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The case for more ecosystem services

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The case for more ecosystem services

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Innehåll

Foreword

Ecosystem services are fundamental to the welfare of humankind, yet these services often remain invisible in many societal decisions. This report contains statistics, studies and research showing how ecosystem services contribute to people's welfare and well-being. The Swedish Environmental Protection Agency hopes that the contents of this report inspire more people to understand and consider ecosystem services when taking decisions related to planning, strategy, investment and other decisions. Another of our goals is for everyone to be able to make use of the report, including people who are not professionally involved in environmental issues.

The arguments are divided into four themes: Water in Urban and Natural Landscapes, Beneficial Organisms, Human Health, and Climate Impact and Adaptation. The arguments are described using real-world examples as far as possible. There is also a description of the many different functions of ecosystems.

The report was produced in response to a government commission on communication initiatives for ecosystem services. The initiatives will contribute to achieving the milestone target of the environmental quality objectives, which requires taking into consideration the significance of biodiversity and the value of ecosystem services in important decisions that affect society by 2018.

The report was written by Ekologigruppen, an environmental consultancy, in collaboration with Belyazid Consulting & Communication, Sustainable Studio and Enveco (now Anthesis Enveco). A reference group consisting of researchers with expertise in each theme has fact-checked the contents (see Appendix 1, Reference group members).

The contact person at the Swedish EPA for this report is Karin Skantze.

Swedish Environmental Protection Agency, November 2018.

Summary

This report presents the case for taking ecosystem services into account when we take different decisions that affect society. The report reveals what we humans and society at large can gain from healthy, multifunctional ecosystems. Our arguments are divided into four themes: Water in Urban and Natural Landscapes, Beneficial Organisms, Human Health, and Climate Impact and Adaptation. The arguments are described as far as possible using real-world examples from places and organisations that systematically include ecosystem services in their operations and decision-making. There is also a description of the many different functions of ecosystems.

The Water in Urban and Natural Landscapes theme discusses how to prevent floods by favouring wetlands, restoring watercourses and working proactively to provide open stormwater solutions. As an added bonus, we also gain aesthetically pleasing environments that contribute to a greater understanding of nature and its cycles, increased biodiversity, purification of stormwater from nutrients and particulates, and a cooling effect during the summer through the regulation of local temperatures.

The Human Health theme is about the improved health that we humans experience when spending time in nature and parklands. As an added bonus, we create the means for providing air pollution control, flood control and stormwater purification, a cooling effect during the summer, carbon sequestration in vegetation and soil, aesthetically pleasing environments and, not least, improved conditions for biodiversity.

The theme of Beneficial Organisms along with Climate Impact and Adaptation use the same approach, with substantiated arguments for ecosystem services including examples and explanations of what we humans gain when we promote ecosystem services in these areas.

The earth's ecosystems are amazing in many ways, not least because they create many of the resources that build the foundation of our societies. But the ability of ecosystems to deliver the services we people depend on is being eroded by an all-too monofunctional use. Altered ecosystems pose great risks to human life and health. To reverse this trend, we need to manage ecosystems so that they can provide many different functions at the same time. In the long run society benefits from multifunctional landscapes and ecosystem-based solutions, in which many different environments and stakeholders contribute to high biodiversity and robust ecosystems.

Introduction

Society gains from multifunctional ecosystems

The earth's ecosystems are amazing in many ways, not least because they create many of the resources that build the foundation of our societies. But the ability of ecosystems to deliver the services we people depend on is being eroded by an all-too monofunctional use. Altered ecosystems pose great risks to human life and health. To reverse this trend, we need to manage ecosystems so that they can provide many different functions at the same time. In the long run society benefits from multifunctional landscapes and ecosystem-based solutions, in which many different environments and actors contribute to high biodiversity and robust ecosystems.

The concept of ecosystem services has evolved in order to create an understanding of the dependence of people's survival and well-being on ecosystems, with all the species and habitats they contain and the vital processes they maintain.[1, 2] Throughout the ages, humans have attempted to maximise the supply of ecosystem services such as the production of food, timber and energy crops, which has led to the erosion of other functions. As a result, the supplying services will also deteriorate because they depend on supporting and regulating services in order to function properly.[3, 4] In the forest, for example, efforts to increase timber production by draining wetlands have resulted in the impaired function of less visible yet important ecosystem services such as nutrient circulation, water regulation and climate control.[5]

Even in cities, activities that have an obvious monetary value, such as infrastructure and real estate, are prioritised over regulating, cultural ecosystem services. The latter, however, are crucial enablers of the urban environment's ability to be a good living environment for people and to contribute to processes like rainwater management and local temperature control, as well as to provide green areas for exercise, play and restoration.[6]

Society today has difficulty valuing and prioritising initiatives that strengthen supporting, regulating and cultural ecosystem services because these (usually) cannot be traded in markets and therefore do not have an obvious monetary value.[7] But this does not mean that they are any less vital for the future prosperity of the human race – on the contrary. Understanding the value of ecosystem services is not a special interest, but concerns us all. Equipped with an understanding of the importance of ecosystem services, politicians, organisations and individuals can make more conscious decisions that affect our future quality of life in a positive direction.

Multifunction – a solution for the future

Ensuring the functioning of supportive, regulating and cultural ecosystem services requires both physical space and consideration through adaptive management and farming techniques. It is easy to believe that the compro-

mise this implies regarding space and efficiency in cities and production landscapes is negative and reduces profitability. But there are several examples of how society in general benefits when cities and landscapes make more room for nature and landscaped vegetation, and thus more stable and stronger ecosystem services[3, 4, 8] (see Facts 1 and 2).

