consumption 31,815	Sprat 24,602
	Cod 11,499	Other pelagics 139,959	Atlantic cod 340,099	Cod 25,111	Sprat 14,791	Cod 1,028
	Lump sucker 10,105	Capelin 102,196	Mackerel 208,079	Saithe 23,160	Cod 11,118	Perch 741
	Red fish 9,106	Haddock 64,948	Saithe 190,295	Mackerel 23,091	Mackerel 3,526	Bream 741
	Crab 4,463	Redfish 56,305	Haddock 159,512		Northern shrimp 1,633	Whitefish 647
Reference year	2005	2010	2011	2010	2011	2010
Source	Statistics Greenland 2012	Statistics Iceland 2012	Statistics Norway 2012	The Danish Directorate of Fisheries 2011	Statistics Sweden 2012b, 2012c	RKTL 2012

Note: numbers are not directly comparable between countries, since sources of information and methods differ between countries.

Table 9.4 Freshwater fish catches in Sweden and Finland

	Sweden	Finland
Total catch (tonnes)	1,366	3,912
Catch by species (tonnes) for the most commonly fishes species	Pikeperch 517 Crayfish 177 Vendace 174 Eel 108 Perch 103	Vendace 2,496 Roach 495 Bream 157 Smelt 148 Perch 142
Reference year	2010	2008
Source	Statistics Sweden 2012b, 2012c	RKTL 2012

Box 9.1 Status of the key marine fish stocks in the Nordic countries (North Sea and Baltic Sea)

- Cod

The North Sea is the one of the most productive marine fisheries, however due to overfishing North Sea cod stocks are currently in poor condition (Pylvänäinen 2010, Fisheries Norway website 2012). According to current estimates, there is an imminent thread of stock collapse if quotas are not reduced drastically (Pylvänäinen 2010).

Other important cod stocks live in the north-east (NE) Atlantic, living mainly in the Barents Sea and spawning off the coast of Northern Norway. In the 1970s NE Atlantic cod stocks were heavily overfished and, due to the coinciding overfishing of capelin, cod also suffered from shortage of prey. In the 1990s quotas were reduced and cod started to recover but the stocks are still overfished today. In Greenlandic and Icelandic waters cod fishing has been reduced/banned until recently and some recovery of stocks can be seen (Pylvänäinen 2010). For example, in Iceland the cod stock has been increasing in recent years; the reference biomass is the largest since 1989 and the spawning stock the largest since 1964 (Nytjastofnar sjávar 2010/2011 — aflahorfur 2011/2012).

- Herring

North Atlantic herring stocks collapsed in the later part of the 20th century due to overfishing. Despite the stock collapse, herring fishing was never banned and that slowed down the recovery. Currently, Norway and Iceland herring stocks are on their way to recovery due to stricter quotas. The North Sea herring fishing was stopped for a while in the 1970s and strict quotas were set in the 1990s which has led to the recovery of North Sea herring stocks to reach at biologically safe levels today with a sustainable harvest (Pylvänäinen 2010, ICES FishMap 2012).

- Barents Sea Capelin

Capelin stocks diminished significantly over the past decades, leading to a closure in fishing from 2003 to 2008. As a result, there has been an increase of the capelin stock over the past years (www.fisheries.no 2012). However, the stocks remain low in Iceland ((Nytjastofnar sjávar 2010/2011 — aflahorfur 2011/2012).

- Baltic Sea cod

Baltic Sea cod is a variety of the marine cod. There are two populations of Baltic cod in the Baltic Sea, both suffering from unsustainable fishing (Pylvänäinen 2010). The cod stocks in Swedish waters have declined 70% in the last 15 years (Garpe 2008). On the west coast of Sweden the situation is particularly severe with the complete loss of certain stocks and a complete lack of fish older than two years. According to ICES advice for Baltic cod, the status was described as historically low. In the Baltic proper cod has not reproduced well due to anoxia and in the eastern Baltic the cod stock constitutes approximately 35% of what is considered biologically safe (ICES 2008 cited in Garpe 2008). In Skagerrak, the current status appears somewhat brighter with an increase in cod stocks noticed in the last couple of years.

- Baltic herring

Baltic herring is a brackish water variety of Atlantic herring (Pylvänäinen 2010). Baltic herring catches have been in decline since the 1980s but – contrary to marine herring – Baltic herring stocks have not declined below unsustainable limits, despite rather efficient harvesting (Pylvänäinen 2010, RKTL 2012). The Baltic herring stocks are also benefiting from the decrease in Baltic Sea cod, the key predator of Baltic herring (Pylvänäinen 2010). However, the growth of Baltic herring has slowed down, possibly due to competition with increased stock of sprat, deceased salinity levels in the Baltic Sea and eutrophication (RKTL 2012).

- Baltic salmon

The stocks of Baltic salmon have diminished significantly over the past decades. Salmon is a migratory species that lives in marine areas but spawn in freshwater rivers. Due to extensive damming of rivers for hydropower plants, migration of salmon (and other migratory fishes) has largely been prevented (e.g. Hallanaro and Pylvänäinen 2002, Lehtonen et al. 2008) leading to decline in salmon populations. Attempts have been made to replace losses of with extensive restocking – and now the majority of Baltic Sea salmon are from restocked populations although the wild population is slightly increasing (RKTL 2012). However, many wild salmon populations, both in the Atlantic and Baltic Seas continue to be under threat (Lehtonen et al. 2008, RKTL 2012). See Annex II for a dedicated case study by Kulmala et al. on Baltic salmon.

- Other marine and Baltic Sea species

In the NE Atlantic, blue whiting, plaice, saithe and haddock stocks are on their way to recovery or doing fairly well. However, there is concern about red fishes and deep-water species of which not much is known. Northern shrimp stocks are generally considered sustainable with the exception of some local stocks that might be overexploited. In the north-west Atlantic, Greenland halibut, yellowtail flounder, Atlantic halibut, haddock and spiny dogfish are recovering. Finally, mackerel stocks in the North Sea remain low, still struggling to recover from the collapse of the 1960s. In the Baltic Sea, several species are under thread due to overfishing, including pollock, ling, turbot and eel (IUCN, cited in Garpe 2008).

Aquaculture

Aquaculture has been practiced since the 19th century in Nordic countries – even since the 17th century in Sweden – however it is only since the 1950s–1970s than the cultivation of fish began on a more extensive scale. At times the growth of aquaculture has been tremendous although some signs of levelling off can now be observed (Paisley et al. 2010).

As with fisheries, Norway is the biggest producer of cultured fish and there are more fish farms in Norway than any other Nordic country (Table 9.5 below). Norway also ranks high on the global scale, being the world's ninth biggest aquaculture producer (Rana 2006, cited in Paisley et al. 2010). Nordic aquaculture takes place either in marine or inland water. Most of the fish farms in Norway and Iceland are coastal whereas land based fish farms dominate in Sweden, Denmark and Finland (Paisley et al. 2010).In terms of species, Salmonid fish (e.g. salmon and rainbow trout) are the most popular cultivated fish but a variety of other species and shellfish are also cultivated in smaller amounts. A speciality is two Finnish sturgeon farms that produce highly valuable beluga-caviar (Paisley et al. 2010). There is also minor organic fish production in Nordic countries.

In addition to cultivating fish for human consumption, fish are also cultivated to replace and maintain diminishing natural fish stocks such as Baltic Salmon (Paisley et al. 2010, Garpe 2008). In Finland, there are many inland farms that cultivate young fish during the summer with a view to releasing them in the wild during the autumn.

In terms of sustainable use of Nordic biodiversity resources, aquaculture could in principle reduce pressure on wild fish stocks. However, as Garpe (2008) points out, most fish farms use wild fish as their food supply. It has been estimated that around 5 kg of wild fish is required to supply 1 kg of salmon fillet (Angervall et al. 2008, cited in Garpe 2008). Other problems relating to aquaculture are eutrophication of natural water courses by fish feed and wastes, and spread of diseases or genes from cultivated fish to wild populations (Paisley et al. 2010). New technical solutions are needed to solve these problems, as well as more ecology/biology based production such as multi-trophic aquaculture.

Table 9.5 Aquaculture in Nordic countries

	Iceland	Norway	Denmark	Sweden	Finland
Number of holdings	51	145,38	366	214	485
Total production (tonnes)	5,704	1,017,711[1]	42,120	9,260[1]	12,031[1]
Production by species (tonnes)	Arctic char 2,700	Salmon 39,575	Rainbow trout 34,499	Rainbow trout 7,859	Rainbow trout 10,984
	Cod 2,000	Rainbow trout 54,538	Eel 1,729	Arctic char 1,307	Whitefish 723
	Salmon 880	Cod 21,240	Other trout 461	Musslor 1,382	Sea trout 7
Value of the aquaculture	Not available	30,750,673 thousand NOK (~4,075,554 thousand EUR)[2]	1,049,367 thousand DKK (~141,233 thousand EUR)[2]	253,700 thousand SEK (~28,957 thousand EUR)[2]	46,300 thousand EUR
Reference year	2008	2010	2010/2007	2010	2010
Source	Paisley et al. 2010	Statistics Norway 2012/ Paisley et al. 2010	Statistics Denmark 2012/ Paisley et al 2010	Statistics Sweden 2012b, 2012c	RKTL 2012

[1] Fish for food.
[2] Based on based on exchange rate in 2012.

Reindeer herding

Semi-domestic reindeer herding is a traditional form of animal husbandry in Arctic regions. It is still very important source of income in Finland, Sweden and Norway (see Chapter 10). In Iceland and Greenland reindeers are mainly free-grazing and hunted as game (see below).

While reindeer can roam freely in Greenland and Iceland, in Finland, Sweden and Norway the reindeer herding area is defined by legislation. The area, situated in the north of the region, covers around 140,000 km^2 in Norway (40% of the land), 160,000 km^2 in Sweden (34% of the land) and 114,000 km^2 in Finland (33% of the land) (Jernsletten and Klokov 2002).

The number of reindeers fluctuates annually and recently there have been dedicated attempts to limit numbers in order to protect the quality of pastures (see below). In Finland, the size of reindeer “stock” was estimated to be around 200,000 animals in 2009, with the existing data also indicating an increase in numbers (185,000 animals in 2001). In

Sweden, the available statistics indicate an increase from 230,000 animals in 1998 to 260,000 in 2005[9] where as in Norway the estimated number of reindeer was 165,000 animals in 2001 (Jernsletten and Klokov 2002). In all countries, however, the current number seems to be below the peak numbers of the late 1980s and early 1990s (around 300,000 animals in Sweden in 1989 and 218,000 in Norway in 1992). Population estimates for reindeer were over 100,000 animals in Greenland in 2006 (Greenland Tourism and Business Council 2012), and varying between 7,000–10,000 animals in Iceland.

As a widespread and dominant ungulate across many tundra and taiga regions, the reindeer plays an important role in affecting ecosystem structure and function (Forbes and Kumpula 2009, Forbes et al. 2006). Animals, both free-ranging and herded, move seasonally between habitats and pastures. Their effects on vegetation and soils vary greatly in space and time depending on factors such as altitude/exposure, snow depth, substrate, moisture, prevailing vegetation type and, most importantly, animal density. Consequently, degrading of pastures due to overgrazing is one of the biggest challenges for reindeer herding in the future. In addition, competing land use with forestry (see Chapter 8) and an increasing number of predators (see Section on “game” below) might affect numbers.

Berries and mushrooms

According to different estimates, over a billion kilograms of berries ripen in the Nordic forests annually, mainly in northern parts of Finland and Sweden (Paassilta et al. 2009, Turtiainen et al. 2011, Jonsson and Uddstål 2002). In Finland, annual average bilberry (*Vaccinium myrtillus*) yields are 22.3 kg / ha and lingonberry (*Vaccinium vitis-idaea*) yields 22.7 kg / ha[10] (Turtiainen et al. 2011) with total yields varying between years. Several other edible berries grow in Nordic nature including cloudberry (*Rubus chamaemorus*), raspberry (*Rubus idaeus*), wild strawberry (*Fragaria vesca*), cranberry (*Vaccinium oxycoccus*), arctic bramble (*Rubus arcticus*) and sea buckthorn (*Hippophaë rhamnoides*) to name a few. In Sweden, yield estimate for cloudberry is 70–90,000 tonnes / year (Jonsson and Uddstål 2002).

Yield estimates for other berries and for countries other than Finland and Sweden were not found in the context of this study. Also, no estimates

[9] http://www.samer.se/1536

[10] Calculated average per ha over years, based on information from several berry stands.

were available for yields of wild mushrooms. However, socio-economic information on the use and harvest of berries and mushrooms in the Nordic countries are outlined in Chapter 10, which could be used as a proxy to gain a more comprehensive picture on the status and trends.

Game

Eurasian elk is the most important big game species in Finland, Sweden and Norway. Other important ungulate species includes roe deer, red deer and wild reindeers. In Greenland, musk oxen are also hunted. Typical smaller game species are arctic hares and grouse species in forested Scandinavia and water fowl and different goose species. In Finland, raccoon dog (*Nyctereutes procyonoides*) hunting has also increased substantially with the number exceeding felled arctic hare numbers (RKTL 2012). Pheasant (*Phasianus colchicus*) is the most hunted game bird in agricultural Denmark. In Iceland, smaller game includes birds like rock ptarmigan or puffin. Finally, in Greenland and Norway whaling is also practised. In Norway, only minke whale is harvested but in Greenland several other whale species are also harvested. Seals and walruses are caught in Greenland and seals are also hunted elsewhere (Statistics Greenland 2012, Heiðarsson et al. 2010, RKTL 2012, Dahl et al. 2009).

Comprehensive and comparable data on the population sizes of game species was available only for the key game species. In addition, information about the numbers of hunted animals can be used as proxies for the overall status of and trends in population sizes. The catches of *Eurasian elk and other ungulates* have risen drastically in Finland and Norway, being now around 80,000 in Finland and 40,000 in Norway (RKTL 2012, Statistics Norway 2012). This can be attributed to Eurasian elk benefiting from modern forestry (e.g. abundance of young forests) and the lack of predators (Lavsund et al. 2003). The estimated Eurasian elk population is around 500,000 individuals in Finland, Sweden and Norway, with an average 88–104,000 individuals in Finland, 90–117,000 in Norway,[11] and 200–300,000 in Sweden (Lavsund et al. 2003, RKTL 2012, Sohlberg et al. cited in Lavsund et al. 2003, Svenska Jägarförbundet 2012). Eurasian elk density in Fennoscandia is estimated to be 0.7–0.8 elk / km^2, with the densest population in Sweden, then Norway and the sparsest in Finland (Lavsund et al. 2003). In Greenland wild reindeer and musk oxen have become so numerous that the population is in danger of collapse due to

[11] In 1991–2000.

overgrazing (Statistics Greenland 2012). Catches of wild reindeer have more than tripled and catches of musk oxen increased from 600 to 2,500. In Iceland wild reindeer hunting is around 1,300 individuals a year to keep the population number stable (Heiðarsson et al. 2010).

Contrary to the above, catches of *small game* (hare and grouse) have gone down in Norway and Finland. In Iceland, catches of rock ptarmigan have gone down drastically in recent years – but this is probably due to natural population fluctuations/cycles (Heiðarsson et al. 2010). However, in year 2003 ptarmigan hunting was banned and hunters are now requested to voluntarily limit ptarmigan catches to their personal needs (Heiðarsson et al. 2010). Catches of several other bird species have gone down (Statistics Iceland 2012), for example puffin catches have gone from 200,000 to a mere 30,000. While some forest bird species are probably suffering from modern forestry practices (CBD Finland 2009), no clear explanations for the general decline in small game populations could be found.

Bears, wolfs and lynxes are protected in the Nordic countries, but special permissions for hunting the former two can be obtained both in Sweden[12] and Finland (RKTL 2012, Naturvårdsverket 2012). In Norway, only nuisance predators can be felled (Direktoratet for naturforvaltning 2012). Current population sizes for bear and wolf in the Nordic countries are outlined in Table 9.6 below. Given the targeted protection, predator numbers have increased in recent years. In total there are some 4,500 lynxes and bears in Norway, Sweden and Finland. Wolves are far less numerous at only around 300. In comparison, around 200 bears (FI and SE) and 100–300 lynxes (FI, SE and NO) are felled annually. The number of felled wolves is significantly lower (Naturvårdsverket 2012, RKTL 2012, Statistics Norway 2012). In Greenland 124 polar bears were felled in 2010 (Statistics Greenland 2012).

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[12] Sweden only started the wolf hunting year 2010 after several years of full protection (Naturvårdsverket/Naturvård/Jakt och vilt 2012).

Table 9.6 Large predator populations in Norway, Sweden and Finland

	Norway	Sweden	Finland
Bear	126	3,200	1,300–1,400
Wolf	19–23	126–143	135–145
Lynx	450	1,500	2,400–2,600
Wolverine	340	360–470	150
Source	Direktoratet for naturforvaltning 2012	Naturvårdsverket 2012 / Dahl et al. 2009	RKTL 2012

It appears that the status of and trends in several key Nordic game species are sustainable and, with few exceptions (see below), the threats concerning game species are often not hunting itself but habitat degradation and fragmentation. Where ungulates (e.g. Eurasian elk and deer) generally benefit from habitat fragmentation – i.e. they are able to find good feeding grounds in seedling stands and young forests – other species including smaller game species and wild reindeer suffer from it (CBD Finland 2009).

In Greenland, there is a notable reduction in bird catches due to overhunting, falling from 400,000 to 200,000 in ten years (1998–2007). The most drastic drop seems to be in guillemots (from 200,000 to 80,000) and eiders (from 80,000 to 25,000). Catches of black guillemots, ptarmigans and black-legged kittiwake have also declined (Statistics Greenland 2012). During recent years efforts have been made to secure sustainable hunting following the scientific biological recommendation on game species, resulting in a successful increase in some populations (CBD Greenland 2010).

Hunting of endangered predators (bear and wolf) remains a very controversial issue in the Nordic countries. The population sizes are clearly very small, however hunting – albeit with special permission – is still allowed annually. Whale hunting in Greenland and Norway is also controversial. The hunting of predators is a difficult issue because they do cause damage for example to sheep or reindeer farmers. On the other hand, both predators and whales are a valuable attraction for foreign and domestic tourists (see Box 12.2).

Drinking water

There are abundant freshwater resources in the Nordic countries (Table 9.7) compared to other European countries (Eurostat 2012) and it is generally acknowledged that overuse of fresh water is not likely to be a problem at the Nordic level – even if water is used in great quantities – as resources are still not abstracted to their full capacity (See Chapter 10). However, there have been issues with water shortage at the local level (e.g. in some regions in Denmark, see Chapter 12), possibly aggravated by climate change in the future.

In terms of the key threats, agricultural fertilizers and pesticides can leak into fresh water sources (e.g. groundwater), especially in intensively cultivated regions such as Denmark. There are also other groundwater pollutants that are of natural / geological origin such as radon and fluoride (Knutsson 2008). Urbanization and transportation also cause pollution problems to fresh water sources. For example, chloride pollution by de-icing salts from roads or heavy metal pollution from urban storm waters can leak into fresh water reservoirs and groundwater (Knutsson 2008).

Table 9.7 Freshwater resources in the Nordic countries

	Denmark	Sweden	Norway	Finland	Iceland
Total fresh water resources (mill m^3)	16,340	175,118	374,011	120,800	170,000
Groundwater available for annual abstraction (mill m^3)	1,000	3,460	137,687	3,000	6,000
Reference year	Latest available*	2009 (total) Latest available* (ground water)	2009	2005 (total) 2001 (ground water)	Latest available*

*In a number of cases, the information available from Eurostat is for "latest available" year without no specification of the year.
Source: Eurostat 2012.

9.2.2 Regulating services

Comparable national level data for the capacity of Nordic ecosystems to provide or maintain different regulating services (i.e. to match the direct indicators) is largely *not available*. Most of the existing studies focus on studying ecosystem processes on a very local scale, with no explicit (spatial) link to the provisioning of ecosystem services. Therefore, they are not considered to be applicable or directly relevant in the context of this assessment.

Recently, there have been European scale attempts (led by JRC and PEER network) for mapping and quantification of ecosystem services and relevant results of those studies have been outlined in the section below (See Section 3.2.2 for more detailed explanation). Based on the JRC and PEER work it has been possible to develop dedicated estimates for the biophysical status and distribution of some key ecosystem services in the Nordic countries (e.g. carbon storage, soil carbon content, nitrogen retention and pollination). Finally, it is to be noted that different models in different countries can make the comparison of existing information difficult between countries as the results vary based on local or national scale models. This should be taken into consideration when interpreting the results.

The information for a limited number of regulating services available from the Nordic countries, namely mitigation of climate change (carbon sequestration and storage), maintenance of water quality (nitrogen retention) and pollination, is outlined below. In addition, information on socio-economic importance as outlined in Chapter 10 can be used as a proxy to support indicative assessments and conclusions.

Carbon sequestration and storage

The importance of forest and other ecosystems for carbon storage and sequestration have globally become key considerations when combating climate change. The importance of forests to global carbon balances is highlighted by the fact that more carbon is in the biomass and soil of forests than in the atmospheric carbon pool (Lorenz and Lal 2010). A significant part of the Nordic region is covered by forest ecosystems, thus Nordic ecosystems play an important role in regulating regional and global carbon balance. There are three different options for Nordic countries to help mitigate climate change: preserving the existing forest and other carbon storages (i.e. actively contributing to not increasing the CO_2 load from forests to the atmosphere), increasing the carbon sequestration in forests and other ecosystems (i.e. removing CO_2 from atmosphere), and using (forest) biomass as "climate-friendly" material for energy production (see Section 9.2.1 above).

In general, carbon sequestration in *tree biomass* is determined by tree growth (Cooper 1982) whereas the size of carbon storage depends also on the losses of carbon, natural mortality and decomposition and harvests. Tree growth, and thus carbon sequestration, is also influenced by climate and weather, amount of sunshine, soil fertility and the composition of species. Based on the above, there is a general trend that carbon is sequestered more efficiently by trees in southern areas of the Nordic countries (see for example Liski et al. 2002, Svensson et al. 2008, Berggren Kleja et al. 2008). Spruce and broadleaved forests also sequester more carbon in their biomass than pine forest, but this difference is partly due to the fact that pine often grows on less fertile sites and thus grows less and slower (Jandl et al. 2007). Forest stand age is also an important factor determining carbon sequestration; middle aged (12–40 years) forest seems to be best at sequestering carbon in tree biomass whilst older forests have bigger carbon storages but slower sequestration rates (Cooper 1982, Jandl et al. 2007, Kolari et al. 2004).

Older forests also seem to have less carbon loss since respiration is lower. The lower respiration is mainly because there is less litter to be decomposed in older forest stands (Kolari et al. 2004). Finally, as no photosynthesis happens in the winter in boreal zone, no carbon sequestration occurs (Kolari et al. 2004).

The *carbon in forest soils* (detritus and soil organic matter) accounts for most of total forest carbon, especially in boreal forests (Gholz and Fisher 1982 cited in Cooper 1982) (Figure 9.1). In cold and humid climates the decomposition is slower, thus more carbon accumulates (Yurova et al. 2007). A Swedish study calculated that the carbon sequestering rate in forest soils decreased from south-western Sweden to northern Sweden (Akselsson et al. 2005). Liski et al (2002) found that the litter input was the main factor influencing soil carbon storage: bigger trees produced more litter and thus more carbon was stored in the soil (see also Akselsson et al. 2005). The composition of species also had significant effects; "other deciduous" trees (meaning deciduous trees other than birch) had biggest litterfall and thus "other deciduous" forest had the biggest carbon sequestering in soil, spruce was the next best followed by pine and birch (Akselsson et al. 2005). To obtain a general picture of the topsoil organic carbon content in the Nordic region the results of the JRC ecosystem service mapping were re-scaled (Figure 9.1). Maes et al. (2011a) used the data from ESDAC[13] as a surrogate for the capacity of ecosystems to maintain the quality of soils. The percentage of carbon in top soils was highest (46–60%) in north-western Finland, and lowest (less than 3.6%) in the open ecosystems in high altitudes, especially in Norway, and some areas in Denmark. Carbon content vary between 3.7–30% in the majority of the forest ecosystems.

As forest area and growing stock has increased in Europe (see Chapter 7) so has the forest carbon stock (Figure 9.2). In general, both above and below ground biomass carbon and soil carbon has increased since the beginning of the last century (Ciais et. al. 2008, San-Miguel-Ayanz et al. 2011, see also Liski et al. 2002). Currently the carbon stock in European forest (above- and belowground biomass) is estimated to be 46,132 Mt (2010) (San-Miguel-Ayanz et al. 2011). According to UNFCCC National reports (2011), the Nordic forests[14] (excluding Iceland) act as a significant carbon sink with an estimated annual gain (i.e. sequestration) of carbon of

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[13] The JRC's European Soil Data Centre http://eusoils.jrc.ec.europa.eu

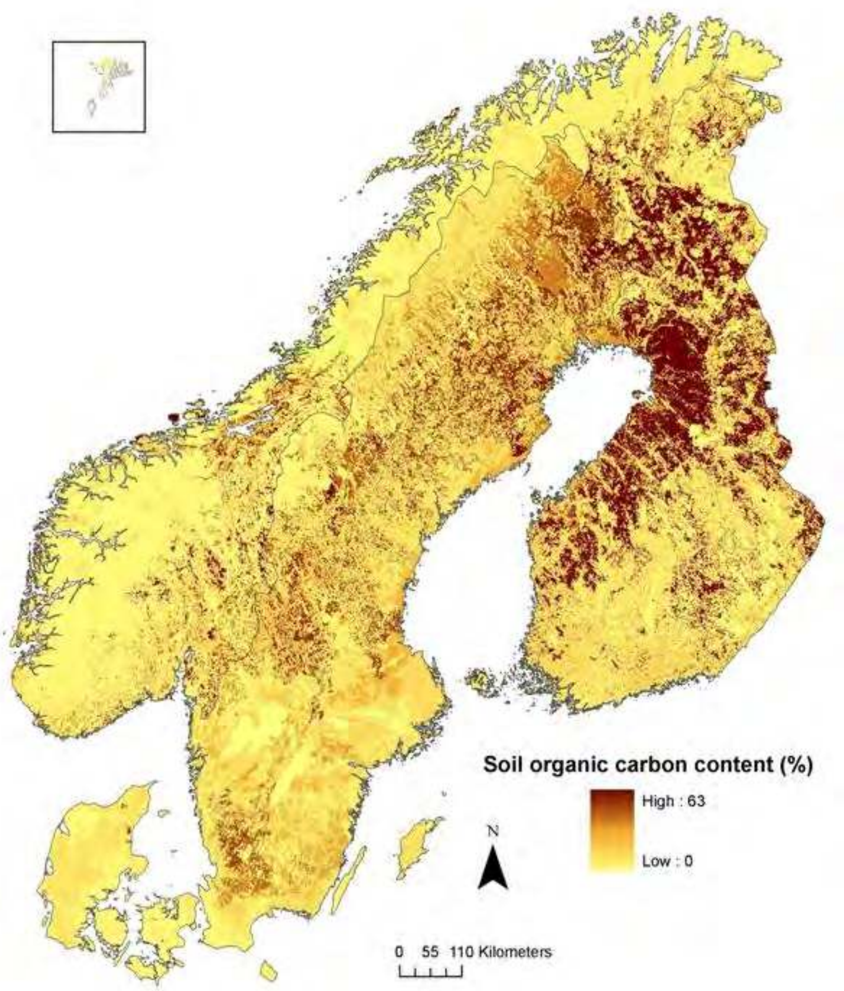
[14] These are for forests included in Kyoto Protocol LULUCF Article 3.4 activities: Forest Management, altogether 62 million ha.

19,799.69 Gg in above and 2,915.90 Gg in below ground biomass. As for Nordic soils, according to 2011 estimates mineral soils gained 7,171.02 Gg carbon, but 4,750.43 Gg carbon was lost from organic soils.

Estimates for the spatial distribution of *above and below-ground carbon* stored in living plant material were based on the CDIAC[15] and Global land cover data 2000 that were re-scaled for the Nordic countries from the JRC data base (Maes et al. 2011a). Carbon storages are the largest in Southern Sweden, some parts of the south-east coast of Norway and south-west Finland, where they can be up to 90–130 tonnes / ha. In the forest ecosystems of the northern parts of Fennoscandia carbon storages vary between 40–70 tonnes / ha. (Figure 9.2).

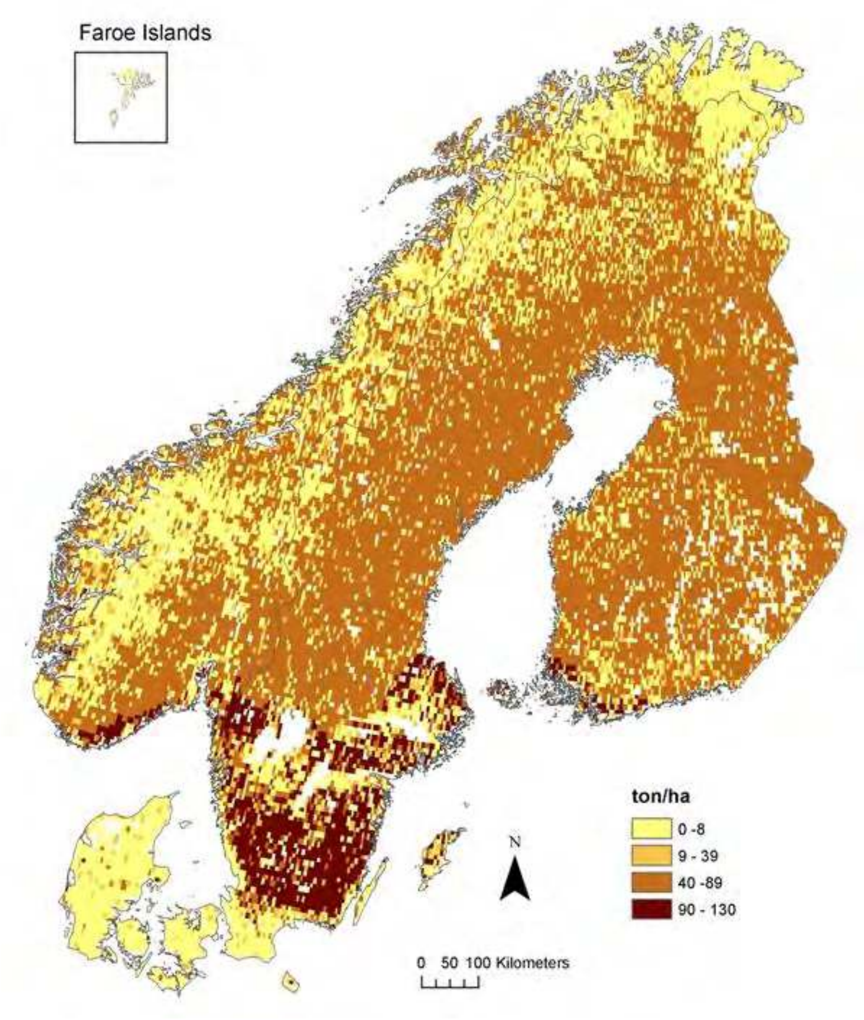
[15] http://cdiac.ornl.gov/epubs/ndp/ndp017/ndp017b

Figure 9.1 Soil organic carbon content based on the models of JRC



(http://esdac.jrc.ec.europa.eu/). Data source: European Commission, Joint Research Centre, Institute for Environment and Sustainability. © SYKE, © European Communities, 1995–2012.

Figure 9.2 Carbon storage (above and below ground) in the Nordic countries (tonnes / ha) based on the models of JRC. (Maes et al. 2011a, 2011b)



Data source: European Commission, Joint Research Centre, Institute for Environment and Sustainability. © SYKE, © European Communities, 1995–2012.

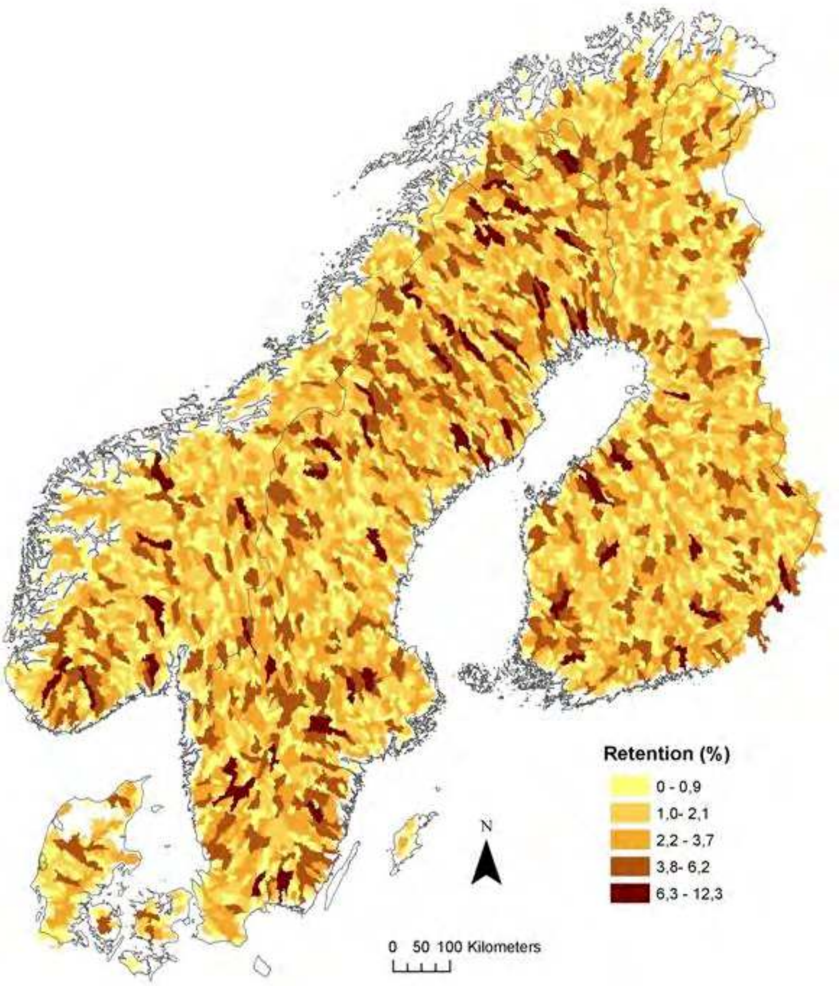
Water purification: nutrient retention

The importance of water quality and restored aquatic ecosystems (especially fresh water) are noted as top priorities in European environmental policies, for example in the Water Framework Directive and the Blueprint for European waters (European Commission 2012). In the Nordic countries the state and quality of the water ecosystems have been relatively good compared to Central or Southern Europe. However, as outlined in Chapter 7, water quality has decreased in many parts of the Nordic region due to agricultural loads, ditching of forests and drainage of mires either for forestry or peat production, or due to nutrient loads from point sources. While agriculture is responsible for most pollution, its effect is concentrated to intensively cultivated regions while forestry impacts waters on a broader scale (Lehtonen et al. 2008).

Nitrogen (N) retention is just one recognised ecosystem service related to water purification while also those linked with other elements such as phosphorous, heavy metals, biochemical compounds, and microbes should be taken into account to do proper comprehensive mapping of the regulating service we call water purification. However, N retention is an indicator for which relatively advanced models are currently available to map the biophysical status of the service. Rivers and streams play a key role in N retention. However, lakes can also be important regulators of N as their presence in the overall systems increases the time available for uptake, sedimentation and denitrification of N within the catchment area. In those aquatic ecosystems biodiversity – especially river bed bacteria, macrophytes and plankton – are the main consumers of in stream nitrogen and recent evidence shows that river retention is positively influenced by aquatic biodiversity. However, the supporting or regulating role of biodiversity is widely missing from the current models, which are normally based only on the physical variables related to climate and geomorphology of the landscape (Maes et al. 2011b).

The challenges related to the different models estimating the biophysical status of water quality regulation are discussed in Chapter 11. Comparison of the Nordic countries (excluding Iceland) based on the GREEN model suggest that retention capacity of nitrogen is 1.31% of total N load for DK, 1.58% for FI, 1.42% for NO and 1.81% for SE, and the amount of total N removed was 2,270 tonnes for KD, 7,853 for FI, 3,567 NO and 14,429 for SE (Maes et al. 2011b). If the total N removed was counted per kilometers of the water way, the national differences can be seen more clearly: 0.910 tonnes / km for DK, 0.228 tonnes / km for FI, 0.150 tonnes / km for NO, and 0.321 tonnes / km for SE (Maes et al. 2011b). However, national models have shown that, at least for FI and SE, the national N budget models that take into account the role of lakes in N cycles result in higher retention values (Lepistö et al. 2006). The capacity of rivers and large lakes for nitrogen retention (%) and removal for the Nordic countries is shown in Figure 9.3. This map is based on the results of the GREEN model originally used for European scale with 10 km resolution, and now re-scaled for the Nordic countries (Grizzetti et al. 2005, Maes et al. 2011a).

Figure 9.3 Nitrogen retention capacity in the Nordic countries based on the JRC models. (Maes et al. 2011a, 2011b)



Data source: European Commission, Joint Research Centre, Institute for Environment and Sustainability. © SYKE, © European Communities, 1995–2012.

A recent assessment by Barton et al. (2012) reveals a relatively good body of evidence related to the provisioning and cultural services from the Nordic watersheds (see Chapter 10 below). However, significantly less data is available for regulating services, especially on a regional and national scale. The existing studies are often local or technically oriented research publications which makes the applicability of their insights difficult on a Nordic scale. However, some of the findings focusing on a wider, regional or national scale are summarised below.

In Sweden the effect of wetlands to catch nitrogen and phosphorous were calculated for the time period 1985–2006 based on the HBV-NP model (Brandt et al. 2009). During the period 1996–2006 1,574 wetlands were constructed in Southern Sweden, covering a total area of 4,135 ha. There was uncertainty in the results due to missing information for the wetlands, and the removal rate of phosphorous in particular was probably overestimated in the calculations. In general, Brandt et al. (2009) concluded that phosphorus reduction was difficult to assess and the models used need to be improved. The results show that the total local removal in these wetlands was 140 tonnes / year for nitrogen and 12 tonnes / year for phosphorus, according to the most realistic assumptions used to describe the character and potential of the wetlands. The effect on the total load to the sea for Southern Sweden was lower, due to retention processes in rivers and lakes: 110 tonnes / year for nitrogen and 9 tonnes / year for phosphorus. The wetland removal was highest in the very south of Sweden where the water discharge and concentrations were high, and where there are few lakes in the river system. The total transport from land to the sea from the south of Sweden was reduced by < 0.2% for nitrogen and 0.5% for phosphorus as an effect of the constructed wetlands.

In Denmark, more than 90% of lowland streams and rivers have been regulated to drain the surrounding land for agricultural production, which has diminished the effects of flooding and increased the flush of nutrients into the water bodies. Background concentrations of nitrogen in streams and lakes varied from 0.06 mg nitrate N / litre to 0.83 mg / litre in the most polluted areas, being within the range of 0.27–0.40 mg / litre in the most of the areas (Kronvag and Hoffmann 2009). Kronvag and Hoffmann (2009) show that ecosystems' capacity for water purification, i.e. rates of nitrogen removal in restored wetlands, varied from 140 to 475 kg of N / ha / year and most often in the range of 200–300 kg. In lakes, the measured nitrogen removal varied from 40 to 252 kg of N / ha / year, estimated values were higher varying from 200–440 kg of N / ha / year.

Wetlands capture nutrients partly by sedimentation and partly by plant uptake. Sedimentation of nutrients and organic matter is possible when the water flow slows down in a wetland. This slowing can be achieved by dense vegetation or by creating a serpentine structure to a watercourse. Sedimentation is a particularly important mechanism in Nordic countries since a major part of runoff occurs at times when plants are not active (Koskiaho et al. 2003). The size and structure of a wetland is an important factor defining its role in nutrient retention within a watershed. Nordic studies estimate that if the size of wetland is less than 1% of the size of catchment, the nitrogen capture is 3–15% (Häikiä 1998, Braskerud 2001, both cited in Koskiaho et al. 2003). If wetland size is increased to more than 3% of catchment size the capture efficiency of nitrogen can be 23–52% (Whigham et al. 1999 and Kovacic et al. 2000 both cited in Koskiaho et al. 2003). Also different buffer zones along streams can be used to capture harmful substances. Forested buff-erzones are very efficient in capturing nutrients (see for example Gundersen et al. 2010, Ahtiainen and Huttunen 1999, Lauren et al. 2005). Agricultural buffer zones can be efficient, removing a major part of nitrogen, phosphorus and particles (Syversen 2005).

Pollination

All pollinators in Nordic countries are insects, the most important being bees (e.g. bumblebees and honeybees) (Söderman 1999). In addition to the wild pollinators, the role of domesticated honeybees is important especially in intensively cultivated agricultural areas in Denmark and south Sweden (Hansen 2006, cited in Axelsen et al. 2011, RahbekPeder-sen 2009a). The production of 84% of crop species cultivated in Europe depends directly on insect pollinators, especially bees (Williams 1994).

A diverse set of pollinators is important, both to secure the pollina-tion service of diverse plants and also for the resilience of the pollination service. Domesticated honeybee colonies are currently suffering from serious infestations of Varroa mites and associated viruses that have caused bee losses worldwide and in Nordic countries (Rahbek Pedersen 2009b). Also, wild pollinators, especially bumblebees, can be active in cooler and more challenging weather conditions than honeybees and therefore they can be considered crucial in the Nordic countries (Corbet et al. 1991, Delbrassinne and Rasmont 1988, cited in Axelsen et al. 2011, RahbekPedersen 2009a).

Nordic plants are dependent on insect pollination to varying degrees; for example apple is approximately 70% dependent on it, while rape (*Brassica napus oleifera*) is only 10–20% dependent on insect pollina-tion. There are many reviews on different plant species dependence on insect pollination (see for example Klein et al. 2007) and recent reviews with Nordic relevance have been undertaken in Denmark and Sweden (see Rahbek Pedersen 2009a and Axelsen et al. 2011). In addition to yield increase, pollinators can also contribute to the quality of yield. With apples and strawberries, for example, as more seeds/embryos are pollinated the fruit grows more evenly round and also usually bigger (Free 1993, see also Andersson et al. 2012). Most studies concern the yield increase contributed by domesticated bees, but the contribution of wild pollinators to yield is less known. In Sweden Bommarco et al. (2011) noticed that red clover seed yields had become less stable at the same time as there had been serious changes in pollinator species composition. A study by Andersson et al. (2012) considered only wild pollinators and their contribution to strawberry pollination: in organic fields there were more pollinators and thus better pollinated and more high-quality strawberries; the total yield however was not considered.

The importance of pollinators for the Nordic countries is widely recognised, however it has been difficult to find comparable data to estimate spatially-explicit pollination potential in varying ecosystems. Pollination potential was recently estimated at the European scale by Maes et al. 2012. Their approach was based on the evidence that different habitats, such as forest edges, grasslands and riparian areas can support nesting populations of wild pollinator insects like bees and bumblebees (Figure 9.4). These populations can pollinate adjacent agricultural crops, fruits, and berries depending on the flight distance of different pollinator species. Re-scaled results of the model on a Nordic scale show that the relative pollinator abundance of bees and bumble bees is higher in Finland, while distribution of crops is higher in Southern Sweden and Denmark where there are more agricultural ecosystems (Table 9.8, Figure 9.4). The dependence of wild berries on pollinators was included in the model, which underestimates their importance in many forest and open ecosystems in the Nordic countries.

Table 9.8 Potential pollinator abundances of bees and bumble bees per country

Country	Potential pollinator abundance index (bees)	
	Mean	Sum
Sweden	0.55	22,471,500
Finland	0.71	21,715,200
Denmark	0.46	1,933,280
Norway	0.48	13,324,500
	Potential pollinator abundance index (bumble bees)	
Sweden	0.67	27,426,700
Finland	0.82	24,903,600
Denmark	0.48	2,009,560
Norway	0.62	17,356,800

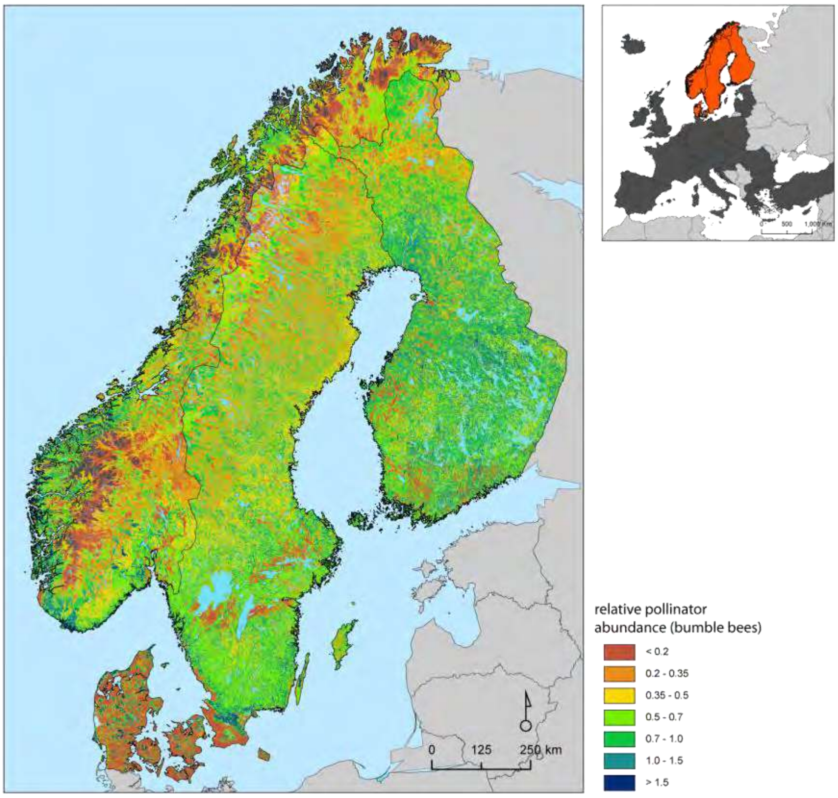
Abundance index varied between 0 and 10 in Europe, and between 0 and 3.86 in the Nordic countries. In table above, the “mean” reflects to the values between all the pixels of each country; the “sum” shows the sum of all the pixels of each country (Maes et al. 2012).

At aggregated EU level, 23.6% of the total production of crops which depend on pollination could be assigned to insect pollination. This figure corresponds to a production deficit if no pollination services were offered by insects. This value decreased to 1% if all crop production was considered, including the large share crops that are not dependent on pollination (Maes et al. 2012).

There is evidence that pollinators – and related services – are in decline in the Nordic countries (e.g. Bommarco et al. 2011 or Samnegård 2011 or Pöyry et al. 2004). Pollinators need both feed and places to nest, and these should preferably be close to one other, as small animals like pollinators cannot move long distances (review Linkowski et al. 2004, see also Samnegård 2011). This is why habitat fragmentation can be detrimental to pollinators. However, some species can fly fairly long distances and these species can even benefit from habitat fragmentation as noticed by Bommarco et al. (2011). In Finland and Sweden, the main reason for pollinator decline is fragmentation and loss of different seminatural grasslands (Pöyry et al. 2004, Bommarco et al. 2011). Presumably, this is also true elsewhere within the region. Diverse seminatural grasslands can also provide feed for more specialised pollinators. In Finland Kuussaari et al. (2007) found that fallows with high plant diversity had more a diverse set of pollinators. Use of pesticides is another reason for pollinator decline, which is why organic farming seems to benefit pollinators. In addition, there have been severe disease incidents among pollinators (Potts et al. 2010) and climate change will also affect pollinators, as it has an impacts on the timing of flowering and timing of high pollinator abundance (Hegland et al. 2009).

Currently one third of Swedish wild bees are considered threatened and 15 species have gone extinct (Gärdenfors 2000, cited in Linkowski 2004). In Finland, 19% of bees (42 species) were threatened and two species have gone extinct. In addition 28 species were considered to be near threatened (Rassi et al. 2001). Although not all species are declining, the general pollinator diversity is, which can result in less reliable pollination services (Bommarco et al. 2011).

Figure 9.4 Relative pollinator abundance of bumblebees in the Nordic countries based on the models of the JRC (Maes et al. 2012)



Data source: European Commission, Joint Research Centre, Institute for Environment and Sustainability. © European Communities, 1995–2012.

9.2.3 Cultural services

Status and trends in ecosystems' biophysical capacity to maintain and deliver cultural services are particularly difficult to measure and estimate. Therefore, their assessment is commonly based on the use of socio-economic proxy indicators (See Chapter 10). Consequently, a *very limited amount* of existing information could be found to reflect the biophysical element of cultural ecosystem services in the Nordic countries.

Recreation is one of the most commonly assessed cultural services and it has been included in the recent studies by JRC and PEER network. Based on this data, indicative estimates and spatially explicit maps describing the capacity of ecosystems to provide recreation services (i.e. so called "recreation potential") have been developed for the Nordic EU countries (DK, FI, and SE).

In addition, in the Nordic countries a number of provisioning services (such as provisioning of game, fish, berries and mushrooms) are closely linked with recreation. Therefore in a number of cases ecosystem's capacity to provide these services might be used as an indicator also for their potential to maintain and "cater for" recreation.

Recreation

Nordic countries (perhaps with the exception of Denmark) are sparsely populated and characterised by vast natural areas and green spaces that are to a large extent freely accessible to the general public. There are over 100 national parks in Nordic countries, complemented by numerous other protected areas (see Table 3.1). Furthermore, new national parks and other protected and/or recreational areas are being continuously established. The majority of these areas are very well maintained with good facilities and signed paths and can be accessed free of charge by the public.

The above elements create a significant "potential" for recreation. For example, according to a recent survey half of Finns live within 200 metres of a forest, and the average distance to a forest is 700 metres. Beaches and agricultural areas are also within walking distance, with the average distance approximately 2 km (Sievänen and Neuvonen 2010). Similarly, the majority of Danes (67%) have green spaces within 300 metres of their home and almost all live within 1 km of a park (Schipperijn et al. 2010).

At the European level, the "recreation potential index" created by JRC combines a range of attributes (e.g. degree of naturalness, presence of protected areas, presence of coastlines and quality of bathing water) in order to provide a composite indicator for the ability of ecosystems to "cater for" recreation (Maes et al. 2011a). Based on these results, the overall recreation potential in the Nordic countries was high in northern Finland and Sweden, and low in Denmark. However, the results can change significantly when the distance between recreation site and living place, and average trip lengths for everyday recreation and vacation recreation, are added into the model. An improved model, using so called Recreation Opportunity Spectrum (ROS) zones, will be further elaborated in the PEER/PRESS reports in the future (Maes et al. 2011b, 2012).

9.2.4 Supporting ecosystem processes and functions

Ecosystem processes underlying the provisioning of all other services are often lacking from ecosystem service assessment – and even classifications – because of the extreme difficulties to estimate their value and contribution to benefits experienced by people. While detailed socio-economic assessment of these services might be both unfeasible and unnecessary (as there would be hardly any life on Earth without these fundamental processes) it should be considered necessary to at least better understand the biophysical status of and trends in these processes, given their essential role in supporting other services. Also, it should not be considered safe simply to assume that these processes will automatically be maintained by mapping, quantifying and valuing – and hopefully protecting – the other types of ecosystem services.

In the context of the TEEB Nordic, no dedicated assessments related to the status of and trends in supporting processes and functions could be found. In general, existing information on the overall status of species and ecosystems (e.g. species numbers) could be used to indicate general ecosystem health and therefore also used as rough proxies for the status of ecosystem processes. However, assessing and elaborating on these aspects beyond the synthesis provided in Chapter 3 falls outside the scope of this report.

10. Socio-economic value of Nordic ecosystem services

10.1 Identification of indicators

Assessing the socio-economic importance and value of ecosystem services (i.e. the anthropogenic "demand" for ecosystem services) is based on identifying indicators that reflect the benefits of these services to human wellbeing (e.g. direct and indirect benefits, public and private benefits). In general, these benefits can be measured by using qualitative, quantitative or monetary information (See Chapter 5).

Table 10.1 provides a list of identified direct indicators and proxies for the socio-economic value of Nordic ecosystem services. The aim is to provide as comprehensive a list of Nordic ecosystem services as possible, accompanied by a comprehensive list of indicators and proxies that could be used to estimate their socio-economic value. Consequently, as in the case of biophysical indicators (Section 9.1), the identified list of indicators can be considered as a "wish list" of information needed to form a reliable picture of the overall socio-economic importance of the full range of Nordic ecosystem services.

A range of existing quantitative and monetary indicators of value have been identified. However, it should also be noted that while quantified and monetary indicators can be useful in highlighting the socio-economic value of services, none of the available indicators and proxies appropriately reflect the overall *sustainability* of the use of services in the long term (e.g. sustainable level of extraction). Several direct indicators in Table 10.1 therefore take this into consideration by foreseeing the need to develop (composite) indicators that somehow better integrate aspects of sustainability (e.g. revenue from sustainable levels of production). This is the case especially for provisioning services.

As in the case of indicators for biophysical status and trends (Section 9.1), the identified socio-economic indicators and proxies are foreseen to be applicable at any level or scale, including being a suitable starting point for developing indicators for Nordic ecosystem services in the *national context*. As with status and trends, the results of the scoping study reveal the difficulty of finding similar sets of indicators for services across the Nordic countries. Significant differences exist in the information available, for example in terms of sources for data and years for which data are available. In addition, several gaps remain in the overall information base.

Finally, given the hierarchy and links between ecosystems services (e.g. the interdependency of provisioning and cultural services on regulating services and ecosystems' supporting processes and functions) and the variability of identified indicators it is not foreseen that the classification presented in Table 10.1 would be as such used to derive an aggregate estimate for the total economic value of ecosystem services, for example, at national level. Some of the indicators are likely to be somewhat overlapping and issues of *double counting* need to be addressed before considering how to calculate aggregate values for multiple ecosystem services at the national scale. In addition, increasing regional scarcity of certain ecosystems services – and increasing marginal benefits derived from such services – needs to be considered. Consequently, while suitable for gaining an overall picture of – and information needs for – the socio-economic value of Nordic nature, the classification of ecosystem services and related indicators presented in Table 10.1 needs to be further developed for the purposes of more detailed economic valuation (e.g. see UK NEA 2011).

Table 10.1 List of identified direct and proxy indicators to estimate socio-economic value of Nordic ecosystem services, suitable to be explored to be adopted at national level "Indicators highlighted in grey are not known to be readily available yet or require development. The table does not aim to classify ecosystems services for the purpose of (aggregated) economic valuation and issues related to overlapping values (double counting), for example between provisioning and regulating services, need to be considered when calculating overall estimates for multiple services."

ECOSYSTEM SERVICE	Identified direct indicators	Identified proxies[1]
PROVISIONING – Food (provisioning of)		
Cattle and dairy production	(Market) value / value added[5] of cattle / dairy production (*sustainable*) Number of jobs / employment /businesses / income related to the sector (direct and indirect)	Cattle / dairy production (current amount or value)
Cattle and dairy production: organic	(Market) value / value added of organic cattle / dairy production (current)[1] Number of jobs / employment /businesses / income	Organic cattle / dairy production (current amount or value)
Cereals	(Market) value / value added of cereal production (*sustainable*) Number of jobs / employment /businesses / income	Cereals production (current amount or value)
Cereals: organic	(Market) value / value added of organic cereal production (current)[1] Number of jobs / employment /businesses / income	Organic cereals production (current amount or value)
Fruit production (from orchards) (apple, plum, pear)	(Market) value / value added of fruit production (*sustainable*) Number of jobs / employment /businesses /	Fruit production (current amount or value)
Fruit production: organic	(Market) value / value added of organic fruit production (current)[1] Number of jobs / employment /businesses / income	Organic fruit production (current amount or value)
Reindeer herding	(Market) value / value added of reindeer meat / products (sustainable) Number of jobs / employment /businesses / income	Size of reindeer herd(s) / stocks (current amount or value)
Fishing: fresh waters and marine	(Market) value / value added of catch (*sustainable*) Number of jobs / employment /businesses / income	Size / value of catch (current amount or value) Number / % of fish and other species in commercial use
Aquaculture: fresh water and marine	(Market) value / value added of cultured fish / other aquaculture (*sustainable*) Number of jobs / employment /businesses / income	Amount of cultured fish and other species (current)
Game	(Market) value / value added of game meat Amount of game meat	NA
Berries (non-cultivated)	(Market) value / value added of harvest Number of jobs / employment /businesses / income	Harvested yield (actual)
Mushrooms (non-cultivated)	(Market) value / value added of harvest	Harvested yield (actual)
PROVISIONING – Raw material and fibre (provisioning of / provisioning sources for)		
Timber and fibre for pulp production	(Market) value / value added of harvest Number of jobs / employment /businesses / income	Volume of harvest (current)
Timber production: sustainable	(Market) value /value added of harvest (FSC) Number of jobs / employment /businesses / income	Volume of harvest (FSC)

Energy: fuel wood	(Market) value / value added of solid wood fuels: small-scale housing Number of jobs / employment /businesses / income	Quantity / use of solid wood fuels: small-scale housing
Energy: other bioenergy	(Market) value / value added of harvested bioenergy source(s) Number of jobs / employment /businesses / income	Volume of harvested bioenergy source(s)
Fodder and forage: hay	(Market) value / value added of harvester hay	Quantity of harvester hay
Fodder and forage: lichens	*No direct market value, see proxy*	(Market) value of reindeer herding
Fertilizers (guano)	(Market) value / value added of guano-based fertilizers Number of jobs / employment /businesses / income	Gathered amount of guano (estimated)
Fibre: wool, leather and fur[2]	(Market) value / value added of wool-, leather- and fur based products Number of jobs / employment /businesses / income	Gathered amount of wool (estimated)
Fibre: down from wild birds (e.g. Common Eider, *Somateria mollissima)*	(Market) value / value added of wild down / wild down-based products Number of jobs / employment /businesses / income	Gathered / used amount of leather (estimated)
PROVISIONING – Medicinal resources / biochemical (provisioning of / provisioning sources for)		
Medicinal products (natural)	(Market) value of natural medicinal products Number of jobs / employment /businesses / income	Volume of resource used currently Number of existing / already used medicinal plants and other resources
Natural food supplements and “health / super” foods (natural)	(Market) value of products Number of jobs / employment /businesses / income	Volume of resource (e.g. berries) used currently Number of existing / already used species (e.g. berries)
Cosmetics (basis / material for)	(Market) value of products using (a substantial amount of) / based on natural material Number of jobs / employment /businesses / income	Investment into bio-prospecting (cosmetics) Number of organisms from which products have been derived (current)
Biochemicals / pharmaceuticals (basis / material for)	(Market) value of products using (a substantial amount of) / based on natural material Number of jobs / employment /businesses / income	Investment into bio-prospecting Number of organisms from which products have been derived (current)
Non-medicinal biochemicals (natural)	(Market) value of products using (a substantial amount of) / based on natural material Number of jobs / employment /businesses / income	*See above*
Models and test organisms	(Market) value of models and test organisms Number of jobs / employment /businesses / income	(Market) value of products based on the use of models and test organisms. Number of businesses / jobs related to the use of models and test organisms
Traditional handicraft	(Market) value / value added of products. Number of jobs / employment /businesses / income	*Not identified*
Fashion and jewellery	(Market) value /value added of products. Number of jobs / employment /businesses / income	*Not identified*
Natural dyes and colorants / dye plants	(Market) value / value added of products. Number of jobs / employment /businesses / income	*Not identified*
Decorative plants (wild)	(Market) value / value added of products	Number of decorative commonly plants used (estimated)

PROVISIONING – Genetic resources (provisioning of)		
Traditional variants and races for crop- and husbandry animal improvement (plants and animals)	(Market) value / value added of products Number of jobs / employment /businesses / income	
PROVISIONING – Fresh water (provisioning of for consumptive use, with focus on the role of ecosystem's biotic elements)		
Fresh water (provisioning of): drinking and potable water, water for other human consumption	(Market) value / value added of (drinking) water, adjusted to reflect the real value (remove effects of any distorting subsidies)	Population / businesses served by renewable water sources
REGULATING SERVICES		
Air quality regulation	Costs related to replacing natural air quality regulation (estimated)	Costs related to respiratory diseases / health problems caused by bad air quality (real or estimated)
CLIMATE: Carbon storage	Value of carbon storage (e.g. based on CO_2 markets)	Costs related to climate change (real or estimated), e.g. based on costs of climate induced natural disasters
CLIMATE: Carbon sequestration	Value of carbon sequestration (e.g. based on CO_2 markets)	*As above*
CLIMATE: Climate patterns (local and regional)	*See proxy*	Costs related to regional extreme events (real or estimated)
NATURAL HAZARDS: Flood prevention / mitigation	*Value of protective function*, i.e. infrastructure / economic activity / human well-being protected by ecosystem-based regulation (real or estimated) *Replacement costs*: costs related to replacing ecosystem-based regulation, including replacing infrastructure and its maintenance (estimated) *Avoided costs*: estimated costs of damage / loss in absence of regulation service	Economic losses associated with flooding (real or estimated) Population living / economic activities situated in areas depending (directly) on ecosystem-based regulation (i.e. facing risks of flooding)
NATURAL HAZARDS: Storm protection	Value of protective function Replacement / avoided costs	Economic losses associated with storms (real or estimated) Population living in areas depending (directly) on ecosystem-based regulation
NATURAL HAZARDS: Avalanche prevention / mitigation	Value of protective function Replacement / avoided costs	Economic losses associated with avalanches (real or estimated) Population living in areas depending (directly) on ecosystem-based regulation
NATURAL HAZARDS: Mud flow / floods	Value of protective function Replacement / avoided costs	Economic losses associated with mud flow (real or estimated) Population living in areas depending (directly) on ecosystem-based regulation
WATER and WATER FLOW: Drainage and stabilisation of water flow (non-flood related)	*Difficult to find a reasonably independent indicator, mostly integrated into values below.*	*Not identified*
WATER and WATER FLOW: Drought mitigation	Value of protective function Replacement / avoided costs	Economic losses associated with droughts (real or estimated) Population living in areas depending (directly) on ecosystem-based regulation (i.e. drought risk areas)
WATER and WATER FLOW: Irrigation	Value of protective function Replacement / avoided costs	*Not identified*

WATER and WATER FLOW: Aquifer recharge	(Market) value of water originating from aquifers, adjusted to reflect the real value (remove effects of any distorting subsidies) Replacement / avoided costs	Economic losses associated with lack of ground water (real or estimated) Population living in areas depending (directly) on ecosystem-based regulation
Water purification and waste treatment	Value of protective function Replacement / avoided costs	Economic losses associated with lack of water quality (real or estimated) Population living in areas depending (directly) on ecosystem-based regulation
Erosion	Value of protective function Replacement / avoided costs	Economic losses associated with erosion (real or estimated)
Soil fertility (maintenance of)	Value of protective function Replacement / avoided costs	*Not identified*
Pollination	Value of crops, fruit, ornamental plants etc. requiring pollination by insects / animals Proportion (%) of relevant business sectors' revenue (e.g. agriculture) that depends on pollination by insects / animals	Replacement costs: costs related to replacing ecosystem-based regulation Avoided costs: estimated costs of damage / loss in absence of service Value of pollination (current)
BIOLOGICAL CONTROL: Pest control (natural)	Value of protective function Replacement / avoided costs	Costs of damage by pests to forestry and agricultural sectors (current)
BIOLOGICAL CONTROL: Disease and pathogen control (plants, animals and humans)	Value of economic activity (e.g. agriculture, forestry, horticulture) protected by ecosystem-based regulation (real or estimated) Replacement / avoided costs	Costs associated with pathogen outbreaks (current)
CULTURAL SERVICES		
RECREATION and TOURISM: Recreational and tourism enjoyment (general)	"Investment in" spending time with different nature-based recreation activities Number of tourists / visitors	Value of service based on stated preference methods (e.g. willingness to pay derived via contingent valuation) and revealed preference methods (e.g. travel cost methods) General investment in the conservation / restoration of natural areas, e.g. local / regional / state budgets for maintenance of green areas, extension of national and nature parks / protected areas, afforestation etc.
RECREATION and TOURISM: Recreational and tourism outdoor activities (hiking, running, skiing etc.)	Money / time invested in carrying out activities (e.g. travel costs, accommodations, equipment) Number of people engaged with an activity	*As above*
RECREATION and TOURISM: Recreational hunting	Money / time invested in carrying out activities (e.g. travel costs, equipment) Number of hunters / hunting licences	*As above*
RECREATION and TOURISM: Recreation and tourism related to fishing	Money / time invested in carrying out activities (e.g. travel costs, fishing licenses, equipment) Number of recreational fishermen / fishing licences	*As above*
RECREATION and TOURISM: Recreation and tourism related to berry and mushroom picking	"Investment in" spending time with different nature-based recreation activities Number of people engaged with the activity	*As above*

Aesthetic values and information	*See proxy*	*As above*
Education and research (information for) (i.e. cognitive development)	Investment in educational visits to nature by different levels of education (e.g. travel costs, time spent, frequency of visits) Number of children / schools and other groups / researchers etc.	*As above*
ART, DESIGN and CULTURE: Design (fashion, interior design etc.), art (literature, paintings, photography etc.),	(Market) value / value added of products using elements from nature as their key point of attraction / closely inspired by nature Number of jobs / employment /businesses related to the sector (direct and indirect) Number of (amateur) nature photographers	Dedicated / earmarked investment into sustainable / natural design, arts etc.
CULTURAL and SPIRITUAL: Nordic, Sami and Inuit values and identity	*See proxy*	Value of service based on stated preference methods (e.g. willing-ness to pay derived via contingent valuation)
Mental well-being and health: stress and related problems and illnesses (reduction of)	Avoided costs to health sector related to benefits provided by nature (estimated) (avoid-ed costs as indicator of value)[3] Avoided costs to organisations and businesses linked with health benefits provided by nature re: sick leave (estimated) (avoided costs as indicator of value)	*Not identified*
Supporting / maintenance / habitat services – Ecosystem processes (maintenance of)		
Nutrient cycling	*Difficult to find "independent" indicators of value for supporting processes and functions, as they are reflected in the value of all other services. Could be possibly done by using the production function approach but does not necessarily suite the purpose of national ecosystem service valuation.*	*Not identified*
Soil formation	*Not identified, see above*	*Not identified*
Photosynthesis	*Not identified, see above*	*Not identified*
Biogeochemical cycles	*Not identified, see above*	*Not identified*
Stability and resilience of ecosystems (maintenance of)	*Not identified, see above*	*Not identified*
Supporting / maintenance / habitat services – Lifecycle (maintenance of)		
Nursery habitats[4]	Avoided costs: costs to fisheries sector due to loosing / having to replace the service	(Market) value of fish stocks depending on nursery habitats
Seed dispersal[4]	Avoided costs: costs of replacing the service	*Not identified*
Species interactions between trophic levels (maintenance and control of)	*Not identified, see above*	*Not identified*

SUPPORTING / MAINTENANCE / HABITAT SERVICES – Biodiversity (maintenance and protection of)		
Genetic diversity	*Not identified, see above*	*Not identified*
Species diversity	*Not identified, see above*	*Not identified*
Habitats diversity	*Not identified, see above*	*Not identified*

[1] Organic production considered sustainable at current level.

[2] Could be specified to include only leather from "wild" sources.

[3] Note: no indicator / information available yet that would make a more direct link between benefits related to time spent in nature etc. and health

[4] Note: risk of double counting with other service values.

[5] Ecosystem services, provisioning services in particular but also some cultural and regulating services, often also include considerable additional energy inputs that are reflect in the price and/or estimated value (e.g. processing and marketing costs of products, costs of investment in infrastructure in recreational areas). Therefore, value added (i.e. the difference between the estimated value and human input, such as the final price and the production cost of a product) would be a more accurate indicator for the monetary value of the service itself.

Indicators highlighted in grey are not known to be readily available yet or require development. The table does not aim to classify ecosystems services for the purpose of (aggregated) economic valuation and issues related to overlapping values (double counting), for example between prpvisioning and regulating services, need to be considered when calculating overall estimates for multiple services.

10.2 Existing knowledge on socio-economic value

Note: there are significant gaps in the existing data on the socio-economic value of Nordic ecosystem services. Consequently, the synthesis provided under Chapter 10.2 does not cover the full range of ecosystem services and indicators outlined in Chapter 10.1. The gaps between the required and existing information are analyses and discussed in Chapter 11.

10.2.1 Provisioning services

A relatively good body of information is available on the socio-economic value of provisioning services in the Nordic countries, allowing some preliminary comparisons to be made between different countries. Information on the amount and monetary value of *agricultural and forestry goods* (e.g. timber, cattle and livestock, cereals and fruits, and fibre) and *fisheries* is commonly available at national level. Some information was also found for the value of non-timber benefits such as berries, mushrooms and game, especially for Finland, Sweden and Norway. There is a lack of national data for other provisioning services, however several interesting case examples were identified for *medicinal, biochemical and genetic resources and ornaments*. No monetary estimates were found for *drinking and potable water*, although there is comparable statistical information related to its overall use.

As before, it should be noted that the available information on the socio-economic value of provisioning services does not reflect the long-term sustainability of these service. It should also be noted that market prices – for provisioning services in particular – generally integrate the costs of additional investments and energy inputs (e.g. processing and marketing costs). Therefore, value added (i.e. the difference between the sale price and the production cost of a product) would be a more accurate indicator for the monetary value of the service ("raw material") itself. However, such information is not commonly available.

Agricultural and forestry goods

Forests are a key socio-economic resource for the Nordic countries, especially in Finland and Sweden and to a lesser extent in Norway. In general, in Finland and Sweden forestry constitutes around 5.5% and 3.5% of national GDP respectively (Köhl et al. 2011b). In Norway, Denmark and Iceland forestry plays much smaller role, a maximum of 1% of national GDP (Köhl et al. 2011b). Finland and Sweden are major exporters of wood pulp (12 million m^3 and 11.5 million m^3 in 2011, respectively)[16] together representing 12.8% of global production (Haagelsen 2011) (Table 10.2 below). Sweden and Finland also produced a significant amount of round wood (75 million m^3 and 50 million m^3 in 2011, respectively).[14] The value added by the forestry sector was 13 billion USD in Sweden and 10 billion USD in Finland in 2006. In Norway it was 2 billion USD and in Denmark 2 billion USD (NB Forest Info 2012). The forestry workforce is some 2–3 persons / 1,000 ha forest in Nordic countries, less in Central Europe (Köhl et al. 2011b).

Value added by the forest sector has been slightly increasing in forestry and the wood industry, except for recent years due to the global economic recession. The pulp industry, however, has been in significant decline (Köhl et al. 2011b). This has resulted in increased discussion on the future role of Nordic forestry, e.g. sustainable alternatives for round wood and pulp production. In particular, the production of biofuels and other alternatives are currently being explored (see sections on biofuels and bio-based resources below).

Table 10.2 The value of forest products in the Nordic countries.

	Denmark	Finland	Iceland	Sweden	Norway
Forest products, export value (US 1,000)	500,562	12,634,022	817	13,012,542	1,794,027

Note: these figures are an average of quantities / year from 2000–2010. Source: NB Forest Info 2012

Fairly free access to nature is common in the Nordic countries which makes the use of non-timber forest products (such as berries and mushrooms) an every-day practice. Table 10.3 outlines the socio-economic value of some marketed non-timber products for northern Europe (i.e. the Nordic and Baltic countries). Denmark is a significant producer of Christmas trees and other decorative tress (Köhl et al. 2011b) while berries form a common non-timber export product in Sweden and Finland. It also seems that the markets for some non-timber products, such as birch sap, are increasing (Box 10.1). More detailed information on the socio-economic value of berries and game is provided in dedicated sections below.

[16] http://www.nbforest.info/country-information

Table 10.3 Production and estimated value of non-timber forest products in Northern Europe (including Nordic and Baltic countries)

Non-timber forest products	Production / year	Value / year
Christmas trees	17 (mil pcs)	132 (mil EUR)
Mushrooms and truffles	4 (mil kg)	12 (mil EUR)
Fruit, berries and edible nuts (million kg)	52 (mil kg)	15 (mil EUR)[1]
Resins, raw material –medicine, aromatic products, colorants, dyes	0.9 (mil kg)	0.2 (mil EUR)
Decorative foliage, incl. ornamental plants (mosses)	0.4 (mil kg)	59 (mil EUR)
Game meat	34 (mil kg)	6 (mil EUR)

[1] Low value / year compared to production / year likely to be explained by relative low number of berried picked and lack of related statistics (see section on "Berries and mushrooms" below).

Source: State of Europe's forest (2011)

Box 10.1 Increasing markets for birch sap

Birch sap has market potential as a traditional health drink and also as a raw material for the food, drink and cosmetics industries. Several companies worldwide turn birch sap into beer, vodka, candies, toffee, syrup, cosmetic products (Lewis, unknown). In Jämtland (Sweden), based on an original recipe from 1785, birch sap is used to produce the sparkling wine Sav™ (Sav™, 2012). The company claims to need absolutely no herbicides or pesticides, thanks to the climate and the resistance of the birch. Birch sap is also said to have many medicinal benefits, although there have been no systematic clinical studies to date. Between Russia, Ukraine, Belarus, Finland, Japan and Alaska millions of dollars are spent on research and development and millions of gallons of sap are collected. Because they are perceived by the public as peculiar and exotic, birch sap products can dictate a higher price than their maple-derived competitors. Each gallon of birch syrup is priced at 270 USD, against 44 USD for maple syrup (although the maple syrup business is substantially wider), and wholesale value is estimated to be 540,000 USD (Lewis, unknown). The industry provides many jobs in otherwise unproductive areas.

With an initial investment of 10,000–20,000 EUR, a *family business in the east Finnish province of Tohmajärvi has been successfully producing birch sap for many years on a small industrial basis*. The company's organic sap is now sold in the largest nation-wide food stores in the country (K-Group stores). According to the company's owners each spring their two-hectare birch grove should yield an income of around 10,000 EUR (Helsingin Sanomat 2011). Up to 97% of the sap is exported. They export to central Europe and they also have also entered the Japanese market (Tschirpke 2006).

Similarly SWESAP, a Swedish Company which started tapping birch sap on a very small scale in 1997, now aims to open markets in Germany, France, Netherlands, China and Japan. The company today has up to 50 professional tappers. Depending on the season they can produce up to 2,000,000 bottles, with possibilities in the future of increasing productivity if required by the market (SWESAP, unknown).

Sap collection – concentrated in two or three weeks in spring when the sugar content of birch sap is optimal – is done by drilling a hole of a few centimetres into the trunk. The hole is blocked up after collection, so there is no significant damage to the tree. This practice is compatible with forestry or any other silvicultural activity that enhances birch growth. Potential downsides to integrated systems may include slightly lower wood quality due to drilling tap holes (Powell 2010).

Greatly relying on agriculture, Denmark has the highest agricultural Gross Production Value (GPV) among the Nordic Countries (7,575 million USD) followed by Sweden (3,680 million USD), Norway (2,749 million USD), Finland (2,649 million USD) and Iceland (370 million USD) (FAO 2012b, see also Table 10.4). In terms of crop production, Denmark, Sweden and Finland have the highest GPV, while in Norway and especially in Iceland, crops make a more modest contribution to primary production value. The most significant elements of the Nordic crops in terms of production value are cereals, potatoes, rapeseed and sugarbeet. Cereals represent 14.3% and 15.6% of the agriculture production value in Denmark and Finland respectively, 6.6% in Norway and 8.6% in Sweden. Potatoes, rapeseed and sugarbeet together represent 10.4% of the agriculture production value in Sweden, 9% in Finland and 7.6% in Denmark. Among the cereals, wheat and barley have the highest production value in each country, while oats and rye have only moderate financial importance in the Nordic countries.

Regarding livestock, cow milk represents a solid share of the value of agriculture production in every Nordic country (Table 10.4). This ranges from 25% of the total agricultural GPV in Denmark to 41% in Iceland. Meat is also an important component of primary production. Pig meat, cattle meat and chicken meat together make up 25% of the total agricultural GPV in Finland and Iceland, 33% in Sweden, 35.7% in Norway and 50.4% in Denmark. Notably, pig meat alone represents 38% of Danish total agricultural GPV. Horse and duck meat represent only a small niche of Nordic livestock production. The sheep meat industry does not make a large contribution to the agricultural GPV in Sweden, Finland and Denmark. It is traditionally more extensive and productive in Norway and especially in Iceland, where it represents an important support to the rural population. In Iceland, for instance, the sheep industry amounts to only 1% of GPV, but 22% of agricultural income.

Table 10.4 Gross Production Value (GPV) of value of key agricultural goods in the Nordic countries for the year 2010 (Constant 2004–2006 million USD), including number of indigenous Nordic species (See section on genetic resources below)

	Sweden	Finland	Denmark	Norway	Iceland
Wheat (million USD)	287	102	711	92	-
Barley (million USD)	150	172	411	14	-
Oats (million USD)	66	95	36	69	-
Rye (million USD)	16	11	31	9	-
Potatoes (million USD)	204	157	296	90	6
Rapeseed (million USD)	77	50	158	7	-
Sugarbeet (million USD)	103	31	128	-	-
Vegetables, fresh (million USD)	14	23	15	3	-
Cow milk, whole, fresh (million USD)	1,127	1,031	1,881	820	153
Indigenous Cattle meat (million USD)	298	210	358	414	30
Indigenous Pig meat (million USD)	751	316	2,934	393	29
Indigenous Chicken meat (million USD)	165	139	171	175	35
Indigenous Sheep meat (million USD)	16	2	6	103	82

[1] Constant 2004–2006 million USD.
Source: FAO 2012b.

Despite its rather moderate financial importance, the sheep industry in the Nordic countries is nevertheless considered important because of the cultural values of traditions dating back to medieval times and for its increasingly important role in landscape preservation. During the summer, sheep graze on vast areas that would not otherwise be utilised and thus produce meat and help prevent overgrowth of the countryside both in mountains and in lowland areas (Vatns 2009). (Table 10.5).

Table 10.5 Sheep meat and wool production and meat consumption in the Nordic Countries

	Norway	Sweden	Denmark	Finland	Iceland
Total sheep meat production (1,000 kg)	23,000	4,100	2,000	700	8,900
Sheep meat consumption / person (kg)	5.7	1.0	0.4	0.6	24
National wool production (1,000 kg)	4,400	1,000	35.5[a]	90	638[b]

a) Amount sold, b) Clean wool.
Source: Vatns 2009.

Marine and freshwater fisheries

Fishing in the Nordic countries is important both as an industry and as a hobby (See Section 10.4). Professional fishing happens mainly on marine areas but freshwaters are popular amongst recreational fishermen. The fisheries industry is of high importance for Greenland and Iceland (and the Faroe Islands) where fisheries and fish production make the single most significant economic contribution to the welfare of societies (Norden 2012). However, in terms of size of catches, Norway is the biggest fish producer of the Nordic countries (Table 10.5 below). Norway is also amongst the biggest fish catchers worldwide, although its catch (2.3 million tonnes / year) is still far behind the biggest producers like China (14.8 million tonnes / year) and Peru (7.4 million tonnes / year). However, Norway is second biggest exporter of fish, directly after China, and Denmark is the fourth biggest (FAO 2010). While fish exports make up almost 6% of Norwegian exports, the fish industry's importance for GDP is fairly negligible (0.5%) (Statistics Norway 2012).

In terms of the importance to livelihoods, the numbers of fishermen are fairly low in the Nordic countries (Table 10.6). In Norway, however, there are a total of 12,000 fishermen, the majority of whom (10,000) work full-time on fisheries (Statistics Norway 2012). In comparison, in Finland the number of full-time fishermen is around 600, and part-time professionals make up almost three quarters of the sector. In addition, there are 300 freshwater fishermen in Finland and 192 in Sweden, with total catches between 4,000 and 13,000 tonnes / year (Table 9.2). The number of fishermen has steadily decreased in Nordic countries (FAO 2010, Statistics Norway 2012, Swedish Board of Fisheries 2008).

Table 10.6 Socio-economic importance and value of marine fishing in the Nordic countries

	Greenland	Iceland	Norway	Denmark	Sweden	Finland
Number of professional fishermen (incl. part time)	3,752	4,500 man years	12,993	2,088	1,600	2,195
Reference year	2004	2005	2010	2008	2012	2010
Source	Statistics Greenland 2012	Icelandic Fisheries 2012 /Statistic Iceland 2012	Statistics Norway 2012	Statistics Denmark 2012	Havs och vatten myndigheten 2012	RKTL 2012
Size of catch (tonnes)	225,413	1,063,467	2,288,623	1,066,428	159,968	122,078
Value of the catch (mil. of nat. currency)	Not available	132,979.2 mil ISK (~ 837 mil EUR)[1]	15,883.6 mil NOK (~2,105 mil EUR)[1]	3,435.5 mil DKK (~462 mil EUR)[1]	970.8 mil SEK (~110 mil EUR)[1]	26.5 mil EUR
Reference year	2005	2010	2011	2010	2011	2010
Source	Statistics Greenland 2012	Statistics Iceland 2012	Statistics Norway 2012	The Danish Directorate of Fisheries 2011	Statistics Sweden 2012b, 2012c	RKTL 2012

[1] Based on based on exchange rate in 2012.

Reindeer herding

Although the worldwide commercial production of caribou and reindeer meat is relatively small it is still a very significant source of income in Finland, Norway and Sweden which together produce substantially more reindeer than the U.S., Canada, and Greenland combined (Humphries, 2007). In north Finland, Norway and Sweden, i.e. Nordic areas where reindeer herding remains a common source of livelihood, approximately 6,500 Sami people work as reindeer herders (Table 10.7 below). In Finland, reindeer herding is not legally limited to Sami people only (unlike in Sweden and Norway) and the number of herders is higher (Unknown 2009). In Greenland reindeer husbandry started only about 50 years ago when domestic reindeer were introduced along with Sami specialists from Norway (Cuyler 1998), resulting in a handful of reindeer farms on the island (Humphries 2007).

Reindeer husbandry is of great importance in the Sami region because the shipping, trading and processing of its products provide numerous jobs. The main business related to reindeer herding is meat production. Recent decades have seen a change in the consumption structure of reindeer meat, which has shifted from being a traditional food consumed within the area of production to a luxury and exotic product for a wider public. For instance, in Finland a major part of reindeer meat was in the 1970s consumed in the north. In 2004, only 28% of the reindeer meat produced was consumed by reindeer owners or sold directly to final customers, while the rest was sold through the retail or catering sector, the majority being consumed in the Helsinki area (Saarni et al. 2007). In Sweden, 38% of the reindeer meat produced in 2005 was consumed by Sami communities, 38% in the rest of the country and 24% exported. In 2005, Finland consumed more reindeer meat than it produced, making it a net importer of reindeer. Overall a very small percentage of reindeer meat is exported from the Nordic countries. Germany, France, Austria, Denmark, and Switzerland all import small amounts of reindeer or have expressed interest in doing so. There has been trade from Greenland to Iceland and Denmark, from Norway to Italy, and from Finland to Germany. The well-known Swedish furniture warehouse IKEA also sells reindeer in their Swedish food section inside its stores (Humphries 2007).

Despite high demand within and outside the producing countries, several studies in Sweden, Finland and Norway have pointed out the low profitability of the reindeer business, which is partly surviving thanks to extensive government subsidies, especially in Norway (Reinert 2006, Bostedt 2001, Saarni et al. 2007). Regardless of its low profitability, reindeer herding is supported by policy action because of its cultural importance, which goes beyond being merely a source of income. In order to increase their income, reindeer herders also engage with several other sources of livelihood such as hunting, production of decorative items and tourism (see related sections below). For example, in Sweden the average reindeer owner receives 43% of his total reindeer husbandry income from meat whereas earnings from sale of deerskins, antlers, hunting and fishing amount to 26% (Jernsletten and Klokov 2002).

Currently, one of the main barriers to profitability seems to be the scarcity of raw material regulated by the reindeer husbandry regulations, setting an upper limit for the number of animals herded. This is, however, deemed necessary to maintain the broader ecological sustainability of the livelihood (see Chapter 9 above). It also appears that profitability is affected by the scale of reindeer ownership. In Finland, the great majority of herders (77.6%) owns between 1 and 49 animals (Jernsletten and Klokov 2002). In Sweden, it has been estimated that a reindeer herding family / company requires more than 400 reindeer for the family to make their livelihood completely from reindeer husbandry. With about 230,000 reindeer and about 930 reindeer herding companies, the average number of reindeer / company is only 247 (Bostedt 2001). Finally, the majority of reindeer meat is processed by large companies which receive most of their turnover from other meat. In Finland in 2004 about 80% of reindeer meat was processed in 20% of the companies. The tightening competition for raw material is a threat to small processors (Saarni et al. 2007).

Table 10.7 Socio-economic importance of reindeer herding in Finland, Sweden and Norway

Country	Herders	Reindeers (No)	Size land (m2)	Organisation	Monopoly	Value of production (mil EUR)[1]		
						2004	2005	2006
Finland	5,600 Sami and non-Sami	186,000[2]	114,000 (33%)	57 reindeer herding cooperatives	No	>10	>10	13
Sweden	3,500 Sami; 1,000 non-Sami	227,000[2]	160,000 (34%)	51 Sami villages	Yes	<5	<5	7
Norway	2,936 Sami	165,000[2]	140,000 (40%)	80 reindeer herding districts	Yes	<10	<10	<10

[1] Based on 2.5–2.8 (FI), 1.5–2.0 (SE) and 2.0–2.3 (NO) million kg / year production of meat in 2004–2006.
[2] Data from 2000 in Finland, from 1998 in Sweden and 2001 in Norway.

Finally, there is a range of broader socio-economic and cultural benefits associated with reindeer herding that are not easily quantifiable. Reindeer husbandry has maintained the traditional free-grazing model and nomadic movement between winter and summer grazing areas. This has kept the northern nature from undergoing those changes – e.g. increased cultivation areas, decreased grazing areas and number of wild forage plants – that occurred in other countries during the last century (Veteläinen et al. 2008). Reindeer herding also has a significant role in keeping remote areas in the north inhabited and it forms the foundation for the Sami culture and tradition. According to Bostedt and Lundgren (2010) more than 50% of Swedish people feel that the main function of reindeer husbandry is to uphold the cultural heritage of indigenous people. A contingent valuation survey revealed that cultural benefits of the Swedish reindeer industry are 2 to 4 times larger than the annual turnover of the reindeer herding industry, ranging from 500 to 900 million SEK (~57 to ~102 million EUR).[17] Hence, traditional welfare accounting methods underestimate the welfare importance of a natural resource-dependent pastoralist culture.

Bioenergy

A significant proportion of energy used in the Nordic countries is already obtained from bioenergy (Scarlat et al. 2011) (Table 10.8) with the main users of this energy being the forest industry in Norway, Sweden and Finland and power plants in Denmark (Scarlat et al. 2011). Other uses for bioenergy include district and household heating (below) and electricity production.

Forests are the main source of bioenergy in the Nordic countries. Sweden and Finland are the leading producers of wood-based energy, with the main source of such energy being co-products and residues from wood processing industries. Wood-based energy is mostly used in large scale district heating and combined heat and power (CHP) plants in urban areas and also in industrial energy applications. In Sweden and Finland the consumption of wood-based energy by the rural population (GJ/rural capita) is more than five times the European average (Köhl et al. 2011b). The demand for wood energy is also increasing. With the exception of Denmark, agriculture is a minor bioenergy source in the Nordic countries. Agricultural sources for bioenergy are mainly straw, oilseeds, manure, biogas and energy crops, mainly short rotation coppice

[17] Based on exchange rate in 2012.

willow in Denmark and Sweden and reed canary grass in Finland (Scarlat et al. 2011).

The use of fire wood for household heating is also very common in the Nordic countries (Scarlat et al. 2011). In Norway and Finland around 60% of households and individual family houses use firewood for heating (Scarlat et al. 2011). Even in less-forested Denmark, 31% of heat supply came from fire wood in 2008. In Sweden it provides 25% of the heating energy used in detached houses (Statistics Sweden 2007, as is cited in Lindroos 2011). Fire wood is often obtained from own forest and the need for fire-wood is often an important motivation for thinning before commercial harvesting takes place (Lindroos 2011). In addition to more household oriented use of thinning products there is growing interest to use logging residues and stumps for bioenergy in industry/industrial scale power plants.

Table 10.8 Estimated potential for bioenergy production and current use of bioenergy in the Nordic countries. Note: the estimates are absolute potentials for biomass and do not reflect broader aspects of sustainability

	Denmark	Finland	Norway	Sweden
Total biomass potential (Petajoules)	147–165	359–460	104–167	554–583
from forest biomass	37–40	158–325	88–124	457–530
from agriculture	55–87	23–29	9–19.8	4–28
Current use/production of bioenergy (PJ)	107	302	54	443
Share of bioenergy of total primary energy consumption %	13	21.4	6	20

Source: Scarlat et al. 2011.

Fibre

Sheep wool is the main fibre of socio-economic significance in the Nordic countries (see section on agriculture and Table 10.9 below). The main income from the sheep industry is based on meat production, while production of wool and pelts only accounts for less than 10% of the value of total income (Vatns 2009). Wool is used for several products, including various types of yarns for hand-knitting and machine knitting blankets, carpets, clothes and souvenirs. Pelts are used for wool skins and nappa leather (North SheD 2012).

Wool has also a strong role and cultural impact. For instance wool is widely employed in Nordic traditional costumes. Handicraft and knitting traditions have been maintained and are still vital in the Nordic countries, with traditional patterns having become a symbol of the Nordic countries national identity abroad. The "Valuing Norwegian Wool" project, launched by the Norwegian National Institute for Consumer Research (SIFO) in 2010, aims to look at the whole lifecycle of wool, finding new innovative approaches to return wool to the forefront of textiles (NICE 2009).

Table 10.9 Sheepskin and wool production in the Nordic countries (tonnes / year). Note: these figures are an average of quantities / year over the period 2000–2010

Country	Sheep skin (tonnes / year)	Sheep skin with wool (tonnes / year)	Sheep wool (tonnes / year)
Denmark	485	436	174
Iceland	1,933	1,603	818
Finland	55	-	84
Sweden	2,396	1,617	133
Norway	7,277	3,638	4,875

Source: FAO 2012b

Another Nordic "specialty" is the market for luxury products made of eiderdown (Somateria mollissima). Eiderdown is a rare resource; while domestic down is harvested from both female and male birds – usually dead and juvenile – eiderdown solely comes from wild female, fully grown, alive birds. During the egg-laying period the female eider sheds some down into its nest, which is collected with no harm to the bird or eggs. Eiderdown is highly appreciated for its cohesive properties and unique thermal and igro insulation. An eiderdown comforter or duvet – commonly considered an ultimate luxury product – contains around 1 kg of filling and may contain eiderdown processed from the raw material of over 60 nests. In addition, the processing of 1 kg of eiderdown takes from one week to four hours, according to the degree of mechanisation.

More than 80% of eiderdown on the world market comes from Iceland (Fish and Wildlife Service 2003). Other Arctic Countries like Alaska (U.S.), Canada, Greenland, Norway Finland and Russia also harvest a small quantity. Most of the Icelandic harvest is exported to Denmark, Germany and particularly Japan. The market value of eiderdown is 2.2 million USD / year for the worldwide average value of eiderdown (Fish and Wildlife Service 2003). In 2009, Icelandic eiderdown export value was 1.2 million EUR (Jóhanneson 2010). The high cost and limited quantity of true eiderdown may even be an incentive for false labelling of eiderdown which may actually have been acquired from another waterfowl species.

The traditional and historical value of eiderdown harvesting is also important in Iceland. Icelanders have used eiderdown for over eleven centuries and have exported it since the 14th century (Fish and Wildlife Service 2003). All nesting colonies are located on private lands and although birds are not captive, they have developed a mutually beneficial relationship with humans. The species has been afforded special protection in Iceland since 1847. Icelandic law allows landowners to have their eider nesting grounds declared "legally protected" during the breeding season, giving farmers the right to deny public access to nest sites and prohibit any shooting. Harvesters also actively control eider predators. Nowadays there are around 350 harvesters in Iceland and six main processors (Sveinsson unknown). Processing – the removal of dirt and feathers – can only be partly mechanised and it is traditionally done by women. Eiderdown is cleaned using highly a specialised secret dry processing technology developed in Iceland.

Berries and mushrooms

Sweden and Finland are the main Nordic producers and exporters of wild berries, mainly bilberry and cowberry (Paassilta et al. 2009). Bilberries are mainly exported to Aasia; China and Japan (MARSI 2010, Paassilta et al. 2009), and cowberries to Central Europe (MARSI 2010, Paassilta et al. 2009). Despite exports, fresh and frozen berries are also imported, mainly from eastern Europe (MARSI 2010, Paassilta et al. 2009). Imports and exports of berries are also common between Sweden, Finland and Norway (Paassilta et al. 2009).

The Nordic forests produce several tonnes of wild berries annually with only a small fraction of them (~2–10%) being used, most at the household level (Paassilta et al. 2009, Turtiainen et al. 2011, Jonsson and Uddstål 2002). There are no on-going annual statistics on the amounts of berries picked and/or marketed across the Nordic countries, however a number of individual studies from Finland and Sweden provide some estimates (see Table 10.10).

Only Finland has official statistics on berries collected for *organised markets*. In 2010, 2,800 tonnes of bilberries and 6,100 tonnes of lingonberries were collected in Finland for organised markets (Table 10.11). However, the share of berries collected for markets has probably increased since berries are now being collected more professionally by foreign pickers (Turtiainen et al. 2011, MARSI 2010). In addition to bilberries and lingonberries minor amounts of other berries are picked. In Finland in 2010, 152 tonnes of cloudberries and 98.4 tonnes of crowberries were collected for organised markets. Other berries like cranberries, arctic bramble, forest raspberries and rowanberries are also known to be picked for markets, although to a much lesser extent (MARSI 2010). In year 2010, the economic value of marketed berries was 13.9 million EUR (based on the price received by berry pickers, MARSI 2010). Most of the marketed berries are picked in northern Finland; in southern Finland berries are picked mainly for household use (MARSI 2010).

In addition to berries traded on organised markets, a significant amounts of *berries are also sold via direct markets* (e.g. via individuals on common market places) or *directly to restaurants* (Turtiainen and Nuutinen 2011). For example, in 2000 the value of berries sold in market places and directly to households or restaurants in Finland was estimated to be 3.4 million EUR (Salo 2005). The value of berries collected for household use was evaluated to be 53.8 million EUR (Salo 2005).

Table 10.10 Socio-economic importance and value of berries in Finland and Sweden

	Finland			Sweden		
	Bilberry	**Lingonberry**	**Source**	**Bilberry**	**Lingonberry**	**Source**
Yield (tonnes/year)	92,000 to 312,000	129,000 to 386,000	Turtiainen et al. 2011	250,000	155,000	Erikson et al. 1979 cited in Jonsson and Uddstål 2002
Harvest for home use (tonnes/year)	13,600 ton-nes in 1997	16,800 tonnes in 1997	Saastamoinen et al. 2000	Approx. 13,000 all berries in 1997*	Jonsson and Uddstål 2002*	
Commercial harvest (tonnes/year)	2,800 ton-nes in 2010	6,100 tonnes in 2010	Marsi 2010	9,500 tonnes in 2000	3,250 ton-nes in 2000	Jonsson and Uddstål 2002

*In 1977 Swedes picked some 40,000 of berries for home use (Hultman, 1983, cited in Jonsson and Uddstål 2001), in 1997 the harvest was approximately 1/3 of this (Lindhagen and Hörnsten 2000, Jonsson and Uddstål 2002).

Table 10.11 Quantities and values of berries and mushrooms picked for markets in 2005 in Finland, Norway and Sweden

Country	Berries		Mushrooms	
	Quantity (tonnes / year)	**Value (mil EUR 1)[2]**	**Quantity (tonnes / year)**	**Value (mil EUR)[2]**
Finland	12,027	11.862	426	1.019
Sweden	13,790	32.435[1]	Not available	Not available
Norway	350	0.524	500	1.873

[1] Value for mushrooms and berries together.

[2] Based on the source, the estimated values for NO and FI are based on collector's price whereas in Swedish the value is based on "... weather conditions and newspaper information".

Source: Turtiainen and Nuutinen (2011).

Most of the companies operating in the berry industry are small to medium size, specialising in either selling berries fresh or making traditional value-added products such as preserves and juices. There are also a small number of larger companies involved in the berry industry that clean and freeze berries to be sold on to industry with a majority of berries picked for organised markets passing through their freezers (Paassilta et al. 2009). In Sweden, and presumably also in Finland, health related products for Asian and central European markets are of growing interest (Jonsson and Uddstål 2001) (See Box 10.2 below). Many natural medicines are made from Nordic berries, and cloudberry and sea buckthorn in particular are also used in cosmetic products. For example, the large Finnish cosmetics producer Lumene uses a range of Nordic berries in their products (See Box 10.3).

From the perspective of berry entrepreneur, for example in terms of diversifying the markets for value-added products of wild berries, the key limiting factor is the availability of wild berries and its sensitivity to environmental conditions (Paassilta et al. 2009). Also, the availability of reliable pickers, varying between seasons, might be an issue, but this is has recently been overcome by contracting semi-professional foreign pickers (Paassilta et al. 2009) who can pick substantially greater amounts than more hobby-based domestic pickers (Ruokatieto 2012).

Box 10.2 Wild berries – the Nordic "super food"

Berries are Nordic super foods: they are rich in vitamins, fibres and polyphenols and antioxidants. Berries contain higher amounts of antioxidants than ordinary fruits (Halvorsen at al. 2002, cited in Törrönen 2006) and they may also have antimicrobial qualities (Puupponen-PImia et al. 2001, 2005a,b,c, Nohynek et al. 2006 and others cited in Törrönen 2006). The high nutrient content of berries – especially that of bilberry, cranberry and lingonberry – is well documented (Törrönen et. al. 2006) and several nutritional claims are allowed for berries in the EU (e.g. "good source of fibres", "natural source of vitamins C/E", "naturally low fat content" EC/1924/2006). In general, a lot of scientific research has been done on the health benefits of berries. However, most studies are in vitro and more clinical human and population testing is needed (Törrönen et. al. 2006).

In addition to the special health benefits of individual berries (below), consumption of berries is seen as an integral part of the healthy and environmentally friendly "Nordic diet" that is being increasingly studied, for example, to address problems with obesity. Importantly, Nordic berries are also rich in flavour and, whilst they are at their best when consumed directly from forests, they are also often used as natural flavour enhancers in sweets such as liquorice. (Törrönen et al. 2006).

Bilberry is perhaps the most studied berry with a growing interest especially in Asian health food markets (Paassilta et al. 2009). Traditionally bilberries have been used for treating stomach problems and diarrhoea (Holm and Hiltunen 2003, Eklöf 2008). Lots of research has been done on bilberry's effects on eye health and enhancing dark vision and there is positive proof on this, although more research is needed. Other bilberry health benefits being researched are inflammatory qualities, support to intestinal health and positive impacts on treating diabetes. (See Törrönen et al. 2006 for details).

Cranberry is another Nordic berry receiving increasing attention. Traditionally, cranberry juice is used to treat urinary tract problems and its efficiency has been proven in scientific tests (see Jepson et al. 2004, cited in Törrönen 2006). Continuous use of cranberry juice decreased the probability of urinary tract problems in a Finnish population study. However, most existing studies concern North-American cultivated cranberries and more studies are needed to see if the effects are similar with the Nordic wild cranberry. Based on knowledge of the content of Nordic cranberry the effects are likely to be similar. Other studies relating to cranberry health benefits concern for example dental health. (Törrönen et al. 2006).

Sea buckthorn is also widely studied and it contains high amounts of vitamin C and E and beneficial fatty acids. It can have positive effects in treating skin problems. Sea buckthorn oil may also have pain relieving effects. (Törrönen et al. 2006).