Biodiversity is a precondition for the long-term capacity of ecosystems to deliver ecosystem services and must therefore be preserved. Biodiversity increases the potential of ecosystems to adapt to long-term changes while increasing the likelihood that ecosystems contain species that can contribute when there are temporary disturbances. In other words, biodiversity strengthens resilience in the system.[5, 9] The creation of multifunctional urban and production landscapes thus requires natural environments and green spaces of different sizes distributed over several spatial scales.[10, 11] These can be planned and managed in the form of a blue-green infrastructure – a network of natural and green areas including water – in order to meet the habitat requirements of a wide range of species, thereby ensuring both biodiversity and ecosystems for the future.[12]

Everyone must contribute: The dilemma of ecosystem services

How much a single landowner is motivated to take steps to strengthen ecosystem services partly depends on how neighbours and surrounding community behave. Some ecosystem services, such as pollination and natural pest control of crops, benefit from more farms in a landscape that manage and create habitats for beneficial insects; the true benefits emerge only when many contribute.[13, 14] But since the cost of different measures is paid by each individual landowner, this encourages them to refrain from contributing and instead free-ride off of their neighbours.[15] This phenomenon is called the dilemma of ecosystem services. It means that it is difficult to provide an incentive to individual stakeholders to act for the common good.

Converting production methods to increase the amount of carbon dioxide that can be sequestered in the soil is also a measure that requires contributions from many stakeholders to deliver benefits to the public, while the trouble and cost are borne by the individual. In this respect, policies and society have a vital role to play by developing appropriate guidelines and other instruments to encourage the different stakeholders in society to share responsibility and costs.

Ecosystem services and the climate

Functioning ecosystem services are needed to adapt society to a changing climate. Climate models show that Sweden will be hit with more and heavier torrential rains, while dry spells and heat waves can also become more common.[16] To mitigate the negative effects of these changes, the majority of ecosystem services need to be strengthened, from those that regulate local temperatures and local and regional water flows to those that impact the water retention capacity and fertility of cultivated soil. If such measures

are taken using ecosystem-related approaches, they contribute not only to society's climate adaptation but to reigning in global warming, by increasing the uptake – instead of emissions – of greenhouse gases.[17, 18]

Fact 1: Ecosystem services from urban nature and parks

Nature, park environments and street trees in our cities provide several ecosystem services, thus forming the foundation of the city as a high-quality living environment for people. When researchers estimated the benefit of wooded natural areas and parkland for urban regions in 25 different cities, compared with the cost of setting up and managing them, their study showed that it was worth the investment in all cases.[8]

The monetary contribution of green spaces to an improved urban environment was estimated through five ecosystem services: air pollution control, temperature regulation, stormwater regulation, carbon sequestration and recreation. When the benefits were compared with the costs of restoration and management of the natural and park areas, it was found that the investments paid off, even though these were conservative estimates that only included functions that could be estimated in monetary terms. The benefit to society is, in fact, significantly higher since different functions of green spaces defy valuation through monetary metrics.

Fact 2: Ecosystem services and regional development

A study from 2009 estimated the monetary value of ecosystem services in Sweden at a regional level. When conventional GDP values were compared with environmentally corrected ones (which took into account emission reductions and human recreation in forests, agricultural landscapes and wetlands), the conditions between the country's "rich" and "poor" regions changed. The forests and wetlands in the north, considered poor in relation to other regions when using conventional metrics, suddenly became richer than other regions. For example, northern Norrland's values for ecosystem services from forests and wetlands were more than twice as high as other parts of the country. High values can thus be found hidden in natural resource-rich regions, in this case mainly in the region's storage of carbon and nitrogen.[19]

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Theme 1: Water in Urban and Natural Landscapes

Blue-green solutions reduce risk of flooding

Climate change is expected to bring with it both increased rainfall and more intense rainfall. Urban environments, with their large areas of sealed land surfaces, reduce the infiltration capacity of the ground and increase the risk of flooding. In densely populated urban areas, this can have devastating consequences for buildings, infrastructure and other societal functions. In rural areas, too, floods can cause major damage such as destroyed crops, nutrient leaching, pollution, erosion and landslides. For this reason, both local and regional planning for climate adaptation are needed using flow-regulating or equalizing measures. Compared with investing in technical solutions – which are often static and require a new and costly solution for each problem – both the individual land or property owner and society in general stand much to gain from ecosystem-related solutions for water flow control.

Urban vegetation and open stormwater solutions reduce risk of urban flooding

In cities, the large proportion of buildings and impermeable land surfaces hinder rainwater from penetrating into the ground; instead, it flows on the surface and is collected in stormwater and sewage systems to be diverted. When there is heavy and intense rainfall, this system fills up quickly. The result is increased risk of flooding and spill-overs as untreated wastewater is released. Trees and other vegetation in cities perform the mighty task of managing rainwater by absorbing and storing the water, and making the soil more porous and receptive to water infiltration. Studies show that just over 60 percent less rainwater runs off paved surfaces that have trees compared with purely paved surfaces during normal summer rains, and that almost no rainwater runs off grassy surfaces because trees, planting pits and lawns collect, evaporate and infiltrate the water instead.[1] The structure of the plantings is of great importance to water management in view of the soil's permeability and storage capacity.[2, 3] In the last decade, it has become common to use so-called structural soils, where the soil is built up from a 40 to 100 cm deep layer of large rocks with diameters of 65 to 150 mm. The skeletal structure is then filled with regular soil. This provides high water permeability; in many cases, large amounts of water can be stored and, in some cases, the water can also be purified. Whether the structural soils also make a positive impact on tree growth and vitality in the long term is currently unclear.[3]

The district of Augustenborg in Malmö used to be frequently affected by basement flooding during heavy rainfall. To address the problem, the stormwater system was renovated at the end of the 1990s. A new ecological system, in which the stormwater was diverted above ground in open areas, complemented the old combined sewage system where wastewater and

stormwater were diverted into a single pipeline. Today, water from roofs and other hard surfaces is collected in gutters and then passes through canals, ditches, ponds and wetlands, before it is finally discharged into the municipal stormwater system. In total, there are 6 km of canals, 0.2 hectares of green roofs and 11 ponds in the system.[4–6] As a result of these measures, basement flooding was reduced and the district was able to cope with the extreme precipitation during the 2007 and 2014 downpours, which hit the rest of Malmö hard.[5–8] Modelling studies conducted after the 2007 downpour showed that runoff to the sewage system was 50 percent lower with the new open stormwater system compared with the older system.[9] The 2014 downpour was estimated to have been a rainfall with 50–200 years' reoccurrence and was the worst downpour in Malmö since measurements began at the end of the 1800s. During this downpour, only one-tenth of the properties in Augustenborg were flooded compared with similar surrounding neighbourhoods that had traditional stormwater solutions. The downpour led to extensive building damage throughout Malmö, and a lower estimate of the total cost is estimated to exceed 600 million Swedish kronor.[10*] Major socio-economic cost savings can therefore be gained if floods in urban areas can be avoided.