Finland probably has the strongest tradition for utilising mushrooms (see Turtiainen et al. 2011 and Lunnan ym. 2005, Lindhagen and Hörnsten 2000) with around 40% of people (around 2.1 million people) engaging in mushroom picking (Sievänen and Neuvonen 2010). There are 23 marketed mushroom species in Finland, however only a few of these have significant market value. In addition, a range of other species is commonly collected for household use. In 2005, around 400–500 tonnes of mushrooms were picked in Finland and Norway respectively, amounting to over 1 million EUR of revenue in both countries (Table 10.9 above). No continuous statistics for mushroom exist, but the existing information indicates that the socio-economic value of mushroom picking is increasing. In summer 2010, 747.5 tonnes of marketed mushrooms (mostly ceps, *Boletus edulis*) were picked in Finland. These 2010 yields entering organised markets resulted in a total income of 2.8 million EUR with the share of ceps being 2.6 million EUR (MARSI 2010). In general, in years of high yield ceps can be the main economic product of pine forests with monetary value two to three times of the annual forest production (Salo 2005).

As with berries, a significant amount of mushrooms are consumed by households and also sold directly (e.g. on market places) to households and restaurants. In 2000, the value of mushrooms sold directly and used directly by households in Finland was estimated to be around 0.8 and 13.5 million EUR respectively (Salo 2005).

There is a very limited amount of information available on mushroom trade. However, it has been estimated that some 482 tonnes of frozen or boiled mushrooms were exported from Finland in 2010 (MAR-

SI 2010). Ceps are highly valued mushrooms in southern Europe, especially in Italy to where they are mainly exported (Cai et al. 2011, MARSI 2010). Recently matsutake mushroom has evoked interest in Sweden and Finland, since it is highly valued in Japan (Bergius and Danell 2000, Yle Lappi 2009).

Game

The socio-economic importance of hunting in the Nordic countries is a combination of revenue providing activity, household subsistence value, and cultural and recreational significance. Around one million Nordic people go hunting every year – almost 5% of the total population (Nordic Hunters Cooperation 2012) (Table 10.12 below). Estimates for the value of game meat were obtained from Finland, Sweden and Norway ranging between 44–125 million EUR / year (Table 10.12 below). In Finland, the value of Eurasian elk was the most important, at 61 million EUR / year.

In terms of the national economy, game plays the most significant role in Greenland where hunting and whaling remain an important parts of people's livelihoods, constituting almost 4% of national GDP (CBD Greenland, Nordic council of ministers website 2012, Statistics Greenland 2012). In particular, hunting is of high socio-economic importance to local communities in terms of cultural identity and it also remains an important means of supplying households with preferred meat.

The number of hunters has remained fairly stable in recent years, at least in Finland, Norway and Sweden (Sievänen and Neuvonen 2010, Statistics Norway 2012, Statistics Sweden 2009, Heiðarsson et al. 2010). Hunters are almost exclusively men but interest among women is growing. Hunting is a highly regulated activity in the Nordic countries. All hunters must obtain a permit from the regional authorities and they must also pass an exam organised by local hunting associations (Nordic Hunters Cooperation 2012, Heiðarsson et al. 2010). In Iceland, reindeer hunting is allowed only with a hunting guide and only one reindeer per hunter is permitted (Heiðarsson et al. 2010). The hunting times and hunted amounts are often regulated by quotas or licenses (Suomen Riistakeskus 2012, Naturvårdsverket 2012, Heiðarsson et al. 2010.) In Greenland, different rules are set for professional and sport hunters (Statistics Greenland 2012). Hunting quotas are set according to the species populations (Nordic Hunters Cooperation 2012) (See Chapter 9). Illegal hunting is not common, but it does pose a known problem in the case of large predators (Naturvårdsverket 2012).

Table 10.12 Socio-economic significance of hunting in the Nordic countries

Country	Finland	Sweden	Norway	Denmark	Iceland	Greenland
Hunters(with licence)	311,000	263,000	195,500	171,119	12,227	6,539
Large mamals (catch / year)	Eurasian elk 68,423	Eurasian elk 80,974	Eurasian elk 36,400	Roe deer 128,200	Reindeer 1,229	Reindeer 15,092
Bears (catch / year)	179	181	3	NA	NA	Polarbear 124
Other species (catch / year)	Mallard 265,400 Wood pigeon 232,100 Black grouse 170,000	Roe deer 119,000 Mallard 91,500 Wood pigeon 71,000	Willow grouse 127,850 Wood pigeon 56,900 Red deer 39,100	Pheasant 721,400 Mallard 485,400 Wood pigeon 299,500	Rock ptarrigan 68,831 Greylag goose 45,828 Puffin 33,074	Guillemot 84,412 Harp seal 84,223 Ringed seal 71,260
Ref. year	2010	2007–2008	2010–2011	2010–2011	2010	2007–2009
Source	RKTL 2012	Hunters: Naturvårdver-ket website, other information: Kindberg et al. 2009. Årsrapport 2007–2008. Viltövervak-ningen	Statistics Norway 2012	Asferg 2011 Vildtudbyt-testatistik for jagtsæso-nen 2010/2011	Hunters: Heiðarsson et al. 2010, other informa-tion Statistics Iceland 2012	Statistics Greenland
Value of game meat (catch / year)	83 mil EUR (mainly Eurasian elk)	1,119 mil SEK (~125 mil EUR)	44 mil EUR	NA	NA	NA
Ref. year	2010	2005–2006	2001			
Source	RKTL 2012	Mattsson et al. 2008	Lunnan et al. 2005			

It should be noted that the socio-economic value of hunting comprises elements other than the value of meat. In Sweden Mattsson et al. (2008) estimated the recreational value of hunting (contingent valuation) to be 2,015 million SEK (~229 million EUR) (7,196 SEK / ~819 EUR / hunter). The gross hunting value (i.e. investment in hunting, value of meat and value of recreation) was therefore estimated to be 3.13 billion SEK (~356 million EUR) for the whole country and over 11,000 SEK / hunter (~1,253 EUR). Also, in Nordic countries the hunting rights usually belong to the land owner and therefore the owner can obtain income by leasing the rights to hunters (see Suomen Riistakeskus 2012, Svenska Jägarförbundet 2012, Lunnan et al. 2005, Sigursteinsdóttir and Bjarnadóttir 2010). Jóhannesdóttir et al. 2006 estimated that the economic value of renting hunting rights could be 298,000 ISK (~1,874 EUR) / land holding / hunting season (cited in Heiðarsson et al. 2010). Hunters also spend money while on hunting trips and on their equipment. In Iceland Sigursteinsdóttir and Bjarnadóttir (2010) asked hunters how much they spend money on their hobby and found out that money spent on reindeer hunting is over 200,000 ISK (~1,258 EUR), most of which goes to hunting licences and equipment, but some of which also goes to hunting guides or accommodation. The money spend on hunting other game was a little less, nearly 160,000 ISK (~1,006 EU), most of it spent on fuel/gasoline, hunting equipments and food/catering.

Ornamental resources

Nordic nature also provides a range of decorative materials. Ornamental plants are produced professionally in Sweden, Finland and Denmark. Denmark is the leading producer of Christmas trees, amounting to over 100 million EUR revenue / year (Köhl et al. 2011a). In North Europe (i.e. Nordic and Baltic countries) 400 tonnes of *wild decorative materials* were collected from forests (mainly Denmark), with an estimated value of 58,824,000 EUR / year (Köhl et al. 2011a, see Table 10.3).

Lichen (mostly reindeer moss *Cladina stellaris*) is one of the most important decorative materials in the Nordic countries, especially in the north. It is used mostly in cemetery floristry but also as a base or decoration in other floristry creations and miniatures. During peak years, some 500 tonnes of lichen has been collected in Finland, with 180 tonnes of lichen exported in 2009 (Metsätilastollinen vuosikirja 2010). A Finnish company Polar-Moos claims to be the biggest lichen producer in Europe and 90% of their income comes from exports, mainly to Central Europe and the U.S. (Polar Moos 2012).

Another important natural decorative material is *willow*. Denmark has a long tradition in using willows in handicrafts and is the biggest producer and user of ornamental willow of the Nordic countries (Järvenranta 2005a). There are a number of commercial willow farms in Denmark (~3–7 ha / farm) and numerous smaller farms that produce willow for their own use. In other Nordic countries, including Finland, willows have traditionally been collected from nature however with the increasing demand the cultivation of willows for decorative use has also started (Järvenranta 2005b). Willows are mostly cultivated organically (Järvenranta 2005a) and are used in different handicraft products such as baskets, garden decorations and garden fences.

In general, however, ornamental production or collection is a minor business in the Nordic countries compared to, for example agriculture or forestry, and in particular materials collected from the wild are probably mostly used by local handicrafts on a very small scale (with a few exceptions). However, even small scale production may have high local importance, offering new business opportunities and employment for rural areas. For example, lichen collection gives income for nine people yearly and for tens of people in summertime on a small island of Hailuoto and elsewhere in Northern Finland (Polar Moos website 2012). Similarly, several reindeer herders increase their income by diversifying into ornamental products such as reindeer skins, bones and antlers as material for clothing and handicrafts. In terms of more recent – and arguably more innovative – use, even reindeer blood has been turned into a marketed product by a Hong Kong based company DNA-Tech, selling – for over 60 EUR / piece – small bottles attached to a pendant containing a drop of reindeer blood (Helsingin Sanomat 2002).

There are hundreds of wild plants and other natural ingredients in Nordic countries that can be used for dyeing. Flowering plants, tree bark, mushrooms, mosses and lichens and even molluscs contain colors that can be used in dyeing fabrics or paper. The process of dyeing clothes predates synthetic dyes and thus natural dyes have been used for a very long time in the Nordic countries. Natural dyes have become increasingly popular in recent times and are being used by enthusiastic amateurs as well as professional artisans and it has become increasingly popular (Kauno 2003). There also seems to be a market demand for natural dyes and, for example, in Finland the production of indigo color from plants has been studied (MTT 2012). In general, cultivating dye plants could be considered as one of the new sources of income for Nordic farmers.

Bio-industry and bioprospecting

Organisms in the Nordic and Arctic regions have evolved under extreme conditions, developing a variety of unique physiological and biochemical characteristics. Bacterial enzymes have been purified and sold for food manufacturing, cotton weaving, washing powders and other uses for decades. Fungi are used in paper production as a surrogate for mechanical and chemical processes to alter the lignin in the cell walls of the wood, converting wood chips to paper pulp. Bioleaching, the extraction of specific metals from their ores using bacteria, is used as a cheaper and more *environmentally friendly* alternative to traditional extraction methods. Bacteria are employed to remove industrial waste, pollutants and undesired substances. In addition, microbes have a promising future within the research and development of pharmaceuticals and other medical applications. Examples of these types of Nordic biotechnological innovations are given in Box 10.3 below.

It has been estimated that around 40 companies are involved in research and development and/or sale of products derived from or based on the genetic resources of the Arctic (Leary 2008). A significant number of the companies are based in the Nordic countries. A search of European and US patent databases has identified 31 patents and or patent applications in relation to inventions based on or derived from the genetic resources of the Arctic (Leary 2008). The jurisdiction of patents and or patent applications in relation to inventions based on or derived from the genetic resources of the Arctic is as follows: 6% in Norway, 6% in Finland, 3% in Iceland, 66% in USA, 10% in Russia, 6% in Japan and 3% in Germany. No patents were identified in the Arctic jurisdictions of Sweden or Denmark.

There is increasing interest from Nordic and Arctic countries in researching biotechnological application based on Nordic and Arctic genetic resources. Norway has the most developed and promising marine biotechnology sector focused on Arctic genetic resources. The Norwegian Government established a national plan for functional genomics (the FUGE Programme), running from 2002 to 2011. The plan is designed to strengthen research in this field to bring Norway up to top international standards. The Research Council of Norway administers and distributes public funding through more than 130 research programmes and activities. The FUGE Programme consistently promoted bioprospecting in the Arctic regions. By 2003, approximately 17.5 million EUR had been committed by the Norwegian Government to fund the FUGE programme. Bioprospecting in northern Norwegian waters and sub-Arctic waters has included looking for enzymes, enzyme inhibiters, antioxidants, and immune modulators from species such as sea anemones, starfish, sponges, sea urchins, and spider crabs. The Mabcent Initiative is a significant element of the FUGE programme bringing together industry and academic researchers interested in the biotechnology potential of the marine genetic resources of the Arctic (Leary 2008) (See Box 10.3).

A number of Nordic plant compounds are currently used by the pharmaceutical industry, e.g. cardiotonic compounds from lily of the valley (*Convallaria majalis*) and foxglove (*Digitalis purpurea*) and endurance increasing compounds from roseroot (*Rhodiola rosea*) (Fabricant and Farnsworth 2001) (Box 10.3). The Nordic genebank project "Spices and medicinal plants in the Nordic and Baltic countries" identified 134 plant species that have medicinal or aromatic properties and that are of current socio-economic interest and that grow wild in the Nordic and Baltic region (Asdal et al. 2006). Recent examples of scientific screening of Nordic plants include sage species tested for their effect on type-2-diabetes in Denmark (Christensen 2009) and Corydalis species on Alzheimer's disease (Adsersen et al. 2006).

While the collection of medicinal plants for the purposes of herbal medicine is common in southern and southeastern Europe it is less common in the Nordic countries (Asdal et al. 2006, Galambosi and Jokela 2002). For example, in Finland some 20 plants are currently collected from the wild and 30 plants are cultivated for commercial medicinal purposes (Enkovaara 2002). Some thousands tonnes of *Drosera rotundifolia*, which grows wild on wetlands, is collected annually in Finland, mainly used by Bioforce in Switzerland in cough tincture (Galambosi and Jokela 2002). Many medicinal plants have become rare – or even threatened – in southern parts of Europe due to over utilisation (Asdal et al. 2006, Galambosi and Jokela 2002). As collection in the Nordic countries has been less intensive, the region still has potential for the (sustainable) use of these plants in the future. There have also been some experiments to cultivate medicinal plants in the Nordic countries. In a Finnish study threat status, cultivation status and commercial possibilities in Europe of several medicinal plants were analysed. Based on the results 20 species seemed be suitable for cultivation trials and as a result the large scale cultivation of some plants has already begun (e.g. *Rhodiola rosea, Arnica montana*) (Galambosi 2009).

Box 10.3 Nordic potential for bio-innovations

- Enzymes

Cold-active enzymes from Arctic bacteria might have an increasing role in industrial production, especially in the food industry. Cold-adapted β-galactosidase will reduce the lactose content of milk at low temperatures. Diverse starch-modifying enzymes, xylanases, and proteases can be used to reduce dough fermentation time and improve the properties of dough in bakeries. In addition, cold-adapted lipases are of considerable interest as flavour-modifying enzymes in the production of fermented food, cheese manufacture, beer treatment, and biotransformation reactions in fine chemical processes (Leary 2008).

Novozymes is a Danish *biotech*-based company famous for launching in 1987 Lipolase®, the world's first fat-splitting enzyme for detergents manufactured with genetically engineered microorganisms. Novozymes is now among the world's biggest enzyme manufacturers. Its sales in 2011 were 10,510 million DKK (~1,413 million EUR). According to Novozymes' own estimates, the global industrial enzyme market grew in 2011 to a total market value of approximately 20 billion DKK (~2.7 billion EUR) (The Novozymes Report 2011). Of course not all of the enzymes are of microbial origin, but a conspicuous number of them are mainly extracted from filamentous fungi, bacteria and yeast.

The major enzyme application in the animal feed industry is the use of phytase. This enzyme releases the phosphate bound in the grain and thus diminishes the need for the addition of inorganic phosphate to the feed. A study estimated that using phytase for all the pigs in Denmark (23 million) would reduce the emission of P to the aquatic environment by 260 t P. This corresponds to around 25% of the diffuse emission of P from Danish agriculture. Furthermore, the phosphate saved by this method corresponds to the annual consumption of phosphate from 1 million people (Scheper et al, 2007a).

- Bioremediation and removal of undesired substance

Energies and resources are being invested in the Nordic Countries for the development of biological treatment for contaminated environments. In Finland, the KAIRA project was carried out by Finnish Forest Research Institute (Metla) from 2004–2007 with considerable support from the mining industry. The industry uses a considerable amount of nitrogen-based explosives which are a major source of ammonia and nitrate in mine waters, much of which flows into surrounding streams and water bodies often causing eutrophication. The aim of the KAIRA project was to develop treatment processes for the removal of ammonia and nitrate released in the environment by nitrogen-based explosives used in mining operations. The research focused on microbes sourced from Svalbard and Northern Arctic Finland, highlighting their potential wide application in the mining industry throughout the Arctic and in other cold climates (Leary, 2008).

In April 2012, a Norwegian team from the University of *Tromsø* found a bacterium that uses methane to build new cell material and produce energy, while the rest is converted into CO_2. Bacteria that feed on methane have been also discovered in landfills, rice paddies and soil, but *Methylobakter tundripaludum*, found in the wetlands of an Arctic archipelago, appears to be particularly suited to Arctic conditions. Further investigations could clarify the implications of this discovery for the reduction of methane emission causing global warming (*Sojtaric*, 2012).

Wetlands in Central Finland were contaminated by a black liquor spill from a pulp mill from 1935–1967. Restoration projects started in the 1980s and since then there had been several attempts to solve the problem, including draining the wetlands. However, none of the proposed solutions reduced the organic load in the area. The polluting substance was mainly attached into the peat fraction of the wetlands and required more efficient treatment of the waters. After a comparative analysis of several proposals, anaerobic treatment was shown to be the best option to restore the wetlands. Anaerobic treatment utilises naturally-occurring bacteria to break down biodegradable material. The project was commissioned and within one year a stable reduction of the polluting substances was observed (Kautola and Pirttijärvi 2007).

The organic waste produced by paper mills is also a potential resource. Following this principle, methods to use paper mills' waste in protein biomass production have been developed. The pekilo process, for instance, has been developed in Finland for the production of single-cell feed using the fungi *Paecilomyces variotii*. The first commercial pekilo plant, built at the United Paper Mills pulp plant at Jämsänkoski, Finland, had an annual capacity of 10,000 tonnes of single-cell protein. Similarly, the fungi *Torula utilis* is used by the Boise-Cascade Corp. as a high protein food extender and animal feed. An industrial ethanol plant connected to a sulfite pulp mill is in operation at Örnsköldsvik in Sweden (Scheper et al, 2007b).

- Birch tar oil – Nordic biocontrol innovation

Birch tar oil (BTO) is made by slow pyrolysis process of birch stems. Originally it was a by-product of barbecue charcoal manufacturing. It contains lots of phenolic compounds that are part of birch's defence mechanism, and that can be harnessed to control pests in agricultural fields and forests. In a series of tests it has proven efficient in repelling slugs and snails as well as voles and also bigger pest animals like deers and Eurasian elk. BTO does not kill pest animals but repels them due to its foul smell. It also proved to be efficient against some insect pests, with aphids proving the most sensitive. BTO also works against pathogens; it has slowed down the progress of potato blight. Finally, it also proved to be a herbicide, killing broadleaved weeds through contact. The safety of the product was also tested. It was concluded that BTO has no harmful effects for the beneficial organisms in the soil – in fact it even proved to be beneficial to soil microbial activity. In aquatic environments the sensitivity of different organisms to BTO varied, but it does not pose a serious hazard to aquatic environments – although it should not be sprayed directly onto waters. (Tiilikkala and Segersted 2009).

There is market demand for ecological pest control. Organic farmers, home gardeners and foresters are all interested in BTO (the latter for use in repelling Eurasian elk). However, proof of safety or efficiency is not enough to bring a product to market. If the product is to be sold as a plant protection agent, it needs to be registered according to EU directives. This means for example that all active ingredients in the product must be accepted at EU level. As there are hundreds of (unknown) active ingredients in natural products like BTO, this demand might prove impossible to overcome (Tiilikkala and Segersted 2009). Currently BTO can be used for experimental purposes and can be sold as a repellent, but permission to sell the product is only granted for one year at a time (Maaseudun Tiede 2008, Uusiutuva metsäteollisuus 2012).

- Pharmaceutical and medical uses

The Armi Project co-ordinated by the Finnish Forest Research Institute (Metla) ran from 2001 to 2004 and isolated some 600 strains of microbes from boreal and Arctic environments in soil sediment, stream water, snow, lichen and moss from Lapland in Northern Arctic Finland and Svalbard in the Norwegian Arctic. Among other new developments in environmental biotechnology, the Armi Project also examined possible pharmaceutical applications, leading to promising results. For example, several of the *Pseudomonas* bacterial strains isolated from soil samples from Lapland showed antimicrobial characteristics with potential to treat ailments like sore throats caused by *streptococci*. A European pharmaceuticals company has subsequently bought the rights to start screening the collection of bacterial strains collected as part of the *Armi* research for anti-cancer drug candidates (Leary 2008).

Pharmaceutical and medical commercial applications of bioactive compounds from Arctic and sub-Arctic marine organisms are being researched by the MabCent. This is one of fourteen Research-Based Innovation Centers initiated by the Research Council of Norway, in a consortium with the University of Tromsø and four Norwegian biotechnology companies: Lytix Biopharma; ProBio Group Holdings; Biotec Pharmacon ASA; and Pronova Biopharma (MabCent-SFI, 2011). A total of 180 million NOK (~23.8 million EUR) has been committed to the MabCent initiative by the Norwegian Research Council, the University of Tromsø and the associated biotechnology companies. Approximately 25% of this funding has been provided by the commercial partners (Leary 2008).

- Nordic medicinal plants

One of the most interesting medicinal plants in the world is roseroot, *Rhodiola rosea*, (Ramazanov and Suarez 1999, cited in Pakonen et al. 2003) which grows wild in Nordic mountainous areas and is rare in temperate regions (Asdal et al. 2006). Roseroot is said to be the northern ginseng (Asdal et al. 2006).

In Arctic regions roseroot has been used as a source of vitamin C and against scurvy (Alm 1996 cited in Galambosi 2006). In traditional medicine roseroot has been used for physical endurance, resistance to altitude sickness and in treatment of fatigue and depression (Brown et al. 2002, cited in Galambosi 2006).

Much clinical testing of roseroot has been done in the former Soviet Union and beneficial impacts on memory and learning, immune response and stress, and cancer have been documented (Galambosi 2006). According to Finnish phytoterapeutic textbooks roseroot is an adaptogenic plant that has the ability to help the human body to adapt to various environmental conditions and environmental stressors. Adaptogens increase non-specific resistance and normalise body functions (Holm and Hiltunen 2003). The most important medically active compounds of roseroot are rosavin, rosin and salidroside which are found in the rhizome. Roseroot products have been used to increase the stress tolerance of astronauts (Galambosi 2006). Adaptogenic plants have a high impact on preventing diseases (Rumjantseva 2002).

Worldwide there is high demand for roseroot (Asdal et al. 2006), especially in the U.S and the demand is calculated to be approximately 20–30 tonnes / year (Economo and Galambosi 2003). Due to high demand wild roseroot has become seriously threatened species in Russia and in central Europe (Galambosi 2006). There is no current threat to wild roseroot populations in Nordic countries and also successful cultivation trials of roseroot has been made in Nordic countries (Economo and Galambosi 2003, Asdal et al. 2006). Plant genotypes from northern origin have more biologically active compounds than plants from southern origin (Pakonen et al. 2003). There are several roseroot products on the markets.

- Cosmetics from Nordic nature

In addition to edible products from Nordic nature, there is an array of ingredients that can be used as cosmetics, e.g. herbs, peat and oils from berries. The Finnish cosmetic company Lumene has profiled its business and image significantly based on the use of Nordic berries (Time Magazine US 2007). Lumene is specialised in Nordic berries and the oils they contain. Lumene uses, for example, cloudberry seed oil which is said to be "age-defying". Other natural ingredients are heather and sea buckthorn used in anti-ageing products, blueberry in eye make-up products, rose-hip in lipsticks, and linen in products for sensitive skin (Lumene 2012). Another Nordic company using berries in their products is Skyn Iceland. They use mainly specifically cloudberry and cranberry – and glacial Icelandic water – which creates a powerful clean image of the company (Skyn Iceland 2012). Lumene and Skyn Iceland are by no means the only cosmetic companies that use Nordic nature in their products, but are perhaps the biggest. Numerous smaller enterprises are more or less dependent on Nordic natural products; for example peat is a widely known health and beauty promoting product that is available in Nordic nature.

Genetic resources

Today eight plant and five animal species provide the majority of food production for mankind (Pylvänäinen 2010). Breeding of crops and farm animals has prioritised productivity, often resulting in a narrow genetic base. Such varieties or breeds are more at risk from changing environmental conditions, such as climate change or disease. Preservation of genetic resources is, therefore, not only a matter of cultural heritage, but also necessary to create breeds with useful characteristics, such as resistance to pests, lower nutrient requirements or, a desired feature in Nordic Countries, tolerance to extreme temperatures.

The Nordic countries host a number of unique breeds related to agricultural systems, all of which have a high socio-economic and cultural significance (Box 10.4). Many of these breeds are now under threat and some have become extinct, like the Finnish long-haired pig (Pylvänäinen 2010). Organised preservation of genetic resources in the Nordic countries is secured by the Nordic Genetic Resource Centre. However, for successful *in situ* conservation, the genetic diversity of landraces should be prioritised by national policies and supported by breeders.

Box 10.4 Socio-economic importance of Nordic breeds

- Precious Nordic horse breeds

The ponies on the Faroe islands are one of the oldest and purest equine breeds. In 1988 an association was formed to save the remaining four individuals from extinction. Today there are a few dozen reproducing ponies (Pylvänäinen 2010). The main use of these ponies is as a show/riding animal. Another Nordic breed comparable in age and purity of the Faroe Pony is the Icelandic horse, brought by the Vikings and surviving only in Iceland for 1,100 years without crossbreeding. Today this landrace is a component of the Icelandic agricultural traditions and plays a large part in the economy from horse racing to trading. Icelandic law prevents horses from being imported into the country and exported animals are not allowed to return (Iceland 2012).

- Spelt: ancient, nutritious and adapted to harsh winters

Spelt (*Triticum spelta*) is among the earliest grains cultivated by human beings. Originally from Asia, it eventually spread to Europe and Scandinavia where it was cultivated for many centuries. The cultivation of spelt in Sweden was discontinued but recommenced in the early 1990s, primarily on the island of Gotland where it never truly stopped. This grain is now gaining popularity on the Scandinavian dinner table, promoted by local wholesalers such as Dinkelboden, a Swedish family company that has grown from selling spelt products in a little village to becoming suppliers for ICA supermarkets throughout Sweden (Dinkelboden 2008). Spelt has a high nutritional value, is less demanding in terms of its cultivation than common wheat and tolerates cold environments (Špokas and Steponavičius 2006).

- Brown bee populations adapted to the Nordic environment

The Nordic brown bee (*Apis mellifera mellifera*) was once the most widespread bee in the world, but it has now become extinct in many European countries due to hybridisation. Even though populations are present in all Nordic countries (except Iceland) the species is considered endangered. The Nordic brown bee does not have a large commercial significance however the breed displays desirable characteristics, such as significant winter hardiness, a strong drive to collect pollen, high longevity of the worker bees and the queen, and flight strength even in cold weather. Additionally, the ability to stand high mineral contents in winter feed is an exceptional genetic adaptation to Calluna vegetation along the Atlantic coastline. A project starting in 2012 aims to clarify the current in situ and ex situ conservation of the Nordic brown bee. The project is led by MTT Agrifood Research Finland, and will be administered by an ad hoc-group comprising specialists from each Nordic country and Latvia (Nordgen 2012).

- Finncattle products gaining popularity

The Eastern Finncattle cows were recognised as a separate breed in the 1890's. The keepers of the Eastern Finncattle founded a breed society in 1898 at the cattle fair in Kuopio. This initiated cattle breeding organisation in Finland. There are around 450 purebread Eastern Finncattle. As an ex situ scheme, embryos and semen doses are annually deposited in a cryo-bank. The breed is currently enjoying healthy popularity. There are a few restaurants in major cities offering products made from the milk and meat of Eastern Finncattle. They are also used in landscape management and even in animal-assisted therapy for kids etc. (Lilja et al. unknown).

Drinking water

The abundant resources of freshwater in Nordic countries are reflected in water abstraction: in Norway and Iceland public water use per capita is much higher than in other European countries (Eurostat 2012). According to the existing information, in Iceland and Denmark the main source for household water if groundwater (Eurostat 1997, cited in Lavapuro et al. 2008) whereas in Sweden and Finland surface water is also used (Table 10.13 below).

Freshwater is used also in agriculture and industry. Agricultural irrigation is modest in Nordic countries (Flörke and Alcano 2004); and other agricultural use of water is livestock watering. In industry, electricity production uses a lot of water in Nordic countries. Groundwater is often used in the food and drink industry, while other manufacturing may also use surface water (Göransson 2008).

Table 10.13 Freshwater resources and use in the Nordic countries

	Denmark	Sweden	Norway	Finland	Iceland
Total fresh water resources (mill m^3)	16,340	175,118	374,011	120,800	170,000
Groundwater available for annual abstraction (mill m^3)	1,000	3,460	137,687	3,000	6,000
Reference year	Latest available*	2009 (total) Latest available* (ground water)	2009	2005 (total) 2001 (ground water)	Latest available*
Surface water use (mill m^3)	10	2,285	Not available	Not available	5
Groundwater use (mill m^3)	650	346	Not available	285	160
Total freshwater use by public water supply / inhabitant (1,000 m^3)	75	100	180	75	275
Reference year	2009	2007	2007	2005	2005
Source	Eurostat 2012	Eurostat 2012	Eurostat 2012	Eurostat 2012	Eurostat 2012

*In a number of cases, information available from Eurostat Database is for the "latest available" year without specifying the year in question.
Source: Eurostat 2012.

As there is no scarcity of drinking water in Nordic countries, there are also no real market prices for it, although communal fees can be charged in some countries (mainly related to water purification, not reflecting water supply). However, given the foreseen impacts of climate change (e.g. possible local scarcities of water) it would be important to explore the value of fresh water in order to prepare and plan for situations where there is some threat of change concerning groundwater quantity or quality. Such estimates would help to consider options for prevention and protection of water resources in case of possible risks.

Some attempts have been made for the economic valuation of groundwater. In Kristianstad, Sweden, the value of groundwater for households, agriculture and industry has been calculated by using a replacement costs method (based on a scenario where the ground waters of Kristiansstad became polluted. Three methods to deal with polluted groundwater were considered: treatment of groundwater, using surface water instead of groundwater (which would demand more treatment) and replacing the old groundwater resources of Kristianstad with new ones. The costs of these methods would be 50, 200 and 500 million SEK (total) (~22.7 to ~57 million EUR), respectively, and production costs would increase by 1.5 to 3 SEK / m^3 (~0.17 to ~0.34 EUR).

On a regional level, the value of groundwater used for agriculture (irrigation) in Kristianstad, Sweden has been estimated at around 110 million SEK (~12.5 million EUR) annually whereas the value of groundwater for the food and drink industry would be between 7 and 14 million SEK[18] (between 797.6 thousand EUR and ~1.6 million EUR) / year (Göransson 2008). Also, the option value of water – the value of currently unused groundwater that might be needed in future – was estimated to be between 90 and 250 million SEK (between ~10 and ~28.4 million EUR). In Denmark, the willingness to pay for good quality drinking water has been surveyed (Hasler et al. 2005). The study shows that Danish people are willing to pay more for groundwater protection than artificial purification of water. Danes were willing to pay almost 50% more on top of their current water bill to have naturally pure groundwater (1,900 DKK / ~255 EUR extra) while the willingness to pay for purified water was only half of the value of naturally clean groundwater (900 DKK / 121 EUR extra).

[18] The value of groundwater for irrigation was measured as the economic value of yield increase (30% since starting irrigation in the 1970s) The value for industrial use was calculated simply by communal water price 3 SEK/m^3 (0.34 EUR/m^3) or with the price that water would be transported from somewhere else 6.33 SEK/m3 (0.72 EUR / m^3) (in this case the water price that Cyprus pays for its water that is transported from Greece was used as reference price).The optional use of water was estimated using the value of communal water price or the price that Cyprus pays for its transported water.

10.2.2 *Regulating services*

There is very limited amount of comparable, national level data for the socio-economic value of regulating services in the Nordic countries. As with status and trends (Chapter 9), most of the existing studies take place on a local scale with limited possibilities to extrapolate the information to national or regional level. The available information includes estimates (direct or proxy) on the value of *mitigation of climate change* (carbon sequestration and storage), *maintenance of water quality* and *pollination*.

Carbon sequestration and storage
While the research on status of and trends in Nordic carbon continue (Chapter 9), some estimates already exist for the monetary value of carbon sequestration and storage. In Finland Matero et al (2007) estimated the value of carbon sequestration of Finnish forest trees to be 1,876 million EUR, and the value of change in mineral soil carbon stock to be 136 million EUR. The calculated values were based on the Finnish carbon tax for fossil fuels (17.1 EUR / t CO_2) with an estimated sequestration capacity by trees of 101.3 Mt CO_2/ year and soils of 7.34 Mt CO_2 / year. In Sweden Gren and Svensson (2004) calculated the annual carbon sequestering value of Swedish forest to be between 29–46 billion SEK (2001 SEK) (~3.3–~5.2 billion EUR) based on the estimated consumption value of 11–18 billion SEK[19] (~1.2–~2 billion EUR) and investment value of 18–28 billion SEK (~2–~3.2 billion EUR).

Water purification
Deterioration of water quality due to the impoverished capacity of ecosystems to retain nutrient flows is a common problem in the Nordic countries in both salt-water and fresh-water systems. This is caused on the one hand by the increasing nutrient input from agriculture and aggravated, on the other hand, by the systematic conversion of wetlands, peatlands and other natural nutrient buffer zones into arable land.

The socio-economic benefits of water purification are manifold, starting with the supply of good quality water for human consumption. Millions of people in the Nordic countries use drinking water originating from lakes and streams and consequently securing the quality of these in

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[19] The consumption value is calculated as 0.38 or 0.6 billion SEK (~43.3 or ~68 million EUR / million tonnes CO_2) / million tonnes CO_2 times carbon sequestration and investment value of 12.7 or 20 billion SEK (~1.4 or ~2.2 billion EUR) / million tonnes carbon sequestration times (0.13 x carbon seq/106m^3) times 106m^3 of growth in standing volume.

land water bodies is of high importance. In Sweden for example, around 50% of the population uses surface water while only 25% get their drinking water from groundwater wells (The Color of Water 2012). In Finland some 40% of drinking water is from surface waters (Ymparisto 2012) (Table 10.11 above). In addition, good quality water is also required by agriculture (e.g. watering livestock) and industry.

Wetlands and other ecosystems play an important role in (pre)purifying water, thereby also decreasing the costs of artificial purification. The economic value of wetland water purification service can be estimated through the cost of wetland creation and efficiency of the service. In several cases (e.g. Denmark, Sweden and Finland) wetlands have proved to be most cost efficient measure against nitrogen leaching (Jacobsen 2002, cited in Atkins and Burdon 2006). These benefits are outlined in more detail in Chapter 10 below. Also, a more concrete example is provided in TEEB Nordic case study by Salminen et al. in Annex II.

Poor water quality also leads to diminished recreational opportunities and values. These services/benefits are also much studied in Nordic countries in relation to watershed services – in addition to nutrient retention and provisioning services (Barton et al. 2012). Good water quality is known to increase people's interests in using waters for recreation. Excess nutrients in water often create massive algal blooms and dense vegetation, and reducing these nuisances makes people want to spend more time in water related activities. Eutrophication of watercourses may also often lead to the disappearance of some fish species such as salmonids and vendace. Thus fisheries, recreational or professional, also benefits from efficient water purification (see also 10.3 below).

In Nordic countries many studies have been carried out to reveal the public appreciation of cleaner surface waters. A summary of these is provided in Table 10.14. In general, these studies can be used as proxy indicators for the value of water purification for the general public (i.e. water purification as a public good). These studies are mainly based on willingness to pay (WTP) studies and do not, therefore, reflect market values or real economic gains.

Table 10.14 Examples of the estimated values for ecosystem's ability to improve water quality (public good)

References	Study area	Method	Estimated impact on recreational services
Appelblad, 2001	Sweden, River Byske	WTP for a day fishing license in the River Byske	WTP under unimproved environmental conditions: 89 SEK (~10 EUR); WTP under improved conditions: 142 SEK (~16 EUR); Consumer surplus: SEK 18 (~2 EUR) / day in 1996
Sandstöm, 1996	Sweden, Laholm Bay and entire Swedish coast	Recreation benefits from hypothetical 50% reduction of the nutrient load	Consumer surplus: 12–32 million SEK (~1.3–~3.6 million EUR) / year for the only Laholm Bay; Consumer surplus: 240–540 million SEK (~27.3–~61.6 million EUR) / year for the entire Swedish coast
Soutukorva, 2001	Sweden, Stockholm archipelago, Stockholm and Uppsala	Recreational benefits from a hypothetical 1-metre improvement in water clarity, 30% reduction of the nutrient concentrations	Consumer surplus 59–93 million SEK (~6.7–~10.6 million EUR) / year in 1998 and 70–110 million SEK (~8–~12.5 million EUR) / year in 1999.
Söderqvist et al, 2000	Sweden, Stockholm archipelago, Stockholm and Uppsala	WTP (higher prices of tap water and agricultural products) for 1-metre improvement in water clarity	500–850 million SEK (~57–~97 million EUR) / year in 1999
Kosenius, A-K, 2010	Finland, Gulf of Finland	WTP for three nutrient reduction scenarios of different intensities in the Gulf of Finland	28,475–53,884 million EUR (total)
Atkins and Burdon 2006	Denmark, Randers Fjord in Arhus County	WTP for hypothetical improvement to obtain good water quality in the fjord	12.02 EUR / month / person over 10 years, totalling 5.5 million EUR a month over 10 years
Eggert and Olsson 2002	Sweden, south-west Swedish coast	WTP for preferred water quality improvements (for biodiversity bathing and fishing)	Mean average WTP from 1,400 SEK (2002 SEK) (~159 EUR) / person for avoiding reduction in biodiversity to 600 SEK (2002 SEK) (~68 EUR) / person for improving biodiversity levels. Extrapolating the results over the whole Swedish population leads to an aggregate estimate of 400–700 million SEK (~45.6–~80 million EUR) for either improving the cod stock or avoiding deterioration of marine biodiversity.
Vesterinen et al. 2010	Finland, inland and coastal waters	Recreational benefits from a hypothetical 1-metre reduction/improvement in water clarity	Swimming benefits loss under impoverished environmental conditions: 31–92 million EUR / year; fishing benefits loss: 38–113 million EUR / year. Swimmers consumer surplus under improved environmental conditions: 29–87 million EUR / year; fishers consumer surplus 43–129 million EUR / year.

Pollination

While estimates are available for the global economic importance and value of pollination, no such overall estimates yet exist for the Nordic countries. A recent study from Finland, however, assessed that the value of honeybee pollination service of selected crops would be around 18 million EUR and of wild berries (bilberry and lingonberry) 3.9 million EUR (Lehtonen 2012). In addition to pollination of commercial crops, there are numerous home gardens in Nordic countries. An estimated value of pollination (by honeybees) in home gardens was 39 million EUR in Finland (Yläoutinen 1994, cited in Lehtonen 2012). In Denmark the value of the general insect pollination service was calculated to be worth 421 to 690 million DKK (~56.6 to ~92.8 million EUR) a year (Axelsen et al. 2011). In Sweden the value of honeybee pollination service was calculated to be 189–325 million SEK (~21.5– ~37 million EUR) (Pedersen 2009a). When considering these values it must be noted that insect pollination of greenhouse crops is often provided by commercial pollinators.

In the absence of overarching and comparable estimates, information on insect pollinated fruit, berries and crops in the Nordic countries can be used as a proxy indicator for the service. The extent and value of Nordic fruit and berry cultivation can be seen in Table 10.15. Although fruit and berry production in Nordic countries is small compared to for example cereal production, it is a notable source of income in several areas, especially at local and regional level. The main cultivated fruit is apple, but cherries, plums and pears are also cultivated. The area under fruit cultivation is biggest in Denmark while berry cultivation dominates in Finland. In addition, other crops cultivated in the Nordic countries that require insect pollination include oilcrops like oilseed rape, turnip rape and tomatoes in greenhouses. Their socio-economic importance is outlined in Table 10.15 below. In general, by using the value of fruit and berries as a proxy indicator the value of pollination amounts to over 250 million EUR / year for the Nordic countries (excluding Iceland).

In addition to commercial production, numerous home gardens and wild berries from forests (see Section 10.2 above) are of socio-economic importance in the Nordic countries. As these quantities are absent from the data below, the figures provided in Table 10.16 can be considered as very conservative estimates of the total socio-economic value of pollination in the Nordic countries.

Table 10.15. Socio-economic importance of fruit production in Nordic countries, reflecting the value of pollination

	Denmark	Sweden	Finland	Norway
AREA UNDER GARDEN PRODUCTION HA				
Fruits	7,797			
(fruits and berries)	1,789	701	Not available	
of which apples	1,684	1,432	669	Not available
Garden berries		2,665	6,073	Not available
of which strawberries	1,137	1,997	3,386	Not available
GARDEN YIELD (TONNES) / YEAR				
Apples	22,973	22,150	5,249	13,581
Strawberries	5,931	11,711	12,764	9,119
Reference year	2010/2006	2008	2011	2009
Source	Statistics Denmark 2012	Swedish Board of Agriculture (2012a)	Matilda maataloustil-asto 2012a	Statistics Norway 2012
Estimated value of garden production (Fruits) million EUR (current prices) / year	30	55	96	72

Table 10.16 Other key crops demanding pollination in Nordic countries, reflecting the value of pollination

	Denmark	Finland	Sweden	Norway	Iceland
Area of tomato 1,000 m2	530	1,144	370	333	42
Reference year	2008	2011	2008	2006	2008
Area of oilcrops (rapes) ha	164,808	92,031	30,305	5,200*	
Reference year	2010	2011	2011	2011	
Source	Statistics Denmark 2012	Matilda maataloustil-asto 2012a, 2012b	Swedish Board of Agriculture 2012a, 2012b	Statistics Norway 2012	Icelandic Agricultural Statistics 2009

* oilseeds.

Regulation of heath

Several studies exploring the positive impact of nature on stress and *mental health* have been carried out in the Nordic countries. Evidence from Sweden, Finland and Denmark indicates that people visiting green environments more often felt less stressed. A Swedish study by Grahn and Stigsdotter (2003) found that the number and duration of visits to nature had an impact on stress levels. In general, people with easy access to nature (i.e. living in the vicinity of parks and other green areas) were the most frequent visitors to nature, therefore also benefitting the most from nature's soothing impact. They also found that garden owners that spend time in their own garden also visited public green environments more often – and consequently they were also least stressed.

A Danish study by Hansen and Nielsen (2005) concluded that even the mere vicinity of green areas had an effect on stress levels, i.e. the closer people lived to green environments the less stressed they were. International clinical studies have shown that nature (forest) visits can lower stress hormone levels as well as blood pressure and heart rate (Karjalainen et al. 2010). A Swedish study showed that a view of nature through the window immediately started to reduce blood pressure after stressful activity and blood pressure continued to lower when examined people went outside for a walk (Hartig et al. 2003, cited in Naturen som kräftkälla 2006).

In Finland it was discovered that urban green areas increase positive feelings (concentrated and excited and energetic) and those who frequently visited natural areas outside cities had reduced negative feelings (e.g. stress, anxiousness, tiredness and irritation). The positive feelings were enhanced even at a relatively low frequency of visits (Tyrväinen et al. 2007). The effects were not limited to leisure time only: walking through green environments on the way to work and/or working and studying in green environments also increased positive feelings and reduced negative feelings (Tyrväinen et al. 2007). It was also found that people's favourite places that were in natural/green environments gave a greater "recharge" experience than favourite places that were in more urban environments (Tyrväinen et al. 2007).

In a Finnish study among elderly institutionalised women it was also found that regular outdoors visits had a positive effect on their self-rated health (Rappe et al. 2006). In a Swedish study elderly people's concentration ability was better after relaxing in natural environments and it was worse after relaxing indoors (Ottosson and Grahn 2005, cited in Naturen som kräftskälla). Also, pre-school children were shown to have better motoric skills and better ability to concentrate when they had access to nature (Grahn 2000 cited in Naturen som kräftskälla). A study from Sweden indicates that removing the possibility of outdoor recreation would have significant negative impacts on people's self-rated health status (Norman et al. 2010). Finally, Hansen and Nielsen (2005) also discovered a negative relationship between obesity and green areas: people living close to green areas were less likely to be obese. Hansen and Nielsen (2005) suggest that closeness to green areas encourages people to be more active in general.

Nature and biodiversity can also have more direct effects on *physical health*. A recently publish study by Henki et al. (2012) shows that biodiversity seems to have an effect on the occurrence of atopic sensitivity (i.e. a predisposition toward developing certain allergic hypersensitivity reactions). The study revealed that children with regular access to nature, for example children living in the vicinity of forests and agricultural environments, were less atopic than children with more limited access to nature. In addition, it appeared that the less atopic children had 25% more non-common plants in their gardens. The land use type of surrounding environments also affected skin's microbial diversity, especially the diversity of gammaproteo-bacteria found on above-ground vegetation. It also appeared that individuals with high gammaproteo-bacteria diversity suffered less from atopic tendencies. Gammaproteobacteria were not abundant on individual's skin but they may have a special role in skin protection (Hanski et al. 2012). Consequently, it appears that health (i.e. non-occurrence of atopic tendencies) was positively connected to environmental and microbial diversity which in turn was positively connected to environmental diversity. The mechanism behind these connections requires more research but the present study gives strong evidence of a perhaps less visible but highly important connection between nature and health. (Hanski et al. 2012).

While individual health cannot be measured in monetary terms, impacts on public health can form a useful indicator for the economic benefits related to nature and health. Stress and stress related illnesses are one of the main illnesses of modern society (Nygren et al. 2002, cited in Grahn and Stigsdotter 2003) that cause sick leave and even early retirements. According to Sahlin (2001, cited in Grahn and Stigsdotter) Swedish health expenditures were 10 billion EUR / year, of which the share of "burn-out syndrome" was 8 billion EUR. In addition bad mental health makes people more vulnerable to several physical illnesses. Another serious factor causing health problems is physical inactivity, whichis estimated to cost some 600 million EUR / year in Sweden (Lindgren and Bolin 2006, cited in The Nature Experience and mental health). From these calculations it can be seen what a tremendous effects stress has on national economies – and thus securing and conserving existing green areas – as well as creating new ones might be a reasonably cheap option to prevent some of these costs.

Nowadays interest in Green care has again risen and there are several practical uses of nature in the field of health care in Norway, Sweden and Finland. The practice is best organised in Norway, where there are 500–600 Green Care farms where people with mental disorders or youngsters with behavioural problems are treated (Haugan et al. 2006). In Sweden, garden therapy is gaining increasing interest (Abramsson and Tenngart 2006). Alnarp garden within the Swedish agricultural university is used in the treatment of patients with depression or burn-out syndrome (Stigsdotter and Grahn 2003). In Finland too "green care" is of growing interest and more entrepreneurs are constantly becoming involved (Suomen Luonto 2012).

Other regulating services

Some evidence exists on the socio-economic benefits of *air quality maintenance* in the Nordic countries. In a Swedish report it was estimated that planting 20 trees every 100 metres of the street Horngatan in Stockholm would result in some 10% of traffic borne particles being captured (Johansson 2009). The costs of reduced air quality to human health can be used as very rough proxies for the economic value of ecosystems' ability to maintain air quality. A study from Oslo revealed that an increase in the amount of small particles in the air was connected to more sick leave and thus poorer labour productivity (Hansen and Selte 2000, cited in Narayan and Narayan 2008). A study of eight OECD countries, including Denmark, revealed that health care costs are positively related to bad air quality, and that investing in better air quality reduces health care costs (Narayan and Narayan 2008). While the two above mentioned studies did not consider ecosystems' role in air quality improvement, even if this role proves to be small, ecosystems and trees in particular have the capacity to further clean the air and thus contribute to better health and lower health care costs. In Nordic countries the ability of trees to capture particles could be of special importance for two reasons: firstly because the use of studded tires increases coarse particles in the air that are best captured by trees (Johansson 2009), and secondly because Nordic cities are generally very green.

Worldwide biocontrol is most used in greenhouses where it is a rule rather than an exception (Menzler-Hokkanen 2006) –this is probably the case also in the Nordic countries. In organic agriculture biocontrol is often the sole pest control method – both in greenhouses and outdoors, making those over 15,000 organic farms completely dependent on these services (See Table 9.1) In Denmark, biocontrol is used in apple orchards against mites and lepidoptera, as well as in strawberry fields and fruit bush gardens against mites and thribs (Sigsgaard 2006). Biocontrol is also used in forestry, e.g. against root rot. Perhaps one of the best known commercial Nordic biocontrol product is Rot Stop® against root rot. It contains the fungus *Phlebiopsis gigantean*, and is produced by Verdera. A new innovative method of biocontrol application is to harness bees to transport the biocontrol agent – in this case a fungus product against *Botrytis cinerea* on strawberries – to where it is most needed (Hokkanen et al. 2008). In a Swedish study (Östman et al. 2003) the yield saved by natural predators was calculated to be 300 kg / ha. The monetary benefit was greater in organic farms (48 EUR / ha) due to their smaller yield and higher production price. In conventional farms the monetary benefit was 41 EUR / ha.

10.2.3 *Cultural services*

There is a wealth of information available on the socio-economic importance and value of recreation and tourism in the Nordic countries, including monetary estimates. This information is, however, obtained mainly though a range of contingent valuation studies such as willingness to pay (WTP) assessments, therefore reflecting the public appreciation of cultural services in different Nordic countries (public value) rather than providing information on the contribution of nature to the actual revenue related to recreation and tourism. However, information on visitor streams to national parks and other recreation areas provide a concrete and direct indication of the socio-economic importance of cultural services.