An evaluation of the stormwater system's sustainability based on technical, environmental, economic and social perspectives showed that the various components of Augustenborg's stormwater solution were significantly more sustainable than traditional solutions.[11] This demonstrates how blue-green water management solutions not only provide a single ecosystem service but instead often imply multifunctional urban landscapes, for the benefit of biodiversity and human well-being as well.

An added bonus

Measures that improve urban water management also help to promote the following:

- Aesthetically pleasing environments.
- Natural environments for education that contribute to a better understanding of nature and natural cycles.
- More biodiverse environments.
- Purification of stormwater from nutrients, heavy metals, oil and other environmentally hazardous substances.[12, 13]
- A cooling effect during the summer, which regulates local temperatures.[2]

Restoration of watercourses and wetlands can reduce the costs of flooding

Over the course of several hundred years, people have straightened and laid watercourses that previously meandered through the landscape in pipes and culverts. Wetlands have been drained out to maximise production in agricultural and woodland areas. This has provided more land for crop cultivation

and forest production, but has also severely impeded the natural ability of landscapes to regulate both high and low water flows. By maintaining, managing and restoring remaining wetlands and watercourses, significant values can be created through improved flow-regulating functions.

Wetlands provide great value and several important functions

An entire 80 percent of Sweden's wetlands are impacted by human interventions such as trenching and peat extraction.[14] Straightened streams and fewer wetlands mean that less water can fit in the system, so heavy rain or snowmelt cause floods that can damage arable land, infrastructure and settlements. It also means that water flows faster toward lakes and seas, leading to an increased risk of erosion, avalanches and landslides when the soil is washed away. Nutrients and pollutants from urban stormwater and from agriculture and forestry are also washed out into lakes and coastal areas to a greater extent when plants and microorganisms do not have the time to absorb and break them down during the short time the water remains in the catchment area.

Both society as a whole and individual players can face significant costs associated with impaired water regulation in watercourses. The major flooding in the United Kingdom in June 2007 cost the economy an estimated 3.2 billion pounds. A significant proportion of this cost affected private individuals (38 percent) and companies (23 percent).[15] Southern Sweden was also hit hard by the June 2007 rains, with major damage in the Svartån and Emån river basins as a result.[16] The municipalites of Ånn and Arvika, lakes Mälaren and Vänern, the Gothenburg area and Kristianstad suffered significant flooding during the 2000s, caused either by snowmelt and heavy spring floods or by torrential rainstorms.[16]

Remaining wetlands and streams with natural flows help provide flood protection that is worth large sums of money, and are therefore worthwhile maintaining and managing. A British study has estimated the monetary values of five different ecosystem services that existing wetlands in the UK help to support: biodiversity, water purification, water supply, flood protection and aesthetic values.[15] This compilation gives a good picture of the multiple functions that wetlands can provide and illustrates great values for functions, experiences and the economy. Flood protection was the service estimated to be worth the most money (608 pounds/hectare wetland/year, on average), followed by biodiversity (304 pounds/hectare/year) and water purification (292 pounds/hectare/year). Since wetlands can produce ecosystem services for a significant amount of time, a long-term perspective is needed in order to reasonably compare the benefit with alternative technical solutions.[17]

It pays to restore watercourses and wetlands

The Höje River in southwestern Skåne represents an example of how water regulation can be improved within a catchment area. The river flows through high-quality arable land in the municipalities of Lund, Lomma, Staffanstorp

and Svedala. The landscape around the river has lost about 90 percent of its wetlands while the river itself has been shortened to half its original length, and the water flow is therefore greatly altered.[18] The construction of so-called two-stage ditches (see Fact 3) along the 12 km of the 35 km long stream can reduce the risk and cost of both erosion and flooding in major downpours, while improving functions that mitigate nutrient leaching and eutrophication of lakes and seas.

The total economic benefit that can be generated for a selection of ecosystem services (erosion control, flood protection and reduced nutrient leaching) by installing two-stage ditches is estimated at 6.5–12.1 million kronor over a 50-year period, which is the approximate time before a two-stage ditch needs to be restored. Since benefits that are difficult to estimate in financial terms are also produced (for example, increased biodiversity and recreational opportunities), and the construction costs are estimated at 6.3–10.6 million, this means that the investment pays off within approximately 50 years, even when only part of the benefit was included in the estimate.[18] In addition, restoration costs are lower than for new construction and therefore profitability increases over time.

Värmdö Municipality has also achieved huge savings by using blue-green solutions to reduce flood risk. The wetland Sjöäng, which is near the urban area, has been restored at a cost of 2.5 million kronor. The simple presence of a wetland that reduces the flood risk of a nearby bicycle path can save the municipality between 2 and 4 million kronor in repaving costs for the path.[19] which means that the restoration cost pays for itself. In addition, the wetland provides many other values and ecosystem services, not least in terms of biodiversity, fish reproduction and urban recreation.