Recreation

Recreation activities in nature, i.e. outdoor recreation related to everyday life that people do outdoors near their home, are extremely popular in Nordic countries (Sievänen and Neuvonen 2010 Romild et al. 2011, Statistics Sweden 2009, Statistics Norway 2012, Hansen and Nielsen 2005). For example, an average adult Finn does some kind of outdoor activity on average 170 times a year (i.e. around three times a week, with 1/3 of people doing such activity daily). Walking and cycling while enjoying the landscape are the most popular outdoor hobbies in Finland (Sievänen and Neuvonen 2010). In Sweden, 36–56% of people reportedly use forests for walking at least 20 times a year. Sunbathing, cycling and swimming in natural waters are also very popular activities in Sweden with a participation rate exceeding 70% (Romild et al. 2011). In Norway, hiking in forests or mountains is practised more than twice a month by almost half of the population (i.e. around 2.4 million people) (Statistics Norway 2012). On average Norwegians engage with outdoor activities 96 days a year, and one in three report that outdoor activities are their most important leisure activity (Odden 2008). Finally, in Denmark approximately 70% of Danes visited green areas several times a week, with parks and other open natural areas being the most popular green areas, followed by beaches (Schipperijn et al. 2010). Recreation in nature is also often associated with health benefits – both physical and mental. No quantitative date for the Nordic countries is available, however several studies and surveys have verified the presumed link between nature and relaxation (e.g. Schipperijn et al. 2010, Odden 2008).

According to a European survey, no national outdoor surveys are done in Iceland (Sievänen et al. 2008) and indeed no statistical information was found. However, a poll from 2004 (cited in Gunnarson et al.

2005) reveals, that despite the limited forest coverage, an average Icelander visits forests 15 times a year. Visits to remote natural areas have also increased since the roads have become better, facilitating access to nature (Gunnarson et al. 2005). Also, on a local level the Heiðmörk natural reserve around Reykjavik is estimated to attract over 500,000 visitors / year (Davíðsdóttir 2010). Typical activities in the area include walking and hiking, cycling and horseback riding (Kristófersson and Eiríksdóttir 2010). The area also has two lakes that are popular for angling (Jóhannesdóttir 2010).

Berry picking, fishing and hunting (i.e. recreation activities closely linked with provisioning services) generally maintain their popularity in the Nordic countries (Sievänen and Neuvonen 2010, Statistics Norway 2012, Lindhagen and Hörnsten 2000, Statistics Sweden 2009). In Finland, the popularity of berry picking seems to even seems to be increasing especially among younger age groups (Sievänen and Neuvonen 2010). Also, the numbers of Nordic hunters are in slight incline, especially among women (Sievänen and Neuvonen 2010, Heiðarsson et al. 2010). However, in Norway the popularity of berry or mushroom picking and skiing has decreased especially among young people (Odden 2008).

Fishing is also a very popular recreational hobby in Nordic countries, and there are over six million recreational fishermen (European Anglers Alliance 2002). In Finland, Sweden and Norway, 44%, 30% and 50% of the population, respectively, reported having engaged in some kind of fishing activity in the past year (Sievänen and Neuvonen 2010, Statistics Sweden 2012b and 2012c, Statistics Norway 2012). The size of catch by recreational fishermen in Finland was 48 million kg in 1998 (Official Statistics of Finland 2000, cited in Toivonen et al. 2000) and 79 million kg in Sweden in 1995 (Bengtsson 1997, cited in Toivonen et al. 2000). At least in Sweden the value of recreational fisheries exceeds the value of commercial fishing. The net value of each kg of fish caught by a recreational fisherman is estimated at 4.2 EUR. Based on this, the net value of recreational fishing has been estimated at almost 79.5 million EUR (Fiskeriverket 2007, cited in Garpe 2008). The value of recreational fishing to the local economy can be estimated by the expenditure of fishermen on the activity (e.g. permits, travel and accommodation) (Box 10.5).

While there is an increasing demand for traditional outdoor activities within all age groups, there is also a tendency for young people to favour more extreme sports like snowboarding, rock climbing and mountain biking. This is increasing the demand for special places where such sports can be practised (Odden 2008). On the other hand, since a significant amount of Nordic people live in cities the green areas around urban settlements are important places for daily outdoor activities. In Helsinki half of the respondents went outdoors daily or every other day (Neuvonen et. al 2007).

Although people's favourite outdoor activities demand no special equipment and are mostly practised in everyday free access environments, outdoor life can still have significant impacts on regional and national economies. In a Swedish study it was calculated that Swedish people spent on average 12,800 SEK / person / year (2009) (~1,461 EUR / person / year) on outdoor activities, of which 5,763 SEK / person / year (~657 EUR / person / year) in their home region (less than 100 km from their home). Altogether Swedes spend around 72,300 million SEK (~8,252 million EUR) on outdoor activities in Sweden, most of which (43,000 million SEK, ~4,908 million EUR) are in their home region (Fredman et al. 2010). Importantly, most of the spending was generated by simple everyday "nature friendly" activities such as walking, cycling, wandering and hiking in nature, picnicking and swimming with only a minority of expenditure arising from activities such as snowmobiles or water scooter driving. The value added from outdoor life expenditure was calculated to be 34,331 million SEK (~3,918 million EUR) and altogether spending on outdoor life would result in 75,637 job opportunities.

Box 10.5 Recreational and educational benefits provided by the Elliðavatn and Vífilsstaðavatn lakes in Iceland

Lake Ellidavatn and Lake Vifilstadavatn are the locations for the Heiðmörk project, the first research project on ecosystem services in Iceland. Both lakes provide various ecosystem services, among which educational and recreational services (Davíðsdóttir 2010).

The lakes provide recreational services mainly through angling. The total value of recreational services was assessed using a single-site travel cost method. Using this method, people's willingness to pay to visit a site can be estimated based on the time and travel costs and the number of trips made. The survey was done during the summers of 2008 and 2009. For Lake Ellidavat the average trip value ranged from 8,620 ISK (~54 EUR) to 12,315 ISK (~77 EUR) with a total of 2,133 annual trips in 2009. The total value of recreational services provided by Lake Ellidavatn is in the range of 19,277,000–27,159,000 ISK (~121,301–~170,967 EUR). For Lake Vifilstadavat, the average trip value ranged from 11,186 (~70 EUR) ISK to 11,848 ISK (~74 EUR) with a total of 336 annual trips in 2009. Therefore, the total value of recreational services provided by the lake is in the range 3,736,124 – 3,957,232 ISK (2009 ISK) (~23,510–~24,900 EUR).

Educational services have been assessed surveying the use of the lakes for education by schools in the capital area. A questionnaire was sent to all schools in the area. The time spent by students at the site was valued relative to total time spent at the school over the school year and the total cost / student. The value of educational services of Lake Ellidavatn has been estimated to be in the range of 3,816,155–4,716,711 ISK (~24,023 – ~29,688 EUR). For Lake Vífilsstaðvatn the total value was between 1,977,801 – 2,024,328 ISK (~12,451 – ~12,743 EUR). The survey does not include the use of both the lakes by preschools and by the University of Iceland. The estimated value is therefore lower than the actual value of educational services provided by the two lakes (Davíðsdóttir 2010).

Tourism

Nature tourism, i.e. overnight trips with activities related to nature, is considered to be one of the fastest growing sectors of international tourism (Hall et al. 2009). It is estimated that the market for nature tourism is increasing at six times the rate of tourism overall (UNWTO 2006, cited in Bell et al. 2007). For example in Lapland, Finland nature tourism is already the most important sector contributing the regional economy (Tyrväinen, 2006, cited in Bell 2007). The trend of more extreme experiences is seen also in nature tourism: there is demand to find more and more untouched nature and wilderness – and thus even the remotest places are being discovered. For example, tourism in more remote areas such as Norwegian Svalbard and Greenland has increased in recent years (Kaltenborn 1996 in Nordic tourism, The fourth CBD Report Greenland).

No statistics specifically related to nature tourism are available for the Nordic counties. However, given the role nature plays in attracting tourism to the Nordic countries, general information on tourism can be used as a rough proxy for the socio-economic role of nature in supporting tourism. This assumption is supported by the fact that all Nordic national travel strongly promotes nature as the Nordic tourist attraction. Yearly some 100 million nights are spent in different tourist accommodation establishments in Nordic countries by domestic or foreign tourists (Table 10.17). Tourism is increasing in all of the Nordic countries.

In addition, visits to or overnights spent in summerhouses can be used as a proxy as summerhouses often are situated in nature and commonly involve nature related outdoor activities. There are perhaps more holiday homes per capita in Nordic countries than anywhere else in the world (1.5 million in total) (Müller 2007). Approximately 50% of Nordic people have access to holiday house and in Finland the figure is over 60% (Sievänen and Neuvonen 2010). Foreigners (including Nordic visitors to other Nordic countries) spend some 15 million nights at holiday houses. Nature is mentioned most often as a main attraction of holiday houses (Venäläinen 1989, cited in Sievänen et al. 2007). Sievänen et al. (2007) also found that younger holiday house visitors could be potential clients for rural tourism entrepreneurs such as wildlife tours or country animal zoos.

Table 10.17 Tourism in Nordic countries that, given the role nature plays in attracting tourism to the Nordic countries, can be used as a very generic indication of the economic importance of cultural ecosystem services related to recreation and tourism

	Finland	Norway	Iceland	Sweden	Denmark
Domestic overnights at all accommodations (exl. private)	14,479,741	13,595,000[b]	862,349	40,005,182	22,728,096
Domestic overnights at holiday houses (inc. summer cottages)	24,768,000[a]	257,569	349,342[a]	2,637,443[c]	3,565,513
Reference year	2011	2010	2010	2011	2011
Source	Statistics Finland 2012	Statistics Norway 2012	Statistics Iceland 2012	SBC/Tillvax tverket 2012	Statistics Denmark 2012
Tourism direct contribution to GDP %	2.1	2.6	5.2	1.7	1.8
Reference year	2012	2012	2012	2012	2012
Source	World Travel and Tourism Council	World Travel and Tourism Council	World Travel and Tourism Council	World Travel and Tourism Council	World Travel and Tourism Council
	[s] Trips to private holiday houses	[b] Guest nights at hotels or similar establish-ments	[c] Nights at Commer-cially arranged holiday houses		

Visitor numbers in national parks can be considered as a direct indication for nature's contribution to recreation and tourism. Systematic surveys of visitors in all recreational areas have only been made in Finland and Denmark (Bell et al. 2007). In Denmark forests and other nature areas receives some 110 million visits yearly and forests and beaches were the most popular places to visit (Skov og Natur i tal 2009). In Finland state owned natural areas receives nearly 5 million visitors in 2011, of which the share of national parks was over 2 million (Metsähallitus 2012). (See also case study by Kajala in Annex II).

Cautios estimates for the value of forest recreation services were calculated to be 810 EUR / year in Finland in 1995–2002 and 800 SEK / ha / year (~91 EUR / ha / year) in Sweden (Matero et al. 2010, Gren and

Isacs 2009). In Finland the economic effect of national parks and other state owned hiking areas on the local economy was calculated to be 143.5 million EUR (See case study by Kajala in Annex II). Reindeer herding and related cultural values also have great significance for the tourism industry in the Finnish Lapland where for instance the income from reindeer and sledge dog safari in Lapland has been estimated at 10 million EUR in 1999 (Hall and Boyd 2005, Keskimölö and Hyppönen 2012).

10.2.4 Ecosystem service supporting the Nordic economy and creating jobs

The most obvious employment opportunities that depend on the sustainable use of natural capital (e.g. ecosystems and their services) are related to agriculture, forestry and fisheries. A summary of the sectoral employment – some of which is also presented earlier in the report – is given in Table 10.18 below. Naturally, current employment numbers should be at best considered as very crude proxies as they do not in any way reflect the current or long-term sustainability of the sectors.

Jobs supported by organic farming or sustainable forestry can, therefore, be considered better indicators. Organic farms financially support approximately 1.5 persons (family or paid staff) / farm / year, i.e. only a little less than a conventional farm (Table 10.18). When multiplying this number of people (i.e. "work unit") by number of farms it can be roughly estimated that organic agriculture supports approximately 3,800 jobs in Denmark, 5,200 in Finland and 8,000 in Sweden. No estimate was found on how sustainable forestry or fishery contributes to employment.

Reindeer herding as a traditional northern Nordic/Sami occupation. In Finland, there are approximately 1,000 reindeer herding families (Hukkinen et al., 2003, cited in Dane and Dana 2007) or 2,500 employees (Vihervaara et al. 2008). In addition, in 1997 there were altogether over 28,000 beekeepers in Nordic countries (4,000 in Norway and Finland, 5,500 in Denmark and 15,000 in Sweden) (Apimondia 1999, Nordic Beekeeping 1999) but it is likely that their numbers have declined during the past decade (Potts et al. 2010).

Table 10.18 Information on jobs depending on the sustainable use of natural capital and nature in the Nordic countries. Note: current rates of employment do not necessarily reflect a sustainable level of utilisation

	Denmark	Sweden	Norway	Finland	Iceland
Jobs related to agriculture	53,500 annual work units	56,700 annual work units	53,200 annual work units	80,700 annual work units	5,207 man years
Reference year	2011	2011	2011	2011	1997
Source	Eurostat 2012	Eurostat 2012	Eurostat 2012	Eurostat 2012	Statistics Iceland 2012
Number of organic farms	2,671	5,000	2,314	4,036	36
Reference year	2010	2010	2011	2010	2009
Source	Statistics Denmark 2012	Jordbruks statistics årsbok 2011	Statistics Norway 2012	Matilda maatalousti-lasto 2012	Icelandic agricultural statistics 2009
Annual work units in organic agriculture, /farm	1.42	1.6	Not available	1.32	Not available
Reference year	2009	2009	Not available	2009	Not available
Source	MTT Talous-tohtori/ FADN 2012	MTT Talous-tohtori /FADN 2012		MTT Talous-tohtori /FADN 2012	Not available
Jobs related to forestry and logging	Not available	34,200,000 annual work units	7,080,000 annual work units	22,000,000 annual work units	Not available
Reference year	Not available	2008	2008	2008	Not available
Source	Not available	Eurostat 2012	Eurostat 2012	Eurostat 2012	Not available
Number of fishermen	2,088 (all)	1,600 (marine) 192 (freshwater)	12,993 (all)	2,195 (marine) 321 (freshwater)	4,500 man years (all)
Reference year	2008	2012 Freshwater 2004	2010	2010 Freshwater 2008	2005
Source	Danish AgriFish Agency (2012b)	Havs och vatten myndighet-en- 2012	Statistics Norway 2012	RKTL 2012	Icelandic Fisheries 2012/ Statistic Iceland 2012

In addition to these jobs that have high importance on the national economy level, there are numerous examples of ecosystem service related jobs that can have high local importance, especially in remote rural regions. Income generated by berries and mushrooms in Finland and Norway can be seen from Table 10.19 below. While pickers often only pick for extra income, some people can have seasonal income even higher than Finnish average annual income (e.g. 1,224 EUR for 5.5 hours a day for 45 days of picking ceps) (Cai et al. 2011). Berry and mushroom picking can have high importance for example for unemployed or retired people in rural areas (Kangas and Markkanen 2001). In addition, the majority of commercial picked berries are now delivered by foreign pickers from lower income countries, as berry picking in Nordic countries can offer them an important livelihood. There are also several smaller nature related businesses that contribute greatly to local economies and employment. For example, small businesses like collecting lichen or processing berries can be important employers in a region (Hailuodon kunta 2012, Paassilta et al. 2009).

There are some hundreds of enterprises offering hunting (and fishing) experiences for tourists in Finland and Sweden (Table 10.20). In Iceland, the employment effects of hunting have been studied in detail. Reindeer hunting in particular has direct employment effects since hiring a guide for reindeer hunting is compulsory. Hunters spending money on reindeer hunting resulted in 11.1 work opportunities (guidance, research and butchery) and small game hunting 4.3 job opportunities. In addition, indirect jobs were estimated to be created via spending on goods and services, 15 and 33 jobs for reindeer and small game hunting, respectively (Heiðarsson et al. 2010).

Nature related tourism can also have a significant direct or indirect impact on employment. In Finland it has been estimated that the regional employment generated by visitors to national parks results in 1,100 man years – an average of 31 / park (Huhtala et al. 2010) (See case study by Kajala in Annex). In Nordic countries there are also several enterprises related to wildlife watching (e.g. whales in Denmark, Norway, Iceland and Greenland and wolves and bears in Sweden and Finland). In Finland, wildlife watching enterprises have been estimated to create a total of 43 man years (direct and indirect) (Eskelinen 2009). Whale watching has increased in popularity especially in Iceland and Greenland in recent years, and in Finland too entrepreneurs expect the wildlife viewing business to grow (O'Connor et al. 2009, Eskelinen 2009). In Norway there are 500–600 farms offering "green care", thus earning extra income aside from farming (Haugan et al. 2006). The interest in such green care enterprises is also rising in Finland and Sweden (Abramsson and Tenngart 2006, Kupari 2012).

Table 10.19 Annual incomes related to berry and mushroom picking and hunting and fishing tourism

	Norway	Finland
Income related to berry picking (1,000 EUR)	524	13,900
Income related to mushroom picking (1,000 EUR)	1,873	2,800
Reference year	2005	2010
Source	Turtiainen and Nuutinen 2011	Marsi 2010
	Sweden	**Finland**
Enterprises related to hunting tourism	Approx. 260	200–400 (fishing and hunting)
Enterprises related to fishing tourism		1,100
Ref year	2003	
Source	Alatalo 2003	Matilainen et al. 2010 and Toivonen 2008

Table 10.20 Business related wildlife watching

	Denmark	Sweden	Norway	Finland	Iceland	Greenland
Enterprises related to wildlife watching	2	18	20	20	10	10
Ref year	2008	2004	2008	2008	2008	2008
Source	O'Connor et al. 2009	Nordmark 2008	O'Connor et al. 2009	Eskelinen 2009	O'Connor et al. 2009	O'Connor et al. 2009

11. Identification of gaps in the existing knowledge

Based on the information gathered in the context of this study, *significant gaps in available data* on Nordic ecosystem services remain. This is especially the case for regulating and cultural services and the supporting processes and functions of ecosystems. In addition, a very limited amount of information (existing indicators) are available to assess the status of and trends in ecosystems' biophysical ability to provide and maintain ecosystem services. These finding are consistent with Layke (2009) and are summarised in Tables 11.1 and 11.2 below. Important concrete information gaps include, for example, lack of estimates reflecting broader cultural and landscape values, lack of data on nature's role in maintaining health, and lack of information on the indirect employment impacts of nature. In terms of ecosystems, there seems to be considerable gaps related to marine ecosystem services (beyond fisheries).

While a number of case studies and local examples can be identified, demonstrating in particular the socio-economic value of ecosystem services, *national and regional level data is often lacking*. In general, the existing national data sources include much better information and statistics on the socio-economic indicators describing, for example, the harvested yields, than of the biophysical indicators showing the actual provisioning capacity of services. However, the annual fish catch or volume of harvested timber do not adequately reflect ecosystems' capacity to provide services in the long term and therefore can only be treated as crude proxies for the biophysical availability of a service (see below).

One of the key challenges was also the lack of comparability between countries due to *national differences in reported units*, both in terms of stocks, flows and yields. This was especially the case for regulating and cultural services. In addition, it was also apparent that the *national and European (e.g. EUROSTAT) statistical data currently available is not very suitable for assessing and comparing ecosystem services*, especially at regional level. Firstly, the available information is often aggregated into few numbers describing the national situation. This might be enough when reflecting differences on a global or continental scale, but more detailed data would be needed at regional level. Secondly, in European scale assessments (e.g. Maes et al. 2010) (statistical) data is often presented in European sub-regional governance units called NUTS (the most detailed at level NUTS3). This system has very different explanatory capacity in the Nordic countries as the number of NUTS3 polygons varies from 11 in DK to 21 in SE, while in Iceland there are only 2 regions (capital and rest). For comparison, Germany is divided into 429 NUTS3 districts. In addition, such an administrative geographic delineation does not take into account land cover or ecosystem characteristics, which have importance especially when dealing with biophysical ecosystem service indicators. It would be especially important to be able to show ecosystems' service delivery capacity in a spatially explicit form, which needs maps describing also minor and small-scale differences in the landscape level – which depends both on land cover or ecosystem type and on abiotic circumstances.

There are also *significant differences between existing models aiming to estimate the biophysical status and availability of ecosystem services*. For example, various water purification models (e.g. European scale GREEN model and national models such as N_EXRET) exist that aim to determine regional nitrogen retention capacity. An example from Finland shows that the application of a national assessment yielded retention of 35% while the European model assumed an average retention of 12% (PEER/PRESS 2010, Maes et al. 2010 and 2012). One key reason for such a big difference between the results from the different models is that the national model takes into account surface waters (i.e. lakes), while the European model does not. This has influence especially in the Nordic countries such as Sweden and Finland. Also, there seem to be substantial differences in input data (e.g. annual coverage) between the existing models. Consequently, it is important to know the limitations of and uncertainties related to such models in order to avoid misinterpretation of the results in a broader context. This word of caution should be remembered also when interpreting the results derived from the European scale to the Nordic countries in the context of this study (Chapter 9). Nationally adjusted models (where they exists) might be more detailed and accurate than those of larger scale, however the comparability of these models between countries might be very limited due to use of different indicators.

Finally, there is the important question of *sustainability*. While unsustainable levels of using a service (e.g. harvesting, overfishing) can manifest themselves relatively quickly using collapses of catches or harvest as proxies for biophysical status, this should not be considered as an appropriate way forward. Also, in several cases exceeding biophysical thresholds can be irreversible and become apparent only within a longer timeframe. For example, provisioning services delivered by actively managed systems, such as agricultural areas or commercial forests, may be produced breaking the "invincible" limit of sustainability with negative impacts on biodiversity and supporting and regulating services apparent only over a longer time frame. In the long term, this may be a threat for resilience and decrease ecosystems' capacity to provide ecosystem services. Anthropogenic input substituting for ecosystem function and "distorting" the availability and value of the provisioning services from managed ecosystems should be taken into account when comparing them with other ecosystem services. This has similarities with some cultural services, such as recreational use of nature, which is strongly supported by human constructions, such as roads and tracks and hiking facilities. Clearly more attention therefore needs to be given to developing a more comprehensive and appropriate system for assessing and monitoring the sustainability of Nordic ecosystems to maintain ecosystem services. This should be supported by defining the limits for sustainable use of ecosystems and their services.

Finally, the role of trade and import and export substitution in determining the value of domestic provisioning services needs further analysis. In general, the greater the elasticity of substitution of anthropogenic for natural "inputs" in production functions for provisioning services, the lower the economic value of "natural inputs", i.e. ecosystem services.

Table 11.1 Data availability related to the stock and flow of ecosystem services (i.e. biophysical indicators)

	Denmark	Finland	Iceland	Norway	Sweden
Provisioning services	Relatively good for goods with markets (proxies), poor for non-market goods	Relatively good for goods with markets (proxies), poor for non-market goods	Relatively good for goods with markets (proxies), poor for non-market goods	Relatively good for goods with markets (proxies), poor for non-market goods	Relatively good for goods with markets (proxies), poor for non-market goods
Regulating services	Limited. No ready-to-use data for indicators; some European scale models available but no national-scale models	Limited. No ready-to-use data for indicators; some good national scale models available, but they are not developed for ecosystem service assessments; some European scale models available	Poor. No ready-to-use data for indicators	Limited. No ready-to-use data for indicators; rather good for some services; a few European scale models available	Limited. No ready-to-use data for indicators; some good national scale models available, but they are not developed for ecosystem service assessments; some Europe-an scale models available
Cultural services	Limited. Some indicators and proxies available	Limited. Some indicators and proxies available	Limited. Some indicators and proxies available	Limited. Some indicators and proxies available	Limited. Some indicators and proxies available
Supporting processes and functions	Poor	Poor	Poor	Poor	Poor

Table 11.2 Data availability related to the socio-economic importance and value of ecosystem services

	Denmark	Finland	Iceland	Norway	Sweden
Provisioning services	Relatively good for goods with markets, poor for non-market goods	Relatively good for goods with markets, poor for non-market goods	Relatively good for goods with markets, poor for non-market goods	Relatively good for goods with markets, poor for non-market goods	Relatively good for goods with markets, poor for non-market goods
Regulating services	Limited at national level. Case study evidence available.	Limited at national level. Case study evidence available.	Very limited	Limited at national level. Case study evidence available.	Limited at national level. Case study evidence available.
Cultural services	Limited at national level. Case study evidence available.	Relatively good. Some national level estimates available, several case examples exist	Limited at national level. Case study evidence available.	Limited at national level. Case study evidence available.	Limited at national level. Case study evidence available.
Supporting processes and functions	Poor	Poor	Poor	Poor	Poor

12. Conclusions

12.1 Ecosystem services in the Nordic countries

While the data available does not yet allow a systematic assessment of the status, trends and value of Nordic ecosystem services some preliminary conclusions can be drawn. The TEEB Nordic scoping assessment reveals that, while in many ways similar to the global level, the range of benefits provided by ecosystem services in the Nordic countries exhibits some characteristics distinct to the region. While provisioning services provided by *agriculture, forestry and fisheries* remain essential also in the Nordic countries a number of other regionally important ecosystem services can also be identified. These include, in particular, *reindeer herding* (especially in the north), *wood-based bioenergy*, non-timber forest products such as *berries, mushrooms and game*, and *recreation and tourism*. In addition, there seem to be a range of existing and novel possibilities related to different bio-innovations (see Box 10.3). Given the area coverage of forests in the region, it is not surprising that mitigation of climate changes (i.e. *carbon storage and sequestration*) is among one of the most significant – or at least most frequently discussed – regulating services provided by Nordic ecosystems. In addition, the importance of *water purification* (e.g. in the context of eutrophication of the Baltic Sea) and *pollination* are often highlighted.

In terms of information available, existing biophysical data on the capacity (status and trends) of Nordic ecosystems to provide services consists mainly of information on stocks, flows or indirect socio-economic proxies (i.e. the use and/or demand of service, outlined in Chapter 10). With the exception of provisioning services, most of the information available is based on individual case studies with very little data available at national and regional level. Available data on the socio-economic value of Nordic ecosystem services consists mainly of information on the quantity and market value of stocks. In addition, a range of studies could be found that reflect the appreciation and public value of ecosystem services (i.e. people's willingness to pay for the improvement of services), including water purification and recreation. With the exception of provisioning services, most of the information available is based on individual case studies with very little data available at national and regional level. Also, surprisingly few estimates were found assessing the costs of service foregone or costs of replacing the service (e.g. regulating services). Finally, no national or regional assessment focusing on the socio-economic role of ecosystems' supporting processes and functions could be identified.

Despite the significant identified gaps in the knowledge base it is, however, evident that a range of ecosystem services are of high socio-economic significance for the Nordic countries, either based on their market value or estimated value for the broader public. On the other hand, it is also clear that several of these ecosystem services including, for example, marine fisheries, water purification and pollination, have been seriously degraded and several others, such as carbon storage, are facing serious risks. In addition, rather alarmingly the information available does not yet allow any conclusions to be drawn on the status of and trends in the majority of services, including their underlying processes and functions. Consequently, it seems evident that further policy actions are needed to address the situation (see Chapter 14).

12.2 Synergies and trade-offs between Nordic ecosystem services

A very limited amount of quantified information such as comprehensive cost-benefit analyses is available on the synergies and trade-offs between ecosystem services in the Nordic countries. However, some preliminary conclusions can be drawn based on the qualitative and/or case study based information identified in the context of this report (Table 12.1).

Table 12.1 Some identified key synergies and trade-offs between different ecosystem services and biodiversity and ecosystem services in the Nordic countries

SYNERGIES	TRADE-OFFS
Recreation ↔ provisioning of berries, mushrooms and game	Provisioning of agricultural products / timber ↔ biodiversity, recreation
Recreation ↔ mental health and identity	Provisioning of agricultural products ↔ purification of water
Sustainable forestry ↔ recreation, provisioning of game, berries and mushrooms	Hunting game (bear, wolves, whales) ↔ wildlife tourism, biodiversity
Extensive / sustainable agriculture ↔ pollination, recreation and tourism, purification of water, biodiversity	Climate change mitigation (carbon storage) ↔ timber and wood production
Climate change mitigation (carbon sequestration) ↔ timber and wood production	Bioenergy (forests) ↔ carbon sequestration, soil fertility, nutrient cycling, biodiversity
Sustainable forestry ↔ recreation, provisioning of game, berries and mushrooms	Provisioning of timber ↔ reindeer herding
	Peat extraction ↔ recreation, aesthetic values, inland water fishing, carbon storage, biodiversity

Note: general contextualisation building on the qualitative and/or case study based evidence presented in the report, no quantitative analysis available.

While the synergies and trade-offs between ecosystem services in the Nordic countries reflect those identified at global level, a number of regional characteristics can be distinguished. Based on the available information, it seems that synergies exist in the Nordic countries between *recreation and the use of non-timber forest resources* such as berries, mushrooms and game. A number of recent surveys have revealed that these two activities are interlinked in people's minds and that it is often even unfeasible to differentiate between the values associated with and / or derived from these services (e.g. Aapala et al. 2012). In addition, both of these services are also linked with several benefits to human health, both physical and mental. Evidence is also available on co-benefits of managing areas for biodiversity conservation. As outlines in Chapter 11 above, protected areas can be a significant source of revenue. Similarly, a recent study from the coast of Finland shows that there are several synergies between *rural welfare and the conservation of biodiversity-rich traditional rural landscapes*, the latter resulting in a range of co-benefits to farmers (Birge and Fred 2011) (Box 12.1).

In addition to the common trade-offs between optimising landuse for agriculture and timber production and the maintenance of other ecosystem services, there are also increasing (potential) trade-offs between the use of *bioenergy and other ecosystem services* across the Nordic countries. In particular, the extraction of peat for energy and related trade-offs with biodiversity conservation and several other ecosystem services is a key issue in a number of Nordic countries, including Finland and Sweden (See Box 12.2). In the case of using logging residue for bioenergy and not allowing it to be left to decompose and mineralise the soil changes might occur in soil quality (nutrition status and micro-fauna) (Kataja-aho et al. 2011). This has an impact on forest growth, which can be detected even after 20 years of whole tree harvesting (Helmisaari et al 2011). Even if these nutrient losses can be replaced by fertilisation, developing techniques to leave the nutrient rich needles in forests would be advisable.

Management of forests for bioenergy generally reduces their capacity for carbon sequestration and storage. There is also an ongoing debate in the scientific world on whether, in the context of climate change mitigation, forests should be used primarily to replace fossil fuels as bioenergy or to sequester and store carbon (e.g. Hedenus and Azar 2009). Pingoud et al. (2010) suggest that a sustainable strategy from the carbon balance point of view would be first to let the forest grow old and thus sequester more carbon, then to use these big trees e.g. in construction materials; in this way the trees still store the carbon and only after the buildings/furniture come to the end of their life should the trees be used for energy (Pingoud et al. 2010). The carbon balance of (forest) bioenergy also depends on the techniques used for converting biomass to energy and it is likely that these techniques will develop in the future to be more sustainable and efficient in terms of unit energy / unit biomass.

In the northern regions of the Nordic countries, *forestry also competes with reindeer herding* (Forbes et al. 2006). Around 75% of reindeers graze in forests for at least some part of the year and forestry activities reduce the amount of forest lichens which are an important food source for reindeers in winter. In forested countries like Sweden, Finland and Norway there may also be conflicting demands between *forestry and recreation* as the landscapes generally created by forestry practices are not perceived to be very attractive. In some areas this might pose a barrier to increasing opportunities for nature tourism since attractive scenery might be the most important factor when choosing a travel destination (Tyrväinen et al. 2001, cited in Bell et al. 2007).

As regards synergies between different Nordic *ecosystem services and biodiversity conservation*, recreation accompanied with extensive use of biodiversity resources is generally seen to support conservation objectives in the Nordic countries. For example, wildlife tourism might provide a competitive incentive for hunting charismatic Nordic species such as bears, wolf and whales (see Box 12.3). While increasing numbers of visitors and tourists might pose a risk for some species (e.g. Kangas et al. 2000), so far the current negative impacts remain rather limited and localised. The maintenance of forest carbon stocks (e.g. conservation of old forests) is also seen to bring co-benefits for biodiversity conservation. The effect on biodiversity of managing forests for carbon sequestering, however, depends on the management method chosen, i.e. whether to maximise sequestration by trees by short rotations or maximise carbon storage by older forest and longer rotations. In a Finnish modelling study biodiversity increased considerably when rotation time was increased to 100 years. Biodiversity was highest in unmanaged forest that also sequestered the most carbon (Hynynen et al. 2005). Biodiversity and carbon sequestration can also be enhanced simultaneously by growing mixed stands of coniferous and broadleaved trees (Hynynen et al. 2005, Eriksson and Berg 2007, Jandl et al. 2007).

Box 12.1 Benefits of conserving traditional rural biotopes in Finland

Traditional rural biotopes (TRBs) are semi-natural farmland habitats formed through traditional agricultural activities, such as grazing and fodder collection. The term traditional rural biotopes is often used in Finland and other Nordic countries to describe a range of semi-natural habitat types ranging from grasslands to grazed forests. These multifunctional biotopes have historically been managed to provide specific ecosystem services (primarily fodder, but also wood, wild food items and agricultural crops). TRBs are usually extensively managed and rich in species diversity, including rare and endangered species. Changing demographics and changes in land use (either intensification or abandonment) are two driving forces threatening the continued existence of TRBs in Finland. Over 90% of the TRBs still in existence in Finland are threatened and over 70% are critically endangered (Raunio et al. 2008).

A recent survey in the western Gulf of Finland, carried out in the context of a project on coastal zone management in the Baltic Sea region (COAST-MAN), identified a range of ecosystem services related to the conservation and sustainable management of TRBs (Birge and Fred 2011). A postal questionnaires were sent to all farms in Raasepori Municipality (N = 326 farms) with a aim to identify farmers that manage or own TRBs and determine whether TRBs provide non-agricultural direct use ecosystem services to either the stewards or off-farm beneficiaries. According to the results 28% (36/131) of all respondents said they had economic activities that bring the public to the farm or result in farm name recognition through farm tourism, direct sales or services. Compared to the non-TRB owners, TRB owners are far more likely to be engaged in direct sales and marketing of their farm and its products. In addition, TRBs are used by off-farm people and do provide identifiable, non-agricultural ecosystem services (including but not limited to hunting, berry/mushroom collecting and bird watching). For example, 85% (112/131) of respondents said that some type of hunting takes place on their farms.

Traditional rural biotopes (alternatively “cultural landscapes”) provide important regulatory, cultural and provisioning ecosystem services. Skärlandet Natura 2000 site Finland’s first landscape conservation area (LCA) and it is a part of COAST-MAN Project. Picture © Traci Birge

Source: case study for TEEB Nordic by Traci Birge

Box 12.2 Trade-offs between ecosystem services at regional level: the debate over negative impacts of peat extraction on ecosystem services provided by inland waters in Finland

Finland is a country of thousands lakes and these ecosystems, and the range of ecosystem services they provide, play an important role for the majority of Finns. For example, lake areas are prime locations for summer cottages, providing important opportunities for recreational activities such as swimming, water sports and fishing. The recreational and aesthetic values associated with lake ecosystems also play an important role in attracting tourism to Finland. Finally, the cultural and spiritual values associated with lake ecosystems are integral to the Finnish culture and psyche, often characterised by an image of a wood-heated sauna by a lake.

There is increasing concern, however, over the negative impacts of peat extraction (for energy) on the environmental status and quality of lake ecosystems due to the load of nutrients, suspended matter and humus originating from the peat extraction sites. Existing evidence indicates that there can be significant trade-offs at local and regional level between benefits derived from peat extraction and benefits provided by lake ecosystems in the area (e.g. several local and/or public benefits). Many cottage owners are convinced that peat extraction is responsible for degrading the quality of lakes, with negative impacts also on the multiple benefits these ecosystems provide. In addition, fishermen are increasingly alarmed over the impacts of peat extraction on fishing areas, with the Federation of Finnish Fisheries Associations recently calling for a re-evaluation of the role of peat extraction in affecting inland water quality (Ahven.net tiedotteet 2011). According to fishermen there is a significant risk that suspended matter and humus from peat harvesting sites accumulate on lake and river beds, destroying habitats used for spawning. Peat extraction also causes dust emissions that are created during the production, loading and transportation of peat. These emissions can also contribute to the increased load of suspended matter and humus in lakes.

Existing studies related to the effects of peat extraction on the status of lake ecosystems, including impacts on the benefits these ecosystems provide, are still relatively scarce. In addition, in most cases it is not possible to differentiate between the impacts of peat extraction and nutrient and organic matter loads caused by other land-use, e.g. forestry or agriculture. However, the existing data shows that the concentrations of solid matter, dissolved organic matter, phosphorus, nitrogen and iron in the run-off water from peat extraction sites are often higher than average (Marja-Aho and Koskinen 1989, Pirkanmaan liitto 2011). Furthermore, humus concentration is high in run-offs from several peat extraction sites (Sallantaus 1986), causing changes in inland water ecosystems and their species composition and functioning (Marja-Aho and Koskinen 1989). Humus also decreases water quality by increasing acidity and colouring the water. Furthermore, the decomposition of deposited organic matter depletes oxygen from the water which leads to the nutrients stratified into sediments to dissolving, aggravating the situation further.

While some information is available on the impacts of peat extraction on water quality, information on the trade-offs between peat extraction and maintenance of other ecosystem services is still lacking. For example, no assessments have been carried out to compare the costs and benefits of peat extraction versus maintenance of other ecosystem services in the area. Also, evidence on the negative impacts of peat extraction on fishing, recreational activities and aesthetic values (eg impacts on property values) is mainly qualitative (see pictures below) and there is a need for quantification of impacts to further support the decision-making processes. However, recent court cases leading to compensation for lost benefits indicate broader recognition of the trade-offs related to peat extraction and can be used as an indirect indication for the value of other ecosystem services. Lake Markkolanlampi in Parkano provides an example of the degradation of the lake ecosystem and related ecosystem services due to the negative impacts of peat extraction. A complaint by residents of the Markkolanlampi area to the Supreme administrative Court resulted in the national peat industry (Vapo Oy) paying 50% of the costs of cleaning the lake as well as paying annual compensation of 330 EUR for the damages caused during 2008–2009 and 230 EUR after that. The court also ruled that Vapo Oy should pay 460 EUR for the period 1995–2007 to compensate for the damage caused to recreation.

Peat extraction is regulated by legislation and (major) pollution of waters caused by extraction is strictly prohibited. An environmental licensing system has been established to regulate the monitoring of water quality downstream from peat extraction areas that are larger than 10 hectares. In practice, Regional State Administrative Agencies are responsible for the implementation of legislation, including licensing monitored. However, given the evidence on negative impacts and existing and/or potential trade-offs between peat extraction and benefits provided by other ecosystem services it appears that the current system for assessing and monitoring the overall costs and benefits of peat extraction are far from adequate. Furthermore, it appears that there is a need to review the existing legislation in order to better reflect – and even minimise – the trade-offs between use of peat and other ecosystem services. According to the Finnish Association for Nature Conservation (FANC), there are significant gaps in the current monitoring requirements; in particular obligations to monitor fine-grained organic matter are lacking (Käytön vesistövaikutuksista 2011). Furthermore, the organic matter (peat) loads are measured in dry-content but when the matter is mixed with water, the emissions appear much greater as the matter is so loose. Finally, significant loads of solid matter can be caused by singular events (e.g. short periods of heavy rain) which are not picked up by the current measurement methods. With 260 applications for new peat extraction areas in the pipeline, urgent focus is required to improve the understanding, assessment and monitoring of the regional trade-offs between peat extraction and ecosystem services.

Mustajärvi, Karvia 9.8.2009. Brown peat in the water is from dust emissions originated from the peat extraction sites as none of the streams from the sites are connected to the lake. Peat extraction sites are at the distance of between 0.3–2.5 km and have been in production since 1974. There is no agriculture by the lake. Picture © Lauri Hyttinen

Mustajärvi 4.7.2010. After energy peat production started in 1974, the sand bottom of the lake has been covered with organic substance and the citizens of the lake have tried to bring this problem to the forefront, without results. Picture © Lauri Hyttinen.

Source: case study for TEEB Nordic by Jenni Simkin

Box 12.3 Trade-offs between wildlife watching vs. hunting

One of the natural attractions of Nordic countries is wild animals. The possibility to see wild animals is advertised on the official tourist websites of every Nordic country. Finland and Sweden advertise with large predators (wolf and bear) while in Iceland, Norway and Greenland there is the possibility to see whales. All these animals are in general endangered and all are hunted to some degree, which has aroused international criticism too; for example whaling in Iceland and Norway and permitting wolf hunts in Sweden.

- Whales in Iceland, Greenland and Norway

Whaling is practiced in Norway, Iceland and Greenland. The main whale species hunted are minke and fin whales, and Belugas and Narwhals are also hunted in Greenland. The annual Greenland catch is some 900 whales (Statistics Greenland 2012). The Norwegian quota was set to 1,286 minke whales in 2011 (Fisheries.no 2012) and in Iceland the quota is some 100 minke and 150 fin whales yearly from 2009–2013 (Husavik whale museum website 2012). Belugas and narwhals are near threatened, and the fin whale endangered.

On the other hand, in 2007 some 114,000 people went to Iceland for whale watching tours, 3,250 in Greenland and 35,360 in Norway in year 2007. The business has been growing strongly in recent years, especially in Greenland and Iceland (O'Connor et al. 2009). The direct expenditure related to whale watching (e.g. tickets) was 6.6 million USD in Iceland, 3.9 million USD in Norway and 313,000 USD in Greenland, in addition to expenditures on accommodation, transport and food that may also benefit local entrepreneurs (O'Connor et al. 2009). Most of the tourists are foreign. There are also some whale watching activities in Denmark (O'Connor et al. 2009).

- Bears and Wolves in Sweden and Finland

In Finland some 10–40 wolves and 70–180 bears have been hunted each year during the first decade of 21st century (RKTL 2012). In Sweden hunting of wolves was only allowed in 2009 and 2010 and then closed again (Naturvårdsverket 2012a). 27 wolves were allowed to be hunted in 2009 (Naturvårdsverket 2012b). Some 180 bears were hunted during the 2007–2008 hunting season (Årsrapport 2007–2008 Viltövervakningen). Both animals are classified as endangered in Sweden and Finland, but their numbers have gone up due to protection measures (CBD Finland 2009). There are currently over 4,000 bears in Finland and Sweden together, and less than 300 wolves (Naturvårdsverket 2012a/Dahl et al. 2009, RKTL 2012).

In Sweden in 2004 there were 18 enterprises that offered wildlife watching tours (Nordmark 2008). There were some 20 entreprises involved in wildlife tours in Finland and on average an enterprise had 300 customers a year which would mean that some 6,000 tourists come annually to watch wildlife, most often bears. All entrepreneurs believed that that wildlife watching would grow in the future. Some 60% of customers were foreign. (Eskelinen 2009). Both Swedish and Finnish wildlife operators are concentrated mainly on bear.

Based on the above, on a regional level more people seem to be involved and interested in wildlife watching than in hunting. As a non-extractive use of nature, wildlife watching could be a good source of income for local communities, whilst simultaneously protecting these animals. Of course the question is not for straightforward, and there are several other aspects involved, such as cultural values. However, as wildlife is a strong part of each Nordic country's image, there should also be a responsibility and willingness to protect these regional treasures.

PART IV:

Responding to the value of nature in the Nordic countries

13. Existing Nordic policy frameworks and tools for ecosystem services

Integrating the value of ecosystem services into policy and decision-making processes has started in in several Nordic countries. However, the concept of ecosystem services is still new to several sectors and, consequently, it still remains to be integrated into national policies and strategies. Integration of the international goals on the value of ecosystem services into National Biodiversity Strategies and Action Plans (NBSAPs), agreed at the 10th meeting of the UN Convention on Biological Diversity in Aichi-Nagoya in 2010, is likely to be one of the key policy tools for accelerating this process. The focus on biodiversity and ecosystem services has also increased in the context of EU policies (e.g. agriculture and conservation of inland water and marine areas). Consequently, it is also foreseen that the EU policy framework – common to Finland, Sweden and Denmark – will also help to enhance the practical implementation of the concept in the future.

In terms of existing concrete tools, *ecosystem services indicators and assessments* and the development of more sustainable and "*green*" *national accounting systems* are considered as key steps in integrating ecosystem services into decision-making (Chapter 6). None of the Nordic countries have yet developed or adopted indicators for ecosystem services, a initial steps have already been taken at least in Finland and Norway. Norway has also initiated a national-scale assessment of ecosystem services. No concrete initiatives exist yet to explore the possibilities for integrating ecosystem services into national accounts, but scoping studies are being initiated in the context of Nordic cooperation by the Nordic Council of Ministers.

To assist the development of indicators, it appears that all Nordic countries have integrated environmental parameters into their national sustainable development indicators. These are environmental, economic and social indicators used to give an overall picture of sustainable development at a national level. In theory, some of the environmental parameters could be linked to or further elaborated to integrate aspects related to ecosystem services (e.g. sustainable use of natural resources). Norway has recently integrated the Nature Index (NI) as one of the indicators for sustainability (Nasjonalbudsjettet 2012, Nasjonalbudsjettet 2011). The aim of the NI is to provide an overview of the state of biodiversity within and across major ecosystems, using a set of 309 indicators selected for each ecosystem to represent its biological diversity. This index provides a more comprehensive and accurate estimation of sustainable development than traditional sustainable development indicators and it also represents a less anthropocentric approach to the analysis of sustainable development.

Finally, a number of pilot assessments of (some) ecosystem services already exist at the local or regional scale. These are usually promoted by international projects. For example, Sweden and Norway pioneered the ecosystem services framework by participating in the Millennium Ecosystem Assessment published in 2005. In Norway, this assessment was supported by a pilot study in 2001 investigating the possibility of an assessment of ecosystem services at a regional scale. However, it took until the end of 2011 before such plans were initiated in practice, in the wake of the TEEB initiative. In Finland, natural resources and the possibilities for adaptation by human society has been the subject of investigation in the Vulnerability Assessment of Ecosystem Services for Climate Change Impacts and Adaptation (VACCIA) project financed by the EU LIFE+ Programme. This project aimed to explore some basic linkages between ecosystem services and climate change. In Iceland, a valuation of the ecosystem services in the Heiðmörk conservation area around Reykjavík was conducted in 2008–2010 as a joint collaboration involving different partners. The Heiðmörk project is the first larger scale research project on ecosystem services in Iceland and it is expected create a basis for the classification and assessment of ecosystem services in Iceland, including to build capacity in applying appropriate valuation methods (Kristófersson and Eiríksdóttir 2010).

In terms of *economic incentives*, schemes supporting biodiversity conservation and groundwater protection in the context of forestry exist in Denmark, Norway, Sweden and Finland (Skjelvik et al. 2011). Usually these are voluntary conservation schemes, with the state acting as a buyer of natural values from landowners. In addition, taxation has been used to secure more sustainable levels of consumption of some resources. For example, in Denmark in Copenhagen and North and East Zealand areas the abstraction of ground water became unsustainable in the 1980s and 1990s with the extraction of groundwater exceeding annual formation, causing the ground water table in these areas to sink

(Prof. Hansen, pers. com). Consequently, a number of policy measures were introduced in the 1990s including a government water consumption tax and increased fee for sewage and waste water treatment. Combined, these raised the price of water significantly and – in combination with other measures – reduced consumption and abstraction. Groundwater tables in these areas are now stable and a little higher than in the 1990s, but the causalities are still debated.

In the context of the EU, the EU Common Agricultural Policy (CAP) has undergone significant changes during the past decades, aiming to decouple subsidies from production. Agri-environmental schemes aiming at enhancing biodiversity values or improving water quality by reducing nutrient leakage exist in all Nordic EU countries (Skjelvik et al. 2011). Some examples also exist of schemes involving funding from private actors (Box 13.1). However, even though they can result in positive externalities for ecosystem services, the majority of existing schemes are not yet specifically directed at ecosystem services (Zandersen et al. 2009a).

Box 13.1 Examples of existing payments for ecosystem services in the Nordic countries

- Carbon sequestration and Carbon Credit Trials in Sweden

In an area of about 40,000 ha in Sveaskog's forest holdings in Övertorneå, northern Sweden, forest management is directed towards maximising carbon uptake. This is through different silvicultural measures, such as improved nutrient status, denser stands and use of improved plant material. By increasing forest growth rates there will be an increase in biomass, thus more uptake of carbon from the atmosphere. The additional CO_2 uptake is to be sold in the market as credits for climate compensation. This is a business to business deal with no public funding. The aim of this project is mainly to develop and demonstrate a system for climate compensation in northern forests through the development and trading of forest carbon (Ecosystem Services in European State Forests – Case Studies 2011).

- Blue mussel farming to improve water quality in Sweden

In Sweden, several initiatives and pilot projects are underway to use Blue mussel farming to improve water quality. In Lysekil Municipality, a payment mechanism has been set up whereby the polluter (the local waste water plant) pays mussel farmers to remove nutrients from the coastal waters. Payments are based on the content of nitrogen and phosphorous in the harvested mussels. Project results show that 3,500 tonnes of blue mussels / year help to remove 100% of the nitrogen emissions of the Lysekil waste water treatment plant. The use of mussels to clean the nitrogen content of the waste water plant saves the municipality close to 100,000 EUR / year compared to using a traditional technique. (Zandersen et al. 2009). Similarly, a collaboration between a number of Danish universities, private companies and international partners from Canada and New Zealand has promoted a project to use blue mussels to mitigate the effects of eutrophication in Danish coastal areas. Development of payment schemes for the environmental services and a tradable permit system for nutrients is intended to be an outcome of this project. (DSC 2012).