An added bonus

Measures that improve water management in the countryside also help to promote the following:

- Better opportunities for biodiversity[15] and habitats for beneficial organisms.
- Wetlands perform a function even during droughts, because water collected in wetlands during rainy periods flows through the water system when it is drier.[20]
- An attractive and varied landscape for recreation.[15]
- Natural environments for education.[21]
- Purification of stormwater from nutrients and pollutants.[3, 12, 15]

Fact 3: Two-stage ditch

When a two-stage ditch is constructed, a grassed bench is created on both sides of the water course's centre part. In addition, the slopes are worked into a flatter slope. As a result, the entire riverbed is widened and provides space for much more water at high flows, while the depth of the centre part is sufficient for aquatic species to thrive so that biodiversity can be maintained or increased.[18]

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* This figure includes costs for insurance companies, claims compensation for wastewater permitting authorities, the City of Malmö's costs, and costs for the municipal housing company's MKB (not covered by insurance). It does not, however, include the costs and deductibles paid by the tenants unless they demanded compensation from their landlord or property owner, who in turn requested compensation from the permitting authority. Source: Marianne Beckmann at VA Syd. The data is presented in the City of Malmö's rainstorm plan, in process 2016.

Theme 2: Beneficial organisms

Increased yields and fewer pests thanks to beneficial organisms

Achieving long-term sustainable agriculture and forestry with well-functioning natural pest control and pollination of crops, wild plants and berries requires a transition away from present-day farming methods. Both individual landowners and society in general greatly benefit from the management of forests, pastures and microhabitats, the planting of flower strips and more restricted ploughing. In the long term the land is impoverished by conventional agricultural and forestry practices, with their crop and tree monocultures across large areas and use of chemical fertilisers and pesticides. Extensive monocultures bring a greater risk of attack from pests, which increases dependence on chemical pesticides. The pesticides are often persistent and can remain in crops, soils and streams and spread to people and natural environments, where they damage beneficial organisms. Measures that favour the ecosystem services of the production landscape are therefore a more viable option for securing local and global supplies of food and bioenergy.

Beneficial organisms contribute to sustainable food production and bioenergy

Intensive forest and agricultural production, along with chemical fertilisers, pesticides and large-scale loss of natural vegetation, have led to a sharp decline in the number of many species and sometimes their complete disappearance from the landscape, both in Sweden and globally.[1] Many of the species whose numbers have been reduced are vital to important functions that agriculture and forestry benefit from, such as the biological control of pests and weeds and the pollination of crops (see Facts 4 and 5). It is a major problem that supplying ecosystem services, such as the production of food and wood, are often favoured at the expense of the supporting and regulating services on which the supplying services depend.[2]

Although the global use of pesticides has increased seven times in the last 40 years, the damage to crops has not diminished.[3] One reason for this may be that pests develop resistance to the pesticides.[4] Therefore, alternative methods for combating pests via regulating and supporting ecosystem services are crucial components of sustainable agriculture and forestry.[5] The large-scale decline in both the number and species diversity of wild insect pollinators is driven by a combination of the loss of flowering landscapes and natural areas and the use of pesticides.[6, 7] Because pollinators help to pollinate wild plants as well as significant crops, this is very worrying. Globally, as much as 90 percent of the vitamin C in the human diet comes from crops that depend on insect pollination8. More than 75 percent of all arable crops worldwide are also wholly or partly dependent on insect pollination, even though the crops that cover the largest areas, especially maize, rice and

wheat, are pollinated by the wind.[9, 10] To secure the future production of a variety of beneficial crops and food, this trend must be stopped.

Limit pest infestations with simple measures that promote natural enemies

Natural enemies of pests and weeds limit attacks by eating adult pests, their eggs and larvae, or by eating weed seeds (see Fact 4). Through relatively simple methods, farmers can improve biological pest control on their farmland whether in conventional or organic farming. Measures with documented positive effects on natural enemies and cereal seed pest control include: reducing the use of pesticides; designating non-spray zones;[11, 12] reducing tillage (ploughing less often[13]); and sowing so-called flower strips adjacent to the fields.[14, 15] Preserving and managing a diverse landscape of grasslands, natural pastures and microhabitats using non-crop vegetation also pays off. This vegetation acts as the habitat and haven of many different beneficial organisms in agricultural landscapes which in turn help to limit infestation by insect pests.[13, 16-19] The use of natural enemies can reduce the damage caused by aphids on spring-sown cereal fields by 45–70 percent, according to estimates based on Swedish field data.[17] Studies also show that biological control of aphid attacks is likely to be more successful and have less variation between years if the fields contain several different species and groups of natural enemies.[12] In Swiss field studies with wildflower strips sown in winter wheat fields, the average crop yield increased by 10 percent within 10 metres of the flower strips because the damage caused by leaf beetles decreased by about 40 percent.[14] In experiments with spring barley in the area around Uppsala, biological pest control of aphids contributed to average crop increases of 303 kg/ha, which corresponded to 23 percent. This is comparable to the crop yield increase that chemical pesticides can provide today.[20]

Birds and bats also help to keep pests in check. In the Netherlands, studies on the great tit, which nest in apple orchards and eat insects and larvae in apple trees, show that ten nesting pairs per hectare can help reduce insect damage to apples by up to 50 percent and increase crop yield by 1,200 kg per hectare. In a crop that normally produces 40,000 kg per hectare, this corresponds to three-percent higher yields, while the only cost is for setting up nesting boxes to entice the birds to breed near the orchard.[21, 22]

Experiments in the United States have shown that bats suppress the number of pests in cornfields by chasing and eating insects at night, and help to reduce fungal growth that often follows after a pest attack.[23] To promote the presence of bats, their nesting sites in agricultural landscapes need to be protected and cared for, including forest groves, the cavities of large, old trees, old buildings and ground cellars. Watercourses and ponds adjacent to nesting sites act as hunting grounds for many species and are important elements of the landscape.[24] It is also important to carefully consider the lighting in such locations since bats thrive in the dark.[25.]

A diverse, flowering cultivated landscape helps pollinators get the job done

In Sweden, bumblebees, other wild bees and hoverflies are the main insects that pollinate crops (see Fact 5). The primary crops that depend on insect pollination are vegetable, fruit and berry crops, as well as rapeseed, turnip rapeseed, field beans and clover seed. For some varieties of rapeseed, the crop yield can increase 11–18 percent as a result of insect pollination compared with wind pollination only.[26, 27] In addition, the market value can increase further because the oil content is higher with insect pollination than with wind pollination. Clover seed cultivation is entirely dependent on insect pollination, and different species of bumblebees are the ones that do the job.[28] For strawberries and apples, too, production depends to a great extent on insect pollination. The pollination, and thus the harvest, also improve if several species-rich insects visit the flowers because the fruit then becomes larger, more well-formed and able to better withstand transport and storage, thereby increasing the market value of the harvested crop.[29–32]

For field beans[33] and strawberries,[30] experiments in Sweden have shown that the number of pollinators increases and the crop yield is higher in areas with organic cultivation, where chemical pesticides are avoided. In addition to reducing the use of pesticides, appropriate measures for promoting pollinators include preserving and managing a diverse cultivated landscape with remaining grasslands so that flowering wild plants remain from spring to late summer.[34] Bumblebees benefit from red clover fields in the landscape,[35] so one appropriate measure could be to allow sections of the clover to bloom by avoiding cutting down buffer strips. Even sowing strips of flower seed mixes in fields or along field boundaries has been shown to result in more pollinators on and around the farm.[36] Since pollinators fly anywhere from a few hundred metres up to a few kilometres to find food, several neighbouring farms should collaborate to make the measures truly successful. The benefit will be greater with collective implementation than if only one single farm creates flowering landscapes.[37]

Honeybees can partly make up for a lack of wild insects, but the contribution of wild species goes beyond what honeybees can do[38, 39] and helps to achieve a more stable pollination from one year to the next, which, for example, has been shown for Swedish red clover seed cultivation.[28] In addition, pollination becomes highly vulnerable if performed by only one species, especially since the honeybee can be subject to several serious diseases.[6, 40] Just as one can spread risk in a stock portfolio, farmers should invest in a variety of pollinators and other beneficial organisms to ensure a good return on their agricultural investment.

Wild pollinators and birds are important for the blueberry harvest

Forest berries are an important resource, both for private individuals who pick berries for their households or for pleasure and for companies in the berry business. To obtain higher yields and larger berries, the blueberry flower needs to be pollinated by insects. They can be anything from small

mosquitoes and flies to moths, bees and bumblebees. Different species of bees are considered to be most effective, and it is said that blueberry stocks in the range of a bee colony have larger berries. This is because a greater number of ovules in the ovary get fertilised, and the size of blueberries partly depends on the number of seeds it contains.[41] Both blueberries and lingonberries pollinated by insects also increase seed and berry set compared with self-pollinated berries.[42] The economic value of the insect pollination of forest berries in Sweden has been estimated to be between 40 and 70 million kronor per year.[43] This figure is based on a Finnish study and has been recalculated for Swedish conditions.[44] The estimate does not include the recreational value of berry picking, and should therefore be interpreted as a lower estimate of the total value of the berries in the forest.

Birds, too, contribute to the berry harvest by acting as a pest control. In experiments in northern Sweden, the damage to blueberries caused by larvae of smaller moths increased by an average of 41 percent when insect-eating birds were kept away from experimental surfaces using net cages.[45]

Promoting the forest's beneficial organisms calls for diverse, old-growth forests and woodland edges that contain elements of deciduous trees and fruit-bearing trees, such as hazel, mountain ash and wild cherry, where both beneficial insects, small birds and other species thrive.[46, 47] This can be achieved through measures such as a greater variation of forest management practices and intensity, which is also expected to be most economical in the long run.[48]

An added bonus

Measures that benefit beneficial organisms also help to promote the following:

- Better opportunities for biodiversity and habitats for rare and endangered species and beneficial organisms.
- An attractive and varied landscape for recreation.
- Natural environments for education.
- Mitigated climate change through increased carbon sequestration in the soil.
- Better soil quality through greater humus content in the soil.

Fact 4: Biological control

Several different types of organisms contribute to the natural regulation of pests, ranging from spiders and beetles to groups such as parasitic wasps, net-winged insects, assassin bugs and the larvae of hoverflies. Most of them control the pest by simply eating its eggs, larvae or the adult animals. For example, ground beetles and ladybirds eat aphids. This type of natural enemy often feeds on a wide range of species. Parasitic wasps instead lay eggs inside the pests themselves, which are then eaten up entirely by the wasp larvae. Parasitic wasps often specialise in attacking a particular species or group of pests. Finally, there are some species (for example, among ground beetles) that are seed-eaters and consume the weed seeds found in fields.

Natural enemies usually do not winter in annual crops, because they are disturbed by ploughing and other forms of tillage. Instead, they use buffer strips, pastures and forest edges around the fields and in the agricultural landscape. These environments are also needed to find food when the fields have been harvested. Managing, maintaining and establishing such environments are therefore essential to support a well-functioning biological control of pests.

Fact 5: Pollinating insects

Insects are the dominating group of pollinators, and at our latitudes different species of bees are the most important group. Even hoverflies – and to some extent other flies, butterflies, hawk moths and beetles – pollinate plants.

Sweden is home to more than 300 species of wild bees, of which about 40 species are bumblebees. The species that are not bumblebees are called solitary bees, because each female builds a nest of her own and collects food for her offspring. Bees come in many sizes, colours and shapes. They are also active during different parts of the summer season, thrive in different environments and prefer to visit, and thus pollinate, different flowers. Therefore, they complement each other in terms of pollination of both wild plants and crops.

The honey bee is a domesticated species and the only species in Sweden that has perennial colonies. In our climate, honey bees are dependent on someone who provides a hive and sugar water during the winter months to cope with their energy needs after honey has been harvested from the bee colony.

The Nordic countries are home to roughly 400 species of hoverflies. Only adult hoverflies feed on pollen and nectar and can pollinate plants. The larvae of many species are instead predators that eat aphids. So, they perform another ecosystem service: biological pest control. Other species' larvae live off of living or dead plant material and fungi and thus contribute to degradation.