There are a number of initiatives in the Nordic countries that could be considered as *investment in green infrastructure*, e.g. initiatives promoting land restoration to support regulation of water and /or recreation. For example, the Boreal Peat land LIFE-project aims to improve the habitat quality of 54 Natura 2000 sites in the unique Finnish peat land network by restoring the natural hydrology of the mires and increasing public awareness of the natural values of mires (LIFE project database 2012*a*). In Norway, Sweden and Finland, forest management companies have received local and governmental funding and support for some green projects (Patterson 2011). The main aim of these initiatives is the creation of leisure facilities or the promotion of other aesthetic, educational and recreational services related to ecotourism. Other examples of green infrastructure investments include land mapping/planning tools, such as Green Posters in Norway and Green Map in Stockholm (Box 13.2). While not directly focused on ecosystem services these frameworks could possibly be applied or used as a basis for integrating ecosystem services into land use planning.

Box 13.2 Developing green infrastructure: spatial mapping and planning tools in the Nordic countries

- Green posters in Norway

Many Norwegian cities have developed "Green Posters" during the last 10–15 years as a method to support land use planning (COST 2012b and Direktoratet for naturforvaltning 2003). The method uses landscape-ecological planning to integrate different values and functions of the urban green areas into city planning. The core functions commonly considered include values and functions for recreation, aesthetic and landscape values, and value related to biological diversity (Thorén et al. 2000). The development of the green poster has been a part of different governmental projects and there are some handbooks and guidelines presenting the structure and process of its creation. The most important reason for the success seems to be that this method helps the planners to work in a structured way to collect data.

- Stockholm Green Map

The City of Stockholm is using a ”green map” as a tool for land use planning (COST 2012b and references within). The map consists of three parts: biotope map, recycling map and sociotope map. Biotopes are identified based on landscape ecology, taking into account biodiversity values. Recycling map identifies areas for recycling of nutrients including areas for recycling of nutrients, waste water treatment, energy production, and areas functioning as “shelterbelts” improving urban climate. Finally, a sociotope is defined as an area used for social functions (e.g. inland water body important for bathing and other recreation).

Based on the expert evaluation and citizens' opinions and perceptions, all open (green) spaces in the city were assigned a specific set of use values. Stockholm's green map is actively used by planning and environmental administrators and it has also formed an integral part of some Environmental Impact Assessments (EIA) and Strategic Environmental Assessments (SEA). The practice has also been taken up by other municipalities, with Gothenburg and Uppsala recently initiating their own sociotope mapping. The use of green maps has also expanded to other Swedish municipalities including, for example, Gothenburg.

See COST project case studies for more information (in English) and contacts: http://www.cardiff.ac.uk/archi/programmes/cost8/index.html

On a *regional level*, cooperation on environmental issues has long been considered crucial by the Nordic countries. In recent years, the value of biodiversity, ecosystem and related services has become an integral theme for Nordic cooperation, carried out in the context of the Nordic Council of Ministers (NCM). The cooperation facilitated by NCM has an important role in raising awareness, promoting knowledge and sharing information regarding the value of ecosystem services across the region.

The Baltic Sea basin is one of the key areas for environmental cooperation between the Nordic countries. This cooperation takes place in the context of the Baltic Marine Environment Protection Commission (HELCOM). The status and value of ecosystem services forms a key future area of interest for HELCOM. For example, the proposal for the Swedish national implementation of the HELCOM Baltic Sea Action Plan (2010) integrates the concept of ecosystem services. In addition, a dedicated research network on ecosystem services has been established in the Baltic Sea basin. This BalticStern network aims to enhance information on the status of and trends in ecosystem services (e.g. their socio-economic importance) in the Baltic Sea.

A dedicated network has also been established to support the restoration of damaged ecosystems in the Nordic countries project ReNo.

ReNo is a Nordic multidisciplinary network of scientists, practitioners, policy makers and entrepreneurs working with ecological restoration. The objective is to conduct national assessments of the extent, status, methods and results of restoration activities in the Nordic countries, analyse the natural and socio-economic processes involved in restoration, identify knowledge gaps and inadequate policy instruments and develop paradigms and guidelines for restoration in the north.

Judging by the assessments of existing policy frameworks and tools, it appears that the integration of benefits provided by biodiversity and ecosystem services into Nordic policies and decision-making processes has been initiated. However, while a number of developments are underway significant efforts are still needed to increase both political commitment to and knowledge on the value of natural capital, and to ensure that these insights are appropriately mainstreamed and implemented in practice at all different levels.

Box 13.3 Implementing TEEB at the local level – experiences from Denmark, Finland and Sweden

A project by the Nordic Council of Ministers was carried out in 2011–2012 to explore the usefulness of the ecosystem service framework for integrating the value of nature into decision-making at a municipality level. The project was run as a collaboration between four Societies for Nature Conservation: the Danish Society for Nature Conservation, the Swedish Society for Nature Conservation, the Finnish Association for Nature Conservation and The Finnish Society for Nature and Environment. Each nation/NGO identified a municipality to join the project. One objective was that the Societies for Nature Conservation, with their strong local presence, could contribute on a municipal level towards the global goal of integrating ecosystem services into local accounting systems and decision-making. The combination of strong political will to work for sustainability and strong academia in the Nordic countries was considered a good platform. The purposes of the project were to increase awareness of the value of ecosystem services among decision-makers and citizens, to support cross-fertilisation between Nordic municipalities and to develop the methodology and spread it further to be replicated in other municipalities and internationally.

The main activity of the project was a workshop carried out at in three different Nordic municipalities: Holbaek in Denmark, Raseborg in Finland and Botkyrka in Sweden. Participants were identified jointly by the project leader, the contact person in the municipality, and the representatives of the Society for Nature Conservation in the respective country. The aim was to gather a range of relevant representatives including civil servants from various departments in the municipality, businesses with relation to the land (i.e. mainly agriculture, forestry, fisheries and tourism), local representatives from nature NGOs and researchers. Each workshop was attended by 13–21 participants.

A central part of the methodology is the joint process with the various stakeholders. Each workshop started by everyone giving their view of what they saw as the municipality's most important values and challenges. Discussions were then focussed around key issues related to ecosystem services including: update on global challenges, the institutional framework for ecosystem services (e.g. relevant policies), definition and lists of ecosystem services and methods for valuation of ecosystem services.

Based on the outcomes of the workshops, the ecosystem services concept was found to be a useful tool and/or framework for highlighting the value of nature to different stakeholders. For example, the concept supports communication as it provides a common language, helps to identify and highlight areas of focus and serves as an awareness raiser and an educational tool. The stakeholder engagement approach adopted by the project was considered useful by many participants, providing an opportunity to identify key issues related to the importance and management of ecosystem services in different municipalities. However, the necessity of doing economic valuation was often disputed and considered to run the risk of being misleading. Some participants also viewed ecosystem services as too complex an issue on which to do an economic analysis. However, it was also agreed that on a number of occasions valuation is a valuable support tool to justify decisions.

Key conclusions and recommendations based on the pilot project can be summarised as follows:

- The participatory approach adopted by the pilot project can be useful support for decisions in the municipality, especially at the project level
- Ecosystem services can provide a useful framework to “bridge” between different municipal departments and actors. With such a common language, monetary valuation of ecosystem services is not always necessary to demonstrate their value
- Ecosystem services provide a useful concept / tool for municipal decision-making processes, especially in the context of environmental impact assessments, and they should be considered in the preparation of municipal master plans and structural plans for land use planning

- In several cases, the data on biological diversity was considered to be limited and this was also considered as one of the key limitations for estimating the value of ecosystem services
- The framework and methods for valuing ecosystem services need to be further developed (and simplified) to be applicable and available for everyday decision-making at municipal level
- Source: Project leader Louise Hård af Segerstad (Albaeco), see also project blog at www.teeblocal.wordpress.com

14. Policy conclusions and recommendations: opportunities and priorities for Nordic countries

14.1 Development of indicators and assessments for ecosystem services

This scoping assessment has clearly emphasised that the first step towards integrating the value of ecosystem services into Nordic policies and decision-making processes would be to *identify and develop a common set of indicators* to assess and monitor the status, trends and socio-economic value of ecosystem services. While the identified key ecosystem services might differ from one country to another, an overarching common set of (core) indicators would beneficial, enabling comparisons to be made between countries and regions as well as facilitating reporting under international policy-processes such as the CBD and EU.

As the assessment shows, there are significant gaps in the information available on the biophysical status of ecosystem services. Furthermore, there is a dire need to develop new and/or improve existing indicators in order to appropriately assess nature's long-term ability to supply services. In particular, appropriate indicators for many regulating services and underlying ecosystem processes and functions, both in bio-physical and socio-economic terms, are largely still missing. More data is available for the socio-economic value of ecosystem services (especially provisioning services), however even this data is inconsistent and allows no clear comparisons to be made between different Nordic countries. Consequently, the development of ecosystem services indicators – both biophysical and socio-economic alike – is foreseen as one of the key required actions in the Nordic countries for future. For example, in Finland a project has been launched to expand the national biodiversity indicators towards national ecosystem service indicators.[20] It is foreseen that cooperation among the Nordic countries would be fruitful to ensure synergies and allow for comparative assessments.

The identification and development of indicators is needed to support the development of comprehensive *national frameworks for ecosystem and ecosystem services assessments* in the Nordic countries, finally paving the way towards the integration of natural capital into national accounting systems (see Section 14.1 below). Significant synergies could also be achieved by enhancing Nordic cooperation in this area. In terms of developing frameworks for national assessments, existing ecosystem service indicators can be broadly categorised by three key functions including indicators tracking performance, monitoring the consequences of alternative policies and scientific exploration (Failing and Gregory 2003, Reyers et al. 2010, Normander et al. 2011). However, these existing approaches alone seem inadequate and ecosystems' biophysical capacity to supply ecosystem services, societies' demand for these services and the interplay of these two factors in the so called socio-ecological system need wider applications of the existing indicators. Therefore, a more comprehensive approach, better linking biophysical and socio-economic indicators, would be to fit these indicators into the "Drivers – Pressures –States –Impacts – Responses" model (DPSIR). The contribution of human-management of ecosystems' capacity to provide services, for example in the context of agriculture, should also be covered by the indicators, whilst it should also be been excluded from the natural measurement.

Furthermore, in previous studies identification and mapping of the landscape's capacity to deliver ecosystem services has been based on the available land cover data. The CLC data base is commonly used in European ecosystem service assessments because of its good geographical coverage (e.g. Maes et al. 2011a, Maes et al. 2011b, Maes et al. 2012). However, CLC has limitations especially when trying to evaluate ecosystem services at the local scale, as well as with some specified ecosystem service classes. For instance, forest and mire ecosystems which are particularly important in several Nordic countries have quite rough classifications in the CLC. Many ecosystem services are dependent on biodiversity. The CLC database can therefore be adjusted with ecosystem data

[20] http://www.biodiversity.fi

bases, for instance the European Nature Information System's (EUNIS) classification of ecosystem types (Vihervaara et al. 2012). Such a classification provides more detailed knowledge about biodiversity and ecosystems and would therefore be more suitable than land use or land cover data bases alone.

14.2 Towards sustainable Green Economy supported by the Nordic nature

Regardless of the gaps in the existing knowledge base, the outcomes of TEEB Nordic synthesis show that natural capital (biodiversity, ecosystems and related services) also underpin socio-economic well-being in the Nordic countries. Nordic countries are already well on their way towards a transition to a green economy. While the approaches taken towards "greening" the economy (or economies) are likely to differ between countries, the results presented in this report clearly indicate that future developments should be based on a sound appreciation of the value and role of nature in underpinning sustainable socio-economic development.

Building on the assessment and monitoring of ecosystem services (see Section 14.1 above), it is generally acknowledged that in order to be truly sustainable, economic systems need to build on a more comprehensive appreciation and understanding of the value of natural capital. This requires the *development of natural capital accounts* that integrate ecosystem services into existing national and/or regional accounting systems (ten Brink 2011, ten Brink et al. 2012). The World Bank is leading the development of such accounting systems at the global level (e.g. the WAVES initiative)[21] and over 50 countries, including Denmark, Finland, Norway and Sweden, and 86 private companies have shown their political commitment to factor the value of natural capital in to decision-making and systems of national accounting (World Bank 2012). At the European level, the European Environment Agency (EEA) is leading the development of ecosystem accounts (EEA 2012). Consequently, it is foreseen that the development of accounting systems will be one of the key priorities for Nordic countries in the near future. A number of studies already exist exploring the possibilities for and implications of inte-

[21] http://www.wavespartnership.org/waves/

grating the broader values of natural capital into regional and national accounts (Box 14.1). These studies indicate that conventional accounts underestimate nature-related wealth and potential sustainable development based on natural capital.

Box 14.1 Changing the big picture: integrating the value of non-market ecosystem services into accounting systems

- Accounting for non-market ecosystem services in Sweden

A study carried out by Gren and Isacs (2009) compared the conventional regional accounts of four Swedish counties (North and South Norrland, Svealand and Götaland) with adjusted accounts that integrated the values of non-market ecosystem services. The study estimated the value of two non-market ecosystem services, namely pollution sequestration and recreational services, for three types of ecosystems: forest, wetlands and agricultural land. The value of these services was then integrated into the conventional income measurement, Gross Regional Product, to create an environmentally adjusted gross regional product (ERP). Interregional comparisons were made for adjusted and non-adjusted regional income per capita. When comparing the four counties using conventional Gross Regional Product, Svealand had the highest per capita income, which is explained by the highest per capita income in Swedish capital Stockholm, which is located in this region. The most northern region had the lowest income. However, when comparing the environmentally adjusted gross regional product (ERP), the ranking changed so that North Norrland was the region with the largest per capita income. This is explained by the relatively large value of non-market ecosystem services in the area. Similar results are shown for economic growth, considered from 1995 to 2000 for GRP/capita and ERP/capita. Growth as measured by change in GRP/capita in the northern regions corresponded to approximately one fifth of the growth in the highest growth region, Svealand. However, growth was increasing significantly for North Norrland when the values of non-market ecosystem services were taken into consideration. The reason is the relatively large increase in areas of forests and wetlands in the northern counties. For both Svealand and Götaland, growth in ERP/capita was lower then growth in GRP/capita, due to the decline in forest areas for both regions. The results from this study indicate that conventional regional accounts may underestimate nature-related wealth and potential sustainable development in regions rich in natural capital.

- Accounting for non-market forest ecosystem services in Finland

A study by Matero and Saastamoinen (2007) explored the links between forest ecosystem services and the economy and estimated the value of such services in the context of forest accounting in Finland. A comprehensive list of ecosystems was taken into consideration, including timber, CO_2 sequestration by trees, hunting and game management, forest-based tourism and recreational activities, the value of berries, mushroom and lichen picking, reindeer meat and Christmas trees. The estimated value for each service was introduced into a theoretical model describing forest-economy interactions. The aggregated value that the analysed ecosystem services supply to society was estimated to be up to 2.6 billion EUR. This value has to be considered mainly as an illustrative estimate, due to several uncertainties and problems encountered during the estimation of the value of each ecosystem service. Nevertheless, this study contributes to reducing the existing gap between green accounting theory and applications. It also shows the limited scope of conventional economic accounts to trace the many ways in which forests contribute to human welfare.

To complement "greener" and more sustainable accounting systems, a range of complementary approaches towards a transition to a green economy can be identified (ten Brink et al. 2012). In addition to avoiding, reducing and restoring environmental damage and conserving nature (i.e. business-as-usual approaches) more active approaches towards management of natural capital can be adopted. These include, for example, *pro-active investment in natural capital and nature-based risk management* via restoration, conservation and improved ecosystem management practices, including restoration of ecosystems for water management, carbon storage and other co-benefits, and implementation of protected area networks.

For example, there is an increasing evidence base to suggest that restoration of wetlands can bring significant benefits to both people and biodiversity. A range of such examples also exist in the Nordic countries (Box 14.2 below and TEEB Nordic case study by Salminen et al. in Annex II). However, additional information is needed, for example, related to the role of different Nordic wetlands in regulating flooding caused by intensified rainfalls due to climate change. In terms of investment in natural protection, clear evidence is available from Nordic countries that financial support for the management of national parks can be a highly cost-effective investment at regional level, proving 10 EUR return for 1 EUR investment for the region (see case study by Kajala in Annex II). In terms of local economy, the nearness of nature also has a positive effect on property prices. For example, a Danish study revealed that houses with a lake view were sold at a significantly higher price than houses without a lake view. The nearness of forests also increased house prices, and it was calculated that the afforestation programme of North Jutland resulted in a 237,000 DKK (~31,881 EUR) increase in house prices. Similar results were obtained from a Finnish study where houses with a forest view had a 5% higher price and an increased distance to forest decreased the price (Tyrväinen and Miettinen 2000).

Approaches pursuing broader environmental sustainability such as measures for *eco-efficiency and wider resource efficiency* though resource pricing and fiscal reform can also be adopted (e.g. fisheries and agricultural subsidy reforms, see Chapter 13) (ten Brink et al 2012). Furthermore, *decoupling the economy from resource use and its negative impacts* through more radical innovation and changes in demand – supported by consumption choice changes through information provision – can be considered. Developing new clean products and processes, for example based on genetic and molecular resources, can also be a viable alternative for Nordic countries (see Chapter 10).

Related to the above, concrete evidence already exists that while non-market ecosystem services form a significant part of marketed products their contribution is usually severely under-priced. Consequently, adjusting market and non-market signals to take into account the true value of ecosystem services should form an integral part of more resource efficient economies. For example, in Denmark Porter et al. (2009) studied a system of agricultural production combining food, fodder and bioenergy (CFE) that requires markedly fewer fossil-based inputs. In addition to food, forage and biomass a range of non-market services were integrated into the study, including biological control of pests, nitrogen regulation, soil formation by earthworms, soil carbon accumulation, hydrological flow into ground water reserves, landscape aesthetics and pollination by wild pollinators. Among the three market components of the experimental CFE system, biomass had the highest gross value (USD 1,146 / ha) followed by pasture (USD 1,134 / ha) and crops (USD 998 / ha). Non-market ecosystem services made up 48% (USD 546 / ha), 81% (USD 918 / ha), and 48% (USD 483 / ha) respectively of the total value of the three CFE components. The value of ecosystem services of the CFE system as a single unit was estimated to be USD 1,074 / ha, of which 64% (USD 685 / ha) resulted from non-marketed benefits. It is important to note that such an assessment of values does not necessarily lead to a use of market based instruments such as pricing. The purpose of valuation can just serve to demonstrate the importance of non-market benefits and other tools, such as regulation and spatial planning, can be used to respond to the appreciation of the value. Finding the most appropriate tool – or combination of tools – to integrate the value of natural capital into decision-making is a key to effective conservation and sustainable use of nature.

Finally, identifying, measuring and valuing ecosystem services do not directly lead to increased use of this knowledge: integration of ecosystem services into decision-making in practise requires the development of more *appropriate means and mechanisms for governing (multiple) ecosystem services* (e.g. Primmer and Furman in prep.). Current frameworks for governing ecosystem services are mainly based on decisions on traditional knowledge production segregated to specific habitats, ecosystems, geographical areas and sectors. This mismatch needs to be overcome by developing tools that, while building on existing knowledge systems and governance arrangements, aim at communicating across ecosystem and sector boundaries.

Box 14.2 Benefits of river and wetland restoration

- Cost-benefit analysis of the Skjern river restoration, Denmark

During the 1960s the Skjern River, the largest in Denmark, was channelised and artificially drained, with meadows, wetlands and shallow lakes converted to arable land. Between 1999 and 2002, 19 km of the Skjern River and 22 km^2 of the cultivated river valley were restored. The project aimed to re-establish a large coherent nature area by improving the water quality, living conditions for wild flora and fauna and the recreational value of the area. A cost-benefit analysis (CBA) of the Skjern River Restoration Project was conducted to compare social benefits and social costs of the restoration project. The analysis included market and non-market values. Non-market values were calculated using economic valuation methods or transfer of benefit estimates from foreign studies. The restoration measures and the loss of rent from agricultural land accounted for the greater part of the costs. The social benefits included a range of recreational and cultural ecosystem services (hunting, angling, hiking, boating, wildlife observation, etc.), regulating services (retention of nutrients, flood risk reduction etc.), provisioning services (farm land, reed production etc.) and other benefits (conservation value of biodiversity). Two variables were taken into account: time horizon (20 years and indefinitely) and social discount rate (3%, 5% and 7%) to produce a total of six CBA scenarios. The majority of scenarios (five out of six) indicated that the benefits of restoration outweigh the costs. Considering an eternal time horizon, the present value of net benefits ranges from 225 million DKK / ~30 million EUR (at a discount rate of 3%) to 8 million DKK / ~1 million EUR (at a discount rate of 7%). Over a 20 year time horizon, the net benefits decrease significantly: 30 million DKK (~4 million EUR) at 3% discount rate and almost zero at 5%. However, only when combining the two strong requirements – a 20-year time horizon with a 7% discount rate – does the project show net benefits. This is not surprising since a sizeable part of the costs are incurred in the initial stages, while the flow of benefits is expected to continue in perpetuity. In other words, from an economic point of view the investment in restoration of the Skjern River is likely to create net socio-economic benefits. (Dubgaard et al. 2002).

- Benefits outweigh risks of large-scale wetland creation, south Sweden

Wetland creation programmes in areas with intensive agriculture are currently in progress in several areas around the world to restore ecosystem services lost after wetland destruction. An important service supplied by wetlands is the retention of nutrients, especially nitrogen, flowing from agricultural land to marine recipients. Restored agricultural wetlands (so called "nitrogen farming wetlands" – NFWs) receive nitrogen (N) loads predominantly as nitrate, facilitating N removal by denitrification. These wetlands created with the aim of N removal may also provide several ancillary ecosystem services, i.e. phosphorus and particle retention, biodiversity enhancement, and recreation. However, the conversion of agricultural soils into waterlogged wetland area is likely to increase climate gas emissions, particularly methane (CH_4), as anoxic conditions and low redox potential in wetlands favour climate gas production and emission. Thiere et al. (2011) investigated the N retention and CH_4 emission originating from watershed-scale wetland creation in South Sweden, planned by the Environment and Countryside program for Sweden 2000–2006 (12,000 ha). Combined data from intensively studied reference wetlands and an extensive wetland survey have been analysed to model N retention and atmospheric CH_4 emission in such systems. According to the study, the planned wetland creation would significantly contribute to the targeted reduction of N fluxes. Using the annual N retention rates predicted by the case study, the 12,000 ha of restored wetlands in Sweden would be responsible for retaining up to 27% (6.8 million kg N annually) of the Swedish environmental objective. However, it should be noted that the estimated N retention rates are based on measurement at one case study location and the real rates may vary between different areas in Sweden. Furthermore, by using the emission rate predicted by the case study, the planned wetland creation would increase the anthropogenic climate gas emission by 0.04% (30 million kg CO_2 equivalents) of the Swedish environmental objective. In conclusion, the beneficial effects of watershed-scale wetland creation are sustained at a comparably low environmental risk. The results also showed that an optimisation of N retention is not likely to significantly increase CH4 emission. Promoting wetland designs to facilitate N retention could be combined with designs favouring a low CH_4 emission risk

14.3 Policy recommendations

The outcomes of the TEEB Nordic scoping assessment indicate that nature plays an integral role in underpinning well-being in the Nordic countries. However, the assessment also highlights that there are significant gaps in terms of existing information on status, trends and more concrete socio-economic value of different services.

Nevertheless, building on this preliminary synthesis and insights Nordic policy and decision-makers at national, regional and local level can now show leadership and foresight in their actions to support the protection and sustainable management of benefits provided by nature. The policy response should not be limited to environmental policies, but should also be mainstreamed into key sectoral policies such as fisheries, agriculture, forestry, climate and energy, transport and tourism. Furthermore, action is needed at all levels of governance and across all key sectors, harnessing also the energy of markets, business, citizens and communities.

Key policy recommendations for future actions include:

- Development of indicators and elaborated (national) frameworks for the assessment of ecosystem services (e.g. the socio-economic valuation of ecosystem services as along the lines of the UK NEA 2011), including biophysical status and trends, and socio-economic importance and value. The list of Nordic ecosystem services accompanied with direct indicators and proxies identified in the context of this scoping assessment can form a useful starting point for these developments
- A number of key gaps in the existing information base can be identified including, for example, lack of estimates reflecting broader cultural and landscape values, lack of data on nature's role in maintaining health, and lack of information on the indirect employment impacts of nature. In terms of ecosystems, there seems to be considerable gaps related to marine ecosystem services (beyond fisheries). Limited information is also available on the development of socio-economic importance of different ecosystem services in the future, e.g. possible future value of yet unidentified benefits. Finally, there is a need to further explore how the substitutability of ecosystem services via international trade affects their socio-economic value. These areas are recommended to be further addressed in the future

- Implementing the international commitment under the World Bank's WAVES (Wealth Accounting and Valuation of Ecosystem Services of which Norway is a partner) initiative linked to the UN led SEEA (System of Environmental and Economic Accounting to develop natural capital accounts with a dedicated focused on the non-market benefits provided by biodiversity and ecosystems, possibly benefiting from and working together with the European Environment Agency (EEA) who is leading work on Ecosystem Capital Accounts
- Further strengthening policy frameworks to manage the transition to a more resource efficient and green economies in the Nordic countries while working with nature and building on the pro-active management of natural capital. Key focal areas include continued reform of harmful subsidies, making increased use of opportunities (including earmarking) for funding investment in natural capital (e.g. management of protected areas and restoration of ecosystems) and exploring innovative solutions for eco-efficiency and decoupling of economy from resources (e.g. via nature-based innovations)
- Working together with business to encourage improving corporate accounting and partnerships that promote conservation and sustainable use of biodiversity and ecosystems. Although not the main thematic focus of this assessment, a number of Nordic examples exist where private sector engagement has led to cost-effective solution and benefits for the environment and biodiversity
- Identifying and agreeing on key areas for Nordic synergies and cooperation including, for example, development of compatible and comparable sets of (core) ecosystem service indicators and frameworks for ecosystem services assessments, identification of thematic areas for cooperation (e.g. assessment and sustainable management of ecosystem services provided by Baltic Sea and other marine areas, sustainable production of forest-based biofuels, assessment of carbon stock and sequestration capacity at Nordic level etc.). To facilitate cooperation, consideration should be given to establishing a dedicated working group for ecosystem services under the Nordic Council of Ministers

Finally, in addition to advancing towards national level frameworks, the Nordic countries (or specific regions) should focus on identifying particularly important policy developments or implementation needs where assessment of the broader socio-economic value of nature would be important to secure sustainable outcomes, especially in the long term. Focusing on such problem- and/or challenge-based assessments is seen as important to complement the overarching assessments and monitoring of the state of Nordic ecosystems and their services and mainstreaming of this information into decision-making processes. The scale of these focused assessments could range from local to national, including also a possibility for assessment in the Nordic context (to ensure that cross-border and regional benefits are duly taken into account). It is foreseen that in all cases such assessment would be based on a combination of qualitative, quantitative and eventually also monetary information, analysed in the most suitable spatial context. The focus and depth of such assessment (e.g. the combination of qualitative, quantitative and monetary information required) would need to be decided on a case by case basis, being proportional to the policy question at hand. Policy areas meriting such focused assessments could include reviews of national strategies for the mitigation of and adoption to climate change, reform of national forest policies and practices to reflect significant changes in the sector, and the development of future policies aimed at conserving and sustainably managing the Baltic Sea basin and other marine areas of Nordic importance. While the specific policy challenges will vary across the Nordic counties, national TEEB initiatives and other similar approaches will help to catalyse the transition to a green economy.

Finally, while the previously neglected economic values of ecosystem services need to be integrated into decision-making it is also important to improve the Nordic decision-making systems so that they recognise – and equally consider – the full range of broader socio-economic values, taking into consideration qualitative, quantitative and monetary evidence. Similarly, the approaches highlighted in this report should be considered complementary – not replacing – already existing strategies for biodiversity conservation. A range of reasons and arguments for nature conservation (e.g. cultural and intrinsic values) cannot be replaced by economics.

15. References

Aakkula, J., Manninen, T. and Nurro, M. (2010). Follow-up study on the impacts of agri-environment measures (MYTVAS 3). Mid-term report.

Aapala,K., Kettunen, M., Haltia, E., Silvennoinen, S., Heikkilä, R., Hokkanen, T. J., Horne, P., Jäppinen, J-P., Lilja-Rothsten, S., Luotonen, H., Maanavilja, L., Ohtonen, A., Ruokolainen, A., Saaristo, L., Sallantaus, T., Tuittila, E.-S., Tukia, H. and Vihervaara, P. (2012) In Ecosystem services in boral mires and peatlands. Proceedings of the 14th annual peat land congress "peatlands in balance", Stockholm, Sweden 3–8 June 2012. Extended abstract No. 309. 6 p.

Abramsson, K. and Tenngart, C. (2006). Nature and Health' in Sweden. In: Hassink, J. and Dijk, van, M. (2006). Farming for Health: Green-Care Farming across Europe and the United States of America. Wageningen UR Frontis Series, 13; 127–134, http://library.wur.nl/ojs/index.php/frontis/article/view/1263, accessed 26 March 2012.

Adsersen, A., Gauguin, B., Gudiksen, L. and Jäger, A.K. (2006). Ethnopharmacological communication Screening of plants used in Danish folk medicine to treat memory dysfunction for acetylcholinesterase inhibitory activity. Journal of Ethnopharmacology 104; 418–422.

Ahtiainen, M. and Huttunen, P. (1999). Long-term effects of forestry managements on water quality and loading in brooks. Boreal Environmental Research 4; 101–114.

Akselsson, C., Berg, B., Meentemeyer, V. and Westling, O. (2005). Carbon sequestration rates in organic layers of boreal and temperate forest soils – Sweden as a case study. Global Ecology and Biogeography 14; 77–84.

Alatalo, M. (2003). Jaktturismnäringen i Sverige 2003. Turist delegationen (Swedish Tourist Authority), Stockholm.

Andersson, G. K. S., Rundlöf, M. and Smith H. G. (2012). Organic Farming Improves Pollination Success in Strawberries. PLoS ONE 7(2) e31599.

Apimondia (1999). Nordic Beekeeping 1999, http://apimo.dk/programs/nordicbeekeeping1999.pdf, accessed 24 April 2012.

Appelblad, H. (2001). The Spawning Salmon as a Resource by Recreational Use: The case of the wild Baltic salmon and conditions for angling in north Swedish rivers. Doctoral thesis, GERUM 2001:3, Department of Social and Economic Geography, Umeå University.

Asdal, A., Galambosi, B., Bjørn, G. K., Olsson, K., Pihlik, U., Radušienè, J., Þorvaldsdòttir, E., Wedelsbäck Bladh, K. and Zukauska, I. (2006). In: Spice and medicinal plants in the Nordic and Baltic countries. Conservation of genetic resources: report from a project group at the Nordic Gene Bank. Alnarp: Nordic Gene Bank; 9–38.

Atkins, J.P. and Burdon, D. (2006). An Initial Economic Evaluation of Water Quality Improvements in the Randers Fjord, Denmark. Marine Pollution Bulletin 53(1–4); 195–204.

Axelsen, J. A., Enkegaard, A., Strandberg, B., Kryger, P. and Sørensen, P. B. (2011): Bestøvningsforhold og –behov i dyrkede afgrøder. Danmarks Miljøundersøgelser, Aarhus Universitet, 47 sider – Faglig rapport fra DMU 832, http://www.dmu.dk/Pub/FR832.pdf, accessed 13 April 2012.

Backes, M., Baumgartner, C., Pils, M. and Plüss. C. (2002). Red Card for Tourism: Ten Principles and Challenges for a Sustainable Tourism Development in the 21st Century. DANTE – The NGO Network for Sustainable Tourism Development, Germany, http://www.unep.fr/shared/publications/cdrom/WEBx0139xPA/statmnts/pdfs/piause.pdf, accessed 18 June 2012.

Barton, D. N., Lindhjem, H., Magnussen, K., and Holen, S. (2012). Valuation of Ecosystem Services from Nordic Watersheds: From awareness raising to policy support? (VALUESHED). TemaNord 2012:506.

Bell, S., Tyrväinen, L., Sievänen, T., Pröbstl, U. and Simpson, M. (2007). Outdoor Recreation and Nature Tourism: A European Perspective. Living Rev. Landscape Res., 1(2), http://www.livingreviews.org/lrlr-2007-2, accessed 9 March 2012.

Berg, L. (2010). Fourth national report to the Convention on Biological Diversity, Sweden. Ministry of the Environment.

Berggren, U. (2009). Elk grazing damage, hunting and wildlife. Swedish Statistical Yearbook of Forestry, 2009, http://www.skogsstyrelsen.se/Global/myndigheten/Statistik/Skogsstatistisk%20%C3%A5rsbok/04.%202000-2009/Skogsstatistisk%20%C3%A5rsbok%202009.pdf, accessed 25 April 2012.

Berggren K., D., Svensson, M., Hooshang, M., Jansson, P-E., Langvall, O., Bergqvist, B., Johansson, M.-B., Weslien, P., Truusb, L., Lindroth, A. and Ågren, G. I. (2008). Pools and fluxes of carbon in three Norway spruce ecosystems along a climatic gradient in Sweden. Biogeochemistry 89; 7–25.

Bergius, N. and Danell, E. (2000). The Swedish matsutake (*Tricholoma nauseosum* syn. *T. matsutake*): Distribution, Abundance and Ecology. Scandinavian Journal of boreal forest Research 15(3); 318–325.

Bergström, I., Mattsson, T., Niemelä, E., Vuorenmaa, J. and Forsius, M. (2011) (eds.) Ecosystem services and livelihoods: vulnerability and adaptation to a changing climate – VACCIA synthesis report. The Finnish Environment 26/2011. Helsinki, Finnish Environment Institute, 74 pp.

Birge, T. and Fred, M. (2011) New ideas for old landscapes: using a social-ecological approach for conservation of traditional rural biotopes – a case study from Finland. European Countryside 3/2: 51–67.

Bjørkeslett, H.K. and Lilleby, I. M. (2005). What is a Clean Fjord Worth? Social Benefit of Measures in Polluted Sediments in the Grenlandsfjords. Norwegian University of Life Sciences (UMB).

Bommarco R, Lundin O, Smith HG and Rundlöf M. (2011). Drastic historic shifts in bumble-bee community composition in Sweden. Proceedings of the Royal Society, Biological Science.

Bostedt, G. (2001). Reindeer husbandry, the Swedish market for reindeer meat, and the Chernobyl effects, Agricultural Economics 26; 217–226, www.elsevier.com/locate/agecon , accessed 28 June 2012.

Bostedt, G. and Lundgren, T. (2010). Accounting for cultural heritage — A theoretical and empirical exploration with focus on Swedish reindeer husbandry, Ecological Economics 69; 651–657, http://www.sciencedirect.com/science/article/pii/S092180090900411X, accessed 27 June 2012.

Boyd, J. and Banzhaf, S. (2007). What Are Ecosystem Services? The Need for Standardized Environmental Accounting Units. Ecological Economics, 63(2–3); 616–626.

Brandt, M., Arheimer, B., Gustavsson, H., Pers, C., Rosberg, J., Sundström, M. and Thorén, A.-K. (2009). Uppföljning av effekten av anlagda våtmarker i jordbrukslandskapet på belastning av kväve och fosfor. Naturvårdsverket, Rapport 6309.

Cai, M., Pettenella, D. and Vidale, E. (2011). Income generation from wild mushrooms in marginal rural areas. Boreal forest Policy and Economics 13(3); 221–226.

Carlsson, F., Frykblom, P. and Liljenstolpe, C. (2001). Valuing Wetland Attributes: An Application of Choice Experiment. Ecological Economics 47; 95–103.

CBD Finland (2009). Fourth National Report on the Implementation of the CBD in Finland. Ministry of Environment.

CBD Greenland (2010). Fourth National Report on the Implementation of the CBD of Greenland, Government of Greenland, The Ministry of Domestic Affairs, Nature and Environment, Greenland.

Christensen, K. B., Minet, A., Svenstrup, H., Grevsen, K., Zhang, H., Schrader, E., Rimbach, G., Wein, S., Wolffram, S., Kristiansen, K. and Christensen, L.P. (2009). Identification of Plant Extracts with Potential Antidiabetic Properties: Effect on Human Peroxisome Proliferator-activated Receptor (PPAR), Adipocyte Differentiation and Insulin stimulated Glucose Uptake. Phytotherapy Research 23; 1316–1325.

Ciais, P., Schelhaas, M. J., Zaehle, S., Piao, S. L., Cescatti, A., Liski, J., Luyssaert, S., Le-Maire, G., Schulze, E.-D., Bouriaud, O., Freibauer, A., Valentini R. and Nabuurs, G. J. (2008). Carbon accumulation in European forests. Nature Geoscience 1; 425–429.

Cooper, C. (1982). Carbon storage in managed forests. Canadian Journal of Forest Research 13; 155–166.

CLC (2006), Corine Land Cover (http://sia.eionet.europa.eu/CLC2006/).

COST (2012a) Case study – The Green Poster of Fredrikstad as a Tool for the Municipality Plan, http://www.cardiff.ac.uk/archi/programmes/cost8/case/greenblue/greenposter.html, accessed at 20 July 2012.

COST (2012b) Case study – Stockholm's Green Infrastructure, http://www.cardiff.ac.uk/archi/programmes/cost8/case/greenblue/stockholmgreen.html, accessed at 20 July 2012.

Costanza, R. (2008). Ecosystem services: Multiple classification systems are needed. Biological Conservation 141; 350 –352.

Cuyler, C. (1998). Success and failure of reindeer herding in Greenland, Greenland Institute of Natural Resources, Nuuk, Greenland, http://193.166.21.102:9091/servlet/com.trend.iwss.user.servlet.sendfile?downloadfile=IRES-1827390440-E0772F68-23212-23181-37, accessed 27 June 2012.

Dahl, F., Jansson, G. and Pehrson, Å. (2009). Vilt och fisk fakta no 4. Adaptiv förvaltning av vilt och fisk, SLU, http://www.slu.se/Global/externwebben/centrumbildningar-projekt/algforvaltning/faktablad-och-artiklar/2009-Faktablad-4-web.pdf, accessed 14 March 2012.

Dana, L.P. and Dana, T.E. (2007). How do self-employed Sami people perceive the impact of the EU and globalisation? Int. J. Business and Globalisation, 1(1); 3–19, http://www.mang.canterbury.ac.nz/docs/dana/Sami.pdf, accessed 27 June 2012.

Danish AgriFish Agency (2012a). Fisheries statistics, http://agrifish.dk/fishery.aspx?ID=46532, accessed 20 April 2012.

Danish AgriFish Agency (2012b). Number of employed in fisheries (based on Statistics Denmark – The RAS statistics), http://webfd.fd.dk/stat/Faste%20tabeller/Beskaeftigelse/bniveaup_eng3.html, accessed 20 April 2012.

Davíðsdóttir, B. (2010). Ecosystem services and human-wellbeing Valuing ecosystem services. In Kristófersson, D.M. (2010). Rannsóknir í Félagsvísindum XI. Reykjavík: The social science research institute.

Desvouges, Johnson, Banzah (1998). Environmental Policy Analysis with Limited Information: Principles and Applications of the Transfer Method. Edward Elgar.

Devictor, V., van Swaay, C., Brereton, T., Brotons, L., Chamberlain, D., Heliölä, J., Herrando, S., Julliard, R., Kuussaari, M., Lindström, Å., Reif, J., Roy, D.B., Schweiger, O., Settele, J., Stefanescu, C., Van Strien, A., Van Turnhout, C., Vermouzek, Z., DeVries, M.W., Wynhoff, I. and Jiguet, F. (2010). Differences in the climatic debts of birds and butterflies at a continental scale. Nature Climate Change.

Dinkelboden (2008), http://www.dinkelboden.se/default.asp?path=24473andpageid=35945, accessed 27 June 2012.

Directorate for Nature Management (2007) Emerald Network in Norway – Final Report from the Pilot Project. Report 2007–1b.

Direktoratet for naturforvaltning (2012). Brochure: Gaupe, jerv, bjørn, ulv og kongeørn, http://www.rovviltportalen.no/multimedia/44383/DN_de_5_store_nett.pdfandcontentdisposition=attachment, accessed 14 March 2012.

Duberstein, J.N. and deSteiguer, J.E (2003). Contingent valuation and watershed management: a review of past uses and possible future applications. Proceedings of the First Interagency Conference on Research in the Watersheds, Benson, Arizona, http://www.tucson.ars.ag.gov/icrw/Proceedings/Duberstein.pdf, accessed 12/04/2012

Dubgaard, A., Kallesøe, M.F., Petersen, M.L. and Ladenburg, J. (2002). Cost-Benefit Analysis of the Skjern River Restoration project. Department of Economics and Natural Resources, Royal Veterinary and Agricultural University, Copenhagen, http://www.ecrr.org/publication/decmak_doc2.pdf, accessed 04 May 2012.

Dudley, N. and Stolton, S. (2003). Running Pure: The Importance of Forest Protected Areas to Drinking Water. World Bank/WWF Alliance for Forest Conservation and Sustainable Use, WWF, Gland, Switzerland. EarthTrends 2003, http://earthtrends.wri.org/pdf_library/country_profiles/bio_cou_208.pdf, accessed 14 March 2012.

EC (2011). Commission Communication on Rio+20 – towards the green economy and better governance, (COM/2011/363), http://ec.europa.eu/environment/international_issues/pdf/rio/com_2011_363_en.pdf, accessed 18 June 2012.

EC (2012a) European Commission's water Blueprint webpage, http://ec.europa.eu/environment/water/blueprint/index_en.htm, accessed 20 August 2012.

EC (2012b) European Commission's Green Infrastructure webpage: http://ec.europa.eu/environment/nature/ecosystems/index_en.htm

Economo, A. and Galambosi, B. (2003). Adaptogeenikasvien käyttö, tutkimus ja markkinat maailmassa. In: Galambosi, B. (2003). Adaptogeenikasvien viljelytutkimus ja käyttö Suomessa. Ruusujuuriseminaari, Mikkeli, 18.6.2002. Maa- ja elintarviketalous 37; 10–19, http://www.mtt.fi/met/pdf/met37.pdf, accessed 20 June 2012.

EEA (2012) Ecosystem accounting and the cost of biodiversity losses – The case of coastal Mediterranean wetlands. EEA Technical report No 3/2010. EEA, Copenhagen. 96 p. http://www.eea.europa.eu/publications/ecosystem-accounting-and-the-cost, accessed at 20 July 2012.

Eklöf, M-L. (2008). Vihreä apteekki : valmista itse luonnon omat lääkkeet. Helsinki, Minerva.

Eggert, H. and Olsson, B. (2002). Heterogeneous preferences for marine amenities: A choice experiment applied to water quality. Working Paper in Economics 126, Department of Economics, Goteborg University.

Enkovaara, A.-L. (2002). Lääkekasvit and rohdostuotteet. Helsinki: WSOY, 2002; 244.

Eskelinen, P. (2009). Karhut elinkeinona – millaisia ovat katselupalveluja tarjoavat yritykset? Riista – jakalatalous — selvityksiä 15/2009, http://www.rktl.fi/www/uploads/pdf/uudet%20julkaisut/selvityksia_15_2009.pdf, accessed 19 April 2012.

European Anglers' Alliance 2002. Social and Economic Value of RECREATIONAL FISHING Northern and Central Europe Data from Actual Surveys, http://www.eaa-europe.org/fileadmin/templates/eaa/docs/angling_socio_brochure.pdf, accessed 2 April 2012.

Eurostat (2012). Eurostat database (agriculture, forestry and water statistics) http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database, accessed 14 March–27 April 2012.

EUSTAFOR and Patterson T. (2011). Ecosystem Services in European State Forests – Case Studies. European State Forest Association, Brussels, http://www.eustafor.eu/failid/File/Publications/Ecosystems%20Services%20Case%20Studies.pdf, accessed 21 February 2012.

Evira (2012), http://www.evira.fi/portal/fi/evira/asiakokonaisuudet/luomu/tilastot_ja_tietohaut/, accessed 14 June 2012.

Fabricant, D. and Farnsworth, N. (2001). The value of plants used in traditional medicine for drug discovery. Environmental Health Perspectives: 109 (1); 69–75.

FAO (2010). Fisheries and Aquaculture Department. The State of World Fisheries and Aquaculture 2010. Rome, Italy, http://www.fao.org/docrep/013/i1820e/i1820e00.htm, accessed 5 April 2012.

FAO (2012a). Fishery and Aquaculture Country Profiles. Sweden, http://www.fao.org/fishery/countrysector/FI-CP_SE/en, accessed 20 April 2012.

FAO (2012b). Value of Agricultural Production, http://faostat.fao.org/site/613/default.aspx#ancor, accessed 20 June 2012

Fisheries (2012), www.fisheries.no, accessed 20 April 2012.

Fish and Wildlife Service (2003). Migratory Bird Permits: Eiderdown From Iceland. Federal Register 68(172), Proposed Rules. Fish and Wildlife Service, Department of the interior, http://www.fws.gov/policy/library/2003/03-22298.pdf, accessed 28 June 2012.

Fisher, B. and Turner, R.K. (2008). Ecosystem Services: classification for valuation. Biological Conservation 141; 1167–1169.

Fisher, B., Turner, R.K. and Morling P. (2009). Defining and Classifying Ecosystem Services for Decision Making. Ecological Economics 68; 643–653.

Flörke, M. and Alcamo, J. (2004). European outlook on water use. Center for Environmental Systems Research – University of Kassel, Final Report, EEA/RNC/03/007.

Forbes, B.C. and Kumpula, T. (2009): The Ecological Role and Geography of Reindeer (*Rangifer tarandus*) in Northern Eurasia. Geography Compass ¾; 1356–1380.

Forbes, B.C., Bölter, M., Müller-Wille, L., Hukkinen, J., Müller, F., Gunslay, N. and Konstantinov Y. (2006). Reindeer management in northernmost Europe: linking practical and scientific knowledge in social-ecological systems. Ecological Studies 184. Berlin, Germany. Springer-Verlag.

Fredman, P., Svensson, B., Lindberg, K. and Holmsted, A. (2010). Ekonomiska värden i svenskt friluftsliv – en enkätundersökning. Friluftliv i förändring, rapport nr 14. Östersund, oktober 2010, http://www.svensktfriluftsliv.se/media/Rapport%20Ekonomiska%20varden%20i%20svenskt%20friluftsliv%202010-10-11.pdf, accessed 30 March 2012.

Free, J. B. (1993). Insect pollination of crops. Academic Press, London, UK.

FSC (2012), http://www.fsc.org/facts-figures.19.htm, accessed 1 June 2012.

Galambosi, B. and Jokela, K. (2002). Uhanalaisten lääkekasvien markkinat ja viljely. Kirjallisuusselvitys. Maa- ja elintarviketalous 17; 88, http://www.mtt.fi/met/pdf/met17.pdf, accessed 20 June 2012.

Galambosi, B. (2006). Demand and Availability of Rhodiola rosea L. Raw Material; 223–236. In: Bogers, R.J., Craker L.E. and Lange D. (2006). Medicinal and Aromatic Plants, http://library.wur.nl/ojs/index.php/frontis/article/view/1235/807, accessed 20 June 2012.

Galambosi, B. (2009). Experiments on the introduction of threatened medicinal plants in Finland. In: Lipman E. (2009). Report of a Working Group on Medicinal and Aromatic Plants. Second Meeting, 16-18 December 2004, Strumica, Macedonia FYR / Third Meeting, 26–28 June 2007, Olomouc, Czech Republic.

Gantioler S., Rayment M., Bassi S., Kettunen, M., McConville A., Landgrebe R., Gerdes H., ten Brink P. (2010). Costs and Socio-Economic Benefits associated with the Natura 2000 Network. Final report to the European Commission, DG Environment on Contract ENV.B.2/SER/2008/0038. Institute for European Environmental Policy / GHK / Ecologic, Brussels 2010.

Gärdenfors, U. (2010). Rödlistade arter i Sverige 2010 – The 2010 Red List of Swedish Species; 590. ArtDatabanken, SLU, Uppsala.

Garpe, K. (2008). Ecosystem services provided by the Baltic Sea and Skagerrak 2008. Naturvårdsverkets report 5873, http://www.naturvardsverket.se/Documents/publikationer/978-91-620-5873-9.pdf, accessed 28 June 2012.

Göransson, A. (2008). Kan grundvatten värderas – Kristianstad kommun. Grundvattenrådet för Kristianstadsslätten, http://www.kristianstad.se/upload/Milj%C3%B6%20Energi/dokument/Grundvatten/Kan%20Grundvatten%20v%C3%A4rderas_Rapport.pdf, accessed 27 April 2012.

Grahn, P. and Stigsdotter, U. (2003). Landscape planning and stress. Urban Forestry and Urban Greening 2:1; 1–18.

Greenland Tourism and Business Council (2012). The propagation of reindeer in Greenland, http://www.greenland.com/en, accessed 28 June 2012.

Gren, I. M. and Svensson, L. (2004). Ecosystems, sustainability and growth for Sweden during 1991–2001. Occasional Studies 4. The National Institute of Economic Research Stockholm 2004, http://www.konj.se/download/18.70c52033121865b13988000102638/OccStud_4.pdf, accessed 23 April 2012.

Gren, I-M. and Isacs, L. (2009). Ecosystem services and regional development. An application to Sweden. *Ecological Economics* 68(10); 2549–2559, http://www.sciencedirect.com/science/article/pii/S0921800909001219, accessed 12 April 2012.

Grizzetti, B., Bouraoui, F., De Marsily, G. and Bidoglio, G. (2005). A statistical method for source apportionment of riverine nitrogen loads. Journal of Hydrology, 304; 302–315

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

Gunnarsson (2005). Country report, Iceland COST E 30 – Economic integration of urban consumers' demand and rural forestry production. Forest sector entrepreneurship in Europe: Country studies. Acta Silvatica and Lignaria Hungarica. Special Edition 2005, http://www.joensuu.fi/coste30/docs/Publication/Iceland.pdf, accessed 28 June 2012.