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Theme 3: Human health

Better public health with access to nature and parkland

Nature areas and parkland contribute to human health, and there are thus great gains to be made, both for society and for the individual, by caring for them. This is especially true in urban locations where nature and parks can be close to people's homes and workplaces. Although public health in Sweden shows a general positive trend, diseases cause major problems for the individual and high costs for society. More and more people in Sweden are suffering from widespread diseases that are caused by sedentary conditions, including obesity, diabetes, high blood pressure and cardiovascular disease. Even stress-related diseases such as mental illness and pain are increasing sharply. Research shows that spending time in parks and nature promotes both physical and mental health, reduces stress and improves the immune response, even without physical exercise. It is therefore important to preserve, develop and create new green spaces to promote human health.

Green spaces help to boost mental and physical health

As a result of spending time in natural surroundings, people feel less stressed, healthier and happier and show an improved ability to concentrate and perform.[1–3] In addition to people's experience of feeling better and healthier, spending time in nature also brings about measurable, positive physical changes in the body, such as a lower heart rate, lower blood pressure and reduced muscle tension.[4] A mere four- to five-minute walk in the forest decreases heart rate and blood pressure.[5] Both perceived and measurable physical health benefits suggest that access to nature and park environments is an important societal issue (see Fact 6).

Many researchers believe that the health benefits of nature are due to the fact that people are more likely to relax when they spend time in nature, leading to increased activity in the parasympathetic nervous system. The parasympathetic nervous system is one of the two parts of the autonomic nervous system and is the system that is most active at rest as the body's energy reserves are built up. The second part of the autonomic nervous system is called the sympathetic nervous system. This is what is activated when the body's resources need to be mobilised, for example in response to stress and tension.[4] In simplified terms, we can say that spending time in nature activates the body's rest mode, which benefits recovery and restoration and thus positively affects our health. Some researchers compare being in nature to taking a multi-vitamin with many active ingredients, not just one or two benefits.[4]

One study shows that patients who had surgery and then had a hospital room overlooking a green area with large trees recovered faster, felt better, had fewer complications (like headaches and nausea) and used fewer pain-

killers than patients in rooms with a view of buildings.[6] Another study shows that a test group that had to walk in natural surroundings after a stressful task had lower blood pressure and felt more positive, less aggressive and had a better concentration ability than a test group that instead took a walk in an urban environment.[7] It is also possible to see improved recovery (in the form of reduced blood pressure) just from being in a room with a view of nature.[7] Increased access to nature and green spaces therefore plays an important part of efforts to reduce poor health in the population. It is worth remembering that not only large parks and green areas provide the opportunity for recovery. Even smaller gardens, street trees and green areas meet the criteria for contributing to recovery.[3]

How long do you need to be in nature? The longer and more often people spend time in nature the better, although it is difficult to calculate how much time is required to gain all the health benefits. An Australian study shows that people who spend longer periods of time in green environments have lower blood pressure and are less depressed, while people who visit green environments more often also exhibit higher social cohesion.[8] In these cases, the length and frequency of the visits were also linked to increased physical activity. The study also showed that spending time in green outdoor environments for 30 minutes once a week reduced the incidence of depression by 7 percent and high blood pressure by 9 percent. The cost of depression-related diseases in Australia alone amounts to AUD 12.6 billion annually (equivalent to SEK 81 billion), which shows that there are huge savings to be made if people were to spend more time in nature.[8] So, when more and more people live in cities, there are clear public health gains from investing in urban landscapes and park environments.

Calmer and healthier children in green environments

The effects of green environments on children's health were examined at two preschools in Scania in southern Sweden, both of which featured play-friendly, popular playgrounds. One school was in the countryside and had a garden-like playground and natural land, while the other had a playground built on a garage roof in an inner-city environment, with vegetation in flower boxes. The children at the nature-rich preschool had both better motor skills and higher concentration levels than the children at the nature-poor school, as well as fewer sick days.[9] The study was later expanded to include several hundred children in preschools in different environments in both Sweden and the United States. The results show clear correlations between the design of the school playgrounds and good levels of physical activity, but also between the green environment and the children's concentration levels and nighttime sleep.[10, 11] Yet other studies show links between green preschool playgrounds and lower body mass index (BMI) as well as improved nighttime sleep in preschoolers.[12] Studies in the United States have also shown that walking and playing in green environments can alleviate ADHD symptoms.[13]

There are also studies indicating a correlation between the presence of asthma among children and the number of street trees in their surrounding environment. One such study was conducted in New York, and the authors believe that the correlation may be due to a high incidence of trees that stimulate more outdoor play, but also because the trees can have a positive effect on air quality by reducing pollution.[14] Studies are currently underway to discover the conditions under which vegetation has a positive impact on air quality and in which ways.[15–17]

An added bonus

Measures that promote recreation, play and recovery in nature and park environments also help to promote the following:

- Increased motivation to exercise, something that generates many different physical and mental health benefits.[4]
- Air pollution control.
- Flow control and purification of stormwater.
- A cooling effect during the summer.
- Carbon sequestration in vegetation and soil.
- Aesthetically pleasing environments.
- Natural environments for education.
- Increased opportunities for biodiversity.