Haagensen, K. M. (ed) (2011). Nordic Statistical Yearbook 2011 (Vol. 49). Nord 2011:001, Nordic Council of Ministers, Copenhagen, Denmark. http://www.norden.org/en/publications/publikationer/2011-001, accessed 19 June 2012.

Hailuodon kunta (2012), http://www.artfood.org/hailuoto/hluoto.htm, accessed 20 June 2012.

Haines-Young, R.H. and Potschin, M.P. (2010a). The links between biodiversity, ecosystem services and human well-being. In: Raffaelli,D. and Frid, C. (Eds.), Ecosystem Ecology: A New Synthesis. Cambridge University Press.

Haines-Young, R. and Potschin, M. (2010b). Proposal for a Common International Classification of Ecosystem Goods and Services (CICES) for Integrated Environmental and Economic Accounting. Report to the EEA, http://unstats.un.org/unsd/envaccounting/ceea/meetings/UNCEEA-5-7-Bk1.pdf, accessed 18 August 2012.

Hall, C.M. and Boyd S.W. (2005). Nature-based tourism in peripheral areas: development or disaster?, Channel View Publications, http://books.google.fi/books?id=uooCGhkyBf8Candpg=PA45andlpg=PA45anddq=reindeer+safaris+million+euroandsource=blandots=YSXizHUG01andsig=6RGRaqW8tlaafQZ5zPCEPNN67uIandhl=fiandsa=Xandei=OAa2T66hIsGp4gTkr627CQandredir_esc=y#v=onepageandq=almost%2010andf=false, accessed 28 June 2012.

Hall,C. M, Müller,D. K. and Saarinen, J. (2009). Chapter 6, Nature based tourism in Northern Wilderness. In: Nordic tourism: Issues and Cases. Channel View Publications, UK.

Hallanaro, E.-L. and Pylvänäinen, M. (2002). Nature in Northern Europe – Biodiversity in a changing environment. Nord 2001:14, Nordic Council of Ministers. Copenhagen, Denmark. p. 350.

Hansen, K. B. and Nielsen, T. S. (2005). Natur og grønne områder forebygger stress. Skov and Landskab. Aalborg, Denmark 2005, http://curis.ku.dk/ws/files/20543963/natur_og_sundhed_haefte_net.pdf.pdf, accessed 26 March 2012.

Hansjürgens, B., Schröter-Schlaack, C., Tucker, G., Vakrou, A., Bassi, S., ten Brink, P., Ozdemiroglu, E., Shine, E. and Wittmer, H. (2011). Addressing the losses through regulation and pricing.The Economics of Ecosystems and Biodiversity in National and International Policy Making. Edited by Patrick ten Brink, Earthscan, London and Washington.

Hanski, I., von Hertzen, L., Fyhrqvist, N., Koskinen, K., Torppa, K., Laatikainen, T., Karisola, P., Auvinen, P., Paulin, L., Mäkelä, M.J., Vartiainen, E., Kosunen, T.U., Alenius, H. and Haahtela, T. (2012). Environmental biodiversity, human microbiota, and allergy are interrelated. Proceedings of the National Academy of Sciences of the United States of America.

Hartig, T., Evans, G.W., Jamner, L.D., Davis, D.S., Garling, T. (2003). Tracking restoration in natural and urban field settings. Journal of Environmental Psychology 23; 109–123.

Hasler, B., Lundhede, T., Martinsen, L., Neye, S. and Schou, J.S. (2005) Valuation of groundwater protection versus water treatment in Denmark by Choice Experiments and Contingent Valuation. NERI Technical Report 543; 176. National Environmental Research Institute, Denmark, http://technical-reports.dmu.dk, accessed 27 April 2012.

Haugan, L., Nyland, R., Fjeldavli, E., Meistad, T. and Braastad, B.O. (2006). Green care in Norway: farms as a resource for the educational, health and social sector; 109–126. In: Hassink, J. and Dijk, van, M. (2006). Farming for Health: Green-Care Farming across Europe and the United States of America. Wageningen UR Frontis Series 13, http://library.wur.nl/ojs/index.php/frontis/article/view/1262, accessed 23 March 2012.

Havs och vatten myndigheten (2012). Yrkesfiske, http://www.havochvatten.se/tillstandsprovning-och-tillsyn/tillsyn/yrkesfiske.html, accessed 20 April 2012.

Hegland, S. J., Nielsen, A., Làzaro, A., Bjerknes A.-L. and Totland, Ø. (2009). How does climate warming affect plant-pollinator interactions? Ecology Letters 12; 184–195.

Heiðarsson, J. Þ., Sigurðsson, S., Sigursteinsdóttir, H. and Bjarnadóttir, E. J. (2010). Economic impact of hunting tourism in rural Iceland. In: Matilainen, A. and Keskinarkaus, S. (2010). The economic role of hunting tourism – examples from Northern areas. Ruralia Institute, Reports 64. University of Helsinki.

Helsingin Sanomat (2002). Finnish reindeer blood for sale in Hong Kong, http://www2.hs.fi/english/archive/news.asp?id=20021212IE1, accessed 28 June 2012.

Helsingin Sanomat (2011). Birch sap can mean additional income for forest owners, Helsingin Sanomat, International Edition, http://www.hs.fi/english/article/Birch+sap+can+mean+additional+income+for+forest+owners/1135265856983, accessed 21/05/2012.

Højring, K. (2002). The right to roam the countryside—law and reality concerning public access to the landscape in Denmark, Landscape and Urban Planning 59(1); 29–41, http://www.sciencedirect.com/science/article/pii/S0169204601002456, accessed 28 June 2012.

Hokkanen, H., Menzler-Hokkanen, I., Mustalahti, A-M., Koivisto, I., Levy, M. and Korhonen, K. (2008). Mansikan Harmaahome: biologinen täsmähallinta haastaa kemiallisen torjunnan. Maataloustieteen Päivät, http://www.smts.fi/mpol2008/index_tiedostot/Posterit/ps035b.pdf, accessed 20 June 2012.

Holm, Y. and Hiltunen, R. (2003). Lääkkeitä luonnosta. Helsinki; Helsingin yliopisto, Lahden tutkimus- ja koulutuskeskus; 119. Oppimateriaaleja / Helsingin yliopiston tutkimus- ja koulutuskeskus Palmenia.

Huhtala, M., Kajala, L. and Vatanen, E. (2010). Local economic impacts of national park visitors' spending: The development process of an estimation method. Metlan työraportteja/Working Papers of the Finnish Forest Research Institute, http://www.metla.fi/julkaisut/workingpapers/2010/mwp149.htm, accessed 28 June 2012.

Humphries, J.E. (2007). Reindeer Markets in the Circumpolar North: An Economic Outlook, University of Alaska, Anchorage Institute for Social and Economic Research, http://www.iser.uaa.alaska.edu/Publications/reindeer_markets_jeh9-13-2007.pdf, accessed 28 June 2012.

Iceland (2012). The Icelandic horse, http://www.iceland.is/the-big-picture/nature-environment/vegitation-wildlife/icelandic-horse/, accessed 28 June 2012.

Iceland Ministry of Fisheries (2012), http://www.fisheries.is/, accessed 20 April 2012.

Icelandic Agricultural Statistics (2009), http://www.bondi.is/lisalib/getfile.aspx?itemid=2211, accessed 14 June2012.

Icelandic Fisheries website/Statistic Iceland (2012), http://www.fisheries.is/economy/fisheries-impacts/employment/, accessed 20 April 2012.

Icelandic Fisheries website/Statistic Iceland (2012), http://www.fisheries.is/economy/fisheries-impacts/employment/, accessed 20 April 2012.

ICES FishMap (2012), http://www.ices.dk/marineworld/fishmap/ices/, accessed 20 April 2012.

IEA (2010). Energy Subsidies: Getting the Prices Right, International Energy Agency. Office of the Chief Economist.

IPCC (2007). Contribution of working group III to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Jacobs, NFO WorldGroup, Gibson, H., Hanley, N., Wright, R., Coulthard, N. and Oglethorpe, D. (2004). An Economic Assessment of the Costs and Benefits of Natura 2000 Sites in Scotland. Final Report, http://www.scotland.gov.uk/Resource/Doc/47251/0014580.pdf, accessed 26 April 2012.

Jandl, R., Vesterdal, L., Olsson, M. Bens, O., Badeck, F. and Rock, J. (2007). Carbon sequestration and Forest management. CAB Reviews: Perspectives in agriculture, Veterinary Science, Nutrition and Natural Resources 2: 017; 1–16.

Järvenranta (2005b). Pajusta on moneksi . Luonnotuote 1/2005; 28, http://www.luontoyrittaja.net/docs/051-s9N-Lehti2005.pdf, accessed 19 April 2012.

Järvenranta, J. (2005a). Vierailu punoi verkostoja tanskalaisiin pajun taitajiin. Luonnotuote 1/2005; 12, http://www.luontoyrittaja.net/docs/051-s9N-Lehti2005.pdf, accessed 19 April 2012.

Jernsletten, J.-L. and Klokov, K. 2002. Sustainable reindeer husbandry. Tromsø, Norway: Arctic Council/Centre for Saami Studies.

Jóhannesdóttir, H. M. 2010. The Economic Valuation of Lake Ellidavatn and Lake Vifilstadavatn. In Daði Már Kristófersson (Ed.), Rannsóknir í Félagsvísindum XI. Reykjavík: The social science research institute.

Johansson, C. (2009). Påverkan på partikelhalter av trädplantering längs gator i Stockholm (The effect of planting trees on particle concentrations along roads). Miljöförvaltningen, Stockholm Report, http://slb.nu/slb/rapporter/pdf6/slb2009_002.pdf, accessed 23 May 2012.

Jonsson, L. and Uddstål, R. (2002). En beskrivning av den svenska skogsbärbranchen. Department report, Swedish University of Agricultural Sciences, Vindeln Experimental Forests, Vindeln.

Jordbruks statistisk årsbok (2011). Statistics Sweden/Jorbruksverket 2011, http://www.jordbruksverket.se/download/18.4b2051c513030542a92800014473/Jordbruksstatistisk+%C3%A5rsbok+2011+Hela.pdf, accessed 14 June2012.

Jordbruksverket (2012), http://www.sjv.se/webdav/files/SJV/Amnesomraden/Statistik%2C%20fakta/Arealer/JO10/JO10SM1203/JO10SM1203_tabeller2.htm, accessed 14 June 2012.

Kaltenborn, B. P. (2009). Cases and Issues 6.1: Svalbard: Wilderness Tourism in the High North; 131–133. In: Hall,C. M, Müller,D. K. and Saarinen, J. (2009). Nordic tourism: Issues and Cases. Channel View Publications.

Kangas, K. and Markkanen, P. (2001). Factors affecting participation in wild berry picking by rural and urban dwellers. Silva Fennica 35(4); 487–495.

Karjalainen, E., Sarjala, T. and Raitio, H. (2010). Promoting human health through forests: overview and major challenges. Environmental Health and Preventive Medicine 15(1); 1–8.

KAUNO (2003). Kasvivärien tuotekehitysprojektin tiedotuslehti 3; 21–23.

Kautola, H. and Pirttijärvi, T. (2007). Recent Applications in Bioprocess Engineering, HAMK University of Applied Sciences, Hämeenlinna, Finland, http://portal.hamk.fi/portal/page/portal/HAMKJulkisetDokumentit/Yleisopalvelut/Julkaisupalvelut/Kirjat/tekniikka_liikenne/HAMK_bioseminar_06.pdf, accessed 28 June 2012.

Keskimölö, A. and Hyppönen, P. (2012). Lapin metsäohjelma 2012–2015. Metsä – keskus Lappi.

Kettunen, M., Berghöfer, A., Brunner, A., Conner, N., Dudley, N., Ervin, J., Gidda, S. B., Mulongoy, K. J., Pabon, L. and Vakrou, A. (2011) Recognising the value of protected areas. In ten Brink (ed) TEEB in National Policy – The Economics of Ecosystems and Biodiversity in National and International Policy Making, pp. 345–399. Earthscan, London.

Kettunen, M., Bassi, S., Gantioler, S. and ten Brink, P. (2009). Assessing Socio-economic Benefits of Natura 2000 – a Toolkit for Practitioners (September 2009 Edition). Output of the European Commission project Financing Natura 2000: Cost estimate and benefits of Natura 2000; 191. Institute for European Environmental Policy (IEEP), Brussels, Belgium.

Klein A.-M., Vaissière, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S.A., Kremen, C. and Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops Proc. R. Soc. B 274: 1608; 303–313.

Knutsson, G. (2008). Hydrogeology in the Nordic countries. Episodes 31(1); 148–154.

Kupari, R. (2012). Luonto parantaa. Suomen Luonto 2/2012; 66–67.

Kolari, P., Pumpanen, P., Rannik, Ü., Ilvesniemi, K., Hari P. and Berninger, F. (2004). Carbon balance of different aged Scots pine forests in Southern Finland. Global Change Biology 10; 1106–1119.

Kosenius, AK. (2010). Heterogeneous Preferences for Water Quality Attributes: the case of Eutrophication of the Gulf of Finland, Baltic Sea. Ecological Economics 69(3); 528–538.

Koskiaho, J., Ekholm, P., Räty, M., Riihimäki, J. and Puustinen, M. (2003). Retaining agricultural nutrients in constructed wetlands—experiences under boreal conditions. Ecological Engineering 20; 89–103.

Kristófersson, D. M. and Eiríksdóttir, K. (2010). Valuing recreational demand: The case of Heiðmörk. In Daði Már Kristófersson (Ed.), Rannsóknir í Félagsvísindum XI. Reykjavík: The social science research institute, http://skemman.is/stream/get/1946/6775/18406/1/25-31_DadiMarKrsitofers_KristinEiriksd_HAGbok.pdf, accessed 02 April 2012.

Kronvag, B. and Hoffmann, C.C. (2009). Ecological and nutrient retention effects of river and floodplain restoration: experiences from Denmark. Presentation in the COST 869 workshop 18–19 May 2009.

Kumar, P. (ed) (2010) The Economics of Ecosystems and Biodiversity (TEEB) – Ecological and Economic Foundation. Earthscan, London and Washington.

Köhl, M, Bastup-Birk, A., Marchetti, M. Cimini, D., Corona, P., Jellesmark Thorsen B., Lasserre B., Pettenella, D., Saastamoinen, O. and Søndergaard Jensen F. (2011a) Criterion 3: Maintenance and Encouragement of Productive Functions of Forests (Wood and Non-Wood). In FOREST EUROPE, UNECE and FAO 2011: State of Europe's Forests 2011.Status and Trends in Sustainable Forest Management in Europe.

Lauren A., Finér, L., Koivusalo, H., Kokkonen, T., Karvonen, T. Kellomäki, S., Mannerkoski, H. and Ahtiainen, M. (2005). Water and nitrogen processes along a typical water flowpath and streamwater exports from a forested catchment and changes after clear-cutting: a modelling study. Hydrology and Earth System Sciences 9(6); 657– 674.

Lavapuro M., Lipponen A., Artimo A. and Katko, T. S. (200)8. Groundwater sustainability indicators: testing with Finnish data. Boreal Environment Research 13(5); 381–402.

Lavsund, S. Nygren, T. and Solberg, E. (2003). Statuss of moose populations and challenges to moose management in Fennoscandia. Alces 39;109–130.

Layke, C. (2009). Measuring Nature's Benefits: A Preliminary Roadmap for Improving Ecosystem Service Indicators. WRI Working Paper, World Resources Institute, Washington DC, http://pdf.wri.org/measuring_natures_benefits.pdf, accessed 2 June 2012.

Lehtonen, T. (2012). Mehiläispölytyksen taloudellinen arvo suomessa viljeltävien kasvien ja luonnonmarjojen sadontuotannossa. Ms Thesis. University of Helsinki 2012.

Lehtonen, H., Rask, M., Pakkasmaa, S. and Hesthagen, T. (2008). Freshwater fishes, their biodiversity, habitats and fisheries in the Nordic countries. Aquatic Ecosystem Health and Management 11(3); 298–309.

Lepistö A, Granlund K, Kortelainen P. and Räike A. (2006). Nitrogen in river basins: Sources, retention in the surface waters and peatlands, and fluxes to estuaries in Finland. Science of Total Environment 365; 238–259.

Lewis, C. (unknown). Birch Industry in Newfoundland Labrador, Sap World Co. Ltd, http://www.nr.gov.nl.ca/nr/forestry/sustainable_forest/sap_world.ppt, accessed 21 May 2012.

Lilja, T., Soini K. and Mäki-Tanila, A. (unknown). Eastern Finncattle, MTT Agrifood Research Finland, Jokioinen, http://www.regionalcattlebreeds.eu/wp/documents/WP1-Breedcase-NautaEasternFinncattle.pdf, accessed 28 June 2012.

Lindhagen, A. and Hörnsten, L. (2000). Boreal forest recreation in 1977 and 1997 in Sweden: changes in public preferences and behavior. Boreal Forestry 73(2);143–153.

Lindroos, O. (2011). Residential use of firewood in Northern Sweden and its influence on forest biomass resources. Biomass and Bioenergy. 35(1); 385–390.

Linkowski, W., Pettersson, M. W., Cederberg, B. and Nilsson, L. A. (2004). Nyskapande av livsmiljöer och aktiv spridning av vildbin. Svenska Vildbiprojektet vid ArtDatabanken, SLU, and Avdelningen för Växtekologi, Uppsala Universitet.

Liski, J., Perruchoud, D. and Karjalainen, T. (2002). Increasing carbon stocks in the forest soils of western Europe. Forest Ecology and Management 169(1–2); 159–175.

Lorenz, K. and Lal, R. (2010). Carbon sequestration in forest ecosystems. Dordrecht : Springer, cop. 2010.

Lumene (2012), http://www.lumene.com, accessed 5 April 2012.

Lunnan, A., Barstad, J., Mitchell-Banks, P. Nyrud, A. Q., Størdal, S. and Vennesland, B. (2005). Country report, Norway COST E 30 – Economic integration of urban consumers' demand and rural forestry production. Forest sector entrepreneurship in Europe: Country studies. Acta Silvatica and Lignaria Hungarica. Special Edition 2005, http://www.joensuu.fi/coste30/docs/Publication/Norway.pdf, accessed 20 June 2012.

MA (Millenium Ecosystem Assessment) (2005). Ecosystems and Human Well-Being: Biodiversity Synthesis. World Resource Institute, Washington, DC.

Maaseudun Tiede (2008), http://www.mtt.fi/maaseuduntiede/pdf/mtt-mt-v65n03s02c.pdf, accessed 21 June 2012.

MabCent-SFI (2011), http://www0.nfh.uit.no/mabcent/, accessed 28 June 2012.

Mace, G., Norris, K. and Fitter, A. (2011). Biodiversity and ecosystem service: a multilayered relationship. Trends in Ecology and Evolution, 27(1); 19–26.

Maes, J., Paracchini, M. L. and Zulian, G. (2011a). A European assessment of the provision of ecosystem services. Towards an atlas of ecosystem services. — JRC Scientific and Technical Reports. European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra.

Maes, J., Braat, L., Jax, K., Hutchins, M., Furman, E., Termansen, M., Luque, S., Paracchini, M.L., Chauvin, C., Williams, R., Volk, M., Lautenbach, S., Kopperoinen, L., Schelhaas, M-J., Weinert, J., Goossen, M., Dumont, E., Strauch, M., Görg, C., Dormann, C., Katwinkel, M., Zulian, G., Varjopuro, R., Ratamäki, O., Hauck, J., Forsius, M., Hengeveld, G., Perez-Soba, M., Bouraoui, F., Scholz, M., Schulz-Zunkel, C., Lepistö, A., Polishchuk, Y. and Bidoglio, G. (2011b). A spatial assessment of ecosystem services in Europe: methods, case studies and policy analysis – phase 1. PEER Report 3. Ispra: Partnership for European Environmental Research.

Maes, J. Hauck, J., Paracchini, M.L., Ratamäki, O., Termansen, M., Perez-Soba, M., Kopperoinen, L. Rankinen, K., Schägner, P., Henrys, P., Cisowska, I., Zandersen, M., Jax, K., La Notte, A. Leikola, N., Pouta, E., Smart, S., Hasler, B., Lankia, T., Andersen, H.E., Lavalle, C., Vermaas, T., Alemu, M.H. Scholefield, P., Batista, F., Pywell, R., Hutchins, M., Blemmer, M., Wulff-Fonnesbech, A., Vanbergen, A.J., Münier, B., Baranzelli, C., Roy, D., Thieu, V., Zulian, G., Kuussaari, M., Thodsen, G., Alanen, E-L-, Braat, L. and Bidoglio G. (2012a). A spatial assessment of ecosystem services in Europe: methods, case studies and policy analysis. Phase 2. PEER report 4.

Maes, J. ,Egoh, B., Willemen, L., Liquete, C., Vihervaara, P., Schaegner, J.-P., Grizzetti, B., Drakou, E.G., LaNotte, A., Zulian, G., Bouraoui, F., Paracchini, M.-L., Braat, L., Bidoglio, G. (2012b). Mapping ecosystem services for policy support and decision making in the European Union. Ecosystem Services, in press. DOI: http://dx.doi.org/10.1016/j.ecoser.2012.06.004

MARSI (2010). Luonnonmarjojen ja -sienten kauppaantulomäärät vuonna 2010 MMM/Suomen Gallup Elintarviketieto oy MMM Helsinki, http://www.mmm.fi/attachments/mmm/uutiset/5xh5r2JFz/MARSI_2010_MMM_rap_Final.pdf, accessed 23 April 2012.

Matero, J. and Saastamoinen, O. (2007). In search of marginal environmental valuations – ecosystem services in Finnish forest accounting. Ecological Economics 61; 101–114.

Matilainen, A., Keskinarkaus, S. and Törmä, H. (2010). The economics of hunting tourism in Finland. In The economic role of hunting tourism –examples from Northern areas. Matilainen, A. and Keskinarkaus, S. Ruralia Institute, Reports 64. University of Helsinki 2010.

Matilda Maataloustilasto (2012), http://www.maataloustilastot.fi/, accessed 14 June2012.

Matilda maataloustilasto (2012a). Puutarhatilastot 2010, http://www.maataloustilastot.fi/puutarhatilastot, accessed 14 March 2012.

Matilda maataloustilasto (2012b). Peltokasvituotanto, http://www.maataloustilastot.fi/kaytossa-oleva-maatalousmaa, accessed 14 March 2012.

Mattsson, L., Boman, M. and Ericsson, G. (2008). Jakten i Sverige—Ekonomiska värden och attityder jaktåret 2005/06. Adaptiv Förvaltning av Vilt och Fisk, Rapport Nr. 1.

Menzler-Hokkanen, I. (2006). Socio-economic significance of biological control. In: Eilenberg, J. and Hokkanen H. M. T. (2006) Concepts and visions of biological control. An Ecological and Societal Approach to Biological Control; 13–25.

Metsähallitus (2012). Metsähallituksen hoitamien suojelu- ja retkeilyalueiden määrä ja pinta-alat 1.1.2011, http://www.metsa.fi/sivustot/metsa/fi/Luonnonsuojelu/Suojelualueet/Suojelupintaalojenkehitys/Metsahallituksensuojelualueet/Sivut/Metsahallituksenhoitamiensuojelujaretkeilyalueidenmaarajapintaalat.aspx, accessed 14 March 2012.

Metsätilastollinen vuosikirja (2011). Chapter 6 Metsien monikäyttö, http://www.metla.fi/metinfo/tilasto/julkaisut/vsk/2011/vsk11_06.pdf, accessed 29 May 2012.

Mtt Taloustohtori/Fadn (2012), https://portal.mtt.fi/portal/pls/portal/tt_mtt.tt_mtt_dimeuadv_pack.laheta, accessed 28 June 2012.

MTT (2012), project SPINDIGO presentation, https://portal.mtt.fi/portal/page/portal/mtt_en/mtt/research/projectdatabase/Projectdetail?p_kielikoodi=GBandp_hakutyypi=perusandp_hanke_seqno=170719, accessed 20 June 2012.

Müller, D. K. (2007). Second Homes in the Nordic Countries: Between Common Heritage and Exlusive Commodity. Scandinavian Journal of Hospitality and Tourism 7(3); 193–201.

Narayan, P. K. and Narayan, S. (2008). Does environmental quality influence health expenditures? Empirical evidence from a panel of selected OECD countries, Ecological Economics, Elsevier, vol. 65(2); 367–374.

Nasjonalbudsjettet (2012). Meld. St. 1 (2011–2012). Melding til Stortinget, Norwegian Ministry of Finance. http://www.statsbudsjettet.no/upload/Statsbudsjett_2012/dokumenter/pdf/stm.pdf, accessed 23 February 2012

Naturen som kraftkälla (2006). Naturvårdsverkets publikation, authors Ottosson, M. and Ottoson, Å. Stockholm 2006, http://www.naturvardsverket.se/Documents/publikationer/620-8252-3.pdf, accessed 26 March 2012.

Naturvådsverket (2012). Jakt och vilt and related sites. http://www.naturvardsverket.se/Start/Naturvard/Jakt-och-vilt/, accessed 30 March 2012.

Navrud, S. and Ready, R. (2007) (eds.) Environmental Value Transfer: Issues and Methods. Springer.

NB Forest Info (2012). Forestry statistics in Nordic and Baltic states (based on FAO statistics), http://www.nbforest.info/country-information, accessed 20 June

Neuvonen, M., Sievänen, T., Tönnes, S. and Koskela, T. (2007). Access to green areas and the frequency of visits – A case study in Helsinki. Urban Forestry and Urban Greening 6(4); 235–247.

NICE (Nordic Initiative, Clean and Ethical) (2009). Wool Project, http://www.nicefashion.org/en/featured-projects/Wool/index.html, accessed 28 June 2012.

Norden (2012), http://www.norden.org/en/the-nordic-region/the-nordic-countries-the-faroe-islands-greenland-and-aaland, accessed 20 June 2012.

Nordmark, M. (2008). Rovdjursturism. Naturvårdsverket Rapport 5688, http://www.naturvardsverket.se/Documents/publikationer/620-5688-3.pdf, accessed 19 April 2012.

Norman, J., Annerstedt, M., Boman, M. and Mattsson, L. (2010). Influence of outdoor recreation on self-rated human health: comparing three categories of Swedish recreationists. Scandinavian Journal of Forest Research 25(3); 234–244.

Normander, B., Levin, G., Auvinen, A-P., Bratli, H., Stabbetorp, O., Hedblom, M., Glimskär, A. and Gudmundsson, G.A. (2009). State of biodiversity in the Nordic countries. An assessment of progress towards achieving the target of halting biodiversity loss by 2010. TemaNord 2009:509.

Nytjastofnar sjávar 2010/2011 — aflahorfur 2011/2012. English summary of the State of Marine Stocks in Icelandic waters 2010/2011 – Prospects for the Quota Year 2011/2012, http://www.hafro.is/Astand/2011/35-engl-sum.PDF, accessed 13 April 2012.

O'Connor, S., Campbell, R., Cortez, H., and Knowles, T., (2009), Whale Watching Worldwide: tourism numbers, expenditures and expanding economic benefits: a special report from the International Fund for Animal Welfare. Yarmouth MA, USA, prepared by Economists at Large, http://cdm266901.cdmhost.com/cdm/singleitem/collection/p266901coll4/id/2891/rec/1 , accessed 19 April 2012.

Odden, A. (2008). Hva skjer med norsk friluftsliv? En Studie av utviklingstrekk i norsk friluftsliv 1970–2004. Trondheim, NTNU.

OECD (2005). Environmentally Harmful Subsidies: Challenges for Reform. OECD, Paris.

OECD (2006). Financial support to Fisheries: Implications for Sustainable Development. OECD, Paris.

Östman, Ö., Ekbom, B. and Bengtsson, J. (2003). Yield increase attributable to aphid predation by ground-living polyphagous natural enemies in spring barley in Sweden. Ecological Economics 45(3); 149–158.

Paassilta M, Moisio S, Jaakola L and Häggman H. (2009). Voice of the Nordic wild berry industry: a survey among the companies. Oulu University Press, Oulu.

Paisley, L. G., Ariel, E., Lyngstad, T., Jónsson, G., Vennerström, P., Hellström, A. and Østergaard, P. (2010). An Overview of Aquaculture in the Nordic countries. Journal of the World Aquaculture Society 41(1); 1–17.

Pakonen, M., Tolonen, A. Laine, K. and Hohtola, A. (2003). Ruusujuuren (Rhodiola rosea L.) vaikuttavista aineista ja niiden analysoinnista. In: Adaptogeenikasvien viljelytutkimus ja käyttö Suomessa : Ruusujuuriseminaari, Mikkeli 18.6.2002 / Galambosi, Bertalan (toim.). Maa- ja elintarviketalous 37; 26–32, http://www.mtt.fi/met/pdf/met37.pdf, accessed 20 June 2012.

Pascual, U., Murandian, R., Brander, L., Gomez-Baggethun, E., Martin-Lopez, B., Verma, M., Armsworth, P., Christie, M., Cornelissen, H., Eppink, F., Farley, J., Loomis, J., Pearson, L., Perrings and C. and Polasky, S. (2010). The Economics of Valuing Ecosystem Services and Biodiversity. The Economics of Ecosystems and Biodiversity (TEEB) Ecological and Economic Foundations. Edited by Pushpam Kumar. Earthscan, London and Washington.

Pimm, S. L., Russell, G. L., Gittleman, J. L. and Brooks, T. M. (1995). The future of biodiversity. Science 269; 347–350.

Polar Moos (2012), http://www.polar-moos.fi/website/index.html, accessed 19 April 2012.

Polasky, S.A. and Segerson, K. (2009). Integrating Ecology and Economics in the Study of Ecosystem Services: Some Lessons Learned. Annual Review of Resource Economics 1; 409–434, http://www.annualreviews.org/doi/abs/10.1146/annurev.resource.050708.144110, accessed18 June 2012.

Porter, J., Costanza, R., Sandhu, H., Sigsgaard L. and Wratten S. (2009). The Value of Producing Food, Energy, and Ecosystem Services within an Agro-Ecosystem, Ambio 38 (4); 186–193, http://www.uvm.edu/giee/publications/Porter%20et%20al.%20Ambio%202009.pdf, accessed 23/04/2012.

Potts, S.G., Roberts, S.P. M., Dean, R., Marris, G., Brown, M. A., Jones, R., Neumann, P. and Settele J. (2010). Declines of managed honey bees and beekeepers in Europe. Journal of Apicultural Research 49(1); 15–22.

Powell, G.W. (2010). Northern Agroforestry and Non-timber Forest Resource Opportunities, http://www.agforinsight.com/?p=257, accessed 21 May 2012.

Primmer, E. and Furman, E. (2012) Operationalising Ecosystem Service Approaches for Governance: Do Measuring, Mapping and Valuing Integrate Sector-Specific Knowledge Systems? (in prep.)

Proposal for Sweden's National Implementation Plan for the Baltic Sea Action Plan (2010). Ministry of the Environment, Sweden, http://www.sweden.gov.se/content/1/c6/14/59/85/8406e2b4.pdf, accessed 28 June 2012.

Pylvänäinen, M. (2010). Nordic Nature – Trends towards 2010. Nordic Council of Ministers. TemaNord 2010: 509.

Pöyry, J., Heliölä, J., Ryttäri, T. and Alanen A. (2004). Perinnebiotoobbien lajiston uhanalaistuminen; 220–223. In: Tiainen, J., Kuussaari, M., Laurila, I. and Toivonen, T. (2004). Elämää pellossa. Suomen maatalousympäristön monimuotoisuus. Edita Publishing, Helsinki.

Rahbek Pedersen, T. (2009a). Honungsbinas ekonomiska betydelse i Sverige – honungsproduktion och pollinering av grödor In: Rahbek, P., Bommarco, R., Ebbersten, K., Falk, A., Fries, I., Kristiansen, P., Kryger, P., Nätterlund, H. and Rundlöf, M. (2009). Massdöd av bin – samhällsekonomiska konsekvenser och möjliga åtgärder. Jordbruksverket Rapport 2009:24.

Rahbek Pedersen, T. (2009b). Massdöd av bin – beskrivning, historik och internationellt samarbete. In: Rahbek, P., Bommarco, R., Ebbersten, K., Falk, A., Fries, I., Kristiansen, P., Kryger, P., Nätterlund, H. and Rundlöf, M. (2009). Massdöd av bin – samhällsekonomiska konsekvenser och möjliga åtgärder. Jordbruksverket Rapport 2009:24.

Rappe, R., Kivela, S. and Rita, H. (2006). Visiting Outdoor Green Environments Positively Impacts Self-rated Health among Older People in Long-term Care. HortTechnology 16(1); 55–59.

Rassi, P., Alanen, A., Kanerva, T. and Mannerkoski, I. (2001). Suomen lajien uhanalaisuus 2000. Ympäristöministeriö and Suomen ympäristökeskus, Helsinki.

ReNo (2012), http://www.reno.is, accessed 28 June 2012.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S., III, Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L. , Corell, R.W., Fabry, V.J., Hansen, J. , Walker, B., Liverman, D., Richardson, K., Crutzen, P., and Foley, J.A. (2009). A safe operating space for humanity. Nature, 461; 472–475.

RKTL (2012). Tilastot (Kalastus, metsästy, vesiviljely) http://www.rktl.fi/tilastot , accessed 30 March–20 April 2012.

Romild, U., Fredman, P. and Wolf-Watz, D. (2011). Socio-economic Determinants, Demand and Constraints to Outdoor Recreation Participation in Sweden. Forskningsprogrammet Friluftliv i förändring, rapport 16, http://www.friluftsforskning.se/download/18.4f5ca4ea12e21490b6e80006408/Fif+rapport+nr+16.pdf, accessed 9 March 2012.

Rumjantseva, L. (2002). Luontaislääkinnän käsikirja. WSOY, Helsinki.

Ruokatieto (2012), http://uutiset.ruokatieto.fi/WebRoot/1043198/X_Arkistoitu_uutinen_tai_tiedote.aspx?id=1094008andNewsItem=1587, accessed 21 June 2012.

Saastamoinen O, Kangas K, and Aho H. (2000). The picking of wild berries in Finland in 1997 and 1998. Scandinavian Jornal of Forest Research 15; 645–650.

Saarni, K., Setälä, J., Aikio, L., Kemppainen, J. and Honkanen, A. (2007). The market of reindeer meat in Finland: Scarce resource – high-valued products, Rangifer Report 12; 79–83, The 14th Nordic Conference on Reindeer and Reindeer Husbandry Research Vantaa, Finland, http://septentrio.uit.no/index.php/rangifer/article/viewFile/273/256, accessed 28 June 2012.

Stigsdotter, U. and Grahn, P. (2003). Experiencing a Garden: A Healing Garden for People Suffering from Burnout Diseases. Journal of Therapeutic Horticulture 14; 38–48.

Salo, K. (2005). Keräilytuotteet. In Rantala, S. Metsäkoulu: 205–216. Karisto Oy.

Samnegård, U., Persson, A. S. and Smith, H. G. (2011). Gardens benefit bees and enhance pollination in intensively managed farmland. Biological Conservation 144; 2602–2606.

San-Miguel-Ayanz, J., Ståhl, G., Vidal, C., Bonhomme, C., Cienciala, E., Korhonen, K., Lanz, A. and Schadauer, K. (2011). Criterion 1: Maintenance and Appropriate Enhancement of Forest Resources and their Contribution to Global Carbon Cycles State of Europe's forests 2011. Status and Trends in Sustainable Forest Management in Europe. FOREST EUROPE, UNECE and FAO.

Sandstöm, M. (1996). Recreational benefits from improved water quality: A random utility model of Swedish seaside recreation. Working Paper 121, Working Paper Series in Economics and Finance. Stockholm School of Economics, http://siti.feem.it/gnee/pap-abs/sandstro.pdf , accessed 19 April 2012.

Sav[tm] (2012), http://sav.se/en/sav/, accessed 28 June 2012.

Scarlat, N., Dallemand, J-F., Skjelhaugenb,O. D., Asplund, D. and Nesheim, L. (2011). An overview of the biomass resource potential of Norway for bioenergy use. Renewable and Sustainable Energy Reviews 15(7); 3388–3398.

Scheper, T., Ulber, R. and Sell, R. (2007a). White Biotechnology, Advances in biochemical engineering/biotechnology 105; 117–118, Springer-Verlag Berlin Heidelberg, http://books.google.fi/books?id=_tXoG93OWHgCandpg=PA13andlpg=PA13anddq=pekilo+processandsource=blandots=AD32CRY-Gzandsig=qu1ML3C-vQ-wm1VcwlJraViDqkIandhl=fiandsa=Xandei=s9OXT8vZCM3DtAbh5smoAQandredir_esc=y#v=onepageandq=pekilo%20processandf=false, accessed 25 April 2012.

Scheper, T., Ulber, R. and Sell, R. (2007b). White Biotechnology, Advances in biochemical engineering/biotechnology 105;13, Springer-Verlag Berlin Heidelberg, http://books.google.fi/books?id=_tXoG93OWHgCandpg=PA13andlpg=PA13anddq=pekilo+processandsource=blandots=AD32CRY-Gzandsig=qu1ML3C-vQ-wm1VcwlJraViDqkIandhl=fiandsa=Xandei=s9OXT8vZCM3DtAbh5smoAQandredir_esc=y#v=onepageandq=pekilo%20processandf=false, accessed 25 April 2012.

Schipperijn J., Ekholm, O., Stigsdotter, U. K., Toftager, M., Bentsen, P., Kamper-Jørgensen, F. and Randrup, T. B. (2010). Factors influencing the use of greenspace: Results from a Danish national representative survey. Landscape and Urban Planning 95(3); 130–137.

Schuck, A. (2006).Forest Resources in Finland, Iceland, Norway, Sweden and the United Kingdom – a Background Note. Working Papers of the Finnish Forest Research Institute 38: 7–13. http://www.metla.fi/julkaisut/workingpapers/2006/mwp038-01.pdf, accessed in 20 August 2012.

Sievänen, T. and Neuvonen, M. (2010). Luonnon virkistyskäytön kysyntä 2010 ja kysynnän muutos. Luonnon virkistyskäyttö 2010. Metlan työraportteja 212, http://www.metla.fi/julkaisut/workingpapers/2011/mwp212.htm. Accessed 9 March 2012.

Sievänen, T., Arnberger, A., Dehez, J., Grant, N., Jensen, F.S. and Skov-Petersen, H. (2008). Forest Recreation Monitoring – a European Perspective. Working Papers of the Finnish Forest Research Institute.

Sievänen, T., Pouta, E. and Neuvonen, M. (2007). Recreational home users – Potential clients for countryside tourism? Scandinavian Journal of Hospitality and Tourism 7(3); 223-242.

Sigsgaard, L. (2006). Biological control of arthropod pests in outdoor crops – the new challenge; 153–169. In: Stengård Hansen, L., Enkegaard, A., Steenberg, T., Ravnskov, S. and Larsen, J. (2006). Implementation of Biocontrol in Practice in Temperate Regions – Present and Near Future. Proceedings of the International Workshop at Research Centre Flakkebjerg, Denmark. DIAS report Plant Production 119. Danish ministry of Food, Agriculture and Fisheries, Danish Institute of Agricultural Sciences.

Sigursteinsdóttir, H. and Bjarnadóttir, E.J. (2010). Social sustainability of hunting tourism in Iceland. In: A.Matilainen and S. Keskinarkaus (2010). The social sustainability of hunting tourism in Northern Europe; 9–28. Ruralia Institute, University of Helsinki.

Sjöberg, P. (2007). Taxation of Pesticides and Fertilizers. Department of Business Administration and Social Sciences, Luleå University of Technology, http://epubl.ltu.se/1404-5508/2005/101/LTU-SHU-EX-05101-SE.pdf, accessed 18 June 2012.

Skjelvik, J.M., Bruvoll A. and Ibenholt K. (2011). Greening the economy: Nordic experiences and challenges, Nordic Council of Ministers, TemaNord 2011:532; 48.

Skov og Natur i tal (2009). Miljøministeriet, Skov- og Naturstyrelsen, http://www.naturstyrelsen.dk/NR/rdonlyres/15C98339-AD4E-4BC3-98F3-B0026319FD5C/0/SNtal09.pdf, accessed 9 March 2012.

Skyn Iceland (2012), http://www.skyniceland.com/, accessed 5 April 2012.

Staub C., Ott W., Heusi, F. Klingler, G., Jenny, A., Häcki, M., and Hauser, A. (2011) Indicators for Ecosystem Goods and Services: Framework, methodology and recommendations for a welfare-related environmental reporting. Federal Office for the Environment, Bern. Environmental studies no. 1102, 17 p. http://www.bafu.admin.ch/publikationen/publikation/01587/index.html?lang=en , accessed 20 August 2012.

Sveinsson, J. (unknown) Real Eiderdown – an expert article about eiderdown. http://eiderdown.com/files/eider_article.pdf, accessed at 20 July 2012.

Söderman, G. (1999). Diversity of pollinator communities in Eastern Fennoscandia and Eastern Baltics: results from pilot monitoring with yellow traps in 1997–1998. Helsinki: Finnish Environment Institute, 1999. The Finnish Environment; 355. Suomen ympäristö, ISSN 1238-7312; 355.

Söderqvist, T. and Scharin H. (2000). The regional willingness to pay for reduced eutrophication in the Stockholm archipelago. Beijer Discussion Papers Series 128. The Beijer International Institute of Ecological Economics, The Royal Swedish Academy of Sciences, Stockholm, http://www.beijer.kva.se/PDF/22897416_artdisc128.pdf, accessed 19 April 2012.

Sojtaric, M. (2012). Bacteria that eat greenhouse gases, Science Nordic, http://sciencenordic.com/bacteria-eat-greenhouse-gases, accessed 28 June 2012.

Soutukorva, Å. (2001). The value of improved water quality – A random utility model of recreation in the Stockholm archipelago. Beijer Discussion Papers Series 135, The Beijer International Institute of Ecological Economics, The Royal Swedish Academy of Sciences, Stockholm, http://www-sekon.slu.se/~bkr/ulv01soutokorva.pdf , accessed 19 April 2012.

Špokas, L. and Steponavičius, D. (2006). Optimization of operating parameters og the threshing unit at spelt wheat harvesting, Eletronic journal paper of Polish Agricultural Universities, 9(3–17), http://www.ejpau.media.pl/volume9/issue3/art-17.html , accessed 28 June 2012.

State of Europe's forests (2011). Status and Trends in Sustainable Forest Management in Europe. FOREST EUROPE, UNECE and FAO 2011.

Statistics Denmark (2012). National statistics (agriculture and fisheries, tourism) http://www.statbank.dk/statbank5a/default.asp?w=1280 , accessed 14 March–19 June 2012.

Statistics Finland (2012). Accommodation statistics, http://www.stat.fi/til/matk/index_en.html, accessed 30 March 2012.

Statistics Greenland (2012). Catch and fisheries statistics, http://www.stat.gl/dialog/main.asp?lang=enandtheme=Catchandlink=FJ and http://www.stat.gl/dialog/main.asp?lang=enandtheme=Fisheriesandlink=FI, accessed 30 March–20 April 2012.

Statistics Iceland (2012). National statistics (fisheries and agriculture, protected areas, tourism, transport and information technology, wages, income and labour market), http://www.statice.is/, accessed 13 March–9 May 2012.

Statistics Norway (2012). National statistics (fishing and fish farming, protected areas, farming, hunting and angling, tourism, leisure) http://www.ssb.no/english/, accessed 9 March–14 June 2012.

Statistics Sweden (2009). Leisure Activities 2006–07. Living Conditions, Report no 118, http://www.scb.se/statistik/_publikationer/LE0101_2006I07_BR_LE118BR0901.pdf , accessed 9. March 2012.

Statistics Sweden (2012a). Protected nature 2011, http://www.ssd.scb.se/databaser/makro/produkt.asp?lang=2&produktid=MI0603 , accessed 19 July 2012.

Statistics Sweden (2012b). Vattenbruk / Aquaculture in Sweden 2010, http://www.scb.se/Statistik/JO/JO1201/2010A01/JO1201_2010A01_SM_JO60SM1101.pdf, accessed 20 April 2012.

Statistics Sweden (2012c). Saltsjöfiskets fångster under december 2011 och hela år 2011, http://www.havochvatten.se/download/18.64f5b3211343cffddb2800021461/JO50SM1202.pdf , accessed 20 April 2012.

Stolton, S., Maxted, N., Ford-Lloyd, B., Kell, S. and Dudley, N. (2006) Food Stores: Using Protected Areas to Secure Crop Genetic Diversity. WWF, Equilibrium Research and the University of Birmingham, UK. http://awsassets.panda.org/downloads/food_stores.pdf, accessed 20 July 2012.

Sumalia, U. R. and Pauly, D. (2007). Catching More Bait: A Bottom-up Re-estimation of Global Fisheries Subsidies. Fisheries Centre Research Reports, 14 (6), University of British Columbia, Vancouver, http://www.fisheries.ubc.ca/publications/catching-more-bait-bottom-re-estimation-global-fisheries-subsidies, accessed 25 April 2012.

Suomen Riistakeskus (2012). Metsästys suomessa, http://www.nordichunters.org/media/Brochure.pdf, accessed 30 March 2012.

Svenska Jägarförbundet (2012), http://www.jagareforbundet.se/Viltet/ViltVetande/Artpresentationer/Alg/, accessed 30 March 2012.

Thiere, G., Milenkovski, S., Lindgren, P-E., Sahlén, G., Berglund, O. and Weisner, S. E. B. (2009). Wetland creation in agricultural landscapes: Biodiversity benefits on local and regional scales. Biological Conservation 142; 964–973.

Svensson, M., Jansson, P.-E. and Berggren Kleja, D. (2008). Modelling soil C sequestration in spruce forest ecosystems along a Swedish transect based on current conditions. Biogeochemistry 89; 95–119.

Swedish Board of Agriculture (2012a). Sveriges officiella statistik – Statististka meddelanden – Trädgårdsproduktion 2008, http://www.sjv.se/webdav/files/SJV/Amnesomraden/Statistik,%20fakta/Tradgardsodling/JO33/JO33SM0901_korrigerad/JO33SM0901_tabeller4.htm, accessed 14 March 2012.

Swedish Board of Agriculture (2012b). Available at internet: http://statistik.sjv.se/Database/Jordbruksverket/Markanvandning/Markanvandning.asp, accessed 14 March 2012.

Swedish Board of Fisheries (2008). Economic Information Concerning Fisheries. Naturvårdsverkets report 5879, http://www.naturvardsverket.se/Documents/publikationer/978-91-620-5879-1.pdf, accessed 20 April 2012.

SWESAP (unknown), Sweden, http://birchsap.se/, accessed 21 May 2012.

Syversen, N. (2005). Effect and design of buffer zones in the Nordic climate: The influence of width, amount of surface runoff, seasonal variation and vegetation type on retention efficiency for nutrient and particle runoff. Ecological Engineering 24(5);483–490.

TEEB (2009). TEEB for National and International Policy Makers. Summary: Responding to the Value of Nature. http://www.teebweb.org/Portals/25/Documents/TEEB%20for%20National%20Policy%20Makers/TEEB%20for%20Policy%20exec%20English.pdf, accessed 19 July 2012.

TEEB (2010). The Economic of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB. http://www.teebweb.org/Portals/25/TEEB%20Synthesis/TEEB_SynthReport_09_2010_online.pdf, accessed 19 July 2012

Ten Brink, P., Lutchman, I., Bassi, S., Speck, S., Sheavly, S., Register, K. and Woolaway, C. (2009). Guidelines on the Use of Market-Based Instruments to Address the Problem of Marine Litter. Institute for European Environmental Policy (IEEP), Brussels and Sheavly Consultants, Virginia, US.

Ten Brink, P., Eijs, A., Lehmann, M., Mazza, L., Ruhweza, A., and Shine, C. (2011). Strengthening Indicators and Accounting Systems for Natural Capital. In ten Brink (ed) (2011) The Economics of Ecosystems and Biodiversity in National and International Policy Making, p.107. Earthscan, London and Washington.

Ten Brink (ed). (2011) The Economics of Ecosystems and Biodiversity in National and International Policy Making. Earthscan, London and Washington.

Ten Brink, P., Mazza, T., Badura, T. and Kettunen, M. (2012). Nature and its Role in the Transition to a Green Economy – A contribution to Rio + 20 (to be published).

The Color of Water (2012). Climate induced water color increase in Nordic lakes and streams due to humus, info1.ma.slu.se/IMA/Publikationer/brochure/The_color_of_water.pdf, accessed 18 May 2012.

The Danish Directorate of Fisheries (2011). Danish AgriFish Agence, http://webfd.fd.dk/stat/Faste%20tabeller/Landinger-1aar/tab3210x_eng.html, accessed 20 April 2012.

The Novozymes Report (2011), http://report2011.novozymes.com/Service/Download+report/The-Novozymes-Report-2011.pdf , accessed 25/04/2012.

Thorén, K.H. (2000). The green poster: a method to evaluate the sustainability of the urban green structure. Environmental impact assessment review, 20(3); 359–371, http://pdn.sciencedirect.com/science?_ob=MiamiImageURL&_cid=271832&_user=949824&_pii=S0195925500000470&_check=y&_origin=article&_zone=toolbar&_coverDate=30-Jun-2000&view=c&originContentFamily=serial&wchp=dGLzVlV-zSkzk&md5=772a8bd3900b1655411d71ee56ff2897/1-s2.0-S0195925500000470-main.pdf, accessed 28 February 2012.

Thrainsson, S. and Davidsdottir, B. (2012). Iceland – Biological Diversity, Ecosystems and Ecosystem Services. Presentation in the JRC workshop, Ispra, Italy, April 2012.

Tiilikkala K. and Segerstedt M. (2009). Koivutisle – kasvinsuojelun uusi innovaatio. Maa- ja elintarviketalous 143. Available on internet: http://www.mtt.fi/met/pdf/met143.pdf, accessed 21 June 2012.