Fact 6: Health benefits of spending time in parks and nature

There are many health benefits to spending time in forests and nature. The levels of substances considered positive from a health perspective often increase after a walk in the forest, but not after a walk in the city. More examples of the positive effects of spending time in nature:

- The cardiovascular-protecting substance DHEA (dehydroepiandrosterone) increases in the blood,[18] which counteracts both obesity and diabetes.[4]
- Walks in the forest increase levels of adiponectin in the blood, a substance that counteracts atherosclerosis (hardening of the arteries) and increases the incidence of so-called killer cells.[18] Killer cells are important components of the immune defence system because they can both kill infected cells and activate other parts of the immune defences. They help contribute to protecting the body against cancer and various types of viral infections.[19]
- Glucose levels are reduced in diabetes patients.[4]
- The levels of inflammatory signal molecules are lowered. These are substances that the body secretes in response to stress or threats and that contribute to the development of diabetes, cardiovascular disease and depression.[4]
- Other medical conditions that can be positively affected by time spent in nature include acute urinary tract infections, intestinal infections, migraines, asthma and dizziness.[4]
- A 90-minute walk out in nature reduces activity in a part of the brain that controls brooding and mental distress, compared with an equally long walk in the city.[20] At the same time, people's own perceived sense of brooding and anxiety also decreases.[20]

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Theme 4: Climate impact and adaptation

Landowners can contribute to reduced climate impact

Adapting agricultural and forestry practices enables the soil to sequester larger amounts of carbon, thereby reducing the carbon footprint while increasing the soil quality for cultivating crops. Climate change is posing some major challenges, and that is a fact. The global average temperature is rising due to greenhouse gas emissions from human activities, such as the combustion of fossil fuels like oil, coal and natural gas. In addition to rising sea levels, longer periods of drought and more torrential rains, our changing climate is bringing changes to several ecosystem processes, which can have several negative consequences that are difficult to grasp today. To avoid further adding to the climate effect, current activities should not only reduce emissions but should also capture the greenhouse gases emitted. Today's agricultural and forestry practices involve large areas of land and therefore have a major impact on both uptake and emissions of greenhouse gases. Altered farming methods can therefore be key to sequestering more carbon to reduce climate impact while adapting production to changing climatic conditions.

More carbon in soil improves soil quality and increases arable land productivity

Today's intensive agricultural production more often than not means that the soil is depleted as the amount of mull, or organic matter, in the soil decreases. This is a problem because it means both that soil fertility decreases and that an ever-smaller amount of carbon is sequestered in the soil, which contributes to climate change.[1] By increasing the mull level in the soil, farmers can increase their productivity while making a contribution to minimizing climate impact.

To increase the amount of mull in the soil, farmers can take measures such as growing perennial crops and grassland, ploughing less, adding straw back into the field and using green fertilisers, cover crops or biofertilisers.[2] Additionally, these efforts lead to an increase in the quantity and activity of all soil organisms. Life in the soil possesses enormous diversity, from single-cell organisms and fungi to beetles and various worms. Most live by breaking down dead plants and animals, thus releasing nutrients that plants and crops can absorb. At the same time, they enrich the soil environment by agitating the soil and creating a more porous structure that facilitates growth of the roots and increases the supply of oxygen. A more porous soil with higher humus content also improves the soil's water retention capacity.[2] All in all, increased humus content can be seen as a way to secure the quality and productivity of farmland, even in the future.

So, is it worthwhile for the individual farmer to adapt his or her cultivation methods in order to maintain or increase the humus content of the soil? Studies of winter wheat in Scania show that a reduction of the humus level from 2 percent to 1 percent results in a reduced yield of about 3 tonnes per hectare. In addition, the need for nitrogen fertilisation increases to maintain this lower yield.[3] Increasing the humus content is thus a way of reducing dependence on fertilisers. By calculating the effects of altered humus levels on the yield over time, it is possible to estimate which measures are economically feasible. A humus content that decreases by 1 percent annually leads to a loss of income of approximately SEK 4,000 per hectare after 20 years, as calculated for autumn wheat.[2] In addition to climate gains, there are economic gains to be made for individual farmers who adapt their cultivation methods to secure the humus content, and carbon, in the soil.

Take care of the land and adapt forestry practices in its best interests

The trees in our forests constitute a vital part of the carbon cycle by storing carbon dioxide through photosynthesis as they grow. Part of this carbon dioxide returns to the atmosphere through the trees' respiration, but most of it is used to build the trees' biomass. Estimates show that terrestrial ecosystems have captured about 30 percent of the global greenhouse gas emissions caused by humans during the period 2000 to 2007.[4] Carbon sequestration of plants on land therefore represents an important ecosystem service.[5, 6] However, both Swedish and international studies have shown that the soil contains even more carbon than the vegetation does; between two and five times as much carbon is found below ground compared with what is found in trees and other vegetation. In the case of forests, approximately 70 percent of all carbon is estimated to be in the soil.[7–9] Therefore, the ground also provides a significant ecosystem service in the form of carbon sequestration, and changes in the soil's capacity to sequester carbon can have a significantly greater impact on forest carbon sequestration than changes in tree growth and biomass have.[10] Generally, management measures that increase disturbance of the soil are considered to result in increased carbon dioxide emissions.[11, 12] Today, however, there are very few concrete studies on how management measures such as ploughing stumps affect the soil and greenhouse gas emissions, and the few studies that exist often contain conflicting results. Research in this area is therefore needed to support suitable forestry guidelines.

The economic significance of the value of carbon sequestration in forests has been demonstrated in the Stockholm-Mälardalen region.[13] The forest's capacity to store carbon and nutrients has been estimated to lead to a 35-percent cost reduction in achieving the EU's climate goals and HELCOM targets (Convention on the Protection of the Marine Environment of the Baltic Sea Area) for reducing nutrient discharge into the Baltic Sea. This corresponds to a value of SEK 307 billion, or 0.45 percent of the Baltic region's GDP. The largest proportion is attributed to carbon sequestration. However,

this type of calculation contains a great deal of uncertainty partly due to uncertainties in the estimation of the amount of carbon sequestration over time.