Tillväxtverket (2012). The Swedish Agency for Economic and Regional Growth. Accommodation statistics, http://www.tillvaxtverket.se/ovrigt/englishpages/tourismindustryissuesandstatistics/accommodationstatistics.4.21099e4211fdba8c87b800017704.html, accessed 30 March 2012.

Time Magazine US (2007). Skin Care's Cold Snap. http://www.time.com/time/magazine/article/0,9171,1594125,00.html, accessed 5 April 2012.

Toivonen, A-L. (2008). Kalastusmatkailu numeroina. Riista- ja kalatalouden tutkimuskeskus. Selvityksiä 13/2008.

Toivonen A.-L., Appelblad H., Bengtsson B., Geertz-Hansen P., Gudbergsson G., Kristofersson D., Kyrkjebø H., Navrud S., Roth E., Tuunainen P. and Weissglas G. (2000). Economic Value of Recreational Fisheries in the Nordic Countries. TemaNord 604, Copenhagen: Nordic Council of Ministers.

Törrönen, R. (2006). Tutkimustietoa marjojen terveellisyydestä ja terveysvaikutuksista. Available at internet: http://www.kuopioinnovation.fi/sites/default/files/Tutkimustietoa_marjoista.pdf, accessed 29 June 2012.

Traustason, B. and Snorrason, A. (2008). Spatial distribution of forests and woodlands in Iceland in accordance with the CORINE land cover classification. Icelandic. Agricultural. Sciences. 21; 39–47.

Tschirpke, S. (2006). Horch, was die Birken flüstern. – Wald Holz 87, 4;43–44; translation by Meister, D. (2008) The production of birch sap in Finland, http://www.waldwissen.net/waldwirtschaft/nebennutzung/produkte/wsl_birkensaft/index_EN, accessed 21/05/2012

Turtiainen, M. and Nuutinen, T. (2012). Evaluation of information on wild berry and mushroom markets in European countries. Small-scale Forestry.

Turtiainen, M., Salo, K. and Saastamoinen, O. (2011). Variations of Yield and Utilisation of Bilberries (*Vaccinium myrtillus* L.) and Cowberries (*V. vitis-idaea* L.) in Finland. Silva Fennica 45(2); 237–251.

Turunen, J. (2008) Development of Finnish peatland area and carbon storage 1950–2000. Boreal Environmental Research 13: 319–334.

Tyrväinen, L. and Miettinen, A. (2000). Property prices and urban forest amenities. Journal of Environmental Economics and Management 39(2); 205–223.

Tyrväinen, L., Silvennoinen, H., Korpela, K. and Ylen, M. (2007). Luonnon merkitys kaupunkilaisille ja vaikutus psyykkiseen hyvinvointiin. Metlan työraportteja 52; 57–77.

Ulrich, R. (1984). View Through a Window May Influence Recovery from Surgery. Science 224; 420–421.

Vihervaara, P., Kumpula, T., Ruokolainen, A., Tanskanen, A. and Burkhard, B. (2012). The use of detailed biotope data for linking biodiversity with ecosystem services in Finland. International Journal of Biodiversity Science, Ecosystem Services and Management.

UNFCCC National reports (2011), http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/6598.php, accessed 23 April 2012.

UK National Ecosystem Assessment (2011). The UK National Ecosystem Assessment: Synthesis of the Key Findings. UNEP-WCMC, Cambridge, http://uknea.unep-wcmc.org/, accessed 18 June 2012

UN (United Nations) (1993). Convention on Biological Diversity, United Nations Treaty Series, 1760, I-30619, http://www.swc.gov.sa/reports/cbd-un-en.pdf, accessed 19 April 2012.

UNCSD (2012) Rio+20 declaration – "The Future We Want". http://www.uncsd2012.org/thefuturewewant.html, accessed 19 July 2012.

UNEP (2011). Towards a Green Economy – Pathways to Sustainable Development and Poverty Eradication. A Synthesis for Policy Makers, http://www.unep.org/greeneconomy/Portals/88/documents/ger/GER_synthesis_en.pdf, accessed 18 June 2012.

UNWTO (United Nations World Tourism Organization) (2009). Tourism Highlights: 2009 Edition.

UNWTO (United Nations World Tourism Organization) (2010). UNWTO Annual Report,A Year of Recovery 2010.

Uusiutuva metsäteollisuus (2012), http://www.oske.net/fifcluster/?x128366=143218, accessed 21 June 2012.

Vatn, A., Barton, D. N., Lindhjem, H., Movik, S., Ring, I. and Santos, R. (2012) Can markets protect biodiversity? An evaluation of different financial mechanisms. Noragric Report No. 60. http://www.umb.no/statisk/noragric/publications/reports/2011_nor_rep_60.pdf, accessed 31 August 2012.

Vatns, S. (2009). The sheep industry in the Nordic Countries, Small Ruminant Research 86(1–3); 90–83, http://www.sciencedirect.com/science/article/pii/S0921448809001813, accessed 28 June 2012

Vesterinen, J., Pouta, E., Huhtala, A. and Neuvonen, M. (2010). Impacts of changes in water quality on recreation behavior and benefits in Finland, Journal of Environmental Management 91; 984–994, http://www.metla.fi/metinfo/monikaytto/lvvi/julkaisut/Vesterinen_2010.pdf , accessed 19 April 2012.

Veteläinen, M., Huldén and M. and Pehu, T. (2008). State of Plant Genetic Resources for Food and Agriculture in Finland, Second Finnish National Report, FAO, http://www.fao.org/docrep/013/i1500e/Finland.pdf, accessed 28 June 2012.

Vihervaara, P., Kumpula, T., Ruokolainen, A., Tanskanen, A., and Burkhard, B. (2012). The use of detailed biotope data for linking biodiversity with ecosystem services in Finland. International Journal of Biodiversity Science, Ecosystem Services and Management.

Vihervaara, P., Kumpula, T., Tanskanen A. and Burkhard, B. (2008). Ecosystem services – a new tool for land use planning. Case study of Forest Lapland, northern Finland. Ecosystem Services Case Studies. Workshop on Ecosystem Services Solution for problems or a problem that needs solutions, Salzau, Germany, http://openlandscapes.zalf.de/openlandscapeswiki_glossaries/ Session%20G%20-%20Case%20studies%20on%20ecosystem%20services.aspx, accessed 20 June 2012.

Virkkala, R. and Rajasärkkä, A. (2011). Climate change affects populations of northern birds in boreal protected areas. Biol. Lett. 7(3); 395–398.

Walker B. (1995). Conserving biological diversity through ecosystem resilience. Conservation Biology 9; 747–52.

Wallace, K.J. (2007). Classification of ecosystem services: Problems and solutions. Biological Conservation 139; 235–246.

WAVES (2012) Wealth Accounting and the Valuation of Ecosystem Services (WAVES) -partnership http://www.wavespartnership.org/waves/, accessed at 20 July 2012.

White, S., ten Brink, P. and Simmons, B. (2011). Recognising the Value of Biodiversity: New Approaches to Policy Assessment. In ten Brink (ed) (2011) The Economics of Ecosystems and Biodiversity in National and International Policy Making, p.131–173. Earthscan, London and Washington

WHO (World Health Organization) 2008. Traditional medicine. Fact sheet 134. http://www.who.int/mediacentre/factsheets/fs134/en/ Williams IH 1994: The dependence of crop production within the European Union on pollination by honey bees. Agricultural Science Reviews 6; 229–257.

Wittmer, H. and Gundimeda, H. (2012) The Economics of Ecosystems and Biodiversity (TEEB) in Local and Regional Policy and Management. Earthscan, London. 384 p.

World Travel and Tourism Council 2012, http://www.wttc.org/research/ economic-data-search-tool/, accessed 21 June 2012.

Worm, B., Barbier, E.B., Beaumont, N., Duffy, J.E., Folke, C., Halpern, B.S., Jackson, J.B.C., Lotze, H.K., Micheli, F., Palumbi, S.R., Sala, E., Selkoe, K.A., Stachowicz, J.J. and Watson, R. (2006). Impacts of biodiversity loss on ocean ecosystem services, Science 314 (580); 787–790.

Wunder, S., Engel, S. and Pagiola, S. (2008). Taking stock: A comparative analysis of payment for environmental services programs in developed and developing countries. Ecological Economics, 65(4); 834–52.

Ymparisto (2012), http://www.ymparisto.fi/default.asp?node=1748andlan=fi, accessed 14 March 2012.

Yle Lappi (2009). Matsutake-innostus valtaa taas lappilaisia. Jorma Korhonen, http://yle.fi/alueet/lappi/2009/08/ matsutake-innostus_valtaa_taas_lappilaisia_950110.html, accessed 28 June 2012.

Yurova, A. Y. and Lankreijer, H. (2007). Carbon storage in the organic layers of boreal forest soils under various moisture conditions: A model study for Northern Sweden sites. Ecological Modelling 204:3–4; 475–484.

Zandersen, M., Grønvik Bråten K. and Lindhjem H. (2009a). Payment for and Management of Ecosystem Services – Issues and Options in the Nordic Context Payment for and Management of Ecosystem Services. Nordic Council of Ministers, Copenhagen, Denmark; 76, http://www.norden.org/fi/julkaisut/julkaisut/2009-571, accessed 08 March 2012.

Zandersen, M., Grønvik Bråten K. and Lindhjem H. (2009b). Payment for and Management of Ecosystem Services – Issues and Options in the Nordic Context Payment for and Management of Ecosystem Services. Nordic Council of Ministers, Copenhagen, Denmark; 65, http://www.norden.org/fi/julkaisut/julkaisut/2009-571, accessed 08 March 2012.

Data sources

EEA: Nationally designated areas (National – CDDA), http://www.eea.europa.eu/data-and-maps/data/nationally-designated-areas-national-cdda-5

European Commission, Joint Research Centre, Institute for Environment and Sustainability, http://eusoils.jrc.ec.europa.eu/library/esdac/Esdac_DetailData2.cfm?id=6

Nordregio Nordic Centre for Spatial Development, http://www.nordregio.se/en/Maps--Graphs/01-Population-and-demography/Population-density-in-2011/

EEA:Corine Land Cover 2006 raster data – version 16 (04/2012), http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2006-raster-2

EEA: Elevation map of Europe, http://www.eea.europa.eu/data-and-maps/data/digital-elevation-model-of-europe

16. Annex I Economic valuation: approaches and methods

In general, several of the socio-economic values related to nature can be assessed in terms of *economic valuation*. In this context the different values are expressed and estimated as socio-economically driven decisions and trade-offs individuals are willing to make, usually expressed in monetary terms (e.g. Polasky and Segerson 2009). In the context of valuating nature, the economic value of ecosystems is based on the marginal changes in the provisioning of ecosystem services resulting from policy action – or inaction – and how people value these changes for their own well-being. In addition to the marginal changes, it is also possible to try assessing the overall and/or absolute economic values of ecosystems in a given moment (e.g. estimating the economic value of all world's ecosystems). However, such attempts are generally considered rather of little or no practical use beyond awareness raising as most decisions facing policy makers, business and people are about marginal changes, not about absolute values of whole ecosystems. Furthermore, there are methodological problems with assessing the total economic value of ecosystems given these estimates would have to build on marginal values that are only appropriate in a specific context. Finally, it is crucial to recognise that economic valuation, in particular in monetary terms, is only one of the tools to assess value ecosystem services. There are several dimensions of human well-being that cannot – or indeed should not - be expressed in monetary terms including good social relations, freedom of choice and action and the intrinsic value of nature (Figure below) (Kumar 2010).

There are *two alternative and well-differentiated approaches for economic valuation* of ecosystems services (Pascual et al. 2010). The *preference-based valuation methods* rely on the assumption that values are formed on the basis of individual preferences and their expressions either through actual or fictional market situations. Crucially, preference-based valuation techniques also assume that values associated with ecosystems services are commensurable in monetary terms, which in turn allows expressing the trade-offs between different uses of ecosystems (e.g. in form of cost-benefit analysis). On the other hand, *biophysical val-*

uation methods use "cost of production" approach, based on the measurement of the underlying physical parameters of objects in question. In other words, this approach considers the physical costs of maintaining a given ecological state (e.g. in terms of labour, surface requirements, energy or material inputs). In general, these two approaches are alternative – not complementary – to one another, i.e. it is not very feasible to combine or compare the results of these assessments.

In general, *the preference-based valuation methods are currently most commonly used to assess the economic value of ecosystem services*. In this context, the values associated with ecosystems are commonly divided into three distinct categories, resulting from their *direct use* by people (e.g. provision of food, water and genetic resources and use of nature for recreation) as well as their *indirect uses* (e.g. the role of nature in regulating air quality, climate patterns, and quantity and quality of water). In addition, people derive a range of *non-use values* from nature, e.g. in terms of protecting the quality and functioning of ecosystems for future generation and appreciating the existence of nature in general. The overall value of the benefits delivered by ecosystems within the preference-based valuation is commonly conceptualised through the total economic value framework (TEV) (e.g. Pascual et al. 2010, White et al. 2011). As before, TEV framework captures only the value of ecosystems from an anthropocentric viewpoint and consequently the intrinsic value of biodiversity falls outside its scope.

Three broad categories of preference-based valuation methods are commonly used to capture the economic (monetary) values embodied in ecosystems. These include direct market valuation, and revealed and stated preferences (Table below). The advantage of using direct market valuation methods (e.g. market prices or avoided cost) is these methods use data from existing markets and hence are able to reveal actual preferences and incurred costs by individuals. The associated data – namely prices, costs and quantities – are usually relatively easy to obtain. However, these methods can only be used for ecosystem services with already established markets. Consequently, market valuation methods can be useful for estimating use values (e.g. provisioning services) while they offer little help to estimate indirect and non-use values and (e.g. many regulating services). Additionally, if the already existing market is distorted, due to for example governmental subsidies, the prices in the markets do not provide reliable reflection of consumers' preferences and hence might provide misleading policy advice.

Revealed preference methods are based on directly observing the individual choices related to the ecosystem services being valued that take place in already existing markets. For instance, looking at the costs people incur (real expenditure and cost of time) by travelling to particular site it is possible to construct a demand function for and consequently estimate the value of the recreational services associated with the location (i.e. travel cost method). Similarly, statistical analysis of the house prices at different locations can be used to estimate the values people attribute to living in areas in close proximity to natural sites (i.e. hedonic pricing). However, revealed preference methods are faced with many obstacles, particularly with regards to high data and resources demands and significant reliance on the assumptions employed for the relationship between the ecosystem service and the surrogate market. Estimated monetary values obtained with stated preference techniques can also be distorted by market imperfections and policy failures.

Stated preference methods is the only category of valuation tools which can be employed to estimate both use and non-use values. In essence, these methods simulate the market demand for the good in question by conducting surveys on hypothetical changes in ecosystem services provision and consequently estimating the monetary values associated with the change. In general, they elicit people's willingness to pay (or willingness to accept) for a change associated with the provision of ecosystem service. This willingness is then aggregated over relevant population to estimate the overall value of a service. However, stated preference methods are often criticised for being too reliant on survey responses rather than observing real market decisions. Therefore, they can be used to indicate the preferences and values of different stakeholders or the broader public, not interpreted as possible concrete revenue or used as a basis for defining schemes for monetary compensation. Also, careful attention needs to be given to the design of such studies to avoid encouraging biased responses.

In addition to the above, there are also *other, more qualitative and quantitative, methods* to assess the economic value of ecosystems and their services. Depending on the context, they might provide more relevant information than conventional economic tools. They might also be employed to complement the economic valuation methods to provide a more comprehensive picture of the overall values associated with ecosystem services. These methods include, for instance, deliberative and social process methods, different qualitative and quantitative assessments or a newly developing technique of resilience valuation (e.g. see Pascual et al 2010).

To sum up, a range of approached and methods are currently being used to estimate the economic value of biodiversity and related ecosystem services, each having their advantages and disadvantages (Pascual et al 2010). There is currently a general preference for market valuation methods as they can be relatively feasible to execute compared to other types of valuations. Also, market valuations are generally considered to provide robust estimates. However, given that only some of the services are fully recognised in the markets, both *market and non-market valuation techniques, often complemented by qualitative and quantitative valuation methods, are needed to assess the overall value of benefits provided by ecosystems*. In addition, as stated above stated preferences might be very suitable for generally illustrating and communicating the importance of and values related to ecosystems and related benefits to different stakeholders and overall public (e.g. see TEEB Nordic Case Studies in Annex II). In other words, although the stated preference techniques are faced with criticism of its ability to provide a reliable estimate of the "real value" they provide a representative estimate of the values people assign to nature, which by itself is a valuable information for policy makers.

Table: Different methods used to capture the value of nature

Approach		Method
Market valuation	Price-based	Market prices
	Cost-based	Avoided cost Replacement cost Damage cost avoided
	Production-based	Production Function approach Factor Income
Revealed preference		Travel cost method Hedonic pricing
Stated preference		Contingent valuation Choice modeling / conjoint analysis

Source: Gantioler et al. 2010 adapted from Pascual et al 2010.

17. Annex II TEEB Nordic case studies

17.1 Benefits of green infrastructure – socio-economic importance of constructed urban wetlands (Nummela, Finland)

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Short title: Socio-economic benefits of constructed urban wetlands (Nummela, Finland)

Key Message: Benefits provided by ecosystem services can be successfully integrated into urban planning and management processes. Monitoring of the Nummela Gateway wetland park over a period of three years shows that constructed wetlands rapidly self-establish, resulting in an increase in biodiversity and the establishment of several ecosystem services (e.g. erosion and flood control, and reduction of pollutants in runoff water). The constructed wetland also provides a range of other benefits including opportunities for recreation and education.

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What was the problem?

Land-use changes and management practices within the Lake Enäjärvi watershed (Municipality of Vihti, Uusimaa Region, Southern Finland) have resulted in poor water quality and related adverse impacts such as increased algal blooms and fish mortality in Enäjärvi. Within the Enäjärvi watershed, a 500 hectare sub-watershed, covering 15% of the entire watershed, has been particularly affected by intense land-use, including agriculture and urban development around the Vihti suburb of Nummela. Wastewater from the Nummela suburb had been released untreated into Lake Enäjärvi until 1973 resulting in elevated lake internal nutrient loads, which are still visible today. Runoff water from the urban areas of Nummela and surrounding agricultural areas (parts of which are undergoing urbanisation) was directed into a stream that had – as a result – lost its natural character. Land-use practices within the watershed caused rain and snowmelt to be followed by flashy flows of polluted runoff water into the stream degrading the stream ecosystem. As a consequence, problems such as erosion, flooding, draught, habitat degradation and low water quality were common in the area, preventing local people from accessing and enjoying from their surrounding natural environment.

To improve the situation, the existing (unsustainable) means for the disposal of runoff water were examined at the watershed level and solutions were sought through a holistic assessment of watershed processes and dynamics. In order to make informed decisions, the quality and quantity of water released from the watershed were monitored with results indicating a direct impact of land-use practices on both water quality and flows. Based on these considerations, a decision was made to create new wetlands along the heavily degraded stream corridor. The interconnected chain of wetlands was foreseen to form an oasis for both people and wildlife at the heart of the growing suburb of Nummela, while also sustainably managing runoff water before it entered Lake Enäjärvi. A participatory planning process involving the local Keepers of Lake Enäjärvi Association (VESY ry) resulted in the municipality acquiring land along the stream and dedicating it as a "functional" zone for water protection.

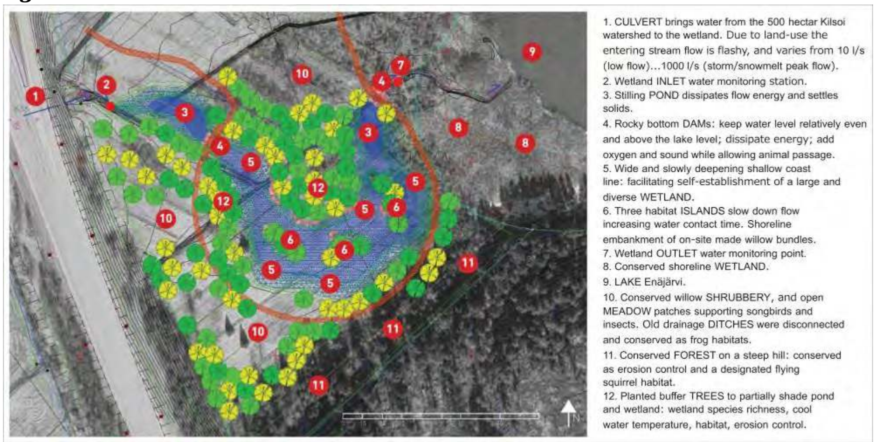
Which ecosystem services were examined? And how?

A network of wetlands (i.e. a zone for urban "green infrastructure") was established along 1.5 kilometres of the degraded stream within the suburb of Nummela including a new 2 hectare wetland park by the lake Enäjärvi, at the mouth of the stream. Several ecosystem services were integrated into the planning, design, and implementation of the zone. Vegetation in the created wetlands was largely allowed to self-establish and only native buffer trees and willow bank stabilisation bundles were planted. Participatory methods were used to integrate the needs of local people into the design, planning and implementation of the project. The stream was first restored and re-named by its old local name Kilsoi. The large wetland park at the mouth of the stream was named the Nummela Gateway Wetland Park, with reference to its function as welcoming both people and wildlife to Nummela.

Regulating services, in particular water purification, erosion control (including river bank stabilisation), regulation of water flow and mitigation of flooding, were taken into consideration when planning and implementing the establishment of wetlands. Wetlands with diverse native riparian vegetation, which support diverse associated microbes important for water purification, as well as diverse insect fauna, which is the basis for rich food webs, were established to ensure appropriate restoration of these ecosystem services. Water quality and flows were monitored to demonstrate positive impacts in practise (see below). Vegetation establishment was monitored to assess success of the chosen self-establishment implementation and as an indicator of biodiversity at the site.

The network of wetlands was also foreseen to provide a range of cultural services to the local public, including opportunities for environmental education and recreation and support to local identity. The wetland areas were made accessible to the public by establishing a network of nature trails. Information boards were created along the trail to provide visual and written information about the ecosystem services at the sites.

Figure 1



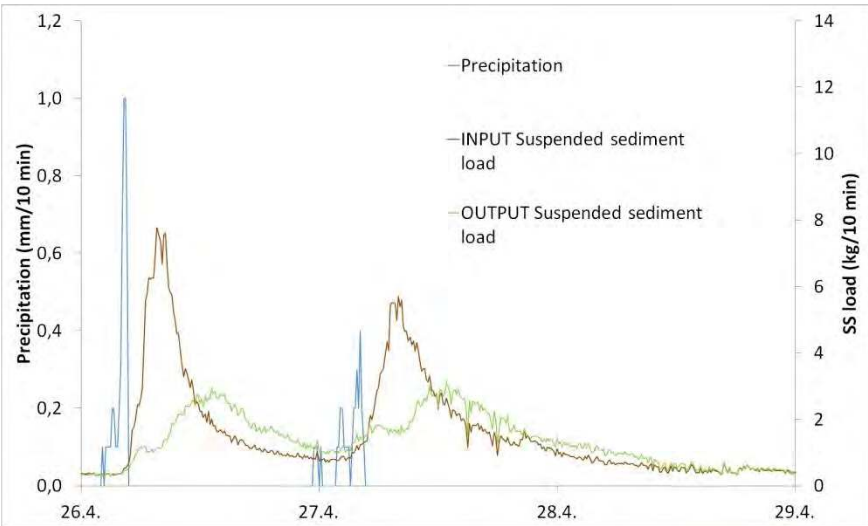
Design of the Nummela Gateway Wetland Park facilitates water purification, flood and erosion control and recreation. Environmental education boards explaining the site's ecosystem services, local flora, microbiota and fauna, are located along the nature trail. Figure by Outi Salminen.

Results

Monitoring of runoff water within Kilsoi watershed revealed clear impacts of land-use practices on water quality and flows. For example, phosphorus rich clay erosion from the tilled and un-vegetated crop fields into the lake Enäjärvi was identified as a typical problem in the area, increasing the risk of algal blooms in the lake. In addition, de-icing salts (NaCl) from urban areas were noted to wash into the stream during snowmelt events, reaching 10–20% of the salinity in the brackish Baltic Sea water. Finally, the runoff water also affected the temperature in the stream as water released from urban areas was observed to be on average circa five degrees Celcius higher than the water from other areas. This could have an impact on the species composition within the stream as cold climate fauna can be sensitive to elevated temperatures.

The success of Nummela Gateway wetland park in improving water quality has been closely monitored. The results clearly show that the constructed wetland plays a crucial role in regulating the flow of runoff water and improving water quality within the watershed (Figure 2 below). For example, monitoring for suspended solids shows that the wetland successfully reduces sediment loads to Lake Enäjärvi, even during snowmelt runoff in spring when biological activity of wetlands is low. The reduction of monitored pollutants within the wetland is higher at higher inflow concentrations. The annual monitoring also indicates that the overall capacity of the wetland to improve water quality increases each year as the vegetation coverage increases and matures. Weather conditions throughout the (hydrological) year impact the wetland clean up capacity during snowmelt. For example, heavy and eroding rain events in early winter may saturate the wetland sediment holding surface, resulting in a lower sediment trapping capacity during snowmelt.

Figure 2



Nummela Gateway Wetland Park reduces the entrance of pollutants such as phosphorus rich clay particles into the Lake Enäjärvi. Monitoring data from late April 2012 (above) show two peaks of suspended sediments following two rain events. In both cases the wetland reduced sediment load into the lake (by 24 and 12%, respectively). During the monitoring period snow had already thawed however the wetland vegetation was still largely dormant. Observed pollutant reductions depend on season, inflow concentration, characteristics of the preceding hydrological events (both recent and over the ongoing hydrological year) as well as design and maturity of the constructed wetland. Graph by Pasi Valkama.

Vegetation was allowed to self-establish with the vegetative succession being monitored on an annual basis (see Figure 3). The monitoring showed a clear increase in plant species numbers on monitored plots: from 57 herbaceous species in the first growing season to 80 species in the second growing season (July 2010 and 2011 respectively). In 2012, the results of monitoring showed that vegetative succession, including competition over light, had commenced resulting in some changes in the species composition at the site: 7 new species had established while 13 species identified in 2011 had disappeared. The wetlands have also become a habitat for threathened frog species and several bird species (e.g. mallard, goldeneye, teal, nightingale and willow warbler). Both the coverage and biomass of vegetation show an annual increase and no invasive species have been found.

Figure 3

A monitored vegetation plot (size 0.5 m^2) in the Nummela Gateway Wetland Park in July 2010, 2011, and 2012. Vegetation self-establishment was rapid and vigorous with all native species. A monitored vegetation plot in the Nummela Gateway Wetland Park in July 2010, 2011, and 2012. Species number, coverage and biomass increased each year. Pictures: Outi Salminen and Eeva Vaahtera.

In terms of cost-effectiveness, it was estimated that the costs of enhancing the existing stream corridor and establishing the wetland park were significantly less than the costs of constructing pipe and culvert storm / runoff water drainage systems. The implementation costs of restoring 250 meters of the most severely eroded and altered Kilsoi stream into an open and vegetated stream corridor amounted to 25,000 EUR (total) whereas the estimated costs of conventional conveyance culverts (i.e. pipes allowing continuous flow of runoff water underground) would have been 125,000 EUR (50,000 EUR per 100 meters) at the clayey site. Similarly, the total costs of establishing Nummela Gateway Wetland Park were 62,000 EUR for 2 hectare of park area (including the construction of 1 hectare of inundated area, nature trail, and 125 planted native trees). The estimated costs of a conventional park were 100 EUR / m^2 (i.e. amounting to several hundred thousands of EUR for 2 ha area). Also, no re-planting of implemented vegetation – which is typically essential for urban parks after the first two years – was necessary, making the one-off costs of the wetland park a cheaper option. Also, the maintenance costs of the wetland park are foreseen to be minimal, including upkeep of the nature trail (annual), and maintenance of wetland meadows and sediment trapping pool (every five to ten years).

What policy uptake resulted / is foreseen to result from examining the ecosystem services?

As a result of wetland creation and the establishment of several ecosystem services (e.g. water purification, recreation and support to local identity) the Kilsoi stream corridor and related Nummela Gateway park have become valued assets within Nummela. In particular, restoring and constructing stream / wetland ecosystems has been found to be a cost-effective means to manage urban runoff water. In addition, the steam corridor and wetland park have created a locally important "multi-purpose" area for both biodiversity and people. Consequently, development of urban green infrastructure in Nummela is foreseen to continue. Further plans for constructing a continuous buffer wetland park along the stream corridor already integrated into Municipality's land-use plans. In addition, in 2012–2017 the urban landscape in Nummela area will continue to be developed based on further identification of its ecosystem services and combining landscape design and management with environmental protection under the EU LIFE+ project "Urban Oases" (ENV/FIN911). This includes, for example, the development of indicators for the status and quality of water, climate, flora and fauna in the area.

Lessons learned

Benefits provided by ecosystem services can form an integral part of sustainable urban development and functional landscapes providing ecosystem services can be successfully integrated into urban planning and management processes. This case study shows that, when well-planned and carefully implemented, flood mitigation and improvement of water quality through sustainable landscaping can be more cost-effective than technical solutions. In addition, they can provide a range of recreational, educational and cultural benefits. At the same time, the establishment of green infrastructure for ecosystem services can support the creation of connected ecological networks with benefits to biodiversity. This case study also shows how investment in monitoring is needed to support fully informed decisions. It also demonstrates how monitoring helps to verify the outcomes of wetland restoration, this way increasing political and public support.

Participatory approaches and engagement of stakeholders in the design and implementation of the process were found beneficial to long-term success. Collaboration between environmental, planning and technical authorities has been crucial. In addition, the local association for water protection (VESY ry) has been an active partner in the project supporting several voluntary actions. The Uusimaa Centre for Economic Development, Transport and the Environment (UUDELY) has participated in project management and monitoring from the beginning, providing guidance and support at the regional level. Appropriate technical expertise (e.g. sustainable landscape design and monitoring) has been secured by involving experts from the University of Helsinki, Luode Consulting Oy, UUDELY, and Water Protection

Association of the River Vantaa and Helsinki Region. Finally, the Finnish Association for Nature Conservation (SLL) has supported communication and environmental education activities.

Figure 4

Design and implementation of the Nummela Gateway Wetland Park was carried out in a participatory manner, taking into account ecosystem services. The outcome is a diverse and dynamic landscape which provides a rich habitat for local species and a valued oasis for local urban dwellers. Pictures: Outi Salminen.

References

Salminen. O., 2010, Constructed landscapes protect the Lake Enäjärvi in Vihti, Ympäristö (3), p. 28–31

Vaahtera, E., 2012, Vegetation self-establishment in a constructed urban wetland – a case study of Nummela Gateway Wetland Park. Master´s thesis, University of Helsinki, Forest Sciences

Acknowledgements[23]

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17.2 Estimating economic benefits of protected areas in Finland – making a case for continued public investment

Compiled by: *Liisa Kajala* (liisa.kajala@metsa.fi)

*Short title***:** Local economic impacts of protected areas

Key Message: The Finnish Forest Research Institute (Metla) and Metsähallitus – Natural Heritage Services have in co-operation assessed the local economic benefits of national parks and other protected areas in Finland. According to the assessment 1 EUR investment in national parks and other key protected areas results in 10 EUR return to local economies. The assessment was one of the key factors that convinced decision-makers that the public investment in protected areas pays back manifold. In the end, planned budget cuts to park management were not implemented and a monitoring of the local impact of visitor's spending was integrated into the visitor information database (ASTA) following nationally standardised methods.

Reviewer: Marianne Kettunen (IEEP), Jannica Pitkänen-Brunnsberg (Metsähallitus – Natural Heritage Services) and Johannes Förster (UFZ)

Suggested citation: Kajala, L. (2012) TEEB Nordic case: Estimating local economic benefits of visitors' spending in protected areas. In Kettunen et al. Socio-economic importance of ecosystem services in the Nordic Countries – Scoping assessment in the context of The Economics of Ecosystems and Biodiversity (TEEB). Nordic Council of Ministers, Copenhagen. Available also at: www.TEEBweb.org

What is/was the problem?

Protected areas provide multiple socio-economic benefits. However, these benefits are often not assessed and remain unappreciated by decision-makers and the wider public alike. Therefore using public funding to maintain protected areas is often of low priority. Consequently, information about the socio-economic benefits of protected areas, such as streams of revenue to local economies from recreation and tourism, can provide valuable support to maintaining and managing these areas.

In Finland, Metsähallitus – Natural Heritage Services is responsible for managing all national parks and other state owned protected areas with funds from the state budget. The demand for information on the socio-economic benefits of protected areas is obvious: in addition to monitoring the effectiveness of management for conserving biodiversity many politicians, local decision-makers and funders are also requesting information on the economic impacts of protection. While all socio-economic values related to protected areas cannot be assessed in monetary terms (eg cultural values), a certain fraction of the use-related values can be captured by estimating the economic impacts of people's visits to the parks, ie how the money spent by visitors is "streamed into" and accumulates in the local economy.

In addition to highlighting the benefits of public investment, understanding the economic impacts of visitor spending can also be used to increase general acceptance of national parks among stakeholders. It also forms a useful basis for planning area's socio-economic development, eg establishing new businesses in the area. Comparing economic benefits between different parks may also provide useful insights into certain success factors that can be replicated elsewhere.

Which ecosystem services were examined and how?

In order to estimate the socio-economic benefits of national parks and other key state-owned protected areas in Finland, Metsähallitus and the Finnish Forest Research Institute (Metla) developed a standardised, easy-to-use method for assessing the local, accumulative economic impacts of visits to parks (Huhtala et al. 2010). In terms of ecosystem services this method focuses on quantifying the economic benefits associated with nature-based recreation and tourism in Finnish national parks, including activities such as hiking, skiing, fishing and camping.

The method builds on the U.S. Money Generation Model 2 (MGM2, Stynes et al. 2000) and it bases the calculations on three key variables: number of visits, visitors' spending, and a set of multipliers that reflect how visitor spending circulates and multiplies in the local economy. In 2010 the method was integrated into the national visitor information database (ASTA) of Metsähallitus, originally developed to estimate the recreational demand in national parks and other protected / recreational areas. This integrated application now allows estimating visitor spending related benefits for each key protected area on an annual basis.

The basic requirement for estimating economic impacts is a comprehensive, standardised visitor monitoring system, including both visitor logs and surveys. Metsähallitus has such a system already in place (Kajala et al. 2007). Even though establishing and maintaining such a comprehensive visitor monitoring system requires significant investment in both time and resources this investment can generate high and diverse returns.

Results

According to the statistics, in 2011 the Finnish national parks and other key protected areas were visited around three million times. The estimated benefits of these visits to local economies ranged between 0.1–30.6 million EUR / year / park, generating an estimated 1–400 man-years of employment. When summing up the benefits at national level, the support of national parks (altogether 37 areas) to local economies amounts to 108.3 million EUR (1,394 man-years) / year (Metsähallitus 2012). According to the assessment 1 EUR investment in national parks and other key protected areas results in 10 EUR return to local economies.

Did the examination of ecosystem services generate impacts on decision-making or policies and, if so, how?

In autumn 2010, Metsähallitus – Natural Heritage Services was facing severe budget cuts, including cuts to funding available for managing national parks and other protected areas. The assessment of economic benefits to local economies played a significant role in the discussions, being one of the key factors to convince the decision-makers that the public investment in protected areas pays back manifold. In the end, the budget cuts were not implemented.

On a more practical level, differences between the local economic impacts across national parks have also alerted the regional and nature tourism enterprises, developers and administrators on the potential business opportunities related to protected areas. It has also become clear that investment in both management activities (eg facilities for visitors) and private sector development is necessary in order to create significant incomes to the regions.

Lessons learned

One of the key lessons learned in the context of the study has been the importance of cooperation between research and practice, ie between organisations like the Finnish Forest Research Institute Metla and Metsähallitus – Natural Heritage Services. Combining theoretical and practical knowledge has provided useful insights into the method and significantly increased the level of confidence in the results.

The methods previously available to assess benefits of protected areas to local economies vary a lot, making it impossible to compare results between different areas, regions and countries. A number of case study – based examples exist, however they are often laborious and resource intensive which hampers long-term follow-up. Therefore, one of the main goals of Metla and Metsähallitus – Natural Heritage Services was to ensure comparability of results between the areas and across time while also the reliability and usability of the method in the long run. In the Finnish assessment, the comparability is now achieved by a nationally standardised data collection (via the ASTA database) and methodology. The results were also compared to previous studies to cross-check their reliability. The developed method is user friendly and free to use for everyone with an access to the ASTA visitor information database.

The process strengthened the assumption that an on-going and standardised visitor monitoring system is a prerequisite for continuous economic impact estimation of protected areas. This is relatively easy in Finland because all the national parks are managed by one government agency that has worked actively with visitor monitoring. Metsähallitus established a group of experts called SMART (Experts on Sustainability and Management of Recreation and Tourism) whose task is to advice and guide national parks and other key protected areas on issues related to visitor monitoring and to further develop the monitoring methods. This guidance is necessary in order to maintain high quality visitor monitoring, crucial to reach reliable economic impact results. On the other hand, it seems that using visitor monitoring data for economic impact estimation has increased the motivation to carry out visitor monitoring: in many national parks the importance of investments into a visitor monitoring system is now understood better than before. The investments into the visitor monitoring system pay themselves back manifold through the diversity of information obtained.

Finally, it is important to keep in mind that while the local economic impacts of recreation originating from park visitors' spending is important information that can have an impact on policy making, this method only describes and takes into consideration certain value types. A more complete picture of the socio-economic importance and value of national parks and other key protected areas would require the inclusion and measurement of many other ecosystem services and socio-economic effects, such as impacts on well-being and health and broader cultural services.

References

Huhtala, M. Kajala, L. & Vatanen, E. 2010. Local economic impacts of national park visitors' spending in Finland: The development process of an estimation method. Working Papers of the Finnish Forest Research Institute. 149. http://www.metla.fi/julkaisut/workingpapers/2010/mwp149.htm. 207 p.

Kajala, L., Almik, A., Dahl, R., Dikšaitė, L, Erkkonen, J., Fredman, P., Jensen, F. Søndergaard, Karoles, K., Sievänen, T., Skov-Petersen, H., Vistad, O. I. and Wallsten, P. 2007. Visitor monitoring in nature areas – a manual based on experiences from the Nordic and Baltic countries. TemaNord 2007:534. ISBN 91-620-1258-4

Metsähallitus 2012. The report on local economic impacts of national parks [in Finnish]. (1.3.2012). Available at: www.metsa.fi/suojelualueetjapaikallistalous

Stynes, D.J., Propst, D.P., Chang, W-H. & Sun, Y.Y. 2000. Estimating National Park Visitor Spending and Economic Impacts; The MGM2 Model. (4.12.2009) Available at: http://web4.canr.msu.edu/MGM2/MGM2.pdf

17.3 Marine Ecosystem Services in the Barents Sea and Lofoten Islands, a scoping assessment

Author: *Kristin Magnussen*

Short title: Marine Ecosystem Services in the Barents Sea and Lofoten Islands – a scoping assessment

Key Message: Ecosystem services provided by marine areas in the Barents Sea and Lofoten Islands have high socio-economic importance in the area. The commercial value of fisheries (including aquaculture) in the area has been estimated to be nearly 13 billion NOK (~ 1.65 billion EUR) in 2009 whereas the recreational fishing among people living in the area is estimated to range between NOK 270–800 million per year (~ 35–100 million EUR). The key question in the future will be how these, and several other ecosystem services, might be affected by potential oil and gas drilling developments in the area.

Reviewer: Marianne Kettunen (IEEP) and Johannes Förster (UFZ)

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What is the problem?

The Barents Sea area is a relatively pristine marine ecosystem, exposed to human impacts to a much lesser degree than, for example, the southern marine areas of Norway such as the North Sea – Skagerrak area. The key question regarding sustainable management of the Barents Sea ecosystem and its services, particularly the Lofoten Islands, is whether – and to what extent – sea drilling for oil and gas should be permitted in the area. The Lofoten area plays an invaluable role in maintaining commercial and recreational fisheries in the area, including supporting the recreational activities and tourism connected to fisheries and marine wildlife watching (see below).

Consequently, the debate surrounding the potential drilling developments has increasingly focused on the broader socio-economic importance and value of marine ecosystems and the foreseen local and regional effects of future petroleum activities, including negative impacts on ecosystem services in the area. Therefore, there is a need to improve understanding of the benefits associated with the Barents Sea ecosystem services in order to estimate the true costs and benefits of the planned drilling developments.

The aim of the scoping assessment was to identify and draw attention to the wide range of benefits provided by ecosystem services in the marine areas of the Barents Sea and Lofoten, supporting socio-economic welfare and people's wellbeing. The assessment, taking place in 2009–2010, was a pioneering attempt to increase the understanding and knowledge based on the value of ecosystem services in Norway (Magnussen et al. 2010).

Which ecosystem services were examined and how?

One of the socio-economically most important ecosystem service in the Barents Sea and Lofoten area is – not surprisingly – *commercial fishing*. Areas around the Lofoten Islands play a crucial role for fisheries at the national level, functioning as important spawning and breeding areas for several commercially important species. The value of commercial fishing in the Barents Sea – Lofoten area was nearly 7 billion NOK (~ 0.9 billion EUR) in 2009,[24] while the value of fish from commercial aquaculture in the area was more than 6 billion NOK (~ 0.75 billion EUR)[25] (Magnussen et al. 2010). At the moment, fisheries activities in the Barents Sea and Lofoten Islands are operating on a relatively sustainable basis however constant efforts should be made to keep the fish stocks in a continued good state, to safeguard these high socio-economic values.

The area, and particularly the Lofoten Islands, has also a long tradition for *recreational fishing and cultural ecosystem services*, mainly connected to fishing and hunting of sea birds, and these are other key values and benefits associated with marine ecosystems. A rough estimate (based on benefit transfer) suggests that people living in the Barents Sea – Lofoten area (the three northern counties of Norway) spend approximately one million days / year fishing in the sea. The value of this activity, estimated as consumer surplus ("the value of recreation days"), range from NOK 270–800 million per year[26] (~ 35–100 million EUR).

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[24] Gross values from fish catch statistics from the Norwegian Directorate for Fisheries.

[25] Gross values from Aquaculture statistics tables from Statistics Norway.

[26] Based on Toivonen et al (2004), Magnussen et al (2010) roughly assumed that 50% of the population in the three counties bordering the Barents Sea – Lofoten area (aged 18-69) fish at least once per year. Based on the same study, the average number of fishing days per fisherman in Norway is 12.9, with 56% of the fishing days spent fishing in the sea (ie 7.2 days at sea / fisherman). Assuming that people in the three northern countries

Further, recreational fishing and other recreational and cultural values play an important role in creating revenue from *tourism* in the area. Lots of international tourists visit the coast of the Barents Sea in order to enjoy activities such as fishing, whale and seal safaris, canoeing, bird watching and nature photography. At the time of the assessment by Magnussen et al. (2010) no figures for the value of marine ecosystems for tourist sector (eg fishing tourism in the area) were available. However, later in 2011 Borch et al. (2011) estimated the economic effects of fishing tourism (direct and indirect effects) in the area (ie the three northern counties surrounding the Barents Sea) to be over 500 million NOK (over 60 million EUR) per year.

The scope of the Magnussen et al. 2010 assessment was broad, aiming to provide a full picture of the wide range of ecosystem services provided by marine areas. Therefore, a dedicated attention was also given to identify and highlight the importance of supporting and regulating services provided by the area, instead of only focusing on the more commonly known – and more "visible" – provisioning and recreational services. For example, Barents Sea and the Lofoten Islands are important for CO_2 sequestration. As mentioned already above, spawning and breeding areas around Lofoten Islands (ie supporting services) form the basis for fisheries and related commercial and recreational activities in the area. Healthy fish populations are also important for a rich variety of sea birds that the coastal areas and their tourism are famous for. They also give a rise to a variety of sea mammals and these areas are important as breeding areas for many species. However, no monetised values (eg contingent valuation studies) were available for the significant biodiversity values of the area. Finally, there are also great expectations for area's potential (ie option value) related to bioprospecting as organisms living in the area need special features to be able to survive the harsh weather conditions. However, no existing or easily available estimates for the socio-economic importance of these services are currently available.

Key identified gaps in knowledge

A range of studies were carried out in the Barents Sea and Lofoten area as part of the Norwegian authorities' work on the management plan for the area. Norway also has a long tradition on marine research, particu-

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behave like the average Norwegian, these figures result in approximately 1 million fishing days by the sea for the population in the three counties. The recreation value per fishing day is assumed to be NOK 270–800, based on recreation values for fishing days in lakes and rivers in Norway (based on Navrud (2001)).

larly with respect to commercially important fish. However, the results of Magnussen et al. 2010 assessment indicate that significant knowledge gaps still exists, making it difficult to assess and value ecosystem services in the area. Particularly, there is a lack of quantitative data that would allow making clear conclusions on the possible ecological and socio-economic consequences of future development on different ecosystem services. This underlines the importance of ecologists and economists working together in the future to define the most accurate research questions, data needs and analyses.

The assessment by Magnussen et al. (2010) did not include any new valuation studies. For marine fisheries and aquaculture market prices were used, with gross values being the only values available. It is considered that while gross values can be used to demonstrate the importance of commercial fisheries in the area they cannot be used to carry out broader benefit-cost analysis of different management options for the areas (eg conservation vs. drilling) or to develop policy measures for more sustainable fishing (eg suggest economic incentives). In order to carry out such studies, there is a need to know the net benefits received from these ecosystem services.

No primary valuation studies exist for non-market ecosystem services in the area. Consequently, basic benefit transfer was undertaken by Magnussen et al. (2010) in order to provide a rough estimate for recreational fishing and hunting of sea birds in the area, while other important ecosystem services, such as broader cultural values, could be described only in a qualitative manner.

Did the examination of ecosystem services generate impacts on decision-making or policies and, if so, how?

Following the scoping assessment, a benefit-cost analysis of oil and gas drilling activities in the area was carried out, building on a number of insights by Magnussen et al. (2010). However, the lack of existing information and analysis (qualitative, quantitative and monetary) limited the integration of ecosystem services into these benefit-cost assessments. Consequently, new studies, focusing on certain ecosystem services or particular marine areas have been initiated, with a view to be carried out in the near future. For example, a research project "*Arctic Games*" by Swedish, Norwegian and Russian researchers, a part of the Swedish research programme "*Mistra Arctic Futures in a Global Context*" and funded by MISTRA foundation (a foundation for strategic environmental research), is planning to carry out a further ecosystem services valuation study in the Lofoten area in 2012, including fisheries as one important ecosystem services. Furthermore, University of Tromsø is planning to undertake a valuation study of the unique cold water coral reefs along the Norwegian coast.

The discussion of petroleum activities in the Barents Sea – Lofoten area is still ongoing and it is hard to judge at the moment what the outcomes will be and which effect the ecosystem service assessments will have on the final decisions. However, it is hoped that the assessment by Magnussen et al. (2010) has broadened the understanding and appreciation of the role marine ecosystems play in supporting the human welfare. As a consequence, a dedicated assessment of ecosystem services was also adopted as a mandatory element for the development of North Sea – Skagerrak area management plan (ongoing). Furthermore, partly inspired by the Magnussen et al. 2010 scoping assessment several sector authorities and NGOs have initiated studies to assess and value ecosystem services in other Norwegian marine areas. The scoping assessment is also foreseen to play a role in the future work of the Norwegian Ecosystem Service Expert committee, appointed by the Government in autumn 2011, tasked to lead the integration of ecosystem services into policy and decision-making in Norway.

Lessons learned

The study by Magnussen et al. (2010) show that ecosystem services assessment can provide an important tool for supporting decision-making in the context of marine environment. However, it also shows that significant gaps still exist in terms of information on the socio-economic role and value of marine ecosystem services. Finally, the assessment also highlights that some important values, such as the importance of supporting and regulating services and cultural values, are hard to capture via monetary valuation. Therefore, qualitative and quantitative assessments are foreseen as important tools for guaranteeing a comprehensive information base for decision-making.

References

Borch, T., M. Moilanen, F. Olsen (2011): Sea fishing tourism in Norway – debates, regulations, structure and effects. [In Norwegian]. Northern Research Institute, NORUT, Tromsø, Norway.

Ibenholt, K., H. Lindhjem, J.M. Skjelvik, I.Rasmussen, H. Vennemo and H. Dypdahl (2010): Socio-economic analysis of potential extended petroleum activities in the Barents Sea – Lofoten area.[In Norwegian]. Vista Analyse, Oslo, Norway.

Magnussen, K., L. Lillehammer, L.K. Helland and O.M. Gausen (2010): Marine Ecosystem Services in the Barents Sea – Lofoten area: Description, assessment and valuation [In Norwegian]. Sweco Norway, Oslo, Norway.

Navrud, S. (2001): Economic valuation of inland recreational fisheries. Empirical studies and their policy use in Norway. Fisheries management and Ecology 8 (4–5); pp 369–382.

Toivonen, A-L., E. Roth, S. Navrud, G. Gudbergsson, H. Appelblad, B. Bengtsson and P. Tuunainen (2004): The Economic value of recreational fisheries in the Nordic countries. Fisheries Management and Ecology, 11 (1); pp 1–14.

17.4 Ecosystem services provided by Baltic salmon – a regional perspective to the socio-economic benefits associated with a keystone migratory species

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Short title: Ecosystem services provided by Baltic salmon

Key Message: Baltic salmon (*Salmo salar L.*) is one of the keystone migratory species in the Baltic Sea. In the past salmon played a central role in the economy and culture of the region. However, salmon population collapsed because of logging, dams for hydropower production, pollution and overfishing. Today salmon is still of great cultural importance as shown for example by estimates of public spending for habitat restoration and WTP by angler. Estimates suggest that the cultural services of salmon are greater than the economic value of commercial salmon landings with a net present value ranging from 6 million EUR to 25 million EUR (ie 0.9–3.6 million EUR / year) in Denmark, Finland, Poland and Sweden for 2009–2015. Baltic salmon plays also an important role in reducing sedimentation, regulating food webs and maintaining the general ecological balance of ecosystems Maintaining and restoring the salmon population requires concerted efforts for habitat restoration and conservation in rivers and the sea.

Reviewers / comments: M. Kettunen (IEEP), M-L. Koljonen and Irma Kallio-Nyberg (Finnish Game and Fisheries Research Institute – RKTL), Johannes F örster (UFZ).

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What is the problem?

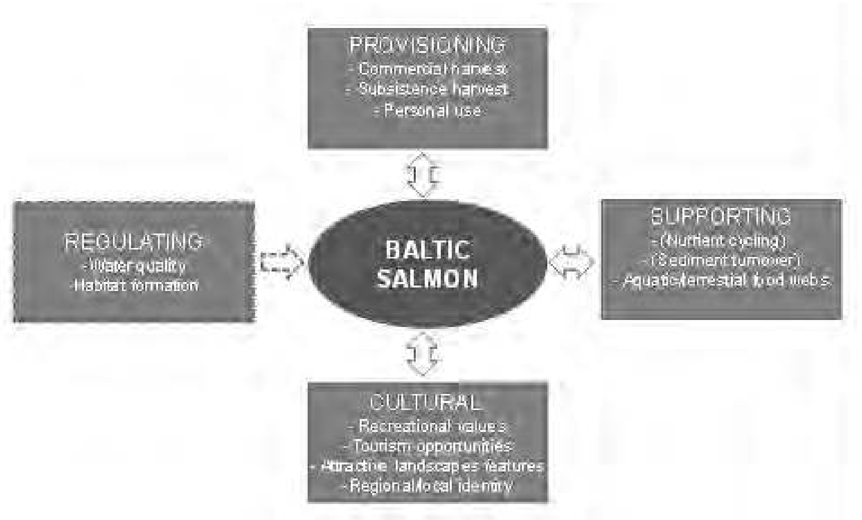
Fish provides one of the major protein sources for humans around the world. They also play an integral role in regulating the structure of marine food webs, maintaining nutrient cycling and contributing to recreation opportunities associated with marine areas. Salmon is also important for cultural heritage and identity. All these services and values have become increasingly threatened due to the collapse of wild salmon stocks.

Baltic salmon (*Salmo salar L.*) is the keystone migratory species in the Baltic Sea. It is an anadromous species, ie the fish are born in fresh water, spend most of their life in the sea and then return to fresh water to spawn. The species is geographically and genetically isolated form Atlantic salmon stocks. Nowadays, Baltic salmon reproduce naturally in nearly 30 rivers, however in the past the number of rivers with *wild* Baltic salmon stocks is known to have been considerably higher, ie around one hundred rivers. Damming, habitat destruction, pollution and intensive fishing have been identified as the main causes of the decline. Presently, the majority of the wild salmon originates from rivers located in Sweden and Finland.

Which ecosystem services were examined and how?

This case study provides an overview on the ecosystem services and associated socio-economic benefits provided by Baltic salmon to Nordic countries over the past decades (Figure 1). In general, the management of Baltic salmon in the Baltic Sea area illustrates the challenges for sustainable management of the multiple benefits provided to a keystone species with regional importance (eg valuation of these benefits). The ecosystems important for Baltic salmon exist at varying spatial scales. Furthermore, the suitability of these ecosystems to salmon depends on habitat diversity and connectivity between the sea and rivers. Also, the benefits associated with salmon – direct and indirect – benefit different stakeholders in different geographical areas.

Figure 1. Ecosystem services of Baltic salmon



Salmon population in the Baltic Sea provide provisioning, cultural and supporting ecosystem services that benefit people. These services involve two-way interactions with feedback to salmon (adapted from Bottom et al. 2009). Nutrient cycling and sediment turnover are not as significant as it is for some Pacific salmon species.

Habitat and supporting services

Salmon is the fish species with the widest migration routes over the Baltic Sea catchment area. As an example, salmon juveniles occupy the headwaters of the River Tornionjoki 400–500 km upstream from the sea, which is the northernmost point of the Baltic Sea drainage area. After 3–5 years' growth in freshwater, juveniles migrate to the sea and half a year later they are feeding herring and sprat in the south-west part of the Baltic Sea proper. These salmon mature after 1–4 years' growth on the feeding grounds, after which they migrate the 2,000 km distance back to their natal headwater rivers for spawning.

At each stage of migration and life cycle, salmon occupies a specific niche which cannot be occupied by any other species of the ecosystem. For instance, salmon juveniles are one the few species that can utilise fast-flowing freshwater habitats in the large northern rivers. No other fish species was able to replace salmon juveniles in fish production during the deep depression in salmon abundance in the latter half of the 20th century. Salmon is adopted to uniquely utilise and link the low-productive, fast-flowing river habitat, which is a good environment for reproduction, with the pelagic sea habitat, which offers good conditions for fast growth due to the high abundance of prey species.

Maintaining food web: Building on the above, salmon juveniles are key consumers of the invertebrate production in fast-flowing sections of spawning rivers. In the fish community of sea some other predatory species are by far more abundant than salmon and therefore quantitatively salmon is not playing a key role in the marine food web. Predatory fishes (pikes, burbots etc.) and several birds (mergansers, seagulls etc.) are eating salmon juveniles both on their freshwater feeding habitat and during their migration. Some river fish species are eating salmon eggs. Seals are eating maturing salmon on their spawning migration, but also salmon in their early marine life belong to their diet. To conclude, salmon plays an important role in maintaining the balance in riverine food webs, both by harvesting invertebrate populations and also providing an important food source for other predatory species (eg a number of species valuable to humans).

Nutrient cycling: Nutrient transportation by salmon between freshwater and sea was important Baltic-wide before the industrial period when salmon spawned in almost all middle-sized and large rivers. Nutrient transportation is nowadays more limited than in the past due to damming and other human activities which have destroyed natural migration and life cycle of salmon in many spawning rivers. Relatively few Baltic salmon have been observed to die in freshwater after spawning and therefore the nutrient transportation from sea to freshwater is not as significant as it is for some Pacific salmon species. However, Baltic salmon do encounter a post-spawning mortality which results in accumulation of carcasses away from the feeding areas. Typically, only 1–2% of salmon eggs survive over hatching, fry and parr stages and contribute to the juvenile salmon (ie smolt) population. Dying eggs, fry and parr are releasing nutrients to the freshwater ecosystem. Currently nutrients are mainly transported between south and north and within the sea, but salmon has a minuscule role in overall within-sea transportation of nutrients.

Reducing sedimentation: Salmon is clearly the largest of the Baltic species which scours river bed while spawning. This bioturbation cleans river bed from, for example, organic particles the sedimentation of which is high in the Baltic rivers. Spawning removes also macrophytes and invertebrates from the sediment, which may more easily be fed by river fish.

Indicator of food web change: Salmon is a top fish predator that eats nearly exclusively sprat and herring, in the south mainly sprat and towards the north increasingly herring, in the Baltic Sea. Thus salmon in a way refines various micronutrients for use of other top predators like mammals, including humans. Salmon muscle indeed contains plenty of polyunsaturated fatty acids, which are beneficial for human circulatory system. However, being at the top of the food chain salmon unfortunately also accumulates harmful substances, ie various environmental toxicants. This feature, on the other hand, also makes salmon as a good indicator species of those toxicants. In the southern Baltic Sea salmon grow fast and thus the concentrations of toxicants in muscle are lower than in the northern sea areas. There are also differences between the feeding grounds. Some toxicants are more common in certain than other areas, and the toxicant patterns may also differ. During the spawning run, when salmon reduces food intake and finally cease it, the concentrations of toxicants in muscle increase. The toxicants of most concern are polychlorinated biphenyls (PCB compounds) and dioxins. In salmon muscle the concentrations of dioxins and dioxins plus PCBs are higher than the maximum allowable concentrations in fish muscle set by EU legislation. On the other hand, analysis results of those dioxin-like toxicants from salmon muscle have been used to adjust EU legislation, and national food administrative authorities are obliged to inform consumers of those concentrations.

Provisioning service

Provisioning of food (fish catch) is the most obvious ecosystem service of salmon. However, in the Baltic Sea region, wild-caught salmon is nowadays a source of living for a relatively small number of fishermen catching salmon for commercial or household subsistence use. The *commercial salmon landings* have been declining from 5,600 tonnes in 1990 to 900 tonnes in 2010, which was the lowest registered landing since 1970. The decline in the landings is mainly caused by a decline in natural survival during the early marine life of salmon (salmon at this stage are called post-smolts), resulting in a decline in the total stock size. Underlying reasons for the declined post-smolt survival are probably in the changes in the biota of the Baltic Sea during the last decades.

Declining stocks, fishing regulations in the coastal areas and the recent landing restrictions due to the dioxin contents of salmon have caused a decline in the commercial fishing effort. The decline in fishing efforts has also been supported by the influx of farmed Atlantic salmon into the European fishing markets. Consequently, there as has been a drop in salmon prices in Europe from 10 EUR / kg in the early 1980s to 3 EUR / kg in 2000.

From an economic point of view the value of the provisioning service is the net present value of the future benefits of the service. When defining this service as the commercial salmon catch then the total net present value of the salmon catch in Denmark, Finland, Poland and Sweden in 2009–2015 is estimated to range from 6 million EUR to 25 million EUR depending on the fisheries policies and the abundance of salmon (which is mostly dependent on survival of post-juveniles) (Finnish Game and Fisheries Research Institute 2009). Based on this, *the annual value of the total landings is 0.9–3.6 million EUR*. This estimate is based on a bioeconomic model that accounts for 15 wild salmon stocks and the stocking of salmon (Finnish Game and Fisheries Research Institute 2009).

Kulmala et al. (2008) studied the optimal management of the river Simojoki salmon stock and found that the annual net benefits from the commercial fishery of the single salmon stock in Finland is 0.06 million EUR. However, the investments in stocking of hatchery reared salmon to supplement fishing possibilities and in river restoration indicate that *the social value of salmon in the region is considerably higher than the value of the commercial catch*. For instance, the Finnish state budget allocated nearly 1.4 million EUR for annual stockings during the years 2000–2004, and over 9 million EUR were spent for habitat restoration during 1997–2005.This reflects the political will to invest in the maintenance of fisheries – for both commercial and non-commercial values – in the region (see below).

Cultural services

Cultural heritage and identity: From time immemorial, Baltic salmon has been an important factor behind the well-being of especially the Northern parts of the Baltic Sea areas. It has provided a source for a healthy diet for the local people and in the old times salted exported salmon brought significant wealth to communities with signs of this still visible in the Nordic landscape. For example, several grand houses built with the money earned from salmon in the 19th and the 20th centuries are still an integral part of the cultural heritage. The annual rhythm of whole villages was adapted to salmon migration, specific professions and skills were developed and buildings constructed to serve salmon fishing. Salmon shaped people's way of living and their thinking. Thus, in several areas people owe salmon their pride, identity and cultural heritage.

Several of today's fishers are descendants of the bygone salmon fishers that markedly contributed in the regional development of the coastal areas still inhabited by the few remaining salmon fishers. The future of salmon fishing, as it is seen today, will probably be more pronounced to sport fishing in the rivers than at present. Salmon is increasingly a cultural service produced by the ecosystem for people representing different professions, living nearby and far away, and it can be a connecting element for very different kinds of people that want to relax in the nature. Yet, salmon is still expected to produce wealth to the today sparsely populated salmon river areas; this is why the inhabitants of those areas struggle for promoting the improvement of the salmon stocks and for developing infrastructure around fishing tourism. Especially in the northern parts of the Nordic countries salmon fishing and overall fishing tourism is considered to have significant potential for the local and regional tourism business (Haapasaari and Karjalainen 2010, Kauppila and Karjalainen, accepted).

Recreational activities, such as recreational salmon fishery, and supply of aesthetic values derived from free flowing salmon rivers, for instance, are typically not fully priced by the market and information about monetary value for these non-marketed goods is not directly available. When required, monetary estimates can be derived from estimating people's willingness to pay (WTP) for a change, such as for improvement in status of particular salmon stock due to the new policy action.

The question about the value of recreational fishing cannot be answered completely based on the current knowledge. *However, studies show that salmon anglers are willing to pay for improved quality of recreational fishing and more importantly for preserving wild salmon stock*. For example, mean WTP estimates per angler vary from 8 EUR to 19 EUR per fishing day (Parkkila 2005, Håkansson 2008, Finnish Game and Fisheries Research Institute 2009, Parkkila et al. 2011). Moreover, results indicate high support (in most cases over 80% of the respondents) for the implementation of the new management programmes aiming to recover the salmon stocks. The fair allocation of the fishing restrictions among different fisher groups seems to be important for the anglers. Interestingly anglers support the restriction of the sea fishery, but they are not willing to pay for the programme that would ban the commercial sea fishery completely.

The purpose of valuation studies is to make the non-market benefits explicit and comparable with other monetary measures. Thus, these mean WTP values per angler are typically aggregated by the number of people who will gain from the change, ie in case of recreational fishing by the size of the angler population in the river area that typically consist of both local anglers and visitors. The motives for recreational fishing seem to be various, such as importance of catching a salmon during the fishing trip, relaxing, good state of salmon stocks, which all are examples of factors affecting fishing experience and value of recreational fishing. This diversity of motives indicates that different ecosystem services are not completely exclusive but interlinked, which complicates estimation of value for recreational fishing. *Successful assessment of the economic value of recreational fisheries of Baltic Salmon necessitate more empirical valuation studies to be conducted in different countries and rivers with their own environmental and user characteristics*. Particularly, the non-use value of preserving the wild salmon stocks should be estimated, which presumes survey data regarding public.

Sustainable future management of Baltic salmon

When applying the concept of ecosystem services in the context of Baltic salmon fisheries management, tackling trade-offs is unavoidable. This involves identifying the beneficiaries whose values and benefits need to be taken into account. Salmon is a part of marine and freshwater ecosystems and thus linked to the social systems at the catchment area. Free flowing rivers can provide a range of ecosystem services but if they are used to produce hydropower then their potential to maintain healthy fish stocks diminishes considerably (eg Karjalainen and Järvikoski 2010). Thus, the management of Baltic salmon and related ecosystem services requires consideration of trade-offs between benefits provided by salmon and benefits arising from the use of river to generate hydropower. In addition, trade-offs also exists between the provisioning and cultural services provided by salmon affected by the regulation of salmon catch and considering the allocation of catch between the commercial and recreational fishers (see below). Finally, the "owners" of fishing right (ie the beneficiaries) change along the long migratory routes, impacting the availability and value of salmon to individual beneficiaries.

To compensate for the current loss of natural spawning areas hatchery-reared salmon has been stocked. However, this reared salmon may mix with the wild salmon in some rivers and cause a genetic risk particularly for small wild salmon populations. Due to this potential risk, it has been recommended that the releases would be gradually stopped: "...in the long-term, the practice of compensatory releases should cease. *In order to preserve the genetic make-up of stocks used in compensatory releases, there is a need to establish a natural life cycle for such stocks in the wild*." (STECF 2009). However, the genetic risk is difficult to estimate. There is a need to use models to estimate how big proportion of the spawning migrating fish could potentially ascend other rivers than their home river or release area. The cost of stocking has also been found to exceed the benefits. However, the estimate of benefits does not account for economic value components like the existence or option values of the gene pool. Therefore, in some cases stocking can still be justified and/or worthwhile in socio-economic terms.

The advice to cease stocking has created a considerable discussion in the Baltic Sea states (eg Finland) as reared salmon component is still considered to be important for professional fishermen. *Stocking can be replaced by increasing the natural reproduction potential by improving wild salmon passage in regulated rivers*. On an average the total number of juveniles can be up to a couple of hundred per spawning adult female, and after the natural mortality in juvenile phase (post-smolt mortality) taking place in the sea the provided number of adult salmon by one spawner can be up to 10–15. However, those rivers with the high enough water quality that would enable salmon reproduction are mostly dammed. Thus, the increase in reproduction possibilities comes with a cost in terms of lost electricity or construction costs of fish ladders.

No estimates are available that would provide an indication of the overall costs and benefits of increasing wild Baltic salmon stocks by addressing its ecological requirements. In general, whether or not the increase in natural reproduction outweighs its costs depends on the number of adult salmon that return to spawn in their home rivers, which in turn is dependent on natural mortality and fishing pressure (ie fishing mortality). Fishing mortality can be controlled via international and national management measures. Highly productive species like salmon has a strong response to management actions particularly at the low stock status. Increase of spawners as a result of fishing regulations may increase quickly the recruitment. On high stock sizes, however, salmon has strong density dependent mechanisms during the early freshwater stage which effectively suppresses the recruitment.

At present the major wild salmon production occurs in rivers that have good quality of spawning and rearing habitats. However, there are also a number of salmon rivers where habitat improvements would be welcomed. Removing the migration obstacles and reducing the eutrophication would benefit the wild salmon production and particularly safeguard the biodiversity of Baltic salmon ecosystem. Salmon in the southern Baltic Sea rivers may have genetic features that are the result from an adaptation to warm summers and higher nutrient levels. These features may become increasingly important for the survival of Baltic salmon as the climate change continues.

Conclusions and lessons learned

Baltic salmon is a keystone migratory species in the Baltic Sea that plays a crucial role in maintaining the functioning of ecosystems and provides a range of socio-economic benefits, eg provisioning and cultural ecosystem services. *However, at present estimates for economic value exist only for a fraction of these benefits*. Protecting the long migration routes of salmon is a key factor for maintaining the range of important ecosystem services provided by Baltic salmon. This, however, involves a consideration of a range of trade-offs, both between different uses of the migratory rivers and between different beneficiaries of salmon. This leads to a complex framework of cultural, scientific, socio-economic and political aspects required to be taken into account when considering the future management of Baltic Sea salmon fisheries.

References

Bottom, D. L., K. K. Jones, C. A. Simenstad, and C. L. Smith. 2009. Reconnecting social and ecological resilience in salmon ecosystems. Ecology and Society 14(1): 5.

Chan, K. M. A., T. Satterfield and J. Goldstein (2012). "Rethinking ecosystem services to better address and navigate cultural values." Ecological Economics 74: 8–18.

Christensen, O., and Larsson, P-O. 1979. Review of Baltic salmon research. ICES Co-operative Research Report, 89. 124 pp.

Erkinaro J., Laine A., Mäki-Petäys A., Karjalainen T. P., Laajala E., Hirvonen A., Orell P., Yrjänä, T.: Restoring migratory salmonid populations in regulated rivers in the northernmost Baltic Sea area, Northern Finland – biological, technical and social challenges. Journal of Applied Ichthyology, in press.

European Commission. 2011. Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL: Establishing a multiannual plan for the Baltic salmon stock and the fisheries exploiting that stock.

Finnish Game and Fisheries Research Institute 2009. The Report of Data Analysis to support the development of a Baltic Sea salmon action plan. Brussels: European Commission. 19 p.
http://ec.europa.eu/fisheries/documentation/studies/baltic_sea_salmon_en.pdf
http://ec.europa.eu/fisheries/documentation/studies/baltic_sea_salmon_annex_en.pdf

Haapasaari P., Karjalainen T.P. (2010) Formalizing expert knowledge to compare alternative management plans: sociological perspective to the future management of Baltic salmon stocks. – Marine Policy 34, 477–486.

Haapasaari, P., C.G.J. Michielsens, T. P. Karjalainen, K. Reinikainen, and S. Kuikka (2007): Management measures and fishers' commitment towards sustainable exploitation: a case study of Atlantic salmon fisheries in the Baltic Sea. ICES Journal of Marine Science. 64: 825–833

Håkansson, C. 2008. A new valuation question: analysis of and insights from interval open-ended data in contingent valuation. Environmental and Resource Economics 39:175–188.

HELCOM. 2011. Salmon and Sea Trout Populations and Rivers in the Baltic Sea – HELCOM assessment of salmon (Salmo salar) and sea trout (Salmo trutta) populations and habitats in rivers flowing to the Baltic Sea. Balt. Sea Environ. Proc. No. 126A.

Holmlund, C. and Hammer, M. Ecosystem services generated by fish populations. Ecological Economics 29, 253–268.

Holmlund, C.M. , and Hammer, M. 1999. Ecosystem services generated by fish populations. Ecological Economics 29: 253–268.

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0470:FIN:EN:PDF

http://www.ecosystemvaluation.org/

ICES. 2011. Report of the Baltic Salmon and Trout Assessment Working Group (WGBAST), 22–30 March 2011, Riga, Latvia. ICES 2011/ACOM:08. 297 pp.

Isosaari, P., Hallikainen, A., Kiviranta, H., Vuorinen, P. J., Parmanne, R., Koistinen, J. & Vartiainen, T. 2006. Polychlorinated dibenzo- p-dioxins, dibenzofurans, biphenyls, naphthalenes and polybrominated diphenyl ethers in the edible fish caught from the Baltic Sea and lakes in Finland. Environ. Pollut. 141: 213–225.

Karjalainen Timo P, Järvikoski Timo (2010) Negotiating river ecosystems: impact assessment and conflict mediation in the cases of hydro-power construction. Environmental impact assessment review 30 (5), 319–327

Karlsson, L., and Karlström, Ö. 1994. The Baltic salmon (Salmo salar L.): its history, present situation and future. Dana, 10, pp. 61–85.

Kauppila, P., Karjalainen, T.P. A process model to assess the regional economic impacts of fishing tourism: a case study in northern Finland. Fisheries Research (accepted)

Kiljunen, M., Vanhatalo, M., Mäntyniemi, S., Peltonen, H., Kuikka, S., Kiviranta, H., Parmanne, R., Tuomisto, J. T., Vuorinen, P. J., Hallikainen, A., Verta, M., Pönni, J., Jones, R. I. & Karjalainen, J. 2007. Human dietary intake of organochlorines from Baltic herring: Implications of individual fish variability and fisheries management. Ambio 36: 257–264.

Kulmala S., Laukkanen M. and Michielsens C.G.J., 2008. Reconciling economic and biological modeling of migratory fish stocks: Optimal management of the Atlantic salmon fishery in the Baltic Sea. Ecological Economics, 64:716–728.

Mäki-Petäys,A., van der Meer,O., Romakkaniemi, A., Orell, P., Rivinoja, P., Erkinaro, J. Lohikantojen palauttaminen rakennetuille joille – mallinnustyökalu tuki- ja säätelytoimien biologiseen arviointiin. RKTL:n työraportteja 1/2012. 42 pp.

Parkkila, K., 2005. Estimating the willingness to pay for catch improvements in the River Simojoki – an application of contingent valuation method. University of Helsinki, Department of Economics and Management. Master's thesis (In Finnish)

Parkkila, K., Haltia, E. & Karjalainen, T.P. 2011. Benefits of the salmon stock restoration for recreational anglers of the river Iijoki – pilot study with contingent valuation method. Riista- ja kalatalous – Tutkimuksia ja selvityksiä 4/2011.

Romakkaniemi, A., Perä, I., Karlsson, L., Jutila, E., Carlsson, U., and Pakarinen, T. 2003. Development of wild Atlantic salmon stocks in the rivers of the northern Baltic Sea in response to management measures. ICES Journal of Marine Science, 60: 329–342.

Turunen, A. W., Verkasalo, P. K., Kiviranta, H., Pukkala, E., Jula, A., Mannisto, S., Rasanen, R., Marniemi, J. & Vartiainen, T. 2008. Mortality in a cohort with high fish consumption. Int. J. Epidemiol. 37: 1008–1017.

Vuorinen, P. J., Keinänen, M., Kiviranta, H., Isosaari, P., Pöyhönen, O. & Ikonen, E. 2012. Organohalogen concentrations and stomach contents in Baltic salmon (Salmo salar L.) during the spawning run. (submitted).

Vuorinen, P. J., Keinänen, M., Kiviranta, H., Koistinen, J., Kiljunen, M., Myllylä, T., Pönni, J., Peltonen, H., Verta, M. & Karjalainen, J. 2012. Organohalogens in Atlantic salmon (Salmo salar L.) and its main prey species, sprat [Sprattus sprattus (L.)] and herring (Clupea harengus L.) from three areas in the Baltic Sea. Science of the Total Environment 421–422:129–143.

17.5 Supporting the protection of the Baltic Sea: assessment of cultural and recreational values

Compiled by**:** *Dalia D' Amato*, *Janne Artell*, *Heini Ahtiainen* & *Marianne Kettunen*

Short title: Cultural and recreational values of the Baltic Sea

Key Message: According to a conservative estimate, almost one third of the respondents in Denmark, Finland and Sweden would be willing to financially support actions aimed at improving the Baltic Sea environment. Majority of the values and uses of the Baltic Sea, such as swimming, diving, fishing, hiking and picnicking, are directly related to cultural and recreational services provided by the sea.

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What is the problem?

The increasing pressure of human activities on the Baltic Sea and within its catchment area is drastically affecting the environmental status of the sea, as well as its capacity to provide valuable ecosystem services. This threat calls for a better understanding of the different values and uses by people in the Baltic Sea States, including several of the Nordic Countries, associate with their marine environment, in order to more effectively safeguard and manage the benefits it provides.

To support these endeavors, an extensive public survey was carried out to gather information on the values and uses of the Baltic Sea in nine Baltic Countries, including Denmark, Finland and Sweden. The survey also explored people's concerns over the marine environment and their attitudes towards various measures for improving it. It is generally understood that the Baltic Sea is of high cultural and recreational significance to the broader public, however gathering evidence of this on broad-scale has been lacking. To address this caveat of lack of information, a comprehensive survey (i.e. BalticSurvey) was carried out in 2010 in the context of the BalticSTERN initiative, an international research network whose purpose is to carry out cost-benefit analyses regarding the environmental problems of the Baltic Sea (Söderqvist et al. 2010).

Which ecosystem services were examined and how?

BalticSurvey did not explicitly focus on ecosystem services, however several of the identified values and uses of the Baltic Sea were directly related to *cultural and recreational services*. These cultural and recreational values further build on the range of *regulating and supporting services*, including ability of the sea to maintain good water quality, healthy fish stocks, charismatic species, and aesthetic and cultural values. In addition, swimming, diving, fishing, picnicking, sunbathing and other similar activities surveyed by the study are also linked to the maintenance and quality of broader ecosystem services in the Baltic Sea basin, such as the ability of coastal wetlands to maintain good water quality. Consequently, highlighting the socio-economic importance of the cultural and recreational values can also help to protect a range of ecosystem services in the Baltic Sea basin.

The BalticSurvey included about 9,000 interviews carried out during spring 2010 in nine countries bordering the Baltic Sea (1,000 interviews / country) (Söderqvist et al. 2010). The survey was designed to guarantee a full comparability of results across all Baltic Sea States. Telephone interviews were used to collect data in Denmark, Sweden, Finland, Germany, Russia and Poland. In Estonia, Latvia and Lithuania, face-to-face interviews were considered a more suitable option. For all countries but one, 1,000 interviews were randomly sampled and surveyed. In Russia, due to its large population and wide geographical extent, the sampling was focused on the urban population of St. Petersburg and Kaliningrad areas.

Results

Importance of cultural and recreational values of the Baltic Sea

The results of the survey indicate high appreciation of the cultural and recreational values of the Baltic Sea. In all the Baltic Sea countries except Russia, more than 80% of the respondents have been at the sea at least once to spend leisure time. People from the surveyed Nordic Countries are the most frequent users of the Baltic Sea for recreational purposes, with the frequency of visits being significantly higher during the summer. The highest proposition of recreational visits (98%) was found in Sweden, followed by 90% in Denmark and 85% in Finland (Söderqvist et al. 2010).

The most common cultural and recreational activities in all the surveyed countries are related activities that depend directly on the ecosystem services provided by the Baltic Sea, including swimming and walking, sunbathing and picnicking on the seashore. Boating and cruises are also relatively common in some countries, including Denmark, Finland and Sweden. Ice-fishing, skiing and skating are enjoyed by around 10% of the respondents in Finland and Sweden.

While most of the people in the Baltic Sea countries have used the sea to spend leisure time, professional experience of the sea is limited. The proportion of respondents saying that they have or have had an occupation that is dependent on the sea is 10% in Sweden, 8% in Finland and 6% in Denmark. This indicates that cultural values (and related ecosystem services) are the main direct benefits of the Baltic Sea to people at the national level.

Insights related to the status of the Baltic Sea

The survey revealed that concerns over the environmental status of the Baltic Sea are similar between the surveyed countries. In Denmark, Sweden and especially in Finland, more than half of the respondents declared to be concerned over the Baltic Sea environment. Furthermore, in Sweden and Finland the majority of respondents felt that the environmental problems of the Baltic Sea belong to the three most important, nation-wide environmental problems.

Litter and damage to marine flora and fauna was perceived as a big problem in all Baltic Sea states, including the Nordic countries. Algal blooms, low quality of coastal waters, and oxygen deficiency in the sea causing complete deterioration of seabed were also a cause of concern. Among the Nordic countries, issues related to water quality were the most common concern in Finland whereas Swedes were the most alarmed over overfishing. All of these identified concerns seem to be closely linked with the identified significant recreational and aesthetic values of the Baltic Sea. They are also all related to the diminished capacity of the sea to maintain a range of regulating or supporting services related to water purification and waste and nutrient retention.

Interestingly, however, the respondents did not feel that the water quality of the Baltic Sea would be restricting recreational opportunities at present. In general, Danes and Swedes consider water quality a less restricting factor than Finns. This is not surprising as Finland accesses the Baltic Sea via the Gulf of Finland, an area which has rather poor water quality in comparison to several other parts of the sea. In most of the surveyed states, including the Nordic countries, respondents did not feel that they themselves were directly responsible for impacting the Baltic Sea environment. Wastewater treatment plants, industry, farmers in the catchment area, professional fishermen, and sea transports and ports were seen as activities and stakeholders responsible for the diminishing environmental of the sea.

Willingness to support actions to improve Baltic Sea environment
The survey revealed that almost 30% of the respondents in Denmark, Finland and Sweden would be willing to financially support actions aimed at improving the Baltic Sea environment. It is to be noted that 25% of the respondents were neutral – or indecisive – in terms of their willingness for financial contribution to conservation (i.e. neither agreed nor disagreed with the posed question). This might have been caused by the lack of detail provided in the survey regarding the concrete conservation actions foreseen to be taken (see "Next steps" below). Consequently, the 30% public support can be considered a conservative estimate.

Results also indicated a strong support within all the surveyed countries for funding actions through increased charges on pollution emissions. *The other types of suggested payments, i.e. increased taxes and increased bills, were considerably less popular*. In general, preferring earmarked payments over increased fee on water or taxes might be explained by the perceived lack of transparency and strong negative connotation associated with taxes and fees.

Did the examination of ecosystem services generate impacts on decision-making or policies and, if so, how?

The results of BalticSurvey provide a comprehensive overview of the present values, uses, perceptions, concerns and attitudes of the general public towards the Baltic Sea in nine different countries, including Denmark, Finland and Sweden. The survey provides quantitative evidence that the Baltic Sea has a significant cultural and recreational value to the broader public and shows that a range of such values and public benefits are at stake if the degradation of marine environment continues.

The outcomes of the survey provide a good basis for guiding the decision-making in the Baltic Sea states both at regional and national level. They can help to assess the true costs and benefits of protecting and restoring marine ecosystem and related services. The survey results can also guide towards identifying and adopting conservation measures most likely to be supported by the general public. The results of the survey also provide a good starting point for further cost-benefit analyses in the Baltic Sea area. Also, the study forms a basis for further environmental valuation studies and possible development of concrete, publicly acceptable mechanisms to fund conservation of the Baltic Sea.

Building on the above and following the BalticSurvey, a contingent valuation study was designed and conducted in all nine littoral countries in 2011 with the purpose of estimating the benefits of reducing eutrophication in the Baltic Sea. With identical surveys and over 10,000 responses, the study elicited willingness to pay measures for two future eutrophication scenarios, built on 50% and 100% delivery of the nutrient loading reduction targets set in Baltic Marine Environment Protection Commission (HELCOM) Baltic Sea Action Plan. The preliminary results indicate that the majority of Finns, Danes and Swedes would be willing to pay to reduce eutrophication in the Baltic Sea (Ahtiainen et al. in prep.). While the stated willingness to pay is rather hypothetical, i.e. it might not reflect the actual amount of money people would pay to support conservation, the results show that they are in general willing to support action and policies for reducing eutrophication. In addition, it is possible to identify the benefits which the society in each littoral country would accrue from the ecological improvements in the Baltic Sea. The results of the valuation study also provide an important input for a comprehensive cost-benefit analysis of combating eutrophication in the Baltic Sea.

Lesson learned

The survey illustrated several challenges associated with collecting comparable data on the public values from different countries, including the importance of correct framing of questions, complex translation issues, homogenous sampling procedures and data collection mode. Active involvement of representatives from all Baltic Sea countries was necessary for constructing the questionnaire in order to secure results that are nationally representative for each country and comprehensible also to people who know very little about the Baltic Sea. This information is likely to be useful for the design of similar regional and/or international surveys.

It should be also kept in mind that the survey results represent a snapshot of today´s society. For example, people’s willingness to contribute financially is likely to be influenced by the general economic situation. Some of the Baltic Sea countries have recently experienced a severe economic crisis, which might have had an impact on attitudes. By repeating this survey in time it would be possible to understand if and why attitudes change over time.

References

Ahtiainen, H., Angeli, D., Artell, J., Czajkowski, M., Hasler, B., Hasselström, L., Khaleeva, J., Meyerhoff, J., Nommann, T., Oskolokaite, I., Pakalniete, K., Semeniene, D., Söderqvist, T. (in prep) Willingness to pay for reduced eutrophication in the Baltic Sea. Article in preparation.

Söderqvist, T., Ahtiainen, H., Artell, J., Czajkowski, M., Hasler, B., Hasselström, L., Huhtala, A., Källstrøm, M., Khaleeva, J., Martinsen, L., Meyerhoff, J., Nõmmann, T., Oskolokaite, I., Rastrigina, O., Semeniene, D., Soutukorva, Å., Tuhkanen, H., Vanags, A. and Volchkova, N. (2010) BalticSurvey – a study in the Baltic Sea Countries of public attitudes and use of the sea, Report on basic findings, Report 6382, Swedish Environmental Protection Agency, http://www.stockholmresilience.org/download/18.5004bd9712b572e3de6800014154/BalticSurvey_bakgrundsrapport_webb.pdf accessed 18/04/2012

17.6 Assessing recreational values of Danish forests to guide national plans for afforestation

Authors: *Marianne Zandersen* and *Mette Termansen*

Short title: Assessing recreational values of Danish forests to guide national plans for afforestation

Key Message: Forests provide a range of recreational benefits and it is essential to include these benefits in decisions related to forest management and/or afforestation. The assessment of recreational values and preferences in North Zealand (DK) found that the per hectare value of recreational services provided varied significantly between different forests – from 5,200 EUR / ha / year to 14,850 EUR / ha / year for the forests with the highest per hectare value and from 200 to 320 EUR / ha for the forests with the lowest per hectare value. The valuation methodology used in the Danish study offers a flexible and spatially explicit approach to assessing the recreational value of forests under different scenarios. However, it also shows that the uncertainty in the benefit estimation needs to be carefully considered and addressed.

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What is/was the problem?

Since 1990 the Danish Government and local authorities are pursuing an ambitious afforestation plan to double the forest area in Denmark in the next 100 years, corresponding to 4,000–5,000 ha annual increase of forest (Miljøministeriet 2002). The aim of the assessment presented in this case study is to guide the implementation of afforestation plan based on the information of recreational benefits associated with forest ecosystems to the Danish public. The competition between different land uses in Denmark is high (e.g. agriculture, industry and urban areas) and therefore assessing benefits associated with forests can help to inform decision-makers on the (socio-economically) most optimal location of new forests. The approach taken in this assessment makes it possible to estimate welfare economic effects of afforestation while taking into account the characteristics and accessibility of existing forests. It also makes it possible to assess the welfare economic effects of recreation when changing the characteristics of existing forest sites, e.g. increasing the total area, age and/or composition of forests.

Which ecosystem services were examined and how?

The assessment focused on the recreational values that forests in North Zealand region in Denmark provide to the public, i.e. cultural and recreational ecosystem services. These included, for example, the use of forests for recreational activities (e.g. walking, jogging, cycling, picnicking, camping or hunting) and aesthetic values. The assessment estimated which type of forests people prefer to visit, the total recreation value that different types of forests provide the public (e.g. how many visits are made to different forest sites on an annual basis.

The assessment was done by combining a *discrete choice model* based on observed data of forest visits, a *count data model* based on a nationally representative household survey and *Geographic Information System (GIS)* which enabled a high spatial resolution. *Recreation value was estimated as the welfare economic value of visiting a given forest site (See Box 1)*. This welfare economic value indicates the value that people attach to visiting forests for recreation purposes and it was modelled based on the observed trade-off between minimising costs of travel and visiting a forest that provides a recreational experience in line with preferences of the individual. Consequently, the recreational value in this assessment was not estimated as the actual amount of money people pay to visit forests (e.g. travel costs).

The assessment was undertaken for all 52 public forests in North Zealand in Denmark, including the region of Copenhagen. Public forests in this region represent the vast majority of all forests. On-site surveys in these forests (21 days over one year) revealed the distribution of visits across the year (Jensen 2003). Combined with the information on frequency of visits, obtained from a representative national household survey by Jensen (1998), the study estimated the total number of visits.

Box 1. Discrete choice model & count data model

The discrete choice approach is based on modelling the factors that influence the decision of an individual choosing between several forests for recreation. It estimates how an individual chooses between different forest sites, under the condition that the individual chooses to go to only one site during one recreational trip. The model is based on observed behaviour of forest visitors during one year in all public forests in a region and is (in this case) modelled for the full population of the same region.

Observed behaviour is combined with a set of individual forest site characteristics such as size, diversity of tree species, diversity of age in tree stands, presence of water, topography and closeness to the coast as well as travel distance from the home of the individual to the forest. By combining the modelling of observed behaviour with the forest characteristics in a random utility framework, the discrete choice model estimates the preferences towards forest characteristics of the total population in the region and the probability of each individual of choosing a given forest.

Combining the probability of visiting a given forest and results of the count data model (i.e. a model that estimates the demand for forest recreation) the assessment evaluates the number of visits and the welfare economic value of access to individual forest sites. This approach is available for visits that were made by car and other motorised vehicles. In the case of Denmark, motorised vehicles represent approximately half of all visits to forests. The valuation can therefore be considered a conservative estimate of the recreation value of Danish forests.

Results of the assessment

In general, previous household surveys indicate that the Danish population of ca. 5 million people (at least in the 1990s) made 155 million visits for forests during one year. The "normal" Dane (i.e. the median) visited forests 10 times per year while 16% of the population visit forest very frequently (from once per week to daily visits). Over time, the frequency of visits has increased significantly by about 15% for people aged 15 to 75 years. It is also known that because visits have become more frequent visitors tend to go to forests for shorter periods of time per trip and to travel less far. The shorter travel distance is clearly linked to the trend that people go less by car to forests and more often by bike or foot. Cars still represent, however, the single most preferred means of transport when visiting forests (Jensen 1998, Jensen & Koch 1997).

The assessment of recreational values and preferences in North Zealand found that the value of recreational services provided varied significantly between different forests. In the region investigated, recreational value provided by the different forests ranged 5,200 to 14,850 EUR / ha / year for the forests with the highest per hectare value while the forests with the lowest per hectare value ranged from 200 to 320 EUR / ha / year (2005 values). The assessment also found that the population has rather heterogeneous preferences towards recreational characteristics of forests. According to the study, the main elements determining demand and preferences for recreational services include the level of accessibility to the sites (i.e. distance from home to site); characteristics of the forest sites (eg size, level of broadleaf species available, age of tree stands, presence of water, degree of open land, nature quality of surrounding areas, slope, distance to coast and species diversity); and visitor characteristics (age, ownership of car and income). Table 1 below shows how forest characteristics impact the values perceived by people. The assessment found that in most of the cases the population of North Zealand shares the same preferences towards structural characteristics of forests.

Table 1. Links between forest characteristic and public preferences for forest recreation

Forest characteristics	Preferences	
Species diversity index (Shannon)	☺/☹	Evidence of different preferences (62% prefer species diverse forests, 38% prefer non-diverse forest)
Fraction of open land in forest (%)	☹/☺	Evidence of different preferences (only 24% prefer open forests, 76% dense forest)
Fraction of trees >60 years old (%)	☺	No evidence of different preferences(preference for older trees in a forest)
Fraction of coniferous trees in forest (%)	☺/☹	Evidence of different preferences (66% prefer coniferous trees in forests, 34% prefer broadleaf trees)
Size of forest (log) (ha)	☺	No evidence of different preferences (preference for a larger forest to a smaller forest, albeit at a marginal decreasing rate)
Distance to nearest coast (log) (km)	☺	No evidence of different preferences (preference for a forest to be closer to the coast, albeit at a marginal decreasing rate)
Slope (index)	☺	No evidence of different preferences (preference for a forest with varied topography)
Fraction of water bodies in forest (%)	☺	No evidence of different preferences (preference for forests with water bodies)

By using data from an identical on-site survey conducted previously (Koch 1978, Jensen & Koch 1997), the assessment in North Zealand was able compare whether and how preferences, demand and monetary values of forest recreation over a 20 year period change (Zandersen et al. 2007a&b). The assessment found that both preferences and demand for forest recreation changed significantly over time. While the average yearly number of visits to forests increased by 15% at the national level, the number of car-borne trips to forests decreased over the period (Koch 1978, Jensen & Koch 1997). People prefer more frequent visits to forests within shorter distances and by other means of transport than cars. Consequently, *forests far away from Copenhagen receive fewer visits and urban fringe forests have become more popular to visit*. The preferences for some site characteristics also changed over time. Over the 20 year period the Danish population appears to have developed a more heterogeneous preference towards species diversity, openness and age of forests. In the latest survey, 62% of the population preferred species rich forests and 76% dense forest whereas 20 years ago the assessment did not find any heterogeneity for appreciating these attributes (i.e. 100% of population preferred species rich and dense forests). On the other hand, old forests were considered more attractive in the current survey (i.e. 100% compared to 82% preference 20 years ago).

Did the examination of ecosystem services generate impacts on decision-making or policies and, if so, how?

The methodology described in this case study has been used by the Danish Ministry of Environment, interested in establishing the economic rationale for public afforestation projects and in showing the case for applying economic models to assessing economic welfare effects of new projects. Seven afforestation sites across Denmark were selected by the ministry for assessment of the expected recreation value (Zandersen et al. 2007c). The sites were located on different regions with different land use typology and closeness to population centres. The evaluation of recreational values of these sites was based on a similar model framework conducted at the national level (Termansen et al. 2004), resulting in estimated recreation values of 560 EUR / ha–2,300 EUR / ha per site (2005 prices). The estimated values between sites varied based on the site characteristics and the availability / characteristics of alternative sites. Agriculture was in all cases the alternative land use of highest economic value, an average income of 940 EUR / ha (2005 prices). According to the estimate, in four of the seven cases afforestation for the purpose of recreation would be more optimal for society than the most likely alternative land use (i.e. agriculture). It should be noted that the methodology only accounts for car-borne recreation (ca. 50% of all forest recreation) and excludes the value all other types of ecosystem services that these forests provide. Focus in all seven afforestation cases was to locate forests in urban vicinity while protecting important drinking water resources. The three forests with per hectare values below the marginal opportunity cost of stopping agriculture were found in areas where either the urban area was very small (5,000 inhabitants); the forest site relatively large (nearly 800 ha) and/or with no natural vegetation surrounding the forest. It is evident that the joined economic welfare gain of afforestation would be higher in all cases when integrating all benefits of forest ecosystems into the valuation model, e.g. maintenance of water supply, carbon sequestration and conservation of biodiversity. The model estimation has also been extended in an analysis for policy makers on spatial assessment of ecosystem services in Europe (Maes et al. forthcoming) focusing on the effects of increased urbanisation in Copenhagen on forest recreation benefits and visits.

Lessons learned

The valuation framework developed in the context of the North Zealand assessment can be applied to estimate a minimum value for new forest recreation sites in areas where afforestation has already been planned and initiated.[33] Furthermore, it can also be applied prior to starting specific afforestation projects in order to find the optimal location and characteristics of new sites or to assess whether afforestation would be beneficial on a given location, given presence and characteristics of exiting recreation sites, population and accessibility. In order for the framework to be operational, it could be further automatised and made more user-friendly for planners and policy makers, this way providing an input to the decision making process of planning the expansion of the forest area in Denmark.

[33] The value of car-borne recreation is a minimum value of the total recreational values of forests. In order to establish a complete cost benefit analysis of afforestation projects, one would need to include the economic welfare value of clean ground water, biodiversity protection, CO_2 sequestration and other ecosystem services provided by forests. These values would need to be deducted from the economic welfare value of continued agriculture to obtain a net evaluation.

The described valuation technique is fairly data intensive and requires a dataset of thoroughly observed visits to forests. However, once such data has been collected, the methodology offers a wide range of applications of direct use for informing policy making when deciding on changing management and/or structures of existing forests or when deciding on the execution of an expansive forest policy. However, given the theoretical basis of the methodology, only visits made by motorised vehicles can be included in the model. The results of the valuation should therefore be considered only as minimum value for benefits related to recreation.

Afforestation is a long term project where maximum welfare may only be reached after 40 to 80 years after the forest has been planted. However, the extrapolations of estimated benefits are often made for 10 to 50 year periods without knowledge of the long-term reliability of transfer functions, welfare estimates or determinants of welfare. Tests of benefit transfer over time and space within the investigated region clearly show that caution is warranted as transfers can lead to errors by either exaggerating or underestimating the true value of the new site. The assessment finds that, where functional transfer models are statistically equal, benefit transfer errors are minimal (-3% to +9% error) (Zandersen et al. 2007a&b). However, also models that are not statistically equal may yield acceptable transfer errors of ±20%. Updating benefit functions may help reduce errors. By updating a functional benefit transfer over time, the assessment found an improvement in average transfer errors to drop from 334% to 24%. Also, any outliers in terms of characteristics of site should be avoided in benefit transfers. In general, an indication of when it is useful to carry out benefit transfer is when the foreseen error of *not* including the value of ecosystem services into model supporting decision-making is larger than the error related to the use of benefit transfer (Rosenberger and Loomis 2011). Similarly, one could also compare the margin of error related to benefit transfers with the costs of conducting new valuation studies.

References

Jensen, Frank S. 1998. *Friluftsliv I det åbne land 1994/1995* [Recreation in the open land 1994/1995] Forskningsserien nr. 25. Hørsholm: Forskningscentret for Skov & Landskab.

Jensen, Frank S. 2003. *Friluftsliv i 592 skove og andre naturområder]* Recreation in 592 forest and other nature sites]. Skovbrugsserien nr. 32. Skov og Landskab, Hørsholm, 2003.

Jensen, Frank S.; Koch, N.E. 1997. *Friluftsliv i skovene 1976/77-1993/1994*. [Recreation in Forests 1976/77-1993/94]. Forskningsserien nr. 20. Hørsholm: Forskningscentret for Skov & Landskab

Koch, N.E. 1978. *Skovenes friluftsfunktion I Danmark. I. Del. Befolkningens anvendelse af landets skove.* [Forest Recreation in Denmark. Part I: The Use of the Country's Forests by the Population] Det forstlige Forsøgsvæsen i Danmark 35, 285–451.

Maes, J., Hauck, J., Paracchini, M. L., Ratamäki, O., Termansen, M., Perez-Soba, M., Kopperoinen, L., Rankinen, K., Schägner, J. P., Henrys, P., Cisowska, I., Zandersen, M., Jax, K., La Notte, A., Leikola, N., Pouta, E., Smart, S., Hasler, B., Lankia, T., Andersen, H. E., Lavalle, C., Vermaas, T., Alemu, M. H., Scholefield, P., Batista, F., Pywell, R., Hutchins, M., Blemmer, M., Fonnesbech-Wulff, A., Vanbergen, A., Münier, B., Baranzelli, C., Roy, D., Thieu, V., Zulian, G., Kuussaari, M., Thodsen, H., Alanen, E., Egoh, B., Sørensen, P. B., Braat, L., Bidoglio, G. (forthcoming). A spatial assessment of ecosystem services in Europe: The Phase II Synthesis Report. PEER report no 4.

Miljøministeriet. 2002. Danmarks Nationale Skovprogram [National Forest Programme of Denmark]. Skovog Naturstyrelsen, Copenhagen, DK.

Termansen, M., McClean, C.J., and Skov-Petersen, H. 2004. Recreational sit choice modelling using high resolution spatial data. Environment and Planning A 36: 1085–1099.

Zandersen, M., Termansen, M., and Jensen, F.S. 2007a. Evaluating approaches to predict recreation values of new forest sites. Journal of Forest Economics 13 : 103–128.

Zandersen, M., Termansen, M., and Jensen, F.S. 2007b. Testing Benefits Transfer of Forest Recreation Values over a Twenty-Year Time Horizon. Land Economics 83(3): 412–440.

Zandersen, M., Termansen, M., Jensen, F.S. and Lars Trier. 2007c. *Værdisætning af friluftsliv i offentlige skovrejsningsprojekter.* [Valuation of Recreation in Public Afforestation Projects] Dansk Skovbrugs Tidsskrift 92(2): 41–61.

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Socio-economic importance of ecosystem services in the Nordic Countries

Nature provides a range of benefits (ecosystem services) that underpin human and socio-economic well-being. Many of these benefits – and the associated economic values – are not acknowledged in decision-making. As a result, nature remains almost invisible in the political and individual choices made. This report presents a synthesis of the socio-economic importance of ecosystem services in the Nordic countries. The study was initiated by the Nordic Council of Ministers (NCM) and the NCM Finnish Presidency in 2011, following in the footsteps of The Economics of Ecosystems and Biodiversity (TEEB) initiative. The study reveals that Nordic ecosystems play an integral role in supporting socio-economic wellbeing. However, a number of gaps in the existing information base still need to be addressed to ensure that these benefits are fully integrated into the Nordic decision-making processes.

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