Preserved wetlands contribute to climate-proofing

Drained peat soils used for agriculture or forestry represent only a few percent of Sweden's land area, but account for a significant part of Sweden's carbon footprint.[14, 15] In 2012, drained peatlands in Sweden emitted a total of 11.4 million tonnes of carbon dioxide equivalent, representing about 20 percent of Sweden's greenhouse gas emissions that same year.[15] The greenhouse gas emissions of drained wetlands have been difficult to highlight in national reports to the UN's Climate Convention and the Kyoto Protocol because they are not distinguishable from the forest net removals for the entire land use sector. Since current logging rates are lower than growth rates in our forests, resulting in ever-increasing wood stocks, there is a net uptake of carbon in the tree biomass. The emissions from drained wetlands are thus not apparent in the calculation results.[14]

There is a long history of planting forests on drained land such as peat bogs (see Fact 7), and this has been proposed as an alternative to counteract carbon emissions from drained wetlands. In the short term, tree planting can reduce emissions from drained land if the trees grow quickly enough so that they have time to capture the soil's released carbon dioxide and store it in the tree biomass. The carbon is then reallocated from soil to vegetation. But in the longer term, these trees will either become older – and not grow as quickly – or be harvested and most likely be turned into short-lived timber and pulp products. Unlike a drier soil, where it is claimed that it creates a cycle of carbon between the air and vegetation, we instead get a continuous decomposition of peat in the soil, with carbon loss to the atmosphere, when new forests are planted and ditches cleared. This is something that continues until the peat is completely gone. Calculations show that drained woodland emits between 700 and 1,100 kg of carbon dioxide per hectare and year;[14] this roughly corresponds to just under one year's carbon dioxide emissions from an average Swedish flat (including heating, hot water, electricity and washer/dryer), or a trip from Stockholm to Paris and back in a medium-sized gas-powered car.

A much better measure, according to some researchers, is rewetting the soil to turn it into wetland. Despite the resulting increase in emissions of the greenhouse gas methane, carbon dioxide and nitrous oxide emissions decline so much that the total emissions of greenhouse gases decrease by between 30 and 90 percent.[16] Because the financial resources for restoring wetlands are limited, the Swedish Board of Agriculture recommends the restoration of those drained peatlands, which represent the largest source of greenhouse gases. When it comes to woodlands, it mainly concerns nutrient-rich and heavily drained soils, because they often emit significantly more greenhouse gases than nutrient-poorer and wetter soils.[15]

Species-rich forests provide higher productivity and more ecosystem services

To increase both the productivity and the number of other ecosystem services in production forests, these forests should contain several different tree species. This is the conclusion of surveys of the species composition of forest trees in more than a thousand sample plots located throughout Sweden.[17] Biomass production was 50 percent higher in a forest with five different tree species than in a forest with only one species, a finding that is somewhat surprising since traditional forestry has often argued the opposite. However, similar results have been presented earlier in studies conducted in the Mediterranean region[18] and in North America,[19] for example. In controlled field trials, increased species richness has either a positive effect,[20] or none at all,[21] on the trees' productivity.

The Swedish study also showed that different tree species are linked to different ecosystem services.[17] The forest's growth rate is linked to the quantity of spruce, while patches of birch play a major role in the carbon sequestration of forest land. No tree species is able to perform all ecosystem services alone. Mixed stocks of spruce, pine and deciduous trees can become even more important in an altered future climate, with higher temperatures and reduced precipitation in the summer.[22] In southern Finland, where less summer precipitation will lead to periods of drought, estimates show that spruce in monocultures have lower growth than spruce growing in mixed stocks with pine and birch. Conifers are often less resistant to storm than deciduous trees.[23] For example, the spruce species was over-represented among tree windfall in the storm "Gudrun" that hit southern Sweden in 2005.[24] Although the conclusions of all the studies are not fully consistent, the forest's resilience to storms can also be greater in mixed stands of deciduous and coniferous trees compared with conifer monocultures.[23] An effort to use mixed stocks enable the forest to adapt to climate change and help to increase carbon sequestration and other important ecosystem services.

An added bonus

Measures that benefit climate adaptation and carbon sequestration in soil and vegetation also help to promote the following:

- Better opportunities for biodiversity and habitats for rare and threatened species.
- Improved control of water flows via wetlands.
- Reduced nutrient leaching to lakes, watercourses and coastal areas.
- An attractive and varied landscape for recreation, in which species such as deciduous trees help to increase the recreational value.[25]
- Natural environments for education.

Fact 7: Drained peat soils

Following the last ice age in the northern hemisphere, large amounts of peat accumulated in wetlands. Wet conditions cause a shortage of oxygen, and because dead plants only partially decompose in those cases they will instead form stocks of peat. Swedish peat soils have been drained since the 1200s, but more frequently since the beginning of the 1800s for agriculture and forestry purposes. A negative consequence of the drainage is, however, that the soil is grown away – the organic material decomposes when the soil becomes drier. The carbon stored in the peat is then converted into carbon dioxide and nitrous oxide, which contributes to climate change. It takes a hundred years or so for two metres of peat to literally disappear into the air when the organic material turns into carbon dioxide. Today, approximately 1 million hectares of forest in Sweden grow on drained peatlands, which is equivalent to about 4 percent of the productive forest land.[14, 15] New drainage is no longer allowed, but exemptions can be obtained in northern Sweden. However, maintenance of existing ditches is permitted.[14]

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* Calculated using emissions allowances from http://www.utslappsratt.se, and based on a normal consumption of 12,000 kWh/yr and flat, as stated by Eon (www.eon.se/normalforbrukning).

Appendix 1. Reference group members

Introduction: Society gains from multifunctional ecosystems

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Theme 1: Water in Urban and Natural Landscapes

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The case for more ecosystem services

REPORT 6850

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Ecosystem services are the foundation of human welfare, yet these services often remain invisible in many societal decisions. This report contains statistics, studies and research showing how ecosystem services contribute to people's welfare and well-being. The arguments are divided into four themes: Water in the City and Countryside, Beneficial Organisms, Human Health, and Climate Impact and Adaptation. The multifunctionality of ecosystems is also described.

The Swedish EPA hopes that the contents of this report inspire more people to understand and consider ecosystem services when taking decisions related to planning, strategy, investment and other decisions. Another of our goals is for everyone to be able to make use of the report, including lay-people not professionally involved in environmental issues. The report was written by Ekologigruppen as commissioned by the Swedish EPA. It has been produced in response to a government commission for communication initiatives for ecosystem services.

